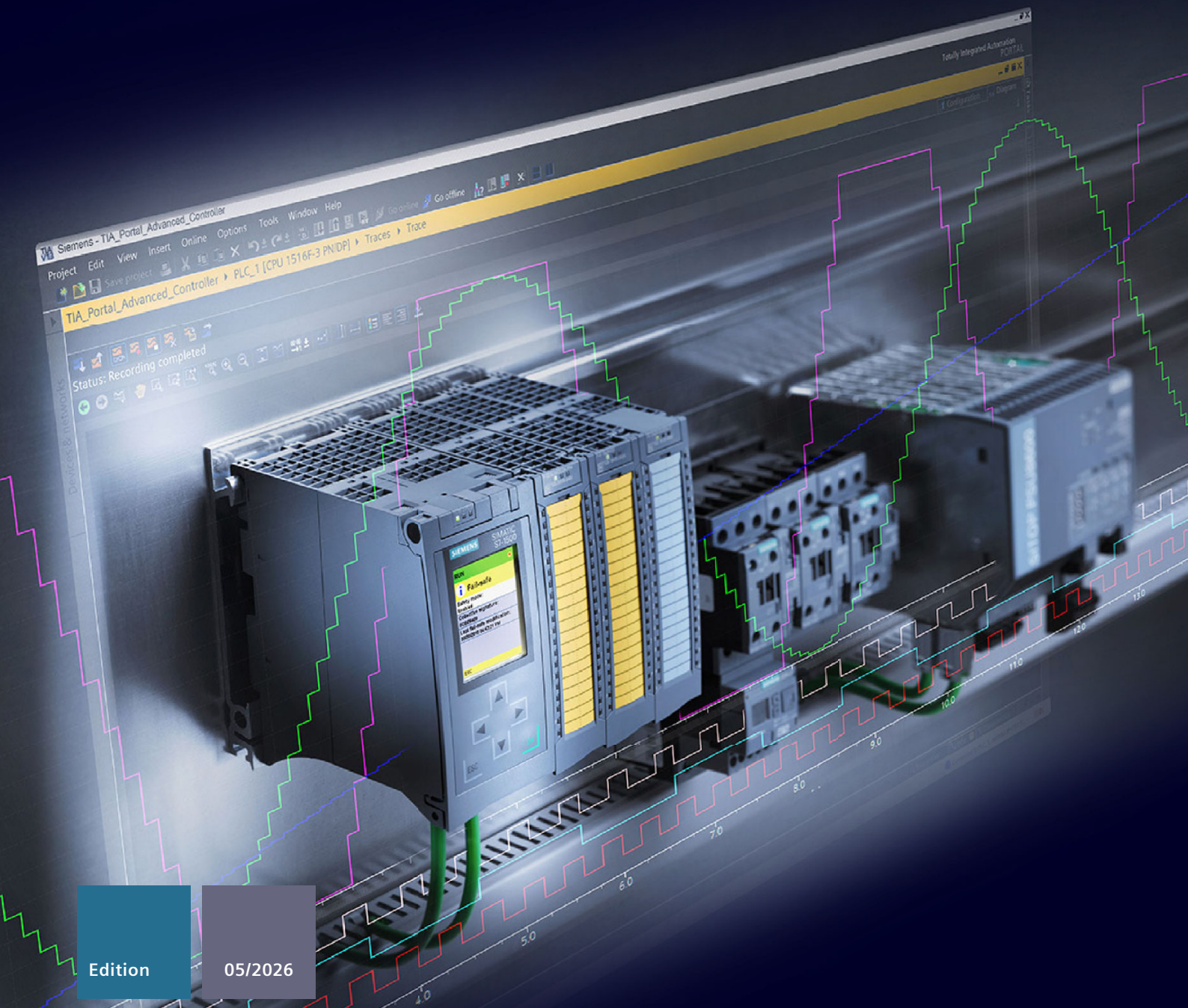
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Edition 05/2026

This document contains a compilation of all manuals for the fail-safe modules. Use the bookmarks at the edge of the screen for navigation.

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Failsafe modules

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S7
S7-1200 Functional Safety Manual

Equipment Manual

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Legal information

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This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

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indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

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The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified persons are those who, because of their training and experience, are familiar with the installation, assembly, commissioning, operation, decommissioning and disassembly of the product and can recognize risks and avoid possible hazards.

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GERMANY

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Preface

Purpose of the manual

The S7-1200 series is a line of programmable logic controllers (PLCs) that can control a variety of automation applications. Compact design, low cost, and a powerful instruction set make the S7-1200 a perfect solution for controlling a wide variety of applications. The S7-1200 models and Windows-based programming tools give you the flexibility you need to solve your automation problems.

This manual provides information about using, installing, and programming the S7-1200 Fail-Safe PLCs and is designed for engineers, programmers, installers, and electricians who have a general knowledge of programmable logic controllers.

Required basic knowledge

To understand this manual, it is necessary to have a general knowledge of automation and programmable logic controllers.

Scope of the manual

STEP 7: In this documentation, STEP 7 is used as a synonym for all versions of the configuration and programming software STEP 7 (TIA Portal). This manual describes or references the following STEP 7 products:

- *STEP 7 Basic* with:
  - *STEP 7 Safety Basic*
- *STEP 7 Professional* with:
  - *STEP 7 Safety Basic*
  - *STEP 7 Safety Advanced*
- S7-1200 fail-safe CPU firmware release V4.6
- S7-1200 fail-safe signal modules (SM) firmware release V2.x

For a complete list of the S7-1200 products described in this manual, refer to the technical specifications article numbers for fail-safe CPUs (Page 183) and fail-safe SMs (Page 183).

⚠ WARNING

The "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" in the current version is the authoritative source for Functional Safety-related information concerning configuring and programming.
Siemens identifies the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) as the authoritative and/or original source in the case of discrepancies between the manuals.
All warnings in the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" have to be observed.

Certification, CE label, C-Tick, and other approvals

Refer to the technical specifications (Page 128) for more information.

Glossary

The definitions in the glossary are provided to give the reader an easy first reference for understanding the terms as used in this manual. Some terms have detailed formal definitions in IEC 61508, EN ISO 13849, IEC 61784-3-3, and associated standards, and must be understood in terms of broad safety concepts detailed in these standards.

Another reference for more exact definitions is the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

Service and support

In addition to our documentation, we offer our technical expertise on the Internet on the customer support web site (http://www.siemens.com/automation/).

Contact your Siemens distributor or sales office for assistance in answering any technical questions, for training, or for ordering S7 products. Because your sales representatives are technically trained and have specific knowledge about your operations, processes, and industry, as well as the individual Siemens products that you are using, they can provide the fastest and most efficient answers to any problems you might encounter.

Special information

NOTE

Important note for maintaining operational safety of your plant

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

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

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

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/products?mfn=ps&pnid=13917&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

Documentation and information

S7-1200 and STEP 7 provide a variety of documentation and other resources for finding the technical information that you require.

- The *S7-1200 Functional Safety Manual* presents an overview of the Siemens Safety software and fail-safe CPUs and signal modules (SMs) and a Getting Started configuration and programming example. However, the focus of the manual is the S7-1200 fail-safe SMs. SM installation, configuration, diagnostics, applications, and technical specifications are emphasized.

  The English version of the *S7-1200 Functional Safety Manual* is the authoritative (original) language for Functional Safety-related information. All translated manuals refer back to the English manual as the authoritative and/or original source. Siemens identifies the English manual as the authoritative and/or original source in the case of discrepancies between the translated manuals.
- The *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* provides information that enables you to configure and program SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance testing of a SIMATIC Safety fail-safe system. Before configuring and programming an actual live fail-safe operation, it is essential that you refer to this manual.

- The *S7-1200 Programmable Controller System Manual* provides specific information about the operation, programming, and the specifications for the complete S7-1200 product family. In addition to the system manual, the *S7-1200 Easy Book* provides a more general overview to the capabilities of the S7-1200 family.
- The *S7-1200 Functional Safety Manual; SIMATIC Safety - Configuring and Programming, Programming and Operating Manual; S7-1200 Programmable Controller System Manual*; and the *S7-1200 Easy Book* are available as electronic (PDF) manuals. You can download or view the electronic manuals from the Siemens Industry Online Support Web site (http://support.industry.siemens.com). These manuals are also available on the Documents Disk that ships with every S7-1200 CPU.
- The STEP 7 (TIA portal) online help information system provides immediate access to the conceptual information, specific instructions, and error code event IDs that describe the operation and functionality of the programming package and basic operation of SIMATIC CPUs.
- The Siemens Industry Online Support Web site (http://support.industry.siemens.com) provides access to the electronic (PDF) versions of the SIMATIC documentation set. Existing documents are available from the Product Support link. With this online documentation access, you can also drag and drop topics from various documents to create your own custom manual.

  You can access online documentation by clicking "mySupport" from the left side of the page and selecting "Documentation" from the navigation choices. To use the mySupport Documentation features, you must sign up as a registered user.
- Siemens also provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, Functional Examples guide you in your safety applications, and Siemens training (SITRAIN) classes offer training in safety standards and products. Visit the following web sites to access these support activities:
  - Safety Evaluation Tool (http://www.siemens.com/safety-evaluation-tool)
  - Functional examples (http://www.siemens.com/safety-functional-examples)
  - SITRAIN (http://www.siemens.com/sitrain-safetyintegrated)
- The customer support web site also provides FAQs and other helpful documents for S7-1200 and STEP 7. Visit the following web sites to access the collection of podcasts:
  - STEP 7 Basic (http://www.industry.siemens.com/topics/global/en/tia-portal/controller-sw-tia-portal/simatic-step7-basic-tia-portal/Pages/Default.aspx)
  - STEP 7 Professional (http://w3.siemens.com/mcms/simatic-controller-software/en/step7/step7-professional/Pages/Default.aspx)
- You can also follow or join product discussions on the Service & Support technical forum (https://support.industry.siemens.com/tf/ww/en/?Language=en&siteid=csius&treeLang=en&groupid=4000002&extranet=standard&viewreg=WW&nodeid0=34612486). These forums allow you to interact with various product experts.
  - Forum for S7-1200 (https://support.industry.siemens.com/tf/ww/en/threads/237?title=simatic-s7-1200&skip=0&take=10&orderBy=LastPostDate+desc)
  - Forum for STEP 7 Basic and Professional (https://support.industry.siemens.com/tf/ww/en/threads/243?title=step-7-tia-portal&skip=0&take=10&orderBy=LastPostDate+desc)

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

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Product overview

1

1.1 Overview

SIMATIC Safety fail-safe system

The objective of safety engineering is to minimize danger to humans and the environment as much as possible through use of safety-oriented technical installations without restricting industrial production and the use of machines and chemical products any more than necessary. The SIMATIC Safety fail-safe system is available to implement safety concepts in the area of machine and personnel protection (for example, for emergency stop (E-STOP) devices for machining and processing equipment).

What are fail-safe automation systems?

Fail-safe automation systems control processes that can achieve a safe state immediately as a result of an unexpected operation or failure. These are fail-safe control processes where an immediate shutdown to safe state does not endanger humans or the environment.

Fail-safe systems go beyond conventional safety engineering to enable far-reaching intelligent systems that extend all the way to the electrical drives and measuring systems. You use fail-safe systems in applications with advanced safety requirements. You can resume production quickly following a safety-related interruption, using the improved fault detection and localization provided in fail-safe systems through detailed diagnostic information.

Achievable safety requirements

SIMATIC Safety fail-safe systems can satisfy the following safety requirements:

- Safety class (Safety Integrity Level) SIL 1 to SIL 3 in accordance with IEC 61508:2010
- Category 2 to 4, Performance Level (PL) a to e in accordance with EN ISO 13849-1:2015

Principles of safety functions in SIMATIC Safety

You implement functional safety using the hardware and firmware of the fail-safe CPUs and signal modules (SM) in conjunction with the safety program downloaded by the software (ES). The SIMATIC Safety system executes the safety function to bring the system to a safe state or maintain a safe state in case of a dangerous event.

The fail-safe SMs ensure the safe processing of field information (for example, sensors for emergency OFF pushbuttons and light curtains and actuators for motor control). The fail-safe SMs have the required hardware and software components for safe processing, in accordance with the required Safety Integrity Level (SIL).

You provide the safety function for the process through the application program that you create or by the reaction of the fail-safe system to a fault. In the event of an error, if the fail-

safe system can no longer execute its actual user safety function, it executes the fault reaction function (for example, the fail-safe system shuts down the associated outputs).

Example of user safety function

If an object interrupts the beam of a light curtain, the fail-safe system stops the motion in the area protected by the light curtain (user safety function):

- The light curtain provides a "1" signal, perhaps redundantly, to say the light beam is not broken or "0" to say the light beam is broken.
- The fail-safe digital input signal module (SM) acquires the signal from the light curtain and provides the state to the fail-safe CPU through a safe communication protocol. Redundant processors with mutual diagnostics in the fail-safe digital input SM provide a high assurance that a "1" is provided only when correct and faults result in a "0" being provided.
- The fail-safe CPU executes your user program for normal control of the motion and includes your programmed safety logic that says a "1" from the light curtain is required to enable the motion. Your programmed safety logic is encoded by the Engineering System in redundant logic steps that gives a high assurance that any fault in CPU execution results in an identified discrepancy and an output of "0". If the CPU fails to receive verifiable communication from the fail-safe digital input SM in a required time, the fail-safe CPU replaces the signal from the fail-safe digital input SM with "0".
- The fail-safe CPU delivers the results of the safety logic to the fail-safe digital output SM through the safe communication protocol. A "1" signal from your safety logic enables motion by turning an output channel ON, or a "0" turns the output channel OFF. Redundant processors with mutual diagnostics in the fail-safe digital output SM provide a high assurance that redundant output switches (series relay contacts or P/M 24 V DC solid state switches) are turned ON only when this is correct and at least one output switch turns OFF if a fault occurs. If the fail-safe digital output SM fails to receive verifiable communication from the fail-safe CPU in a required time, the fail-safe digital output SM replaces the signal from the fail-safe CPU with "0" and turns outputs OFF.

1.2 Hardware and software components

S7-1200 Fail-Safe CPUs and SMs

The following fail-safe V4.x CPUs and fail-safe signal modules (SM) are available with the STEP 7 Safety releases. You can use any of the listed S7-1200 fail-safe SMs centrally on any of the S7-1200 fail-safe CPUs:

- CPU 1212FC DC/DC/DC
- CPU 1212FC DC/DC/RLY
- CPU 1214FC DC/DC/DC
- CPU 1214FC DC/DC/RLY
- CPU 1215FC DC/DC/DC
- CPU 1215FC DC/DC/RLY
- SM 1226 F-DI 16 x 24 VDC
- SM 1226 F-DQ 4 x 24 VDC
- SM 1226 F-DQ 2 x Relay

An S7-1200 fail-safe system requires a fail-safe CPU and fail-safe SMs. The integrated I/O on the CPU is not fail-safe, but can be used to perform other control functions.

The S7-1200 standard signal modules (SM), communication modules (CM), and signal boards (SB) can be used in the same system with fail-safe SMs to perform your application control functions that do not require a rated Safety Integrity Level (SIL). Standard SMs that are supported for use with fail-safe SMs have the article numbers (6ES7--- ---32 0XB0) or later.

Hardware components for PROFINET IO

You can use the following fail-safe components in S7-1200 Fail-Safe on PROFINET IO:

- Fail-safe CPUs with built-in PROFINET interface
- Fail-safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - ET 200eco PN fail-safe modules
  - ET 200AL fail-safe modules
  - ET 200MP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200M fail-safe modules
  - ET 200pro fail-safe modules
  - Fail-safe GSD-based, PROFIsafe-capable I/O devices (for example, a light curtain or laser scanner)

NOTE

You must use V4.2 or later S7-1200 Fail-Safe CPUs when configuring PROFINET IO fail-safe components.

Hardware components for PROFIBUS DP

You can use the following fail-safe components in S7-1200 Fail-Safe on PROFIBUS DP:

- Fail-safe CPUs with the CM 1243-5 (PROFIBUS DP master)
- Fail-safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - ET 200MP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200M fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-safe GSD-based, PROFIsafe-capable DP slaves (for example, a light curtain or laser scanner)

NOTE

You must use V4.2 or later S7-1200 Fail-Safe CPUs when configuring PROFIBUS DP fail-safe components.

NOTE

You can only use PROFIBUS DP fail-safe modules that support PROFIsafe mode V2 with the S7-1200 CPU.

PROFINET shared device functionality

The "Shared Device" function allows the fail-safe and standard modules or submodules of an IO device to be shared by different IO controllers. One IO controller exclusively controls each module or submodule of the shared IO device.

Without the "Shared Device" function, you assign each I/O module or submodule of an IO device to the same IO controller. If you have sensors that are physically close to each other, but must provide data to different IO controllers, then you require several IO devices.

Refer to the S7-1200 Programmable Controller System Manual (https://support.industry.siemens.com/cs/ww/en/view/109478121) and the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for detailed information about PROFINET shared device configuration.

Required software components

You require one of the following software combinations:

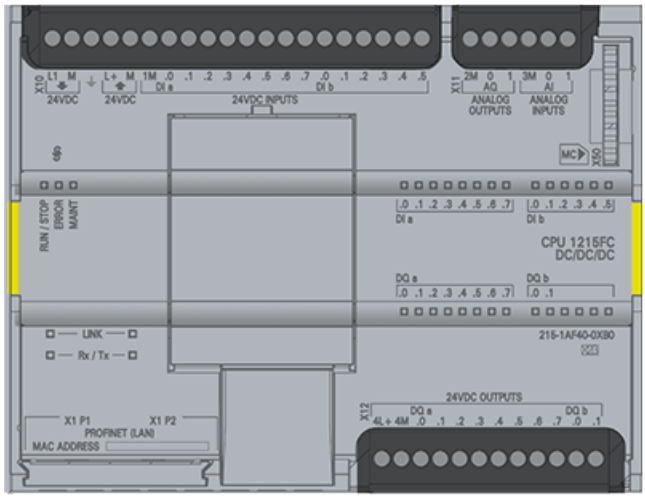
- *STEP 7 Basic* with the *STEP 7 Safety Basic* optional package
- *STEP 7 Professional* with *STEP 7 Safety Basic* optional package
- *STEP 7 Professional* with *STEP 7 Safety Advanced* optional package

STEP 7 Safety Advanced and *STEP 7 Safety Basic* are the configuration and programming software packages for the SIMATIC Safety fail-safe system. In both software packages, you receive the following:

- Support for configuring the fail-safe CPUs and SMs in the hardware and network editor of the TIA portal
- Support for creating the safety program using LAD and FBD and integrating error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your safety program in LAD and FBD with special safety functions

1.3 S7-1200 Fail-Safe CPUs

The fail-safe CPU executes your safety program along with standard applications programs. Communication between the fail-safe CPU and the fail-safe signal modules is verified using the PROFIsafe protocol.



Safety program

You can create a safety program using the program editor. You can program fail-safe function blocks (FB) and functions (FC) in the Function Block Diagram (FBD) or Ladder Logic (LAD) programming languages and create fail-safe data blocks (DB).

The fail-safe system performs a dual execution using coded processing. The fail-safe system automatically performs safety checks and inserts additional fail-safe logic for error detection and error response when the safety program compilation occurs. This ensures the detection of failures and faults and appropriate execution of reactions to maintain the fail-safe system in the safe state or bring it to a safe state.

In addition to the safety program, you can run a standard user program on the fail-safe CPU. A standard program can coexist with a safety program in a fail-safe CPU. The fail-safe CPU protects the safety-related data of the safety program from the unintentional effects of the data of the standard user program.

⚠ WARNING

You cannot put an S7-1200 Fail-Safe system that provides safety-related functions into operation after installation or modification until after you successfully validate the safety-related functionality.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
An S7-1200 Fail-Safe system that provides both safety-related functions and standard (non safety-related) functions must not be put into operation in order to use the standard functions before you successfully validate the safety-related functions, even if all fail-safe signal modules go to the error state and thus remain safe.

You can exchange data between the safety program and the standard user program in the fail-safe CPU by means of bit memory or data of a standard DB.

1.3.1 Behavior differences between standard and fail-safe CPUs

1.3.1.1 Safety mode

Safety mode

In safety mode, the safety functions for fault detection and fault reaction are activated in the following:

- Safety program of the fail-safe CPU
- Fail-safe signal modules (SM)

Safety mode of safety program

The safety program runs in the fail-safe CPU in safety mode. The safety program activates all safety mechanisms for fault detection and fault reaction. You cannot modify the safety program during operation in safety mode.

You can deactivate and reactivate the safety mode of the safety program. "Deactivated safety mode" enables the safety program for online tests and changes as needed while the fail-safe CPU is in RUN mode.

For SIMATIC Safety, you can switch back to safety mode only after an operating mode change of the fail-safe CPU from RUN to STOP to RUN.

Safety message frame

In safety mode, the fail-safe CPU and fail-safe SMs consistently transmit data between them in a safety message frame. The safety message frame in accordance with PROFIsafe standards consists of the following:

- Process data (user data)
- Status byte/control byte (coordination data for safety mode)
- Virtual Monitoring Number (encoded in CRC signature, provides keep-alive mechanism and detection of out-of-sequence messages)
- CRC signature

1.3.1.2 Fault reactions

Safe state

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe signal modules (SM). This applies to both sensors and actuators.

Passivation

Passivation applies safe state values to the fail-safe SM or channel(s) instead of process values when the fail-safe system detects faults. The safety function requires passivation of the fail-safe SM or channel(s) in the following situations:

- When the fail-safe system starts up
- If the fail-safe system detects overall module faults, such as RAM or Processor failures
- If the fail-safe system detects errors during safety-related communication between the fail-safe CPU and the fail-safe SM through the PROFIsafe safety protocol (communication error)
- If fail-safe channel faults occur (for example, short-circuit and discrepancy errors or internal faults of fail-safe input or output channels)

When passivation occurs in a digital input fail-safe SM, SIMATIC Safety provides the safety program with safe state values (0) instead of the process data pending at the fail-safe inputs in the input process image.

When passivation occurs in a digital output fail-safe SM, the SM sets the passivated channel(s) to a value of (0).

Reintegration

Reintegration returns the process from passivation to a normal state after successful diagnostics determine that the fault has cleared. After reintegration of a fail-safe digital input, SIMATIC Safety again provides the process data pending at the inputs to the safety program. For a fail-safe digital output, SIMATIC Safety again transfers the output values provided by the safety program to the fail-safe outputs. Reintegration from safe state values to process data can be automatic or require acknowledgement by your safety program. See "Reactions to faults" (Page 102) for steps to reintegrate.

Detection and response to faults

SIMATIC Safety systems detect and respond to faults in several different conditions:

- Faults in the fail-safe CPU hardware and firmware
- Faults in the fail-safe user program
- PROFIsafe communication errors caused by conditions in either the fail-safe CPU or SMs
- Fail-safe SM-wide errors such as microprocessor errors or memory errors
- Fail-safe SM channel errors such as discrepancy errors, wiring shorts, or internal channel faults

Fail-safe CPU faults and fail-safe user program faults often result in the CPU operating mode being set to STOP. You can reintegrate PROFIsafe communication faults once communication is successfully restored. In most cases, you cannot reintegrate SM-wide faults because these faults require the fail-safe SM to be power-cycled. You can often reintegrate and return channel faults to proper operation by removing the fault and reintegrating the channel.

Virtual monitoring number, cyclic interrupt time, and F-monitoring time

The following parameters are integral to fault reactions:

- Virtual monitoring number: The PROFIsafe protocol provides time monitoring and detection of message sequence errors by means of a periodically-updated monitoring number.
- Cyclic interrupt time: The cyclic interrupt time is the interval by which the F-runtime group executes and determines how often the fail-safe CPU sends the PROFIsafe frame to the fail-safe SMs. When you add a fail-safe CPU to your project, STEP 7 creates Functional Safety Organization Block 1 (FOB_1) (OB123 by default). FOB_1 contains the cyclic time interrupt time, and you can configure the cyclic interrupt time (100ms by default).
- F-monitoring time: The F-monitoring time is the amount of time an SM or CPU waits for an error-free communication including a new Virtual Monitoring Number before passivating channels. You can configure the F-monitoring time. The fail-safe CPU and SMs must receive a valid, current safety message frame with a valid monitoring number within the configured F-monitoring time.

If the fail-safe system fails to detect a valid monitoring number within the F-monitoring time, the fail-safe system passivates the fail-safe SM. Expiration of an SM's F-monitoring time causes a transition to safe state for all F-inputs or F-outputs of the SM.

CRC (Cyclic Redundancy Check) signature

A CRC signature contained in the safety message frame protects the validity of the process data in the safety message frame, the accuracy of the assigned address references, and the safety-relevant parameters.

If a CRC signature error occurs during communication between the fail-safe CPU and fail-safe SMs, the fail-safe system passivates the fail-safe SMs.

1.3.1.3 Restart of fail-safe system

The operating modes of the SIMATIC Safety system differ from those of the standard system only in terms of the restart characteristics.

Restart characteristics

When you switch a fail-safe CPU from STOP to RUN mode, the standard user program restarts in the usual way. When you restart the safety program, the fail-safe system initializes all data blocks with the F-Attribute with values from load memory. This is comparable to a cold restart.

The fail-safe system attempts to reintegrate each fail-safe SM at restart. In contrast to the standard user program, you cannot use startup OBs in the safety program.

1.3.1.4 Firmware update

NOTE

Fail-safe SM firmware (FW) updates

If 24 V DC power to the fail-safe SM is interrupted during the FW update, then the FW update must be started again with a memory card.

You cannot complete re-started FW updates from a web server or the TIA Portal.

Refer to the S7-1200 Programmable Controller System Manual (https://support.industry.siemens.com/cs/ww/en/view/109478121) for firmware update procedures.

1.4 S7-1200 Fail-Safe signal modules (SM)

1.4.1 Overview

Siemens intends for the S7-1200 fail-safe products to be used to help solve functional safety in machine applications.

There are three fail-safe SMs in conjunction with the S7-1200 V4.x release:

- SM 1226 F-DI 16 x 24 V DC
- SM 1226 F-DQ 4 x 24 V DC
- SM 1226 F-DQ 2 x Relay

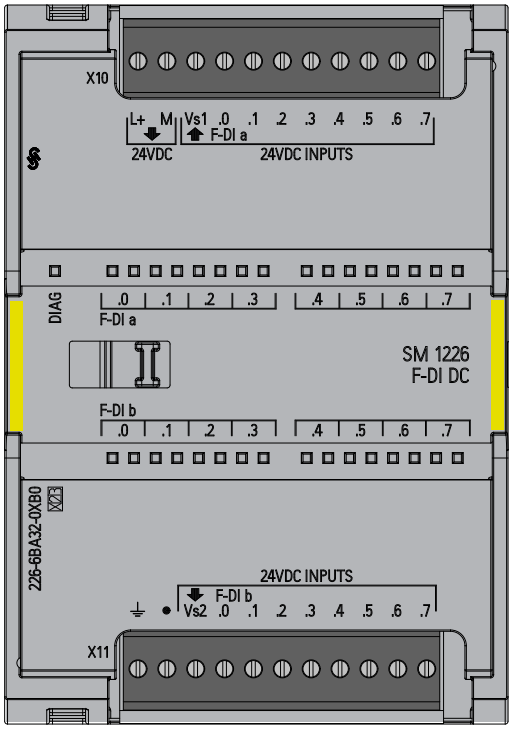
Redundant two-processor functional safety design

The major difference between S7-1200 fail-safe and standard SMs is that failsafe SMs use redundancy to achieve functional safety, including two processors that control fail-safe operation. Both processors monitor each other and verify that they are executing the same code at the same time, automatically test the I/O circuits, and set the fail-safe SMs to safe state in the event of a fault. Each processor monitors internal and external power supplies and module internal temperature and can passivate the module if an abnormal condition is detected.

Safety-related input and output signals form the interface to the process. This enables direct connection of single-channel and two-channel input signals from devices such as emergency STOP buttons or light curtains. The fail-safe SM redundantly combines the safety-related signals internally and passes the unified result on to the CPU in a fail-safe manner for further processing.

The fail-safe CPU sends the safety-related outputs from the CPU to the fail-safe SM for each individual output channel. Each output then sets two independent switches for each channel, a P and M solid-state switch, or two independent relays.

1.4.2 SM 1226 F-DI 16 x 24 V DC



The SM 1226 F-DI 16 x 24 V DC is an S7-1200 signal module (SM) for use in fail-safe applications. The inputs are rated for connection to 24 V DC sensors/switches and 3/4-wire proximity switches (for example, BEROs: Siemens line of no-touch sensors) and have an EN61131-2 type 1 input rating.

The module has two sensor supply outputs that can each power eight external sensors (inputs).

Inputs and test circuit

The F-DI consists of 16 input channels (F-DI a.0...a.7, F-DI b.0...b.7). You can configure these inputs as sixteen one-out-of-one (1oo1) inputs (SIL 2/Category 3/PL d), eight one-out-of-two (1oo2) inputs (SIL 3/Category 3 or Category 4/PL e), or combinations of 1oo1 and 1oo2 channels. One microcomputer monitors inputs a.0 to a.7, and the other microcomputer monitors inputs b.0 to b.7. The corresponding channels from a and b (a.0, b.0), (a.1, b.1)...(a.7, b.7) form a 1oo2 channel group. The "a" input, the first of the two inputs, conveys the signal in a 1oo2 configuration. For example, if you wire I8.0 and I9.0 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal appears at only the I8.0 input when you close or open the circuit for both.

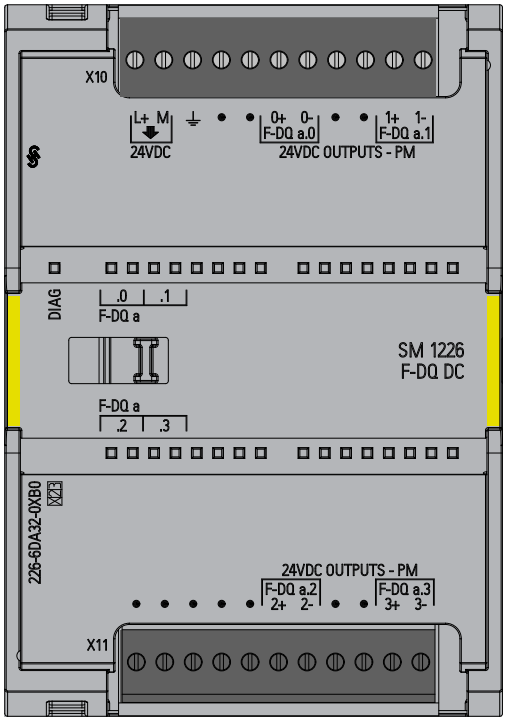
When you configure a channel group as 1oo2, the two controllers must sense the same input change within a configured time. Otherwise, the two controllers detect a discrepancy error. The F-DI reports the 1oo2 input back to the fail-safe CPU as a single input.

If you use a sensor supply output to provide power to a sensor, you can enable short-circuit testing. The short-circuit test checks for shorts to plus voltage by periodically pulsing the sensor output off and verifying that the associated input is off. This short-circuit test also checks for shorts to the other circuit in a 1oo2 paired input because the test pulses the two sensor outputs off at different times. The short-circuit test does not detect shorts between inputs in the same sensor group.

The processors cooperate in providing internal test pulses to each others process input circuits, after the initial field interface, to verify that sensing electronics are responsive to "1" and "0" inputs.

You can achieve Category 4 in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards.

1.4.3 SM 1226 F-DQ 4 x 24 V DC



The SM 1226 F-DQ 4 x 24 V DC is an S7-1200 signal module (SM) for use in fail-safe applications and is suitable for solenoid valves, DC contactors, and indicator LEDs. It has four outputs with P- and M-switching that are rated for connection to 24 V DC actuators with up to a 2.0 A rating.

Outputs

The F-DQ DC consists of four output channels (F-DQ a.0...F-DQ a.3). You can use each output for SIL 3 applications. Each output consists of two switches:

- A P-switch connects 24V positive (L+) to the load.
- An M-switch connects the load to M or 24V return.

Both switches must be turned ON for current to flow to the load.

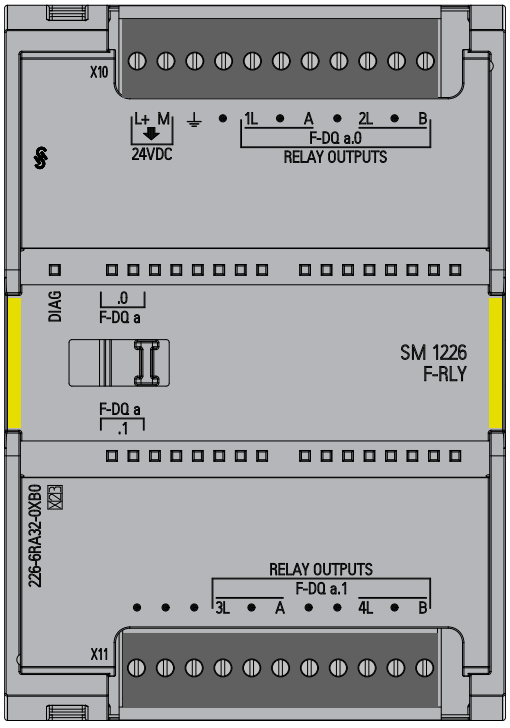
The F-DQ DC uses two microcomputers to implement the safety function. One microcomputer controls the P-switch while the other microcomputer controls the M-switch. There is feedback from the P-switch output to the other microcomputer that is controlling the M-switch. Likewise, there is feedback from the M-switch output to the other microcomputer

that is controlling the P-switch. The feedback verifies that the output switches are operating properly and in the commanded state.

You must configure a "Maximum readback time" that specifies the allowed delay for the output voltage to respond to the switch change.

The F-DQ DC regularly tests each "OFF" switch "ON" briefly, and each "ON" switch "OFF" briefly, to verify that each switch is still functional and under independent control. Your configured "Maximum readback time" also sets the duration of the "OFF" test pulse. You must configure a "Maximum readback time switch on test" which sets the duration of the "ON" test pulse. You should choose these durations short enough to not affect your load.

1.4.4 SM 1226 F-DQ 2 x Relay

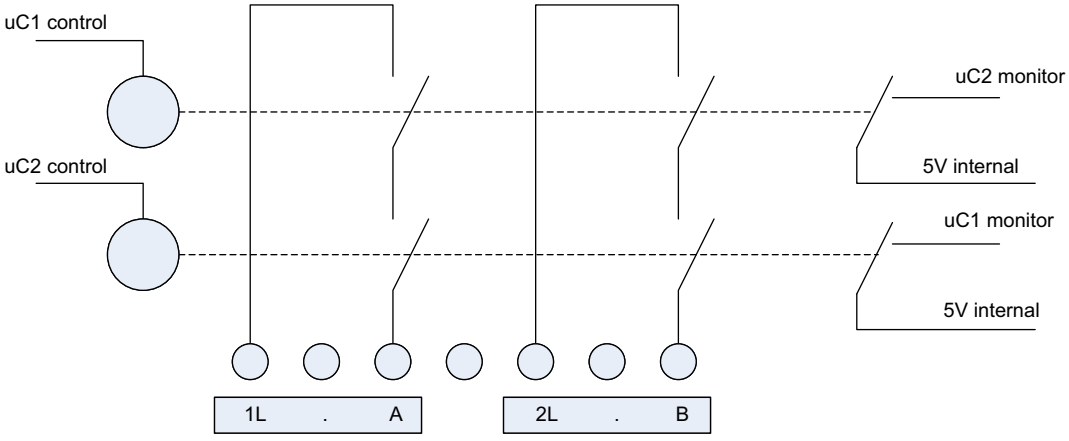


The SM 1226 F-DQ 2 x Relay is an S7-1200 signal module (SM) for use in fail-safe applications. The F-RLY has two output channels (F-DQ a.0 and F-DQ a.1). Each channel includes two circuits that switch mechanically-linked contacts at the same time. Each circuit has two contacts in series controlled by independent relay coils.

Each circuit can directly control an actuator in SIL 3 applications. You can use the two circuits together to control redundant contactors or relays for SIL 3 applications with interposing relays.

The F-RLY uses two microcomputers to implement the safety function. Different microcomputers control the two series relay contacts in each circuit. Control of each relay coil by one microcomputer is verified by the other microcomputer monitoring the mechanically-linked sense contact.

The series contacts in each circuit are switched in sequence to avoid common mode failure by the welding of both contacts.



Output channel a.0: Two circuits controlled as one process output channel.
Refer to the isolation description in the SM 1226 F-DQ 2 x Relay (Page 176) Specifications, Digital outputs table.

Outputs

You can use each of the two relay output channels for SIL 3 applications.

NOTE

Relay contacts of the SM 1226 F-DQ 2 x Relay are designed to Overvoltage Category III. You can use them in AC mains circuits without further overvoltage protection.
Relay contact outputs and AC inputs for fail-safe S7-1200 CPUs and standard (non fail-safe) I/O modules do not meet requirements regarding Overvoltage Category III, as applicable to EN 50156-1 conforming equipment (burner applications).
When using the SM 1226 F-DQ 2 x Relay in safety critical circuits of burner applications, you can use the relay contact outputs and AC inputs for fail-safe S7-1200 CPUs and standard (non fail-safe) I/O modules, but only if used in one of the following:

- SELV/PELV circuits
- Circuits connected to the electrical mains with permanent, recognized protection that reduces transients to Overvoltage Category II

Otherwise, the CPU and I/O system, including the SM 1226 F-DQ 2 x Relay, will not meet the Overvoltage Category III requirement for burner applications.

⚠ WARNING

Adjacent relay contacts in the same channel of the SM 1226 F-DQ 2 x Relay are not rated to separate AC line from SELV / PELV.
Death or serious personal injury and damage to machines and equipment can result if SELV/PELV circuits are wired adjacent to high voltage circuits on this module.
The A and B circuits of each output must either be both AC line or both SELV.

Getting started

2

2.1 Introduction to example

2.1.1 Instructional videos

The "Getting Started" chapter contains eleven instructional videos. Nine instructional videos take you step-by-step through many of the configuring and programming tasks. These instructional videos show the completed task at the beginning of the video, with a fadeout to a step-by-step tutorial that demonstrates all of the required sub-tasks:

- "Procedure" (Page 28) (shows a wiring overview of the S7-1200 Fail-Safe application example)
- "Step 1: Configuring the S7-1200 CPU 1212FC, CPU 1214FC, or CPU 1215FC" (Page 32) (step-by-step tutorial)
- "Step 6: Creating an F-FB" (Page 49) (step-by-step tutorial)
- "Step 7: Programming the safety door function" (Page 50) (step-by-step tutorial)
- "Step 8: Programming the emergency stop function" (Page 51) (step-by-step tutorial)
- "Step 9: Programming the feedback monitoring" (Page 53) (step-by-step tutorial)
- "Step 10: Programming the user acknowledgment for reintegration of the fail-safe SM" (Page 55) (step-by-step tutorial)
- "Step 11: Programming of the main safety block" (Page 57) (step-by-step tutorial)
- "Step 12: Compiling the safety program" (Page 58) (step-by-step tutorial)
- "Step 13: Downloading the complete safety program to the fail-safe CPU and activating safety mode" (Page 59) (step-by-step tutorial)
- "Step 13: Downloading the complete safety program to the fail-safe CPU and activating safety mode" (Page 59) (second video; shows the end result of the LAD programming steps)

2.1.2 Requirements for configuring and programming

These instructions will guide you step-by-step through a specific example for configuring and programming with *STEP 7 Safety*.

You will become acquainted with the basic functions and special features of *STEP 7 Safety*.

It should take one or two hours to work through this example, depending on your experience.

Requirements for the example

The following requirements must be met:

- In order to understand these Getting Started instructions, you need general knowledge of automation technology. You also need to be familiar with *STEP 7* and *STEP 7 Safety*.
- You need an S7-1200 station consisting of the following components:
  - Fail-safe CPU (CPU 1212FC, CPU 1214FC, or CPU 1215FC)
  - Fail-safe digital input signal module: SM 1226 F-DI 16 x 24 V DC
  - Fail-safe digital output signal module: SM 1226 F-DQ 4 x 24 V DC
- *STEP 7* and *STEP 7 Safety* must be correctly installed on your Windows-based programming device with an Ethernet interface.
- The programming device must be connected to the fail-safe CPU through the PROFINET interface.
- The CPU 1212FC, CPU 1214FC, or CPU 1215FC and other hardware must be fully installed and wired. Instructions for this can be found in the "S7-1200 Programmable Controller System Manual" (https://support.industry.siemens.com/cs/ww/en/view/109478121).

⚠ WARNING

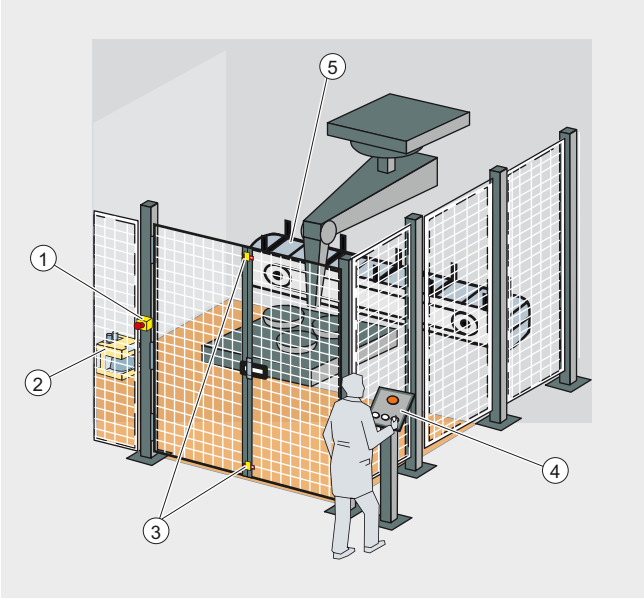
As a component in plants and systems, the S7-1200 is subject to specific standards and regulations depending on the area of application. Please note the applicable safety and accident prevention regulations (for example, IEC 60204-1 (General Requirements for Safety of Machinery)).

The example in these Getting Started instructions serves as an introduction to configuring and programming of *STEP 7 Safety Advanced*. It does not lead to actual live operation in every case. Before you do this, it is essential that you refer to the current version of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en). The warnings and other notes contained in that manual must be heeded at all times even if they are not repeated in this document!

Serious injury and damage to machines and equipment may result if these regulations are ignored.

2.1.3 Example structure and task definition

Production cell with access protection



① Emergency stop (E-Stop)
② Laser scanner
③ Safety door
④ Control panel with start and acknowledgement pushbuttons
⑤ Conveyor motor

A laser scanner monitors the entry to the production area. A safety door secures the service area.

Entering the production area or opening the safety door results in a stop or shutdown of the production cell similar to an emergency stop.

The system can only be restarted when the emergency stop is cancelled, the safety door is closed, and the laser scanner detects no one in the protected area. The user must acknowledge that conditions have returned to a safe state before production can be restarted.

2.1.4 Procedure

The example in these Getting Started instructions consists of the following sections:

Configuring

For this example, you must configure the following S7-1200 fail-safe CPUs and SMs:

- Fail-safe CPU (CPU 1212FC, CPU 1214FC, or CPU 1215FC)
- Fail-safe CPU standard digital inputs for user acknowledgement, feedback loop, and start pushbutton
- SM 1226 F-DI 16 x 24 V DC for connecting an emergency stop switch, the position switches for monitoring a safety door, and the laser scanner for monitoring the entry area
- SM 1226 F-DQ 4 x 24 V DC for connecting a motor

The configuration is described in the "Configuring" (Page 31) section.

Programming

Once the configuration is successfully completed, you can program your safety program.

In our example, a fail-safe block is programmed with an emergency stop, a safety door function, a feedback loop (as restart protection, when an incorrect load exists), and a user acknowledgement for reintegration. The block is then compiled to form a safety program.

The programming is described in the "Programming" (Page 44) section.

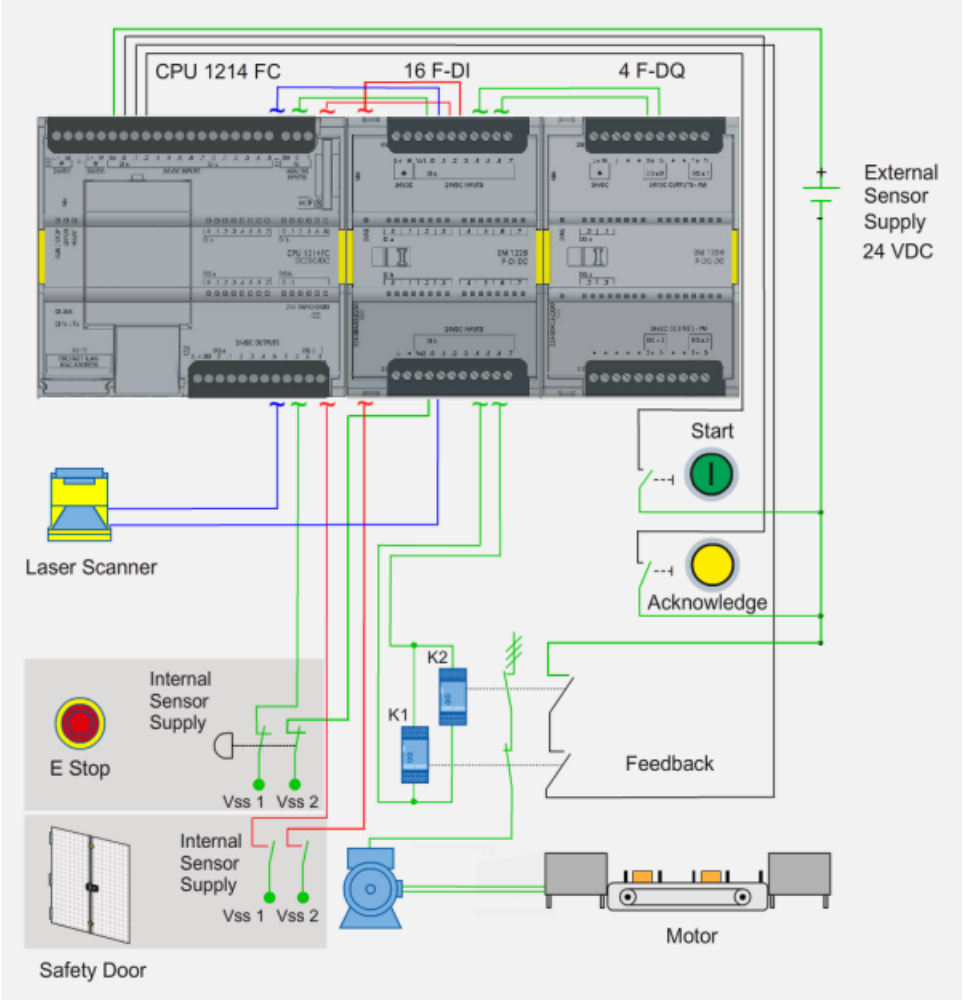
Operating the Getting Started example

This interactive graphic gives you the opportunity to become familiar with how the example functions in this Getting Started.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

The video switches the Laser Scanner, E-Stop, and Safety Door on and off to simulate unsafe conditions. Each device operates independently of the the other two devices. If you do activate a device, you must deactivate the device before continuing.

The video shows you that you must press the "Acknowledge" button to notify the system that you have returned to a safe state. Then, you can press the "Start" button to operate the system again.



The table below describes the steps and their actions:

Step	Action	Description
1	Activate the E-Stop. [1, 2]	This action prevents resumption of the operation.
2	Trigger the Laser Scanner. [1, 2]	This action prevents resumption of the operation.
3	Open the Safety Door. [1, 2]	This action prevents resumption of the operation.
4	Deactivate the Laser Scanner. [3]	The Laser Scanner deactivates.
5	Deactivate the E-Stop. [3]	The E-Stop deactivates.

[1] The activation of the E-STOP, trigger of the Laser Scanner, or opening of the Safety Door can be done in any order or individually to stop operations and bring the system to a safe state.

[2] To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device; 2. Press the Acknowledge button; 3. Press the Start button.

[3] This allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart operations.

Step	Action	Description
6	Close the Safety Door. [3]	The Safety Door closes.
7	Press the Acknowledge button.	The safety program requires acknowledgement.
8	Press the Start button.	Restart your operations.

[1] The activation of the E-STOP, trigger of the Laser Scanner, or opening of the Safety Door can be done in any order or individually to stop operations and bring the system to a safe state.

[2] To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device; 2. Press the Acknowledge button; 3. Press the Start button.

[3] This allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart operations.

2.2 Configuring

2.2.1 Introduction

⚠ WARNING

You may come into contact with live electrical wires connected to the main power supply.
Only wire the S7-1200 fail-safe CPU control system when the input power is turned OFF.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.

The installation and wiring of the S7-1200 fail-safe CPU is described in the S7-1200 Programmable Controller System Manual (https://support.industry.siemens.com/cs/ww/en/view/109478121).

Configuring the Hardware

In STEP 7 Safety, you configure the following S7-1200 components:

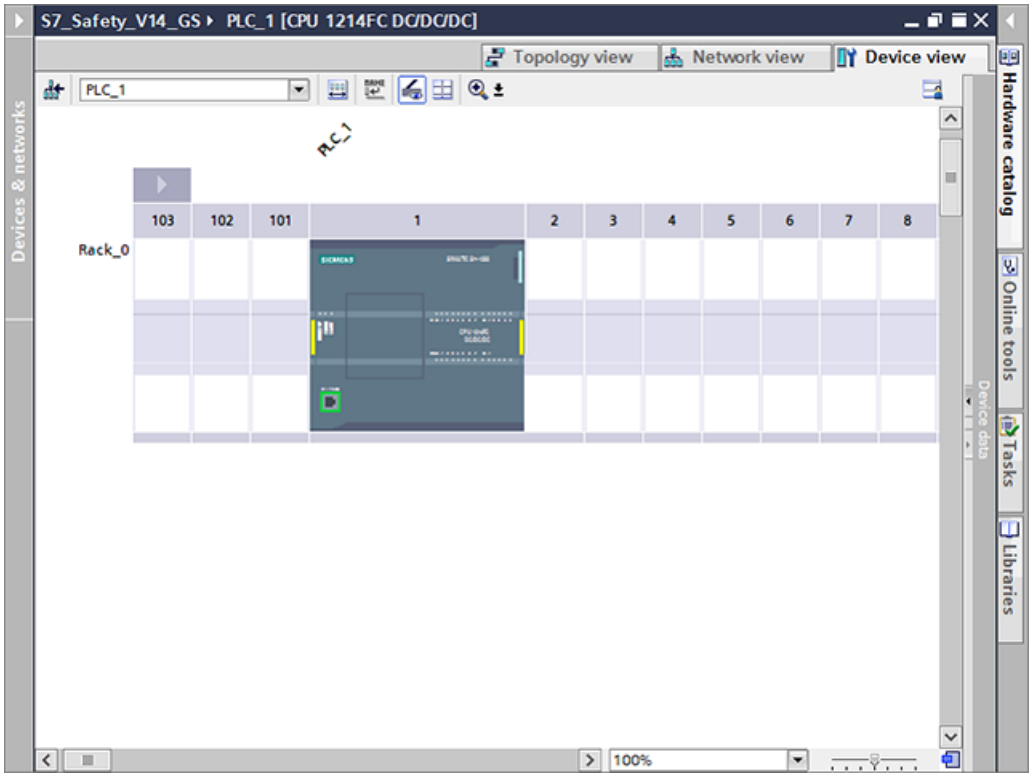
- Fail-safe CPU
- Fail-safe CPU standard digital inputs for user acknowledgement, feedback loop, and start pushbutton
- Fail-safe digital input SM for connecting an emergency stop switch and position switches for monitoring a safety door and the laser scanner
- Fail-safe digital output SM for connecting a motor

2.2.2 Step 1: Configuring the S7-1200 CPU 1212FC, CPU 1214FC, or CPU 1215FC

In this step, you create a new project, add a fail-safe CPU, and assign parameters.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. In the portal view of STEP 7 Safety, create a new project named "S7_Safety_V14_GS"
2. Use "Add new device" to add a CPU 1214FC.

NOTE

Any of the six available fail-safe CPUs (1212FC DC/DC/DC, 1212FC DC/DC/Relay, 1214FC DC/DC/DC, 1214FC DC/DC/Relay, 1215FC DC/DC/DC, or 1215FC DC/DC/Relay) may be used in this example.

Result: The Device View containing the CPU 1214FC opens.

3. Locate the "Fail-safe: F-parameters" area.

   You can change the following parameters or accept the default setting:

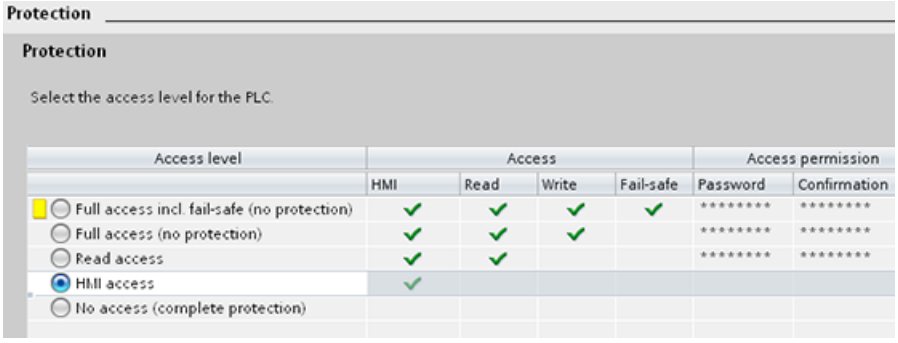
   – "Low limit for F-destination addresses": Default value is suitable for a stand-alone fail-safe S7-1200 CPU with local fail-safe SMs.
   – "High limit for F-destination addresses": Default value is suitable for a stand-alone fail-safe S7-1200 CPU with local fail-safe SMs.
   – "Central F-source address": Default value is suitable for a stand-alone fail-safe S7-1200 CPU with local fail-safe SMs.

– "Default F-monitoring time for central F-I/O": A valid current safety message frame must be received from the fail-safe CPU to a fail-safe SM within the F-monitoring time. Otherwise, the fail-safe SM goes to safe state. The F-monitoring time must be set high enough so that message frame delays are tolerated and, at the same time, low enough that the process can react as quickly as possible when a fault occurs. By default, the F-monitoring time for each fail-safe SM is taken from the "Default F-monitoring time for central F-I/O" parameter of the fail-safe CPU. However, you can configure the F-monitoring time individually for each fail-safe SM. Refer to Section 5.2: "Configuring common F-parameters" (Page 95) for further information.

Leave the default values unchanged for this example.

4. Move to the "Protection" area.

   Select the "Protection" property to select the protection level and enter passwords. "Full access incl. fail-safe (no protection)" protection level with a fail-safe write protection password is the lowest level for a fail-safe CPU. Enter and confirm a password for the required protection. Passwords are case-sensitive.



When you download this configuration to the fail-safe CPU, the user has HMI access and can access HMI functions without a password. To read data, the user must enter the configured password for "Read access", the password for "Full access (no protection)", or the password for "Full access incl. fail-safe (no protection)". To write data, the user must enter the configured password for "Full access (no protection)" or the password for "Full access incl. fail-safe (no protection)".

Access protection for the fail-safe CPU

The fail-safe CPU provides five levels of security for restricting access to specific functions. When you configure the security level and password for a fail-safe CPU, you limit the functions and memory areas that can be accessed without entering a password.

Each level allows certain functions to be accessible without a password. The default condition for the fail-safe CPU is to have no restriction and no password-protection. To restrict access to a fail-safe CPU, you configure the properties of the fail-safe CPU, and enter and confirm the password.

Table 1-1 Security levels for the CPU

Security level	Access restrictions
Full access incl. fail-safe (no protection)	Allows full access without password. This is the lowest level of protection for a fail-safe CPU.
Full access (no protection)	Allows full access, except write access to fail-safe blocks. Password is required for modifying (writing to) fail-safe blocks and for changing the CPU mode (RUN/STOP).

Security level	Access restrictions
Read access	Allows HMI access and all forms of PLC-to-PLC communications without password protection. Password is required for modifying (writing to) the CPU and for changing the CPU mode (RUN/STOP).
HMI access	Allows HMI access and all forms of PLC-to-PLC communications without password protection. Password is required for reading the data in the CPU, for modifying (writing to) the CPU, and for changing the CPU mode (RUN/STOP).
No access (complete protection)	Allows no access without password protection. Password is required for HMI access, reading the data in the CPU, for modifying (writing to) the CPU, and for changing the CPU mode (RUN/STOP)

Result

The new project has been created and the configuration of the fail-safe CPU is complete.

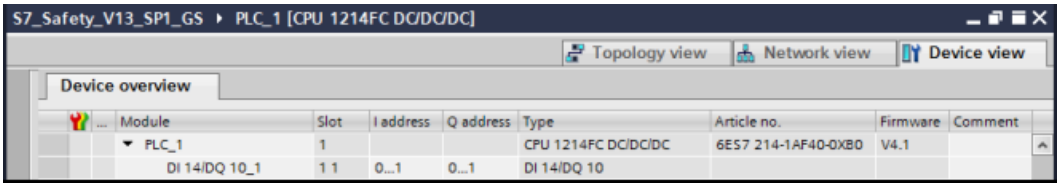
2.2.3 Step 2: Configuring fail-safe CPU standard digital inputs for user acknowledgement, feedback circuit, and start pushbutton

In this step, you assign parameters of fail-safe CPU standard digital inputs for the non-fail-safe signals (user acknowledgement, feedback loop, and start pushbutton).

Procedure

1. Assign the input address of the fail-safe CPU standard digital inputs to "0" for this example. Assign the output address of the fail-safe CPU standard digital outputs to "0" as well. You can assign these addresses in the CPU device configuration under "DI 14/DQ 10", "I/O addresses".

   Refer to the "CPU 1214FC Device view" information from the TIA Portal shown below:



Result

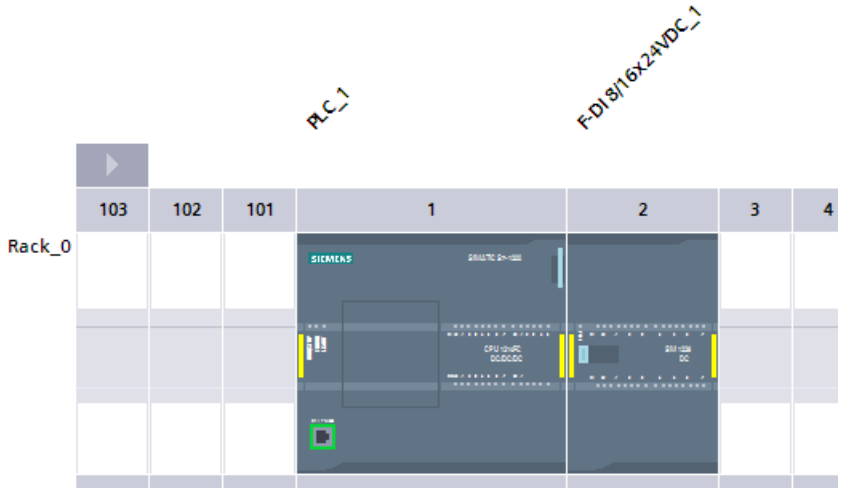
The configuration of the fail-safe CPU standard digital inputs is now complete.

2.2.4 Step 3: Configuring an SM1226 F-DI 16 x 24 V DC for connecting an emergency stop switch, position switches, and the laser scanner

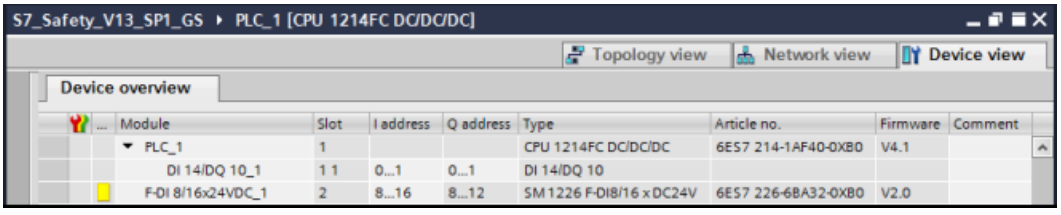
In this step, you configure an F-DI for connecting an emergency stop switch, the position switches for monitoring a safety door, and the laser scanner for monitoring the entry area.

Procedure

1. In the Device View of the S7-1200, use drag-and-drop to add an F-DI 8/16x24VDC_1 digital electronic module from the hardware catalog to slot 2.



2. Open "Device data" to display the "Device overview" area. Here, you can change the starting addresses for the inputs and outputs of your fail-safe module. Use the module default I/O addresses of "8" and "8" for this example (inputs begin at byte 8, and outputs begin at byte 8).



NOTE

The fail-safe SMs each use both Is and Qs, even though they may physically only have input channels or only have output channels.

The F-DI can have 8 - 16 input channels; however, the SM requires 9 input (I) bytes and 5 output (Q) bytes.

3. Return to the "Device view" and select the F-DI 8/16x24VDC_1. Under the "Properties" tab, select the "IO tags" tab. This action displays the "Process value" and "Value status" bits for the fail-safe module. Here, you can define tags for each channel:



Name	Type	Address	Tag table	Comment
	Bool	%I8.0		
	Bool	%I8.1		
	Bool	%I8.2		
	Bool	%I8.3		
	Bool	%I8.4		
	Bool	%I8.5		
	Bool	%I8.6		
	Bool	%I8.7		
	Bool	%I9.0		
	Bool	%I9.1		
	Bool	%I9.2		
	Bool	%I9.3		
	Bool	%I9.4		
	Bool	%I9.5		
	Bool	%I9.6		
	Bool	%I9.7		
	Bool	%I10.0		
	Bool	%I10.1		
	Bool	%I10.2		
	Bool	%I10.3		
	Bool	%I10.4		
	Bool	%I10.5		
	Bool	%I10.6		
	Bool	%I10.7		
	Bool	%I11.0		
	Bool	%I11.1		
	Bool	%I11.2		
	Bool	%I11.3		
	Bool	%I11.4		
	Bool	%I11.5		
	Bool	%I11.6		
	Bool	%I11.7		

Each Process value bit has an associated Value status bit that reports whether the corresponding process value is valid or passivated. Value status bits are ON for valid data and OFF for data associated with passivated channels. If an entire module or a single channel is passivated, the associated Value status bits are OFF.

To check the Process value bits and the Value status bits, you must know where these bits are mapped in the module. For an F-DI 8/16x24VDC_1, the first two bytes of the input (I) image register are the Process value bits, and the next two bytes of the input (I) image register are the Value status bits. For example, if the module starting address is I8.0 and Q8.0 for the F-DI 8/16x24VDC_1 and you have a 1oo1 configuration, then the Process value bits and corresponding Value status bits are allocated as shown in the following table:

Process value	Value status bit
I8.0	I10.0
I8.1	I10.1
I8.2	I10.2
I8.3	I10.3
I8.4	I10.4
I8.5	I10.5
I8.6	I10.6
I8.7	I10.7
I9.0	I11.0
I9.1	I11.1
I9.2	I11.2
I9.3	I11.3
I9.4	I11.4
I9.5	I11.5
I9.6	I11.6
I9.7	I11.7

If you have a 1oo2 configuration, then the Process value bits and corresponding Value status bits are allocated as shown in the following table:

Process value	Value status bit
I8.0	I10.0
I8.1	I10.1
I8.2	I10.2
I8.3	I10.3
I8.4	I10.4
I8.5	I10.5
I8.6	I10.6
I8.7	I10.7
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-

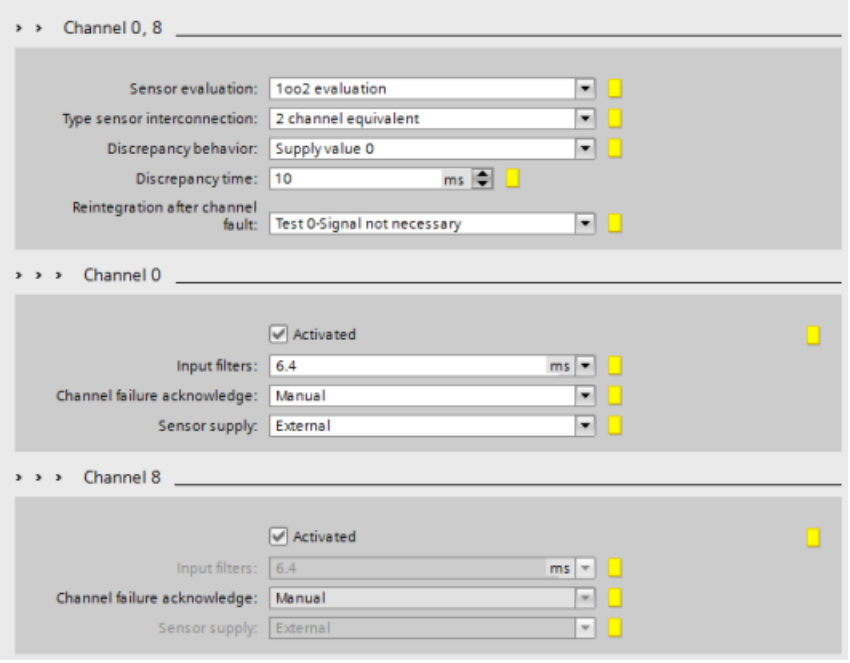
4. Under the "Properties" tab, select the "General" tab, and then select the "F-parameters" area. Here, you can change the following parameters or apply the default settings:
   – "F-monitoring time": A valid current safety message frame must be received from the fail-safe CPU to the F-DI within the F-monitoring time. Otherwise, the F-DI goes to safe state. The F-monitoring time must be set high enough so that message frame delays are tolerated and, at the same time, low enough that the process can react as quickly as possible when a fault occurs and run without impairment. By default, the F-DI's F-monitoring time is taken from the "Default F-monitoring time for central F-I/O" parameter of the fail-safe CPU.

     NOTE
     The "cyclic interrupt time" is a closely-related parameter to the F-monitoring time. The cyclic interrupt time is the interval by which the F-runtime group executes and determines how often the fail-safe CPU sends the PROFIsafe frame to the fail-safe SMs. When you add a fail-safe CPU to your project, STEP 7 creates Functional Safety Organization Block 1 (FOB_1) (OB123 by default). FOB_1 contains the cyclic interrupt time.

   – "F-destination address": A unique PROFIsafe address is critical for every F-IO used in a safety system (network and CPU-wide). Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for procedures to set and verify unique PROFIsafe addresses in networked systems.

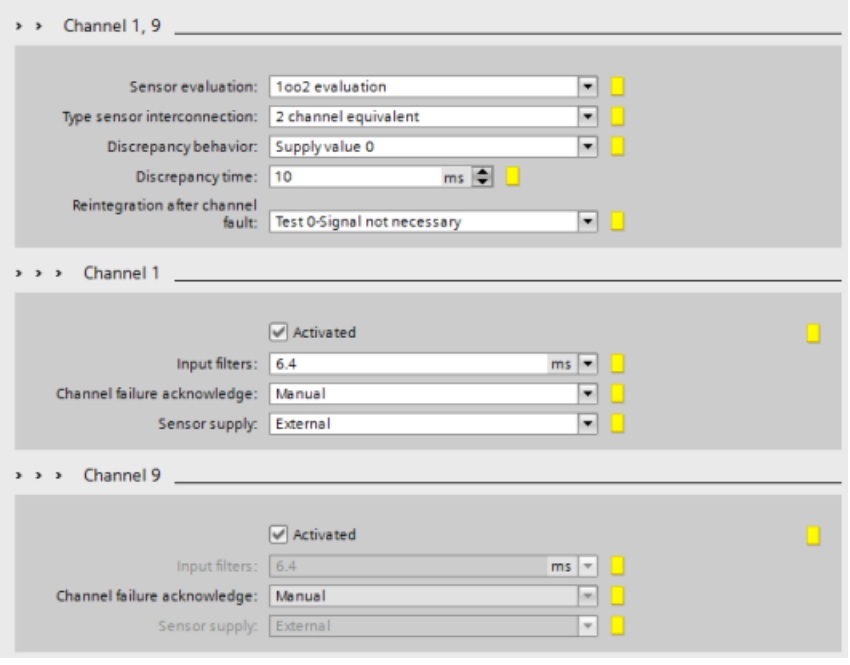
   Leave the settings unchanged for the F-parameters for this example.
5. Select the "DI parameters" area.
   Deactivate (uncheck the box) the "Short-circuit test" parameter for this example.
6. In this example, a two-channel emergency stop switch (emergency stop) is connected to channels 0 and 8.
   In our example, these channels are wired to Process value bits I8.0 and I9.0. The first of the two inputs, I8.0, conveys the signal in this 1oo2 configuration. Expand "DI parameters" and "Channel parameters" and select "Channel 0, 8".

Enter the settings as shown in the following figure:

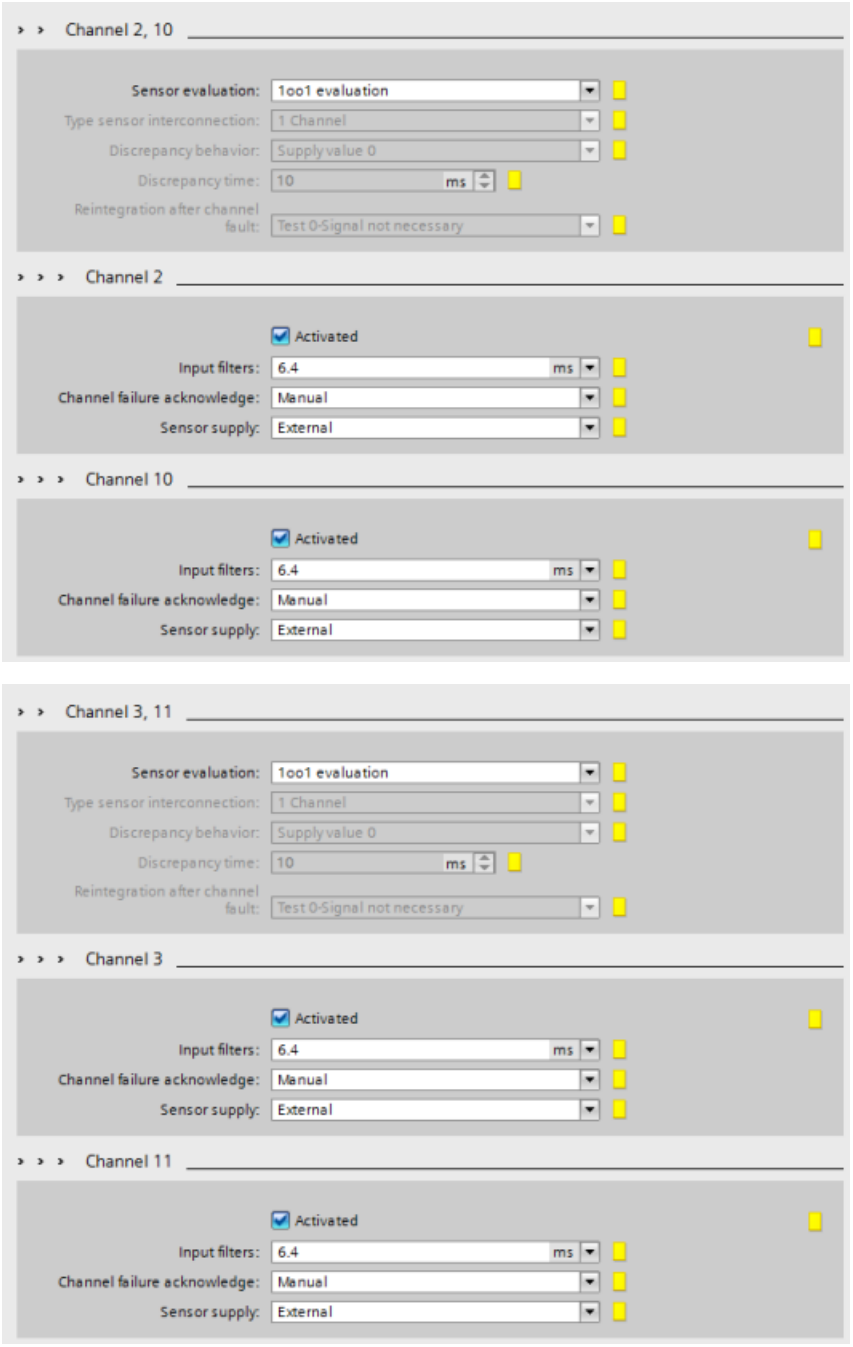


7. In this example, the laser scanner for monitoring the accessible entry area is connected to channels 1 and 9.

   Make the settings as shown in the following figure:



8. In this example, the position switches for monitoring a two-channel safety door are connected to channels 2 and 3.
   Make the settings as shown in the following figure:



9. Disable the following unused DI channels by clearing the "Activated" check box:

-
-
- 4
- 5
- 6
- 7
- 10
- 11
- 12
- 13
- 14
- 15

Result

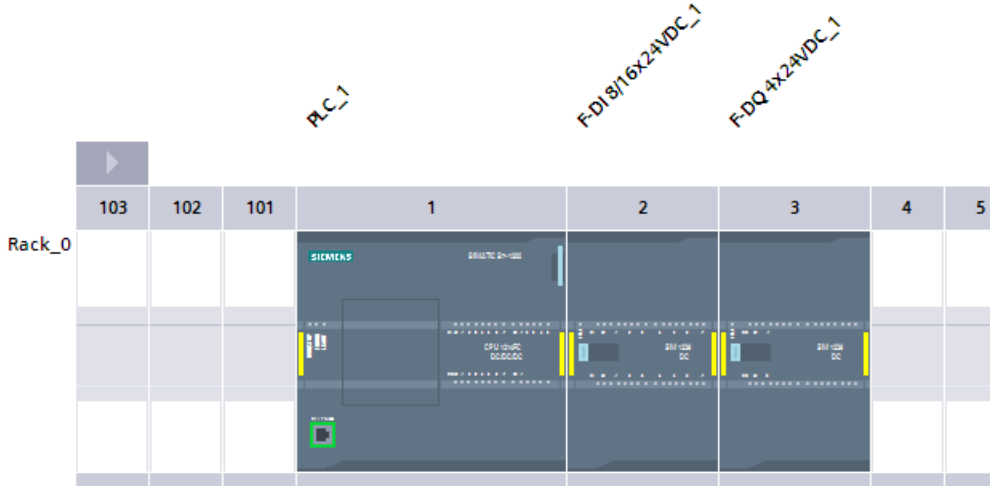
The configuration of the F-DI is now complete.

2.2.5 Step 4: Configuring an SM 1226 F-DQ 4 x 24 V DC for connecting a motor

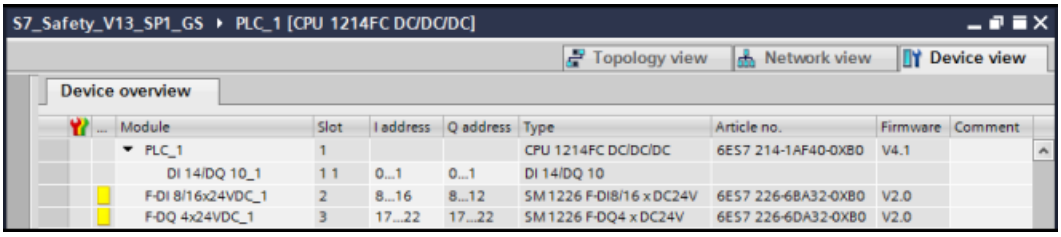
In this step, you configure an F-DQ DC for indirect connection of a motor to channel 0, using 2 contactors.

Procedure

1. In the Device View of the S7-1200, use drag-and-drop to add an F-DQ 4x24VDC_1 digital electronic module from the hardware catalog to slot 3.



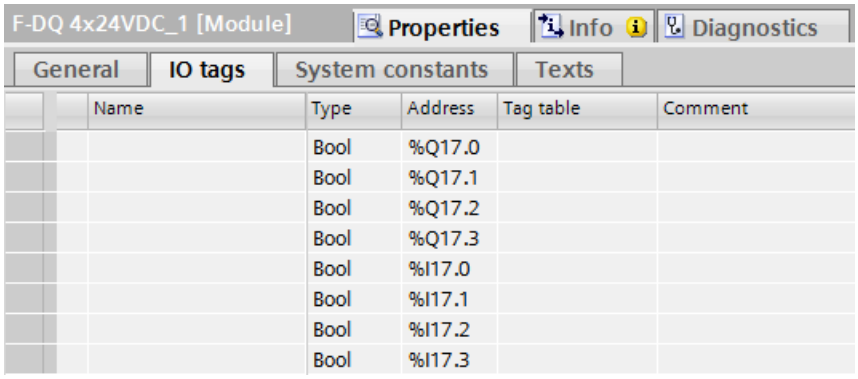
2. Open "Device data" to display the "Device overview" area. Here, you can change the start addresses for the inputs and outputs of your fail-safe module. Use the module default I/O addresses of "17" and "17" for this example (inputs begin at byte 17, and outputs begin at byte 17).



NOTE

The fail-safe SMs each use both Is and Qs, even though they may physically only have input channels or only have output channels.
The F-DQ DC has 4 output channels; however, the SM requires 6 input (I) bytes and 6 output (Q) bytes.

3. Return to the "Device view" and select the F-DQ 4x24VDC_1. Under the "Properties" tab, select the "IO tags" tab. This action displays the "Process value" and "Value status" bits for the fail-safe module. Here, you can define tags for each channel:



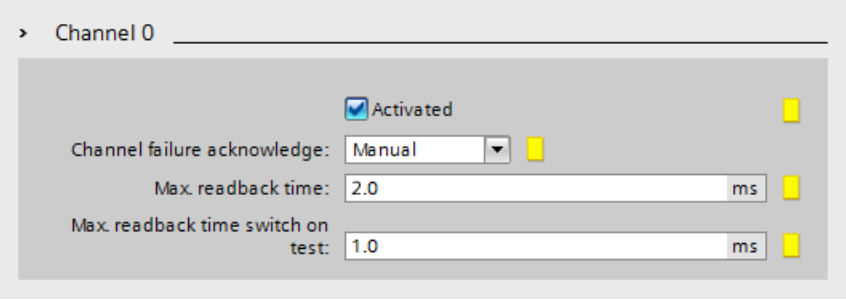
Each Process value bit has an associated Value status bit that reports whether the corresponding process value is good. Value status bits are ON for good quality and OFF for bad quality. If an entire module or channel is passivated, the associated Value status bits are OFF.

To check the Process value bits and the Value status bits, you must know where these bits are mapped in the module. For an F-DQ 4x24VDC_1, the first four bits of the output (Q) image register are the Process value bits, and the first four bits of the input (I) image register are the Value status bits. For example, if the module starting address is I17.0 and Q17.0 for the F-DQ 4x24VDC_1, then the Process value bits and corresponding Value status bits are allocated as shown in the following table:

Process value	Value status bit
Q17.0	I17.0
Q17.1	I17.1
Q17.2	I17.2
Q17.3	I17.3

4. Under the "Properties" tab, select the "General" tab, and then select the "F-parameters" area. Here, you can change the following parameters or accept the default settings:
   – "F-monitoring time": A valid current safety message frame must be received from the fail-safe CPU to the F-DQ DC within the F-monitoring time. Otherwise, the F-DQ DC goes to safe state. The F-monitoring time must be set high enough so that message frame delays are tolerated and, at the same time, low enough that the process can react as quickly as possible when a fault occurs and run without impairment. By default, the F-DQ DC's F-monitoring time is taken from the "Default F-monitoring time for central F-I/O" parameter of the fail-safe CPU.
   – "F-destination address": A unique PROFIsafe address is critical for every F-IO used in a safety system (network and CPU-wide). Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for procedures to set and verify unique PROFIsafe addresses in networked systems.

   Leave the settings unchanged for the F-parameters for this example.
5. Select the "DQ parameters" area. Here, you can change channel-specific parameters or apply the default settings.
   Enter the settings for the example as shown in the following figure:



6. Disable the unused DQ channels 1, 2, and 3 by clearing the "Activated" check box.

Result

The configuration of the F-DQ DC is now complete.

2.2.6 Summary: Configuring the Hardware

Summary

So far, you have configured the following S7-1200 components according to the task definition for the example:

- Fail-safe CPU
- Fail-safe CPU standard digital inputs for user acknowledgment, feedback loop, and start pushbutton:
  - Starting byte addresses of the input and output data areas: IB0 and QB0
  - Input channel (bit) 0 for re-integration acknowledgement (I0.0)
  - Input channel (bit) 1 for feedback (I0.1)
  - Input channel (bit) 2 for start (I0.2)

- Fail-safe digital input SM (F-DI 8/16x24VDC_1) for connecting an emergency stop switch, position switches for monitoring a safety door, and the laser scanner for monitoring the accessible production area:
  - Starting byte addresses of the input and output data areas: IB8 and QB8
  - Input channel (bits) 0 and 8 for the emergency stop (I8.0)
  - Input channel (bits) 1 and 9 for the laser scanner (I8.1)
  - Input channel (bit) 2 for one safety door position switch (I8.2)
  - Input channel (bit) 3 for other safety door position switch (I8.3)
- Fail-safe digital output SM (F-DQ 4x24VDC_1) for connecting a motor:
  - Starting byte addresses of the input and output data areas: IB17 and QB17
  - Output channel (bit) 0 for indirect switching of a motor using 2 contactors (Q17.0)

You can now continue with programming the safety program.

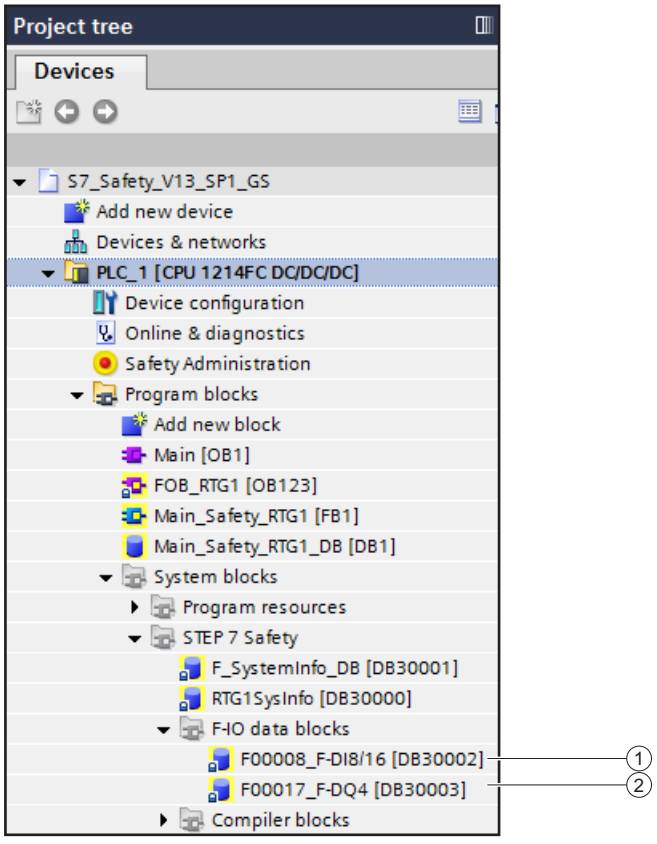
2.3 Programming

2.3.1 Introduction

In this example, a fail-safe function block (F-FB) will be programmed with a safety door function, an emergency stop function (safety circuit for switch-off in case of emergency stop, open safety door, or someone entering the protected area monitored by the laser scanner), a feedback circuit (as protection against reclosing in case of faulty load), a user acknowledgement for reintegration, and indirect switching of a motor using two contactors. The programmed F-FB will then be compiled to form a safety program and downloaded to the fail-safe CPU.

Fail-Safe SM data blocks (F-IO DBs)

An F-IO DB is automatically generated when you add a fail-safe SM to your configuration. The F-I/O DBs generated for the example I/O are located in the "Project tree" in the "Program blocks", "System blocks" folder:



① "F00008 F-DI16 [DB30002]": Fail-safe digital input SM 1226 F-DI 16 x 24 V DC data block (DB)

② "F000016 F-DQ4 [DB30003]": Fail-safe digital output SM 1226 F-DQ 4 x 24 V DC data block (DB)

The default name of the F-I/O DB is formed from the fixed prefix "F", the start input address of the fail-safe SM, and the names entered in the properties for the fail-safe SM in the hardware and network editor.

You can access the tags of the F-I/O DB with a fully qualified DB access (that is, by specifying the name of the F-I/O DB and the name of the tag).

Programming

You can program the safety program in LAD and FBD. In so doing, the instructions, data types, and operand areas you can use are subject to certain restrictions (see the "Programming" chapter, "Overview of programming" section of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en)).

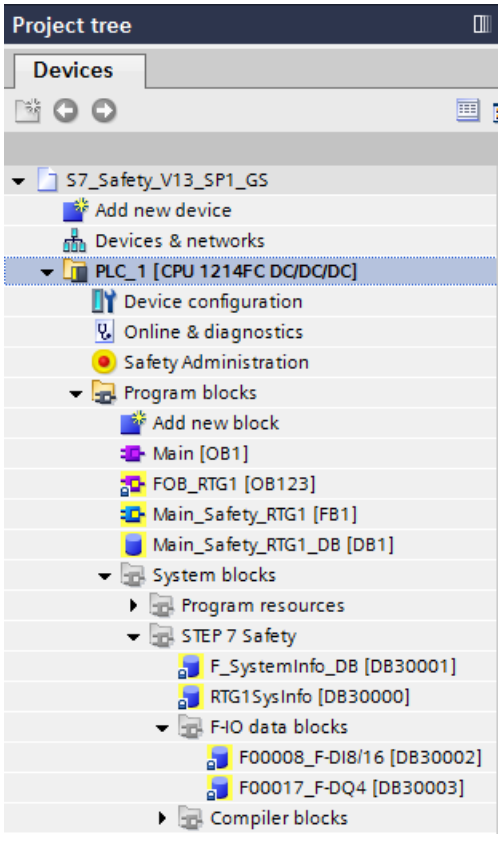
The FBD programming language is used in this example.

NOTE
Fail-safe signals are shown in yellow in the "LAD/FBD Editor".

NOTE
Note the rules for the program structure in the "Programming" chapter, "Defining F-runtime groups" section of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

2.3.2 Step 5: Specifying the centralized settings for the safety program

When the fail-safe CPU is inserted, an F-runtime group and the associated main safety block are created by default and assigned to the CPU. An F-runtime group consists of an F-OB (cyclic interrupt OB) that calls a main safety block FB. Additional user-specific safety functions must then be called from this main safety block:



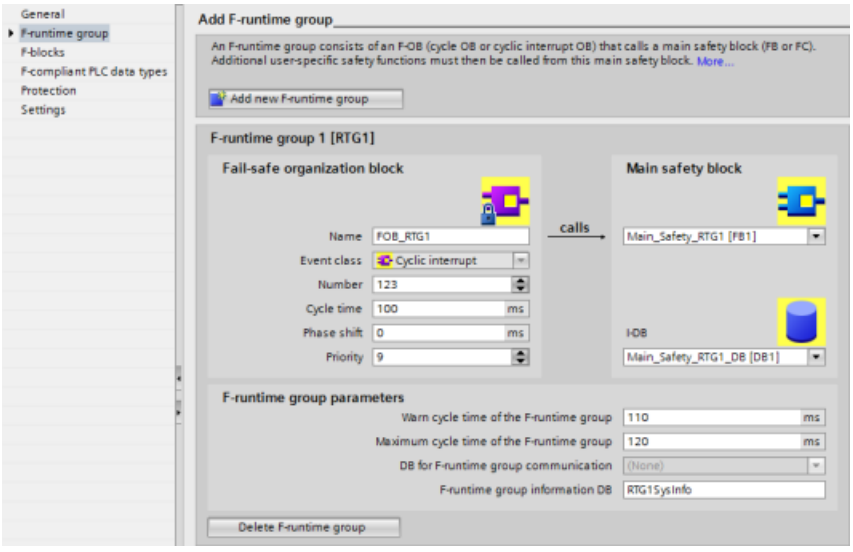
The first step in programming of the safety program is the main safety block. The main safety block is an F-FB (with instance DB) that is called from the "Fail-Safe Organization Block" (F-OB) (cyclic interrupt OB) assigned in each F-runtime group. The F-OB has a higher priority than other standard OBs.

F-blocks created by the user are called from the main safety block. You can change the calling block and the called block at any time.

After the safety program is executed, the standard user program will resume.

Opening the Safety Administration editor

1. In the "Project tree" of the fail-safe CPU, double-click on "Safety Administration".
   Result: The "Safety Administration" editor opens.
   You make central settings for the safety program in the Safety Administration editor.
2. In the area navigation of the Safety Administration editor, click "Safety runtime group". The F-runtime group is created automatically when the fail-safe CPU is created and the associated main safety block is displayed:



The cyclic interrupt OB (FOB_1 [OB123]) calls the main safety block (Main_Safety [FB1]) by default. The F-blocks created by the user are called from the main safety block. You can change the calling block and the called block at any time.

Leave the preset blocks for this example.

For additional information on the Safety Administration editor, refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

Numbering ranges of fail-safe system blocks

When the safety program is compiled, F-blocks are automatically added in order to generate an executable safety program.

By default, the system automatically manages the numbering range, which is displayed in the Safety Administration editor under "Settings".

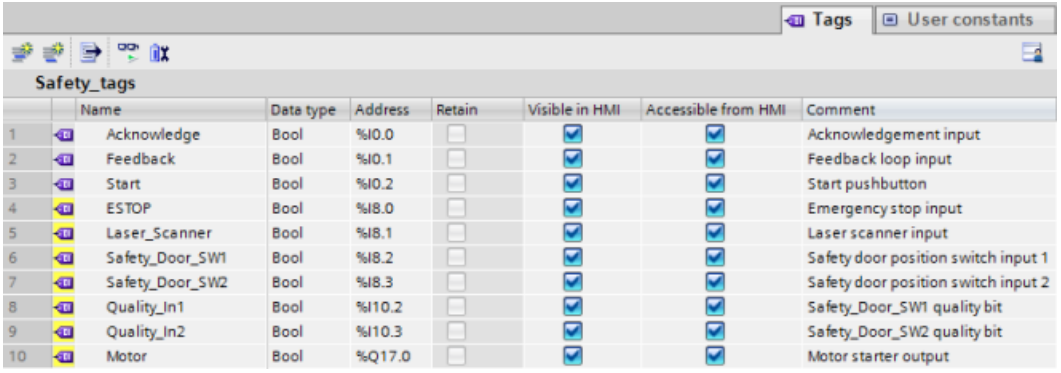
Keep the pre-assigned settings for this example.

Specifying inputs and outputs for the safety program

After configuring the hardware as described in Steps 1 to 4, the following fail-safe CPU and SM DBs are available for programming the example:

Configured hardware	Start input address	Symbolic name
Fail-safe CPU standard digital inputs CPU 1214FC	IB0	PLC_1 [CPU 1214FC DC/DC/DC]
Fail-safe digital input module SM 1226 F-DI 16 x 24 V DC	IB8	F00008_SM 1226 F-DI 16 x 24 V DC
Fail-safe digital output module SM 1226 F-DQ 4 x 24 V DC	IB16	F00016_SM 1226 F-DQ 4 x 24 V DC

Assign the following symbolic names for the fail-safe inputs and outputs:



Tags | User constants

Safety_tags

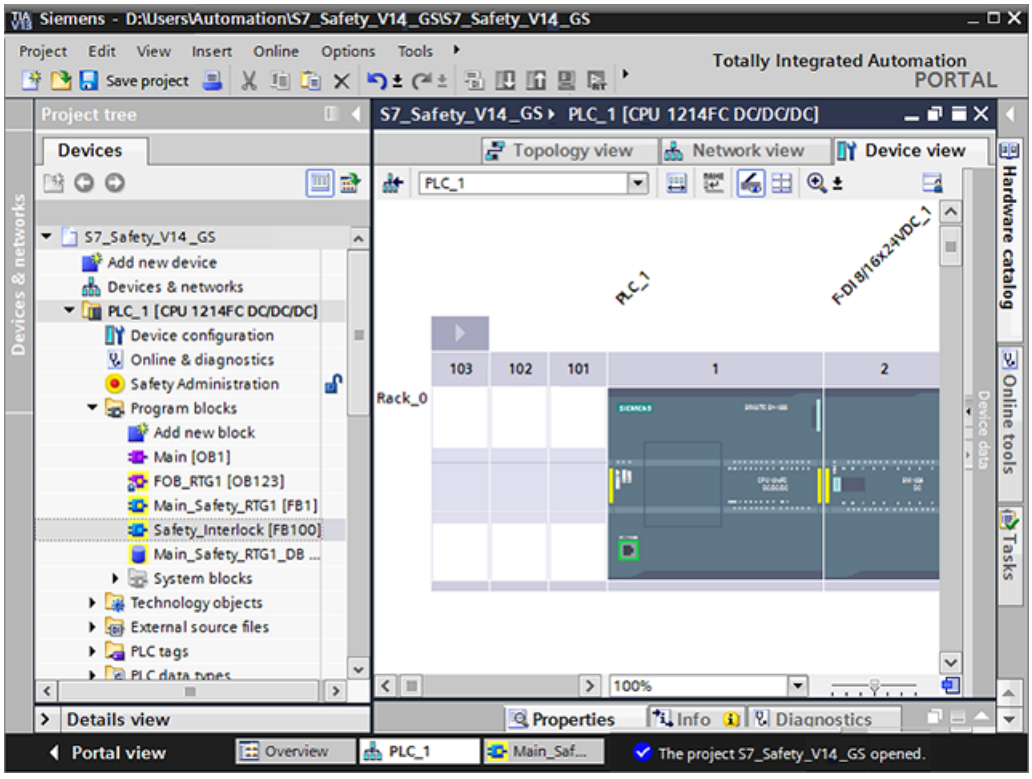
	Name	Data type	Address	Retain	Visible in HMI	Accessible from HMI	Comment
1	Acknowledge	Bool	%I0.0		☑	☑	Acknowledgement input
2	Feedback	Bool	%I0.1		☑	☑	Feedback loop input
3	Start	Bool	%I0.2		☑	☑	Start pushbutton
4	ESTOP	Bool	%I8.0		☑	☑	Emergency stop input
5	Laser_Scanner	Bool	%I8.1		☑	☑	Laser scanner input
6	Safety_Door_SW1	Bool	%I8.2		☑	☑	Safety door position switch input 1
7	Safety_Door_SW2	Bool	%I8.3		☑	☑	Safety door position switch input 2
8	Quality_In1	Bool	%I10.2		☑	☑	Safety_Door_SW1 quality bit
9	Quality_In2	Bool	%I10.3		☑	☑	Safety_Door_SW2 quality bit
10	Motor	Bool	%Q17.0		☑	☑	Motor starter output

2.3.3 Step 6: Creating an F-FB

In this step, you create the F-FB where you will program the safety functions for this example.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. Insert an F-FB. Go to the "Program blocks" folder of the fail-safe CPU and double-click "Add new block".

   The "Add new block" dialog opens.
2. Under "Name" enter "Safety_Interlock" for the name of the F-FB.
3. Click the "Function block" button on the left.
4. Select "FBD" as the language for the F-FB.
5. Under "Number" choose the "Manual" option, and enter 100.
6. Ensure that you select the "Create F-block" check box so that a fail-safe function block is created.
7. Close the dialog box with "OK"

Result

The F-FB "Safety_Interlock" is created in the "Program blocks" folder and opens automatically in the "FBD Editor".

You can now continue with programming the safety functions in the next step.

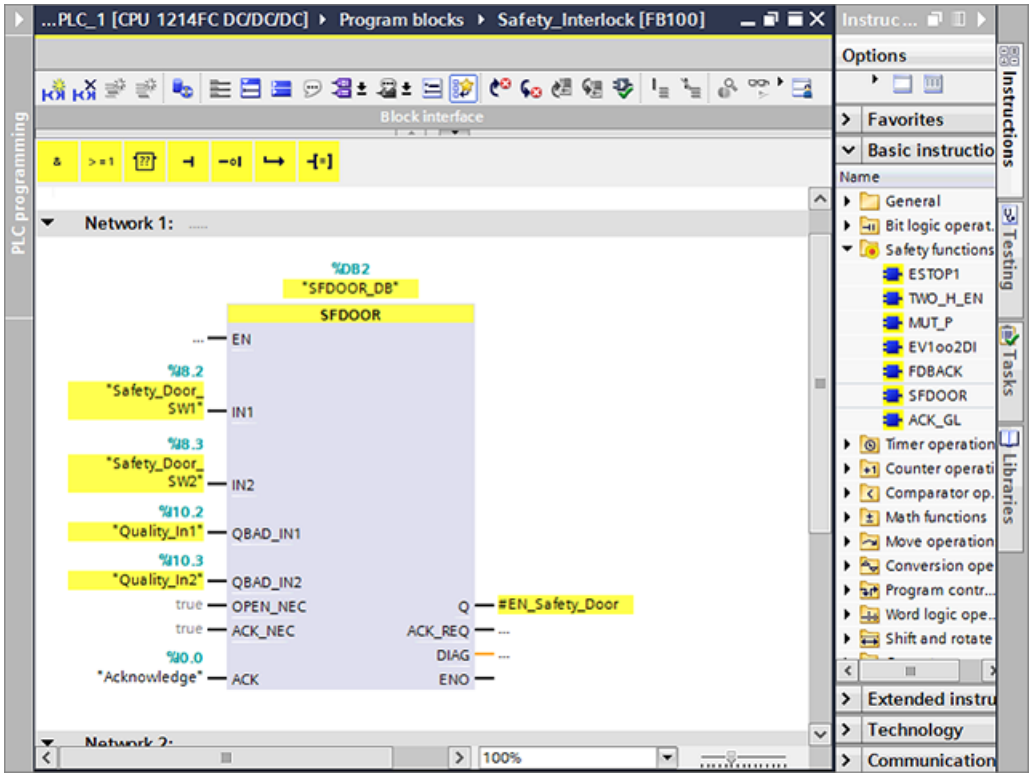
2.3.4 Step 7: Programming the safety door function

In this step, you program the safety door function for this example.

The safety door secures the application's service area. Opening the safety door results in a stop or shutdown of the production cell similar to an emergency stop.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. In the interface of the "Safety_Interlock" F-FB, create a static tag of data type "Bool" named "EN_Safety_Door" (Enable safety door).
2. Insert the "SFDOOR" instruction from the "Safety functions" subfolder of the "Instructions" task card.
3. Click "OK" to confirm the "Call options" dialog.
4. Initialize the inputs and outputs with parameters as described in the table below.

Result

The programming of the safety door function is now complete.

Parameter assignment of the "SFDOOR" instruction

Inputs/outputs	Parameter	Data type	Description	Default
"Safety_Door_SW1" (I8.2)	IN1	Bool	Input 1	FALSE
"Safety_Door_SW2" (I8.3)	IN2	Bool	Input 2	FALSE
"Value_status_In1" (I10.2)	QBAD_ IN1	Bool	Value status bit signal for input IN1 [1]	TRUE
"Value_status_In2" (I10.3)	QBAD_ IN2	Bool	Value status bit signal for input IN2 [1]	TRUE
TRUE	OPEN_NEC	Bool	TRUE = Opening required on startup	TRUE
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (Pushbutton)	FALSE
#EN_Safety_Door	Q	Bool	Output (Enable safety door)	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

[1] The two inputs QBAD_ IN1 and QBAD_ IN2 must be interconnected. In this example, both safety door position switches are connected through the SFDOOR and ESTOP1 program logic with the QBAD signal of the F-I/O DB of the SM 1226 F-DQ 4 x 24 V DC in the FDBACK program logic.

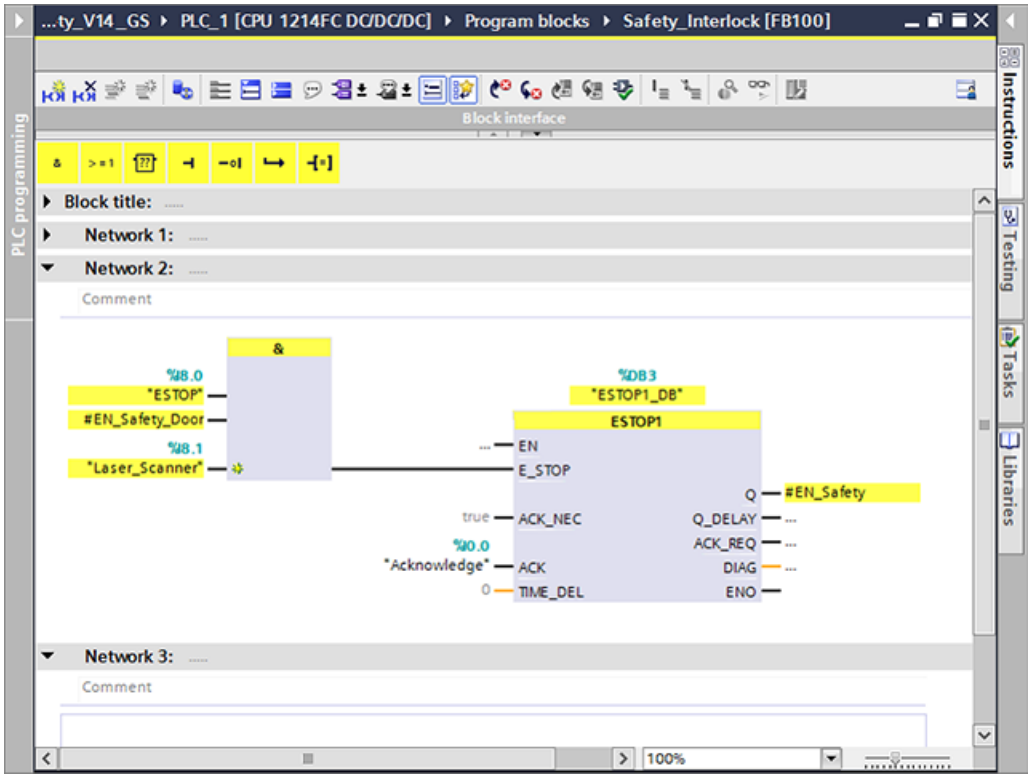
2.3.5 Step 8: Programming the emergency stop function

In this step, you program the emergency stop function for this example.

Used for emergencies only, the emergency stop button is a safety measure to immediately shut down all machine functions. An emergency stop button must be highly visible in color and shape and must be easy to operate in emergency situations. In this example, the emergency stop is a manual push button attached next to the safety door entrance to the service area enclosure. The emergency stop function provides shutdown in the case of an emergency stop, an open safety door, or someone entering the protected area monitored by the laser scanner.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. In the interface of the "Safety_Interlock" F-FB, create a static tag of data type "Bool" named "EN_Safety" (Enable safety circuit).

   NOTE

   If the emergency stop is off, the safety door is closed, and the protected area laser scanner is not triggered, the inputs from the emergency stop, safety door, and the laser scanner are all true. All three inputs must be true, before the ESTOP1 instruction can power "EN_Safety". When "EN_Safety" is true, then the user knows that his operation is back to normal and that he can startup safely.

2. Insert a new network.
3. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card.
4. Insert a third input to the "AND logic operation" instruction and initialize the inputs of the instruction with parameters as described in the table below.
5. Insert the "ESTOP1" instruction from the "Safety functions" subfolder of the "Instructions" task card.
6. Click "OK" to confirm the "Call options" dialog.
7. Initialize the inputs and outputs of the instruction with parameters as described in the table below.
8. Connect the output of the "AND logic operation" instruction to the "ESTOP" input of the "ESTOP1" instruction.

Result

The programming of the emergency stop function is now complete.

Parameter assignment of the "AND logic operation" instruction

Inputs	Parameter	Data type	Description	Default
"ESTOP" (I8.0)	Input 1	Bool	Emergency STOP	FALSE
#EN_Safety_Door	Input 2	Bool	Enable safety door	FALSE
"Laser_scanner" (I8.1)	Input 3	Bool	Laser scanner	FALSE

Parameter assignment of the "ESTOP1" instruction

Inputs/outputs	Parameter	Data type	Description	Default
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (using a pushbutton)	FALSE
T#0MS	TIME_DEL	Time	Time delay	T#0MS
#EN_Safety	Q	Bool	Enable safety circuit	FALSE
—	Q_DELAY	Bool	Enable is OFF delayed	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

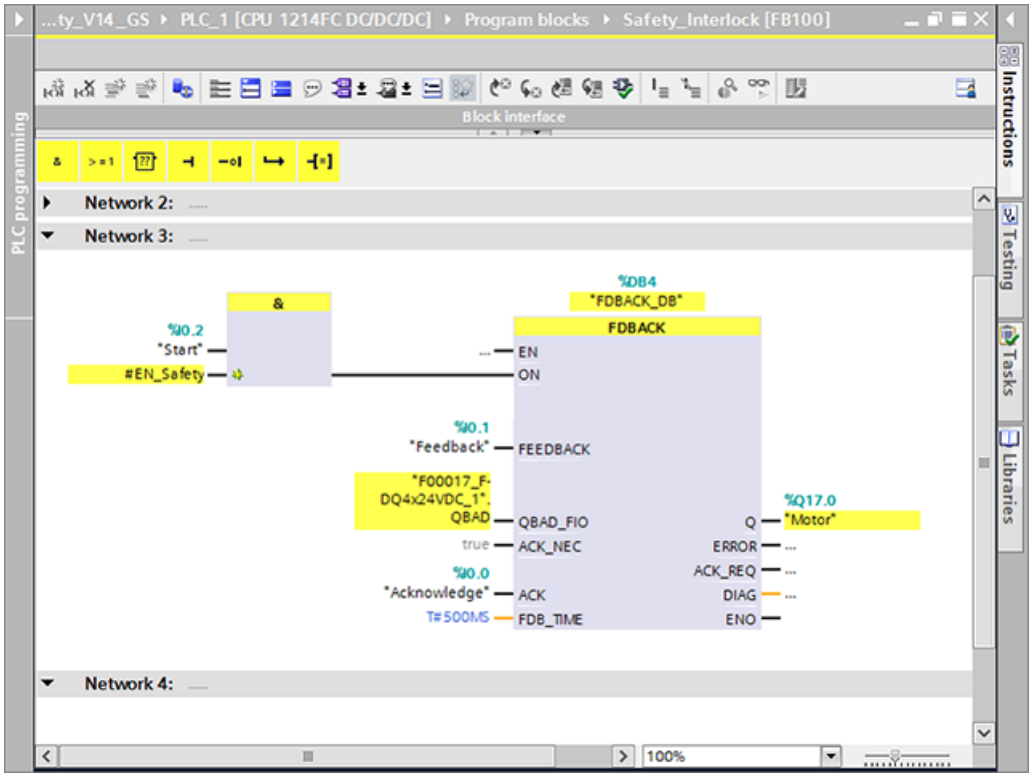
2.3.6 Step 9: Programming the feedback monitoring

In this step, you program the feedback circuit monitoring for this example.

The feedback circuit provides protection against restarting normal operations while unsafe conditions still exist. The system can only be restarted when the emergency stop is cancelled, the safety door is closed, and the laser scanner detects no one in the protected area.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. Insert a new network.
2. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card.
3. Initialize the inputs of the instruction with parameters as described in the table below
4. Insert the "FDBACK" instruction from the "Safety functions" subfolder of the "Instructions" task card.
5. Click "OK" to confirm the "Call options" dialog.
6. Initialize the inputs and outputs of the instruction with parameters as described in the table below.
7. Connect the output of the "AND logic operation" instruction to the "ON" input of the "FDBACK" instruction.

Result

The programming of the feedback monitoring is now complete.

Parameter assignment of the "AND logic operation" instruction

Inputs	Parameter	Data type	Description	Default
"Start" (I0.2)	Input 1	Bool	TRUE = Switch on output	FALSE
#EN_Safety	Input 2	Bool	Enable safety circuit	FALSE

Parameter assignment of the "FDBACK" instruction

Inputs/outputs	Parameter	Data type	Description	Default
"Feedback" (I0.1)	FEEDBACK	Bool	Readback input	TRUE (No error detected)
"F00016_F-DQ4".QBAD	QBAD_FIO	Bool	QBAD signal from the fail-safe signal module DB of output Q [1]	FALSE (No error detected)
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (via pushbutton)	FALSE
T#500MS	FDB_TIME	Time	Readback time	T#0MS
"Motor" (Q16.0)	Q	Bool	Output	FALSE
—	ERROR	Bool	Readback error	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

[1] In this example, this is the QBAD signal from the F-I/O DB of the SM 1226 F-DQ 4 x 24 V DC.

2.3.7 Step 10: Programming the user acknowledgment for reintegration of the fail-safe SM

In this step, you program the user acknowledgement for reintegration of the fail-safe signal module I/O for this example.

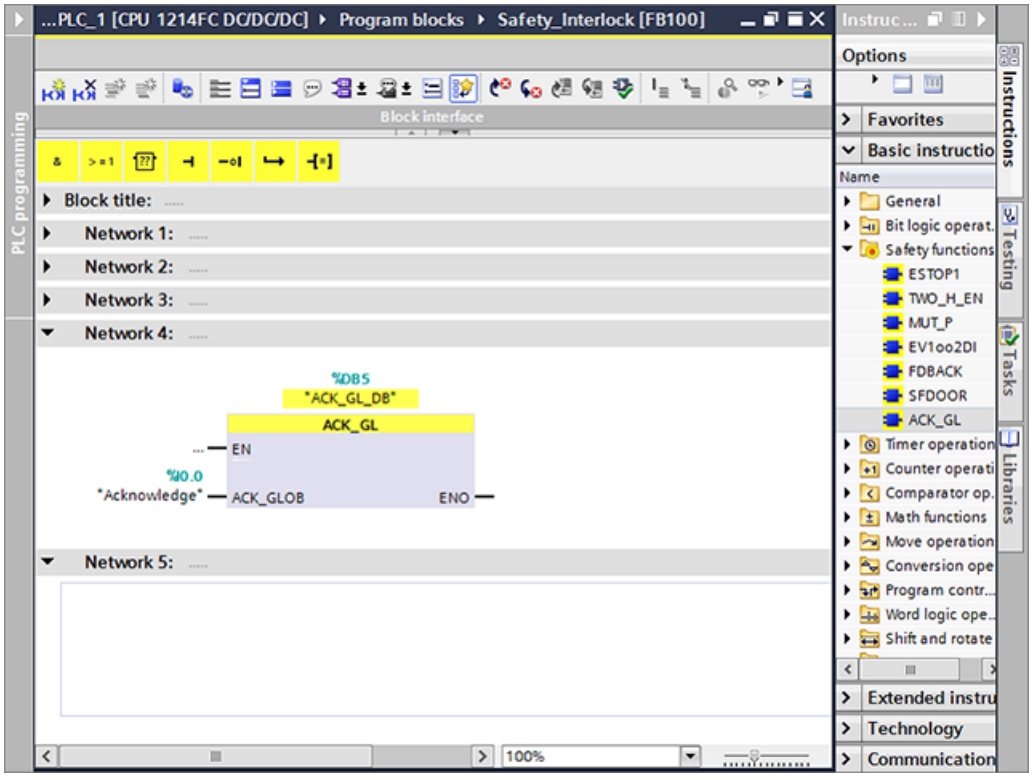
The user must acknowledge that conditions have returned to a safe state before production operations can be restarted.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure

In your safety program, you must provide a user acknowledgment for the reintegration of the fail-safe signal module I/O. In order to acknowledge in the event of passivated F-I/O, the acknowledgement pushbutton is evaluated using a standard input. In this example, this is the "Acknowledge" input.

You can use the ACK_GL instruction to reintegrate all F-I/O of an F-runtime group.



1. Insert a new network.
2. Insert the "ACK_GL" instruction from the "Safety functions" subfolder of the "Instructions" task card.
3. Click "OK" to confirm the "Call options" dialog.
4. Initialize the input with parameters as described in the table below.

Result

The programming of the user acknowledgment is now complete.

Parameter assignment of the "ACK_GL" instruction

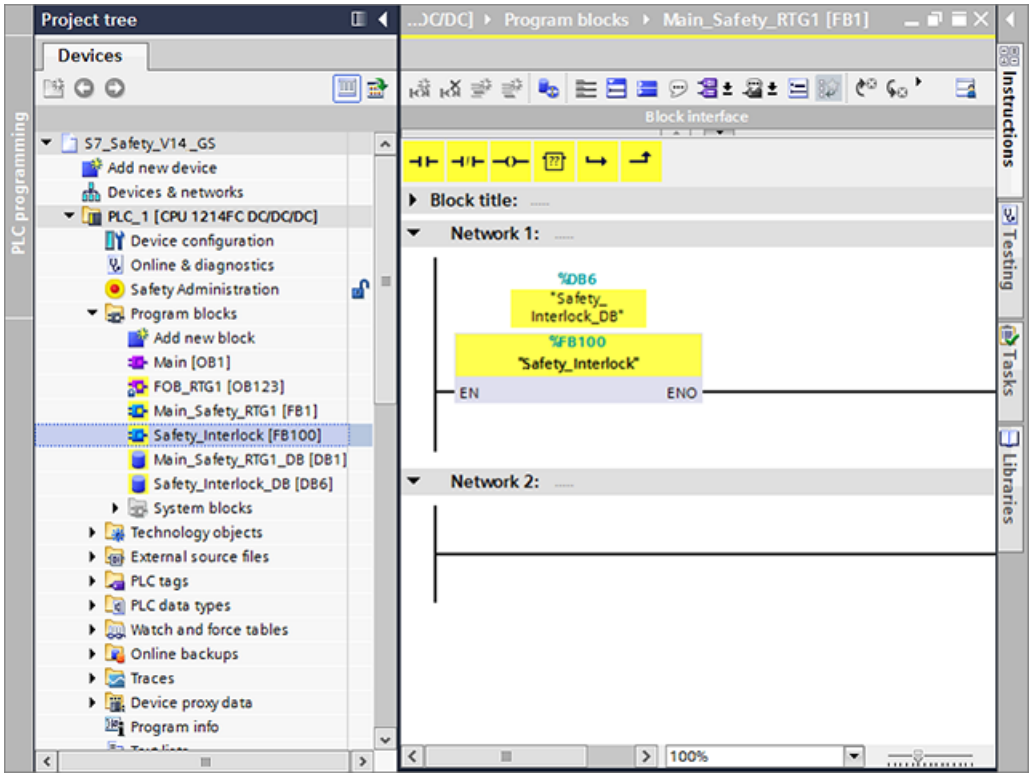
Input	Parameter	Data type	Description	Default
"Acknowledge" (I0.0)	ACK_GLOB	Bool	Acknowledgement for reintegration	FALSE

2.3.8 Step 11: Programming of the main safety block

In this step, you program the main safety block for this example.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. Double-click in the project navigation to open the main safety block "Main_Safety".
2. Use drag-and-drop to insert the F-FB "Safety_Interlock" in Network 1 of the main safety block.
3. Click "OK" to confirm the "Call options" dialog.

Result

The F-FB "Safety_Interlock" will now be called cyclically by the main safety block.

You have now programmed the functionality according to the task definition of the example. You can now proceed with the next steps to compile the safety program, assign device names, and download the safety program along with the hardware configuration to the fail-safe CPU.

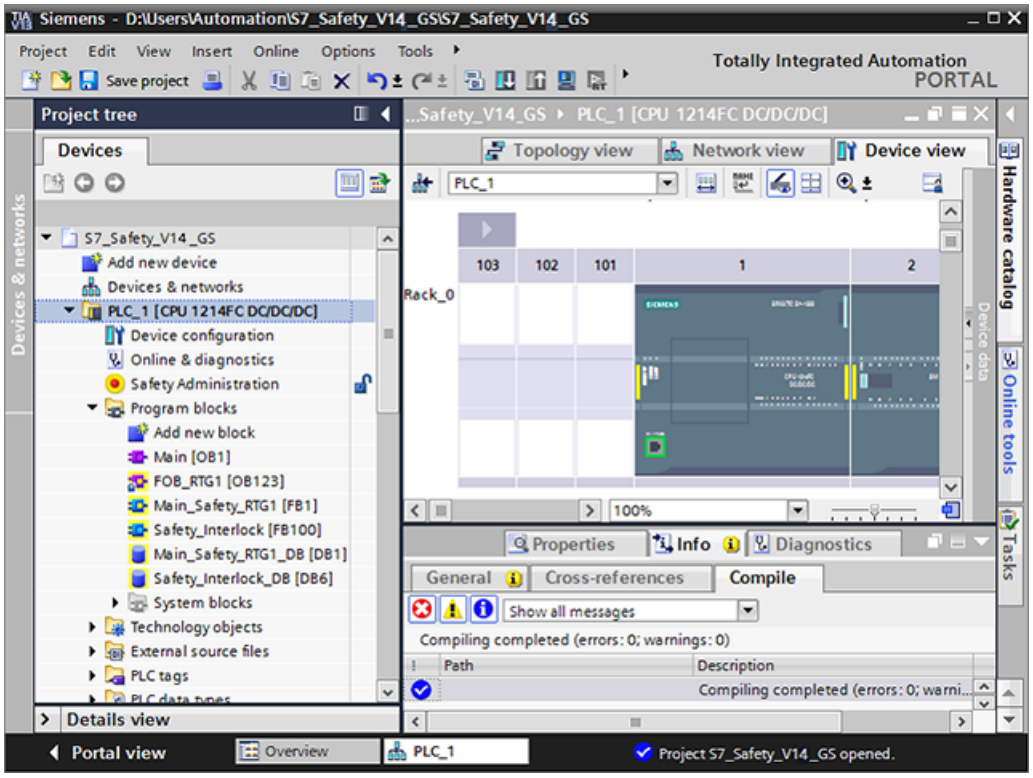
2.3.9 Step 12: Compiling the safety program

In this step, you compile the safety program and the hardware configuration.

A consistency check is performed on the execution-relevant F-blocks when the safety program is compiled, that is, the safety program is checked for errors. Any error messages are output in an error window. After a successful consistency check, the additionally required F-blocks are generated automatically and added to the F-runtime group in order to generate an executable safety program.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. Select the fail-safe CPU in the project tree.
2. In the shortcut menu for the fail-safe CPU, select "Hardware and software (only changes)". The safety program is now compiled.

Result

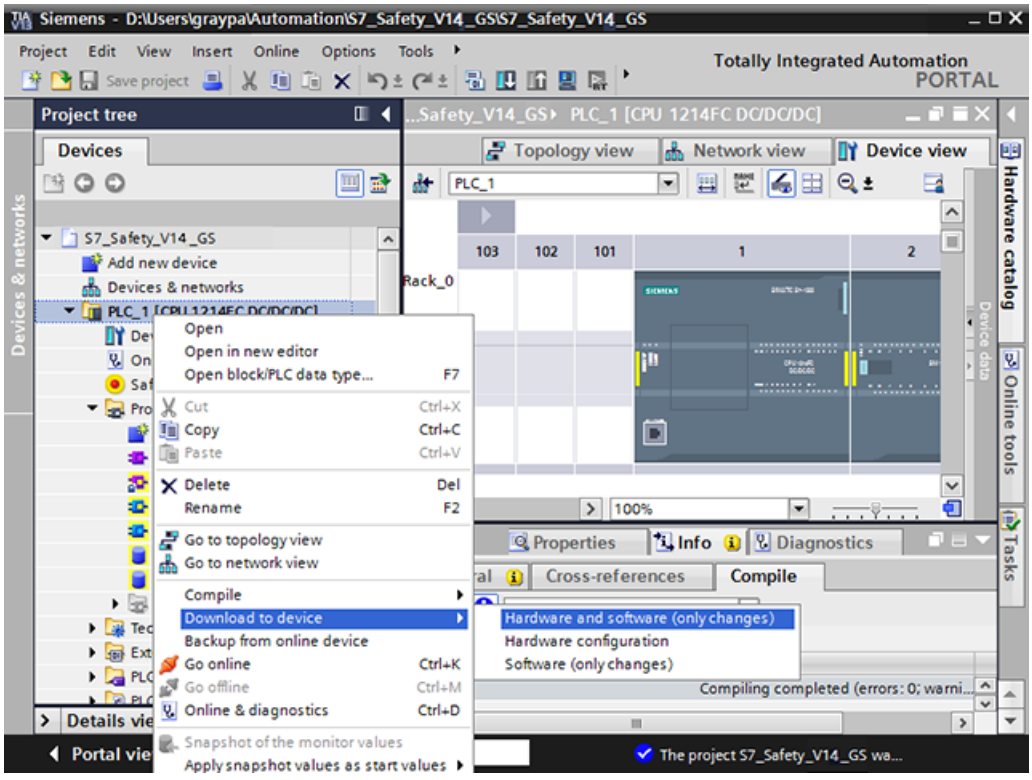
If compilation is successful, the result is always a consistent and executable safety program comprising all F-blocks with F-attributes. You are notified of this with the message "Safety program is consistent".

2.3.10 Step 13: Downloading the complete safety program to the fail-safe CPU and activating safety mode

In this step, you download the hardware configuration and the safety program to the fail-safe CPU.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

Procedure



1. In the "Project tree", select the fail-safe CPU.
2. In the shortcut menu for the fail-safe CPU, select "Hardware and software (only changes)". If an online connection to the fail-safe CPU does not yet exist, you will be prompted to establish this connection.
3. Select "Consistent download" in the "Action" column in each case.

NOTE

To download the entire safety program, the fail-safe CPU must be in STOP mode.

4. Click the "Load" button.
   Result: The "Load results" dialog is displayed.
5. Click the "Finish" button.
6. In the "Project tree", double-click "Safety Administration".

7. In the "Safety Administration" editor, check to see if the F-collective signatures of all F-blocks with F-attributes match online and offline to confirm whether your offline safety program blocks match what is in your connected CPU. You must be online in order to perform the signature comparison.
8. To activate safety mode, switch the fail-safe CPU from STOP to RUN mode.

   The Safety Administration editor displays the current safety mode status in the "General" area under "Safety Mode Status".

NOTE

Once a safety program has been created, you must perform a full function test according to your automation task (see SIMATIC Safety Configuring and Programming Manual (http://support.automation.siemens.com/WW/view/en/54110126/0/en)).

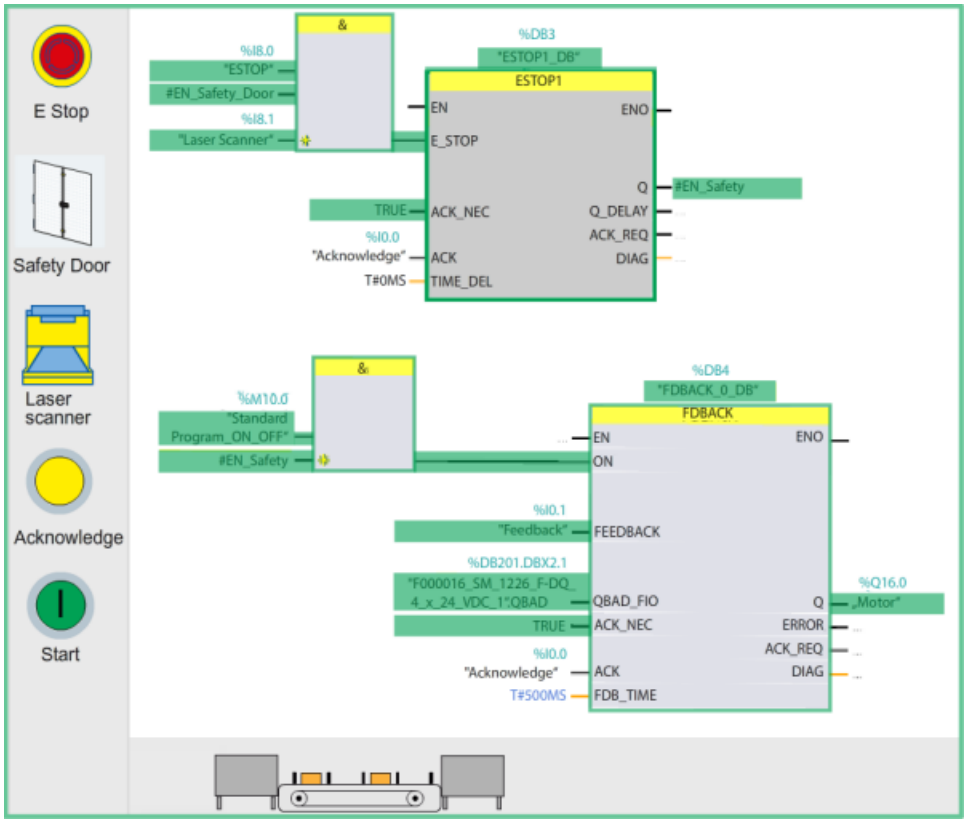
Result of programming

You have now finished creating the safety program according to the task definition of the example. In this interactive graphic, you can become familiar with the functions you just programmed.

When you move to this page, you activate the instructional video. Move your cursor over the image, and the video controls (rewind, pause, go back, or go forward) appear at the bottom of the video screen. Move to another page to deactivate the video.

The video switches the Laser Scanner, E-Stop, and Safety Door on and off to simulate unsafe conditions. Each device operates independently of the the other two devices. If you do activate a device, you must deactivate the device before continuing.

The video shows you that you must press the "Acknowledge" button to notify the system that you have returned to a safe state. Then, you can press the "Start" button to operate the system again.



The table below describes the steps and their actions:

Step	Action	Description
1	Activate the E-Stop. [1, 2]	This action prevents resumption of the operation.
2	Deactivate the E-Stop. [3]	The E-Stop deactivates.
3	Press the Acknowledge button.	The safety program requires acknowledgement.
4	Press the Start button.	Restart your operations.
5	Open the Safety Door. [1, 2]	This action prevents resumption of the operation.
6	Close the Safety Door. [3]	The Safety Door closes.
7	Press the Acknowledge button.	The safety program requires acknowledgement.
8	Press the Start button.	Restart your operations.
9	Trigger the Laser Scanner. [1, 2]	This action prevents resumption of the operation.
10	Deactivate the Laser Scanner. [3]	The Laser Scanner deactivates.
11	Press the Acknowledge button.	The safety program requires acknowledgement.
12	Press the Start button.	Restart your operations.

[1] The activation of the E-STOP, trigger of the Laser Scanner, or opening of the Safety Door can be done in any order or individually to stop operations and bring the system to a safe state.

[2] To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device; 2. Press the Acknowledge button; 3. Press the Start button.

[3] This allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart operations.

Fail-Safe signal module (SM) applications

3

This chapter presents typical application examples for connection of functional safety input and output channels, with a statement of the safety performance (SIL/Category/PL) that is possible for each example.

The PLC system typically contributes only a small part of the total probability of dangerous failure. The probability of dangerous failures of the sensors and actuators will typically be far larger than the PFH/PFD of the PLC system. Faults in the wiring system can also be a substantial contributor.

To achieve a targeted level of safety performance for each safety function, you must:

- Choose an appropriate architecture
- Choose sensors and actuators that are appropriately rated
- Provide a safety program that meets the requirements of the safety function
- Provide diagnostics and proof tests to maintain the ratings of the sensors and actuators
- Use wiring installation practices, diagnostics, and proof tests to assure wiring integrity
- Control operating and maintenance procedures for the lifetime of the installation

The S7-1200 Fail-Safe system provides a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each S7-1200 fail-safe component is stated assuming no field proof test within the lifetime of the product. Sensors and actuators typically require regular proof tests to maintain an expected level of safety performance.

The reaction time of each safety function depends on the reaction time of each component, including the sensor, the PLC system, and the actuator. "Fail-Safe response times" (Page 186) gives further information on delay times through the PLC components. You must choose PLC parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to total delay from safety demand input to safe actuator response, you must consider these additional time-related factors. Refer to "Fail-Safe response times" (Page 186) for exact information:

- To be assured of a safety response, a safety demand signal from the input sensor must last long enough to be seen by the safety program. Your configured filter time, discrepancy resolution time, short circuit test duration, and F-monitoring times all contribute to this time.
- The SM 1226 F-DQ 4 x 24 V DC provides ON test pulses to OFF switches, and OFF test pulses to ON switches, to test that the P and M switches respond. The OFF test pulse duration can be as long as your configured "Maximum readback time". The ON test pulse duration can be as long as your configured "Maximum readback time switch on test". The ON test pulse is only provided to one of the P or M switches at a time, but in the presence of single fault this could apply energy to your load. Your actuator should not respond to an OFF signal up to the "Maximum readback time" duration, or to an ON signal up to the "Maximum readback time switch on test" duration.

- Both the SM 1226 F-DQ 4 x 24 V DC and SM 1226 F-DQ 2 x Relay expect to complete and confirm any commanded transition from ON to OFF output state. After your program changes process output value from "1" to "0", you should not change the "0" back to a "1" until the F-DQ DC readback time or the F-RLY response time has completed. The affected output passivates on commanded "0" states that are too short to confirm.

⚠ WARNING

The safety performance of your installation depends on your design and continued maintenance of each complete safety function.
The S7-1200 fail-safe CPU and fail-safe signal modules provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.
Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.
You must choose all components of your installation and complete your design and maintenance according to accepted safety standards and practices to achieve your required level of safety.

3.1 Digital input applications

You should consider the application modes presented here along with the features of the SM 1226 F-DI 16 x 24 V DC as described in the overview. Refer to "SM 1226 F-DI 16 x 24 V DC" (Page 22).

These are the main features to keep in mind:

- You configure each channel as a 1oo1 or part of a 1oo2 evaluation pair.
- The corresponding channels from input bytes "a" and "b" (a.0, b.0), (a.1, b.1)...(a.7, b.7) form a 1oo2 channel group.
- Within this restriction, you can assign 1oo1 and 1oo2 in any order.
- Short-circuit testing requires use of the internal sensor supply. VS1 must be used with inputs a.0...a.7, and VS2 must be used with inputs b.0...b.7.
- If you enable the short-circuit test, both Vs1 and Vs2 are configured with the same parameters. All channels you configured for internal sensor supply will be subject to the same short-circuit test. You configure a test duration (length of dark time) and test interval (time between dark tests).
- The sensor supply is monitored to detect short-circuit or overload. It is cycled once on each power up to assure control and readback are working, and the readback is monitored during input short circuit tests.
- You configure a discrepancy time to identify unacceptable differences between 1oo2 inputs.
- You configure a filter time for each channel or each 1oo2 pair.

You can achieve Category 3 in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach Category 3 by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failure unless additional measures are applied.

You can achieve Category 4 in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Category 4.
- The duplicated external wiring of 2 sensors to 2 input points is vulnerable to accumulated fault dangerous failure unless additional measures are applied.

The F-DI is recommended for SIL 3/PL e only when 1oo2 evaluation is selected. A single high-integrity sensor can be rated up to SIL 3/PL e, but it should be wired and configured for 1oo2 evaluation for the channel to achieve SIL 3/PL e.

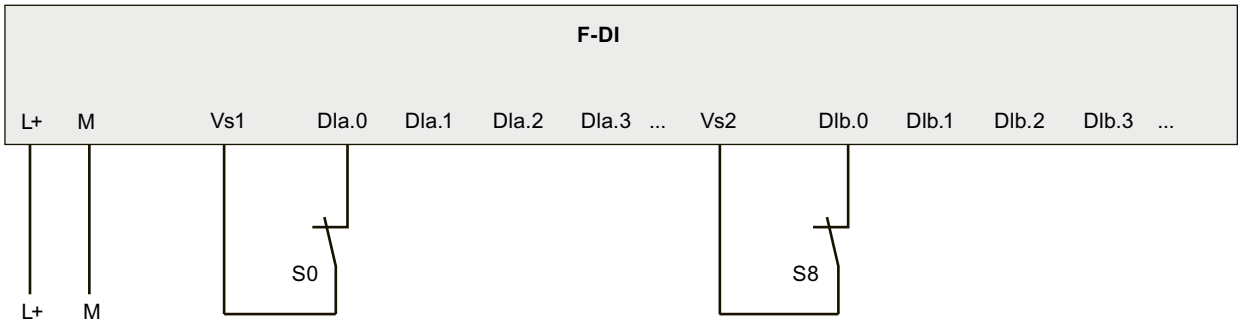
3.1.1 Selecting the digital input application

Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

Table 1-2 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Sensor supply	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
1 and 2	Internal or External	1oo1 evalution	Single input	1 channel	2/3/d	
3 and 4	Internal or External	1oo2 evaluation	Two inputs	2 channel equivalent	3/3/e	
5	Internal			2 channel equivalent	3/3/e	3/4/e
6	External				3/3/e	
7	Internal			2 channel - 3 wire non-equivalent	3/3/e	3/4/e
8	External				3/3/e	
9	Internal			2 channel - 4 wire non-equivalent	3/3/e	3/4/e
10	External				3/3/e	

3.1.2 Applications 1 and 2: 1oo1 evaluation of a single sensor



If short circuit detection is used, VS1 must be used with a.x inputs and VS2 must be used with b.x inputs.

Figure 1-1 F-DI Application mode 1: Internal sensor supply

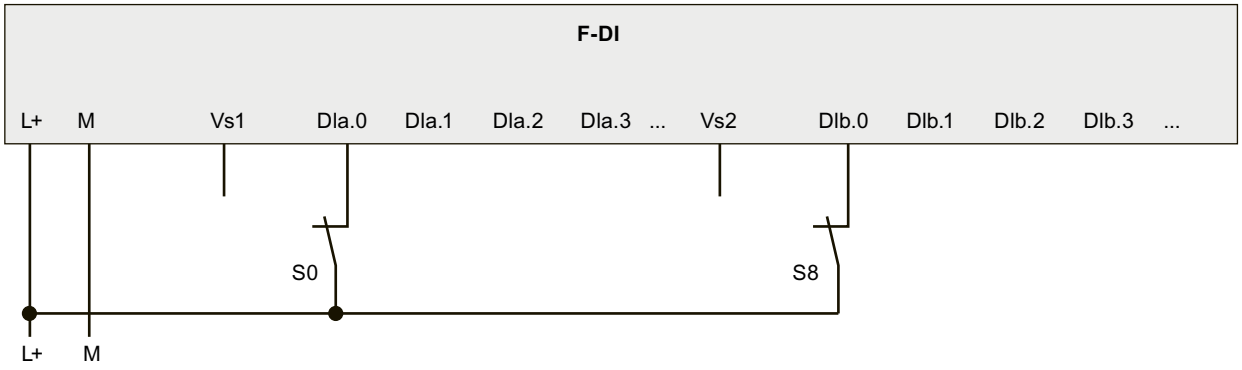


Figure 1-2 F-DI Application mode 2: External sensor supply

3.1.3 Applications 3 and 4: 1oo2 evaluation of a single sensor

You cannot configure short-circuit detection for this type of connection. Vs1 testing causes F-DI b.x inputs to fail.

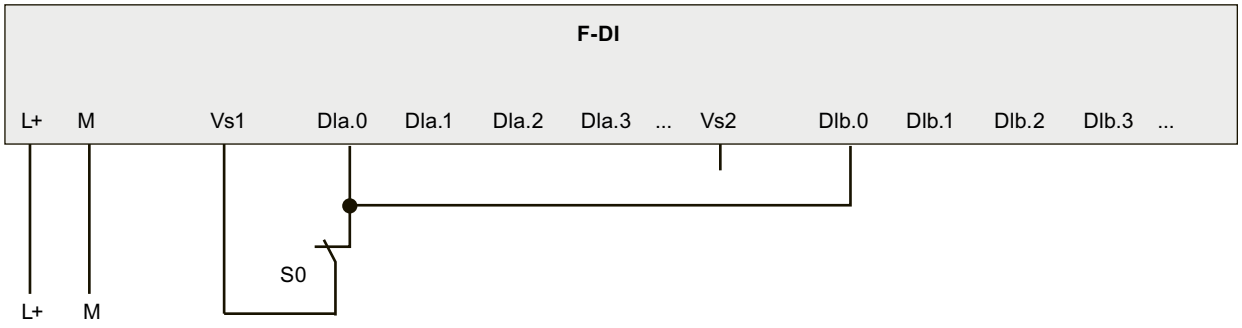


Figure 1-3 F-DI Application mode 3: Internal sensor supply

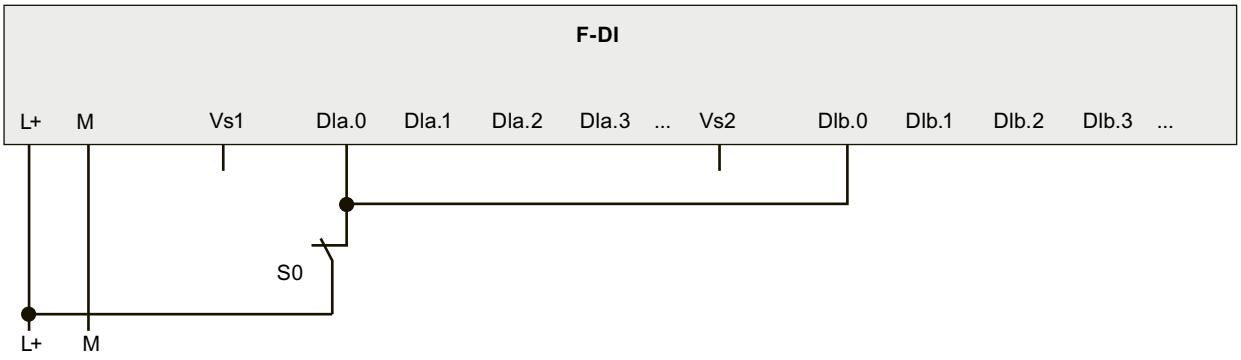


Figure 1-4 F-DI Application mode 4: External sensor supply

3.1.4 Applications 5 and 6: 1oo2 evaluation of independent equivalent sensors

S0 and S8 can be dual contacts of a single sensor.

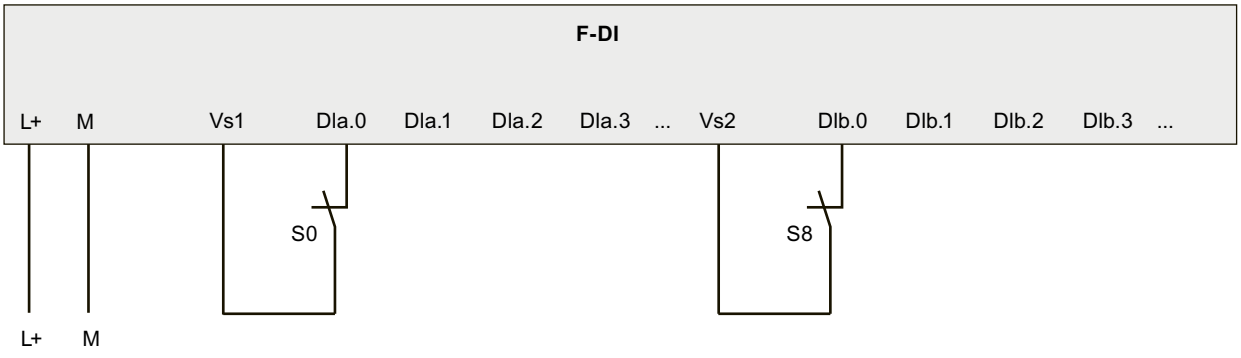


Figure 1-5 F-DI Application mode 5: Internal sensor supply

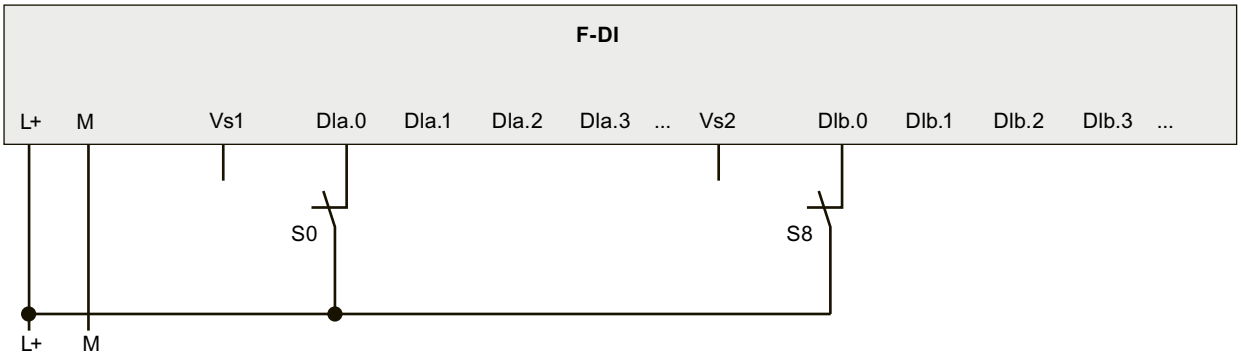


Figure 1-6 F-DI Application mode 6: External sensor supply

3.1.5 Applications 7 and 8: 1oo2 evaluation of 3-wire, non-equivalent sensor circuit

In non-equivalent mode, short-circuit testing can be enabled on a 3-wire circuit. The module expects that the logic "0" circuit will not change with the sensor dark test.

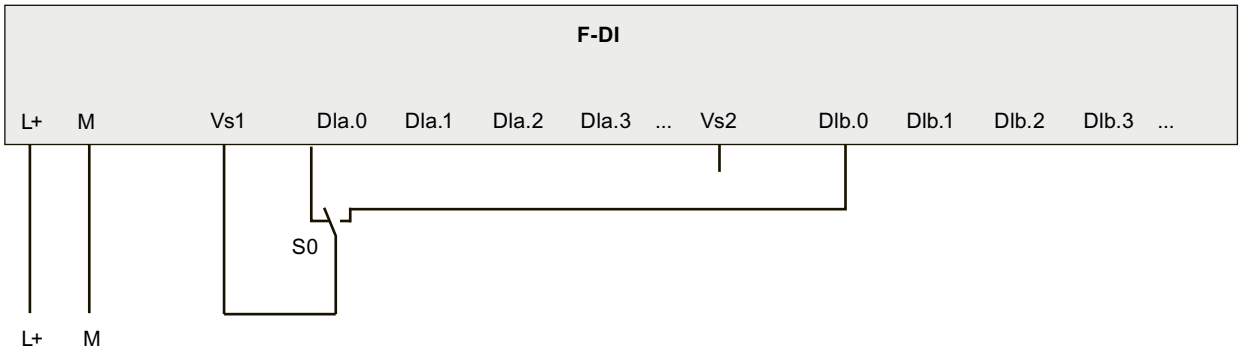


Figure 1-7 F-DI Application mode 7: Internal sensor supply

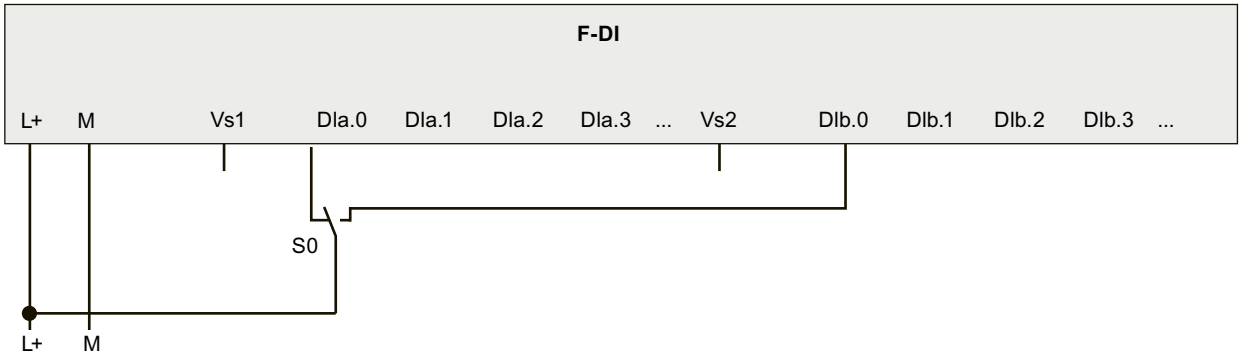


Figure 1-8 F-DI Application mode 8: External sensor supply

3.1.6 Applications 9 and 10: 1oo2 evaluation of 4-wire non-equivalent sensor circuit

S0 and S8 can be dual contacts of a single sensor.

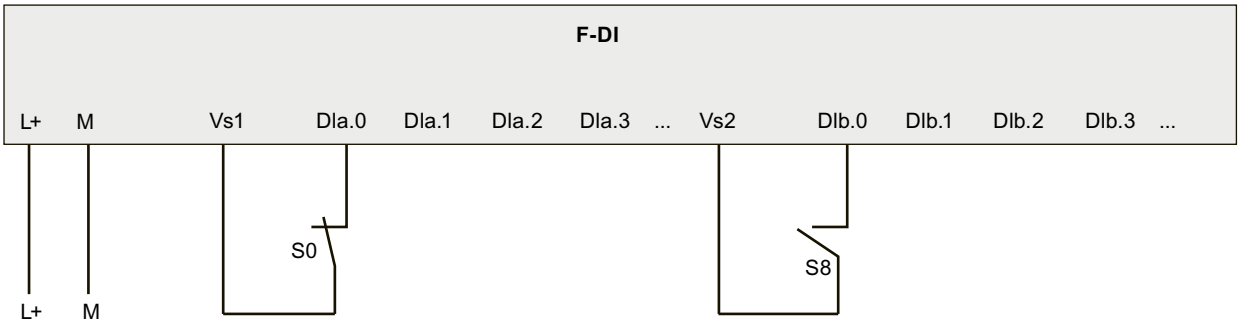


Figure 1-9 F-DI Application mode 9: Internal sensor supply

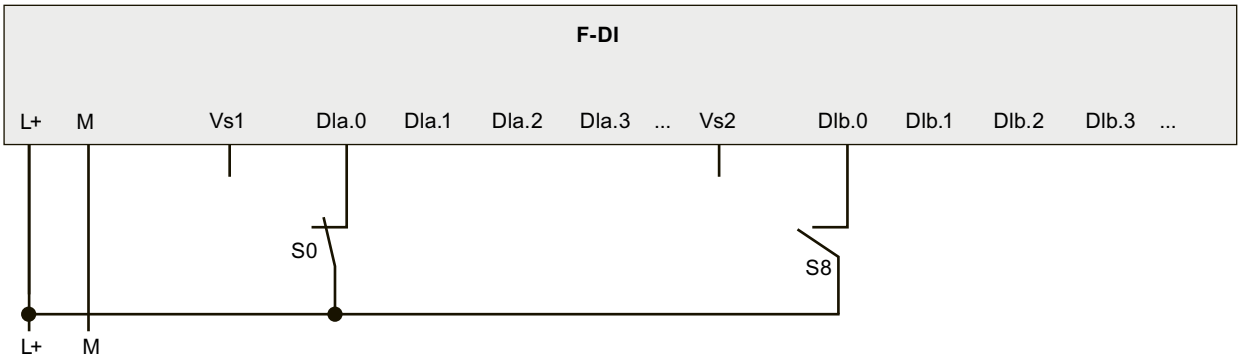


Figure 1-10 F-DI Application mode 10: External sensor supply

3.2 Digital output applications

You should consider the application modes presented here along with the features of the SM 1226 F-DQ 4 x 24 V DC and SM1226 F-DQ 2 x Relay as described in the overview. Refer to "SM 1226 F-DQ 4 x 24 V DC" (Page 23) and "SM 1226 F-DQ 2 x Relay" (Page 24).

These are the main features to keep in mind for the SM1226 F-DQ 4 x 24 V DC:

- The F-DQ DC separately controls current flow in the P (24 V to load) and M (load to common) sides of the circuit.
- The voltage at P and M outputs is read back to confirm proper state.
- The P and M switches are regularly tested with short ON and OFF pulses to confirm control.
- You must configure readback times that allow the external voltage to respond but do not cause your load to physically respond.
- Internal current limiting as described in the data sheet may be sufficient in combination with your 24 V DC supply, but you must consider whether additional current limits or fuses are necessary. Refer to Appendix A.3.3.3: "Specifications" (Page 170) (SM1226 F-DQ 4 x 24 V DC).

These are the main features to keep in mind for the SM1226 F-DQ 2 x Relay:

- The F-RLY controls each circuit with two independently-controlled series contacts.
- The series contacts are sequenced to avoid welding as a common cause failure.
- All internal relays include mechanically-linked sense contacts with read back.
- You must configure a maximum ON time for each channel, effectively the time between tests that the channel can be turned OFF. For SIL 3 applications, this time must be 30 days or less.
- There are two complete circuits for each process channel.
- The two circuits on each channel must be the same voltage category: both SELV/PELV or both line voltage
- Each circuit must be protected by an external fuse as defined in the data sheet.

All output channels are controlled as 1oo2 with cross-diagnostics.

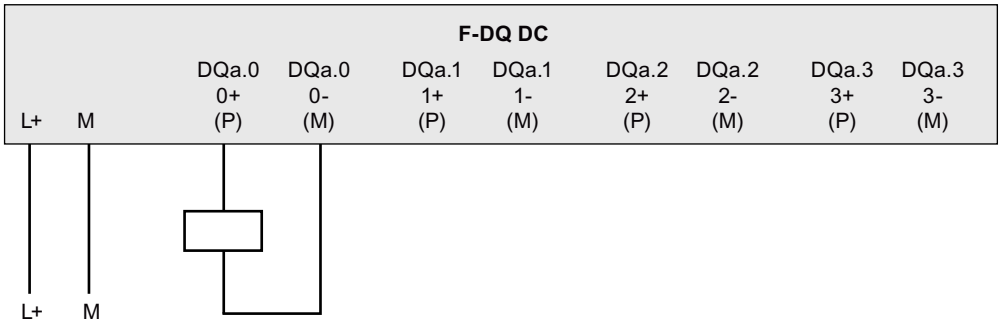
All applications shown are capable of reaching SIL 3/Category 4/PL e.

To reach Category 4, external contactors must be SIL-rated with sense contacts. You must read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs.

3.2.1 Selecting the digital output application

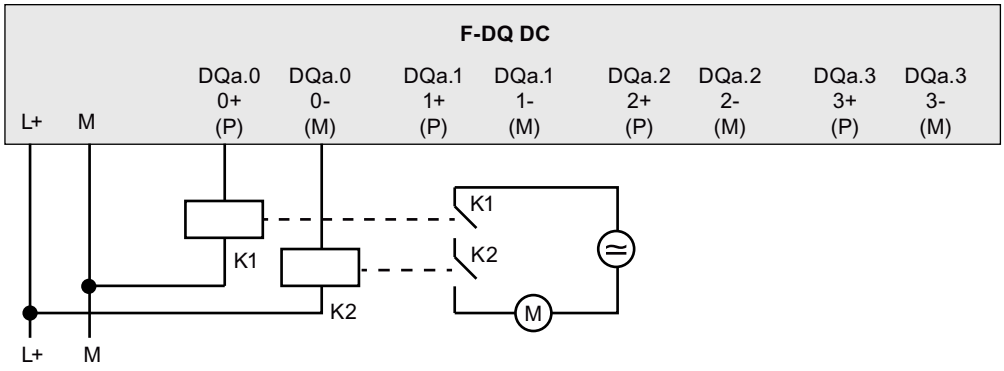
Application	Module	Description
1	DC	Directly-connected SIL-rated actuator
2	DC	External contactors: Separate P and M controlled contactors
3	DC	External contactors: Parallel connected between P and M
4	DC	External contactors: Separate output channels for each contactor
5	Relay	External contactors: Separate circuits of one output channel
6	Relay	Directly-connected SIL-rated actuator
7	Relay	Directly-connected SIL-rated actuator, switching both load conductors

3.2.2 Application 1: Wiring a directly-connected SIL-rated actuator

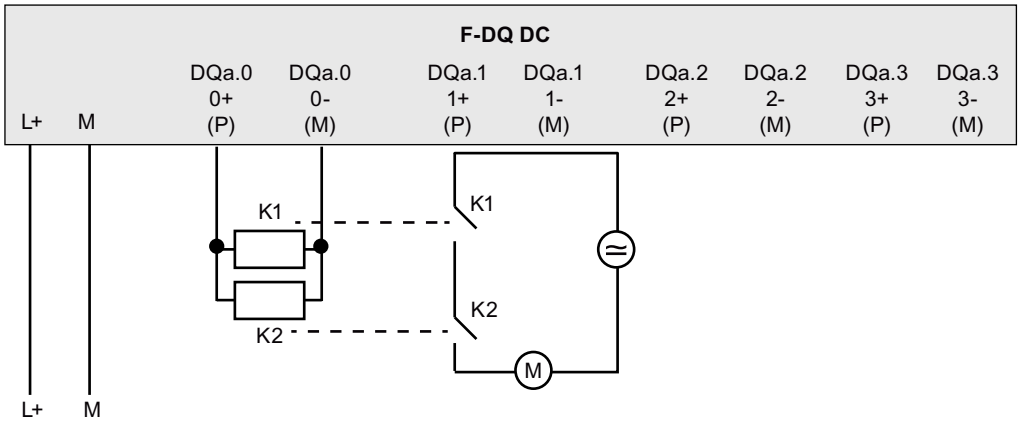


3.2.3 Application 2: Wiring external contactors: Separate P and M controlled contactors

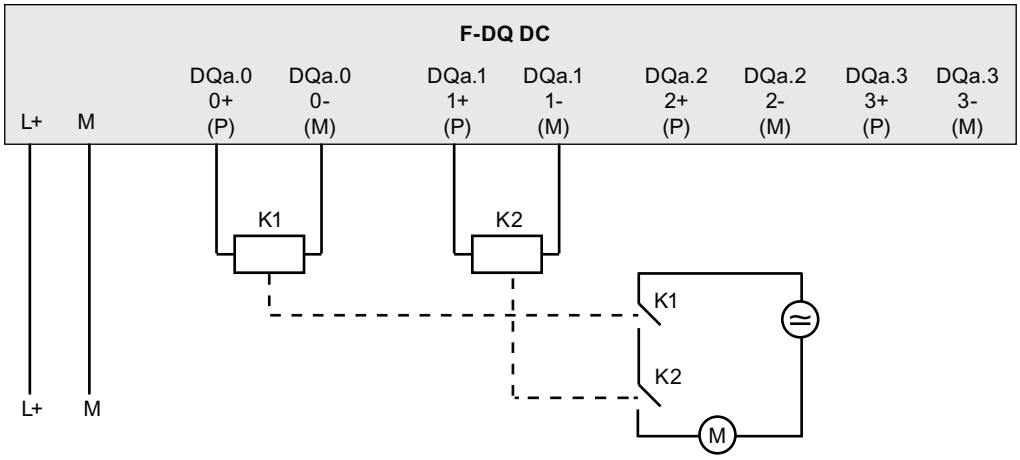
A short-circuit between the P and the M output can immediately lead to dangerous failure. You must prevent this failure mode by proper separation and protection of conductors.



3.2.4 Application 3: Wiring external contactors: Parallel connected between P and M

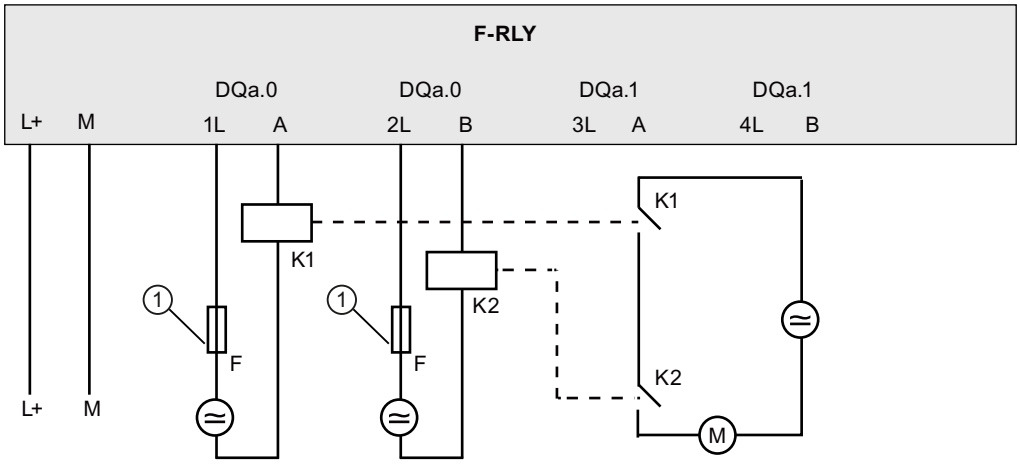


3.2.5 Application 4: Wiring external contactors: Separate P and M output channels for each contactor



3.2.6 Application 5: Separate circuits of a relay channel controlling external contactors

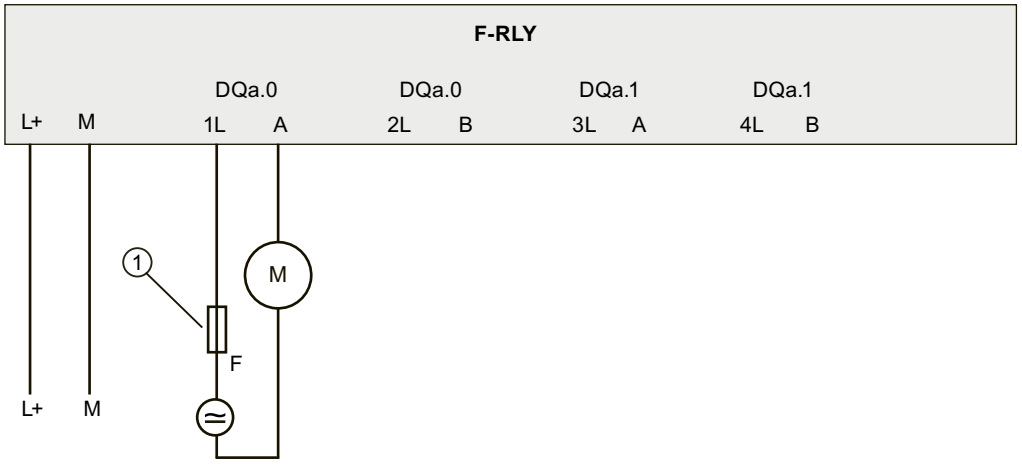
Redundant external relays or contactors are controlled by independent electrical circuits that are switched as a single process variable channel.



① External fuse (Refer to F-DQ 2 x Relay "Specifications" (Page 176), "Digital outputs" table, "Short-circuit protection of output" for external fuse details.)

3.2.7 Application 6: Wiring a directly-connected SIL-rated actuator

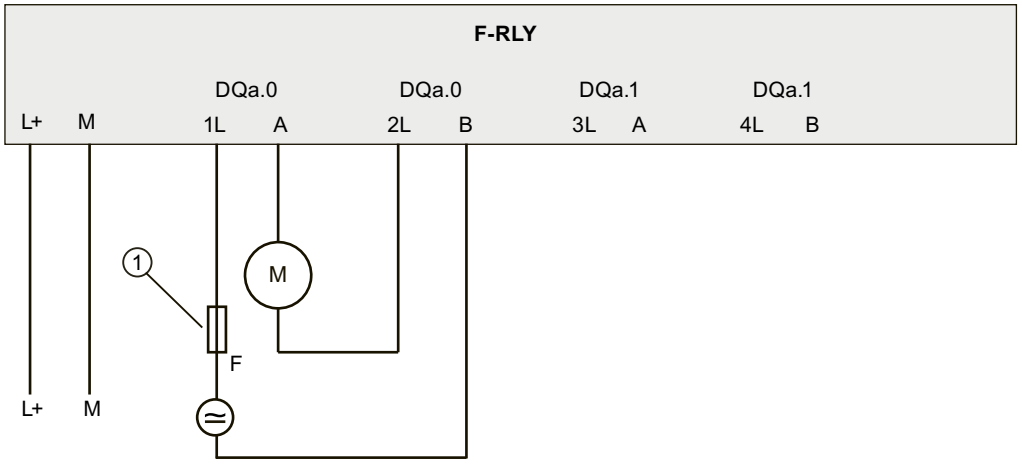
A short-circuit from 1L to A or equivalent fault can lead immediately to a dangerous failure. You must prevent this failure mode by proper separation and protection of conductors.



① External fuse (Refer to F-DQ 2 x Relay "Specifications" (Page 176), "Digital outputs" table, "Short-circuit protection of output" for external fuse details.)

3.2.8 Application 7: Wiring a directly-connected SIL-rated actuator, switching both load conductors

By switching both conductors to the load, this arrangement provides extra protection for faults to power or ground in the external wiring that might energize the load device.



① External fuse (Refer toF-DQ 2 x Relay "Specifications" (Page 176), "Digital outputs" table, "Short-circuit protection of output" for external fuse details.)

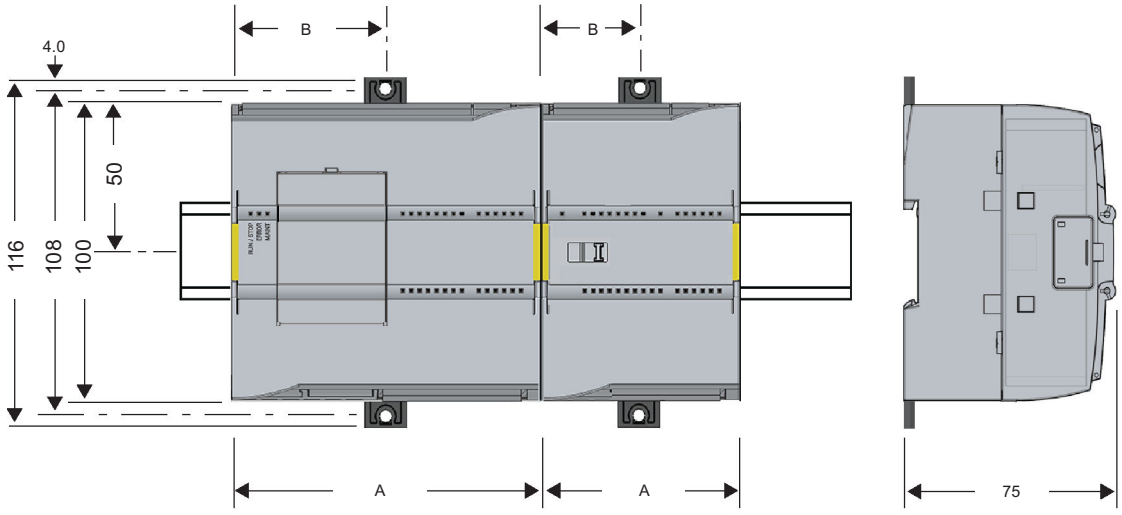
Fail-Safe CPU and signal module (SM) installation

4

4.1 S7-1200 Fail-Safe modules installation and removal

4.1.1 Mounting dimensions for S7-1200 Fail-Safe modules

CPU 1212FC, CPU 1214FC
(measurements in mm)



CPU 1215FC
(measurements in mm)

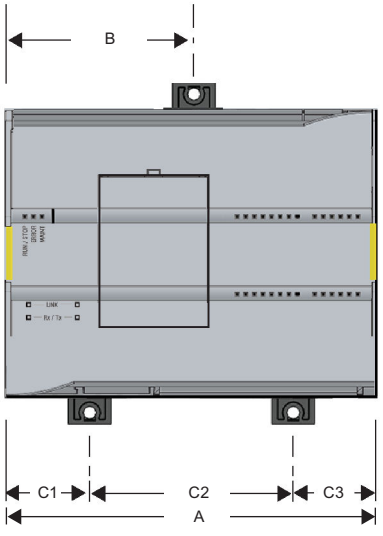


Table 1-3 Mounting dimensions (mm)

S7-1200 Fail-Safe devices		Width A (mm)	Width B (mm)	Width C (mm)
Fail-Safe CPU	CPU 1212FC	90	45	--
	CPU 1214FC	110	55	--
	CPU 1215FC	130	65 (top)	Bottom: C1: 32.5 C2: 65 C3: 32.5
Fail-Safe signal modules (SM)	SM 1226 F-DI 16 x 24 VDC SM 1226 F-DQ 4 x 24 VDC SM 1226 F-DQ 2 x Relay	70	35	--

Each fail-safe CPU and SM supports mounting on either a DIN rail or on a panel. Use the DIN rail clips on the module to secure the device on the rail. These clips also snap into an extended position to provide screw mounting positions to mount the unit directly on a panel. The interior dimension of the hole for the DIN clips on the device is 4.3 mm.

A 25 mm thermal zone must be provided above and below the unit for free air circulation.

4.1.2 Guidelines for installing S7-1200 Fail-Safe devices

The S7-1200 equipment is designed to be easy to install. You can install an S7-1200 either on a panel or on a standard rail. The S7-1200 assembly can be oriented either horizontally or vertically. The small size of the S7-1200 allows you to make efficient use of space.

Expansion module installation rules:

- Standard and fail-safe signal modules (SM) are installed on the right side of a CPU. Fail-safe CPUs allow a maximum of 8 signal modules, if the total of all expansion module CPU loads does not exceed the CPU's 5 V DC and 24 V DC power supply load limits. Fail-safe and standard modules may be intermixed on the right side of the CPU.
- Communication modules (CM) are installed on the left side of the CPU. Fail-safe CPU's allow a maximum of 3 communication modules, if the total of all expansion module loads does not exceed the CPU's 5 V DC and 24 V DC power load limits.
- Signal boards (SB), communications boards (CB), and battery boards (BB) are installed on top of the CPU. A maximum of 1 signal board, communication board, or battery board is allowed for any CPU.

The S7-1200 standard signal modules (SM), communication modules (CM), and signal boards (SB) can be used in the same system with fail-safe SMs to complete your application control functions that do not require a rated Safety Integrity Level (SIL). Standard SMs that are supported for use with fail-safe SMs have the MLFB numbers (6ES7--- ---32 0XB0).

The S7-1200 fail-safe CPUs support many of the PROFIBUS and PROFINET distributed fail-safe I/O. Refer to "Hardware and software components" (Page 15) for further information.

Electrical equipment standards classify the SIMATIC S7-1200 system as Open Equipment. You must install the S7-1200 in a housing, cabinet, or electric control room. You should limit entry to the housing, cabinet, or electric control room to authorized personnel.

The installation should provide a dry environment for the S7-1200. SELV/PELV circuits are considered to provide protection against electric shock in dry locations.

The installation should provide the appropriate mechanical strength, flammability protection, and stability protection that is approved for open equipment in your particular location category according to applicable electrical and building codes.

Conductive contamination due to dust, moisture, and airborne pollution can cause operational and electrical faults in the PLC.

If you locate the PLC in an area where conductive contamination may be present, the PLC must be protected by an enclosure with appropriate protection rating. IP54 is one rating that is generally used for electronic equipment enclosures in dirty environments and may be appropriate for your application.

⚠ WARNING

Improper installation of the S7-1200 can result in electrical faults or unexpected operation of machinery.
Electrical faults or unexpected machine operation can result in death, severe personal injury, and/or property damage.
All instructions for installation and maintenance of a proper operating environment must be followed to ensure the equipment operates safely.

Separate the S7-1200 devices from heat, high voltage, and electrical noise

As a general rule for laying out the devices of your system, always separate the devices that generate high voltage and high electrical noise from the low voltage, logic devices such as the S7-1200.

When designing the layout of an S7-1200 inside your panel, consider the heat generating devices and locate electronic devices in the cooler areas of your cabinet. Reducing the exposure to a high temperature environment extends the operating life of any electronic device.

Consider also the routing of the wiring for the devices in the panel. Do not place low voltage signal wires and communications cables in the same tray with AC power wiring and high energy, rapidly switched DC wiring.

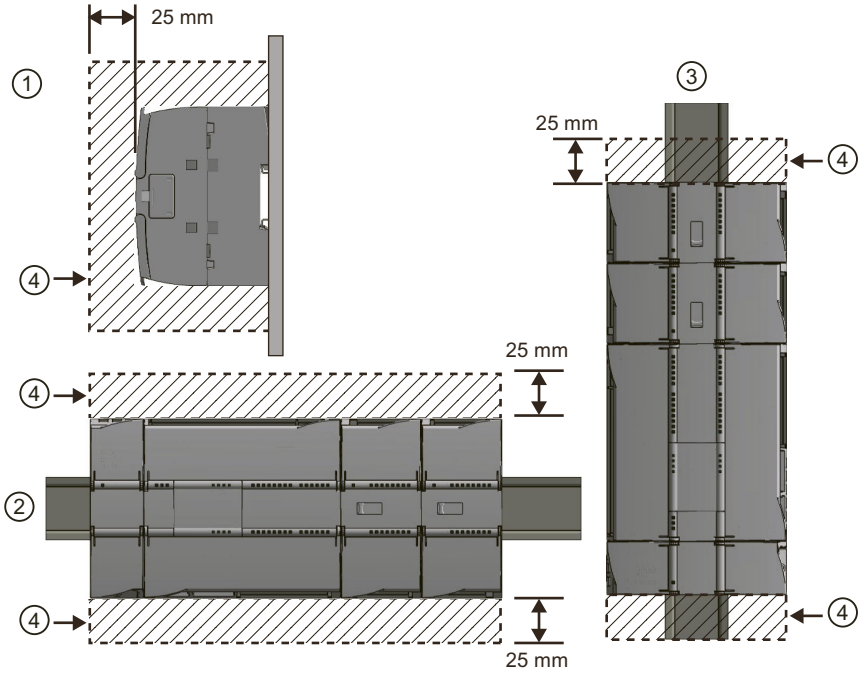
Provide adequate space for cooling and wiring

S7-1200 devices are designed for natural convection cooling. For proper cooling, you must provide a clearance of at least 25 mm above and below the devices. Also, allow at least 25 mm of space between the front of the modules and the inside of the enclosure.

⚠ CAUTION

For vertical mounting, the maximum allowable ambient temperature is reduced by 10 degrees C.
Orient a vertically mounted S7-1200 system as shown in the following figure.
Ensure that the S7-1200 system is mounted correctly.

When planning your layout for the S7-1200 system, allow enough clearance for the wiring and communications cable connections.

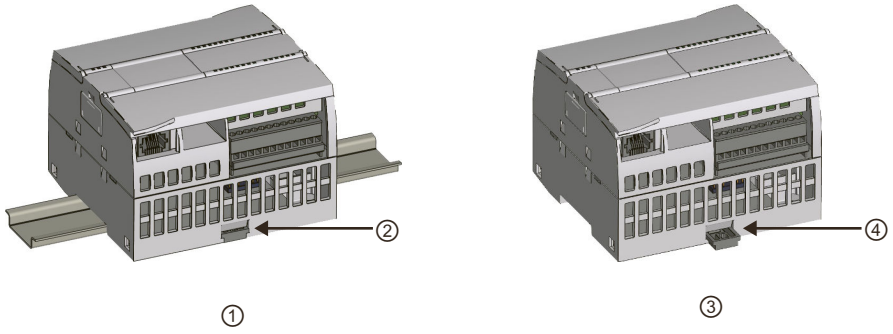


① Side view
② Horizontal installation
③ Vertical installation
④ Clearance area

4.1.3 Installation and removal safety rules

Installing and removing the S7-1200 devices

The CPU can be easily installed on a standard DIN rail or on a panel. DIN rail clips are provided to secure the device on the DIN rail. The clips also snap into an extended position to provide a screw mounting position for panel-mounting the unit.



① ③

① DIN rail installation
② DIN rail clip in latched position
③ Panel installation
④ Clip in extended position for panel mounting

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

⚠ WARNING

Installation or removal of S7-1200 or related equipment, with the power applied, could cause electric shock or unexpected operation of equipment.
Failure to disable all power to the S7-1200 and related equipment during installation or removal procedures could result in death, severe personal injury and property damage due to electric shock or unexpected equipment operation.
Always follow appropriate safety precautions and ensure that power to the S7-1200 is disabled before attempting to install or remove S7-1200 CPUs and related equipment.

Always ensure that whenever you replace or install an S7-1200 device you use the correct module or equivalent device.

⚠ WARNING

Incorrect installation of an S7-1200 module may cause the program in the S7-1200 to function unpredictably.
Failure to replace an S7-1200 device with the same model, orientation, or order could result in death, severe personal injury and property damage due to unexpected equipment operation.
Replace an S7-1200 device with the same model, and be sure to orient and position the module correctly.

⚠ WARNING

Do not disconnect equipment when a flammable or combustible atmosphere is present.
Disconnection of equipment when a flammable or combustible atmosphere is present may cause a fire or explosion which could result in death, serious injury and property damage.
Always follow appropriate safety precautions when a flammable or combustible atmosphere is present.

NOTE

Electrostatic discharge can damage the device or the receptacle on the CPU.
Make contact with a grounded conductive pad or wear a grounded wrist strap whenever you handle the device.

4.1.4 Installing and removing an S7-1200 FC CPU

You can install the CPU on a panel or on a DIN rail.

NOTE
Attach any communication modules to the CPU and install the assembly as a unit. Install signal modules separately after the CPU has been installed.

Set up the CPU rail clips:

- **For DIN rail mounting**, make sure the upper DIN rail clip is in the latched (inner) position and lower DIN rail clip is in the unlatched (extended) position, for both CPU and attached CMs.
  - After installing the devices on the DIN rail, move the lower DIN rail clips to the latched position to lock the devices on the DIN rail.
- **For panel mounting**, make sure the DIN rail clips are pushed to the extended position.

To install the CPU on a panel, follow these steps:

1. Locate, drill, and tap the mounting holes (M4), using the dimensions shown in the mounting dimensions table (Page 73).
2. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power.
3. Extend the mounting clips from the module. Make sure the DIN rail clips on the top and bottom of the CPU are in the extended position.
4. Secure the module to the panel, using a pan head M4 screw with spring and flat washer. Do not use a counter-sink screw with beveled head. Apply only enough torque to flatten the spring washer.

NOTE
If your system is subject to a high vibration environment or is mounted vertically, then panel mounting the S7-1200 is recommended.

Table 1-4 Installing the CPU on a DIN rail

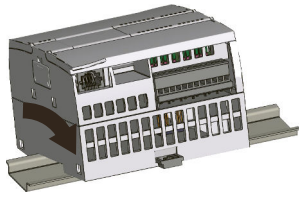
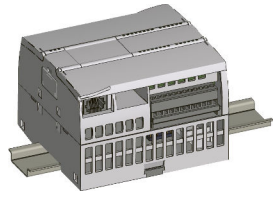
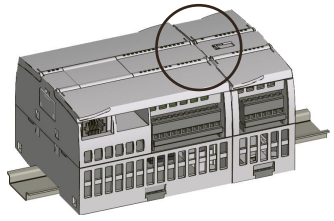
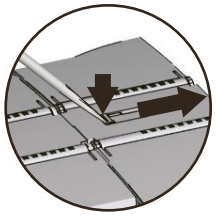
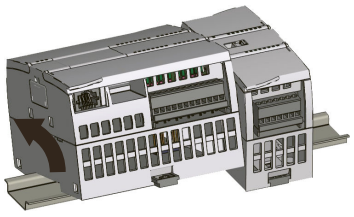
Task	Procedure
	1. Install the DIN rail. Secure the rail to the mounting panel every 75 mm. 2. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 3. Hook the CPU over the top of the DIN rail. 4. Pull out the DIN rail clip on the bottom of the CPU to allow the CPU to fit over the rail. 5. Rotate the CPU down into position on the rail. 6. Push in the clips to latch the CPU to the rail.
	

Table 1-5 Removing the CPU from a DIN rail

Task	Procedure
  	1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Disconnect the I/O connectors, wiring, and cables from the CPU. Refer to the terminal block removal instructions (Page 80). 3. Remove the CPU and any attached communication modules as a unit. All signal modules should remain installed. 4. If an SM is connected to the CPU, then retract the bus connector: – Place a screwdriver beside the tab on the top of the signal module. – Press down to disengage the connector from the CPU. – Slide the tab fully to the right. 5. Remove the CPU: – Pull out the DIN rail clip to release the CPU from the rail. – Rotate the CPU up and off the rail, and remove the CPU from the system.

4.1.5 Installing and removing a signal module (SM)

Table 1-6 Installing an SM

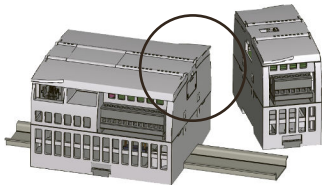
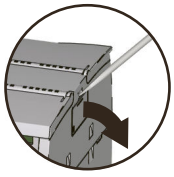
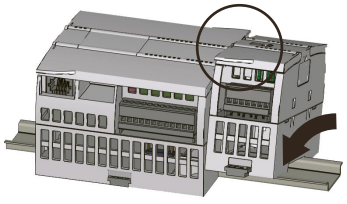
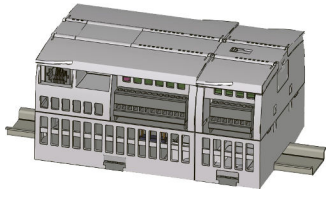
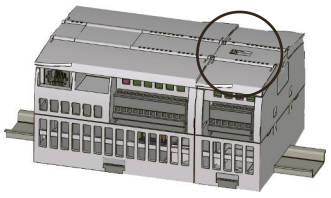
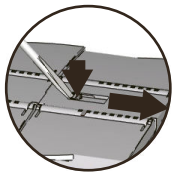
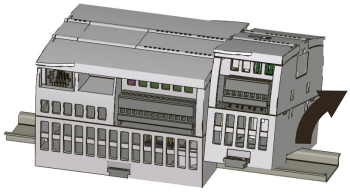
Task	Procedure	
		Install your SM after installing the CPU. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Remove the cover for the connector from the right side of the CPU. – Insert a screwdriver into the slot above the cover. – Gently pry the cover out at its top and remove the cover. Retain the cover for reuse.
	Connect the SM to the CPU: 1. Position the SM beside the CPU. 2. Hook the SM over the top of the DIN rail. 3. Pull out the bottom DIN rail clip to allow the SM to fit over the rail. 4. Rotate the SM down into position beside the CPU and push the bottom clip in to latch the SM onto the rail.	
		Extending the bus connector makes both mechanical and electrical connections for the SM. 1. Place a screwdriver beside the tab on the top of the SM. 2. Slide the tab fully to the left to extend the bus connector into the CPU. Follow the same procedure to install a signal module to another signal module.

Table 1-7 Removing an SM

Task	Procedure
 	You can remove any SM without removing the CPU or other SMs in place. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Remove the I/O connectors and wiring from the SM. Refer to the terminal block removal instructions (Page 80). 3. Retract the bus connector. – Place a screwdriver beside the tab on the top of the SM. – Press down to disengage the connector from the CPU. – Slide the tab fully to the right. When another SM is connected on the right, repeat this procedure for that SM.
	Remove the SM: 1. Pull out the bottom DIN rail clip to release the SM from the rail. 2. Rotate the SM up and off the rail. Remove the SM from the system. 3. If required, cover the bus connector on the CPU to avoid contamination. Follow the same procedure to remove a signal module from a signal module.

4.1.6 Removing and reinstalling the S7-1200 terminal block connector

CPUs, signal boards (SB) and signal modules (SM) have removable connectors to make wiring easy.

Table 1-8 Removing terminal blocks (CPU example)

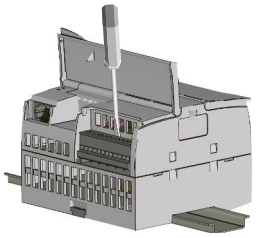
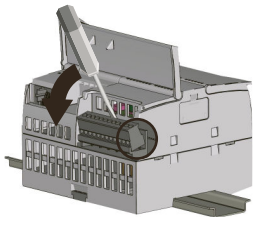
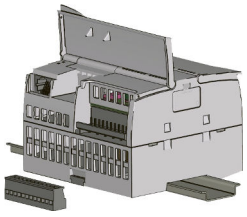
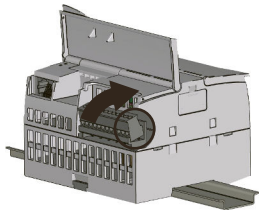
Task	Procedure
 	Prepare the system for terminal block connector removal by removing the power from the CPU and opening the cover above the connector. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Inspect the top of the connector and locate the slot for the tip of the screwdriver. 3. Insert a screwdriver into the slot. 4. Gently pry the top of the connector away from the CPU. The connector releases with a snap. 5. Grasp the connector and pull away from the CPU.

Table 1-9 Installing the connector

Task	Procedure
	Prepare the components for terminal block installation by removing power from the CPU and opening the cover for connector. 1. Ensure that the CPU and all S7-1200 equipment are disconnected from electrical power. 2. Align the connector with the pins on the unit. 3. Align the wiring edge of the connector inside the rim of the connector base. 4. Press firmly down and rotate until the connector snaps into place. Check carefully to ensure that the connector is properly aligned and fully engaged.
	

4.2 Fail-Safe system electrical design rules

4.2.1 Safe functional extra low voltage requirement (power supplies and other system components)

⚠ WARNING

Fail-safe modules must be operated with safe functional extra-low voltage (SELV, PELV) power sources.
To maintain safe S7-1200 low voltage circuits, external connections to communications ports, analog circuits, 24 V DC nominal power supplies, and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards.
The external power supply should limit the maximum voltage to 35 V DC even under fault conditions. Please consult the manufacturer's data for the power supplies that you use.

Maximum applied voltage to S7-1200 Fail-Safe devices

- Operational voltage: The fail-safe CPU and fail-safe signal modules operational voltage is 20.4 V DC - 28.8 V DC, 35 V DC surge for 0.5 second. Operation of the unit to specifications is assured by design and testing. Defined transients from defined source impedances per EN 61000-4-2, 61000-4-4, 61000-4-6, as specified in the data sheet for each product, may be imposed on this voltage without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 V DC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 V DC. These power supplies must be specified by the manufacturer to limit the output voltage to 35 V DC or less under fault conditions. Otherwise, external protection must be supplied that will reliably open the circuit or limit the output voltage to less than 35 V DC to the CPU and signal modules.

- Surge immunity: Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. This protection must be sufficient to clamp surge voltages and/or open the supply circuit to assure the PLC system is not exposed to voltages greater than 35 V DC. One specification for evaluation of protection from lightning type surges is found in EN 61000-4-5, with operational limits established by EN 61000-6-2. S7-1200 DC fail-safe CPUs and fail-safe signal modules require external protection to maintain safe operation when subject to surge voltages defined by this standard. Refer to Appendix A.1.5.1: "Surge immunity (Page 123)" for further information.

Requirements for power supplies in the event of voltage interruption

To ensure adherence to IEC 61131-2 and NAMUR Recommendation NE 21, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirement in your product standards (for example, 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions. The latest information on PS components is available on the Internet.

⚠ WARNING

All power supply and fail-safe signal module circuits must be connected together to a common voltage reference or must be isolated SELV circuits.
The power supply M terminals on the fail-safe CPU and the fail-safe SMs must be connected together or isolated as SELV. Failure to do so can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to SM isolation boundary.

4.2.2 Power budget

4.2.2.1 Connecting power to the S7-1200 system

Fail-safe CPUs require an external SELV/PELV 24 V DC power supply for the CPU's 24 V DC power input (the 24 V DC L+ and M terminals, with an **arrow pointing into** the CPU module). The external 24 V DC supply powers the CPU's internal 5 V DC supply that provides power for the CPU, signal modules (SM), signal board (SB), and communication modules (CM). 24 V DC power is available at the CPU's 24 V DC power output (the 24 V DC L+ and M terminals, with an **arrow pointing out of** the CPU module).

NOTE

Sensor supply connections for safety inputs
If you want to use a sensor supply source from the PLC for safety inputs, you should use the sensor supply provided on the fail-safe DI signal modules.

The purpose of a power budget calculation is to ensure that the power requirements of all CPU powered elements (fail-safe CPU, fail-safe SM, standard SM, and CM) do not exceed the available CPU power:

- You may not be able to connect the maximum number of signal modules and communication modules, if you exceed the CPU's 5 V DC power output capability.
- You may need to use external 24 V DC power for some system elements, if you exceed the CPU's 24 V DC power output capability.

NOTE

Power limits for 5 V DC and 24 V DC supplied from a fail-safe CPU.
Exceeding the power budget of the CPU may result in not being able to connect the allowed maximum number of add-on modules.

Refer to the technical specifications for information about power input requirements (CPUs, SMs, SBs, and CMs) and CPU power output limits (5 V DC and 24 V DC).

Refer to the "Calculating a power budget" (Page 84) to determine CPU power output capability.

Expansion module installation rules:

- Standard and fail-safe signal modules (SM) are installed on the right side of the CPU. Fail-safe CPUs allow a maximum of 8 signal modules, if the total of all add-on module CPU loads does not exceed the CPU's 5 V DC and 24 V DC power supply load limits. Fail-safe and standard modules may be intermixed on the right side of the CPU.
- Communication modules (CM), are installed on the left side of the CPU. A maximum of 3 communication modules is allowed for a Fail-safe CPU, if the total of all add-on module CPU loads does not exceed the CPU's 5 V DC and 24 V DC load limits.
- Signal boards (SB), communications boards (CB), and battery boards (BB) are installed on top of the CPU. A maximum of one signal board, communication board, or battery board is allowed for any CPU.

⚠ WARNING

Do not connect separate power supplies directly in parallel.
This can cause a conflict between the power supplies, as each supply tries to establish its preferred output voltage level.
The result of this conflict can be shortened lifetime or the immediate failure of one or both power supplies, with consequent unpredictable operation of the PLC system. Unpredictable operation could result in death, severe personal injury and property damage.
A CPU 24 V DC supply and any external power supply should provide power to different load points.

For improved electrical noise protection, the commons (M) of the different power supplies should be connected.

Some of the 24 V DC power inputs in an S7-1200 system are interconnected, with a common logic circuit connecting multiple M terminals. For example, the following circuits are interconnected when designated as "not isolated" in the technical specifications: the 24 V DC power supply of the CPU, the power input for the relay coil of an SM, or the power supply for a non-isolated analog input. All non-isolated M terminals must connect to the same external reference potential.

⚠ WARNING

Connecting non-isolated M terminals to different reference potentials will cause unintended current flows that may cause damage or unpredictable operation in the PLC and any connected equipment.
Failure to comply with this guideline could cause damage or unpredictable operation which could result in death or severe personal injury and property damage.
Always ensure that all non-isolated M terminals in an S7-1200 system are connected to the same reference potential.

4.2.2.2 Calculating a sample power requirement

CPU power budget calculation for example system

The following example shows the power requirements for a system that includes:

Quantity	Module	Module type
1	CPU 1214FC DC/DC/Relay	Fail-safe CPU with 14 standard (not fail-safe) digital inputs and 10 standard (not fail-safe) digital outputs
1	SB 1223 2 x 24 V DC Input/ 2 x 24 V DC Output	Standard I/O signal board with 2 digital inputs and 2 digital outputs
1	CM 1241 RS422/485	Communication module
1	SM 1226 F-DI 16 x 24 V DC	Fail-safe signal module with 16 digital inputs
1	SM 1226 F-DQ 4 x 24 V DC	Fail-safe signal module with 4 digital outputs
1	SM 1226 F-DQ 2 x Relay	Fail-safe signal module with 2 relay outputs
3	SM 1223 8 DC In/8 Relay Out	Standard signal module with 8 digital inputs and 8 relay outputs

This example system uses a total of 56 inputs and 42 outputs with a mix of standard and fail-safe I/O. If a digital input channel is disconnected and not used, then that input is excluded from the power calculation.

The current supply and consumption numbers are obtained from each module's technical specifications.

The example budget shows inadequate 24 V DC CPU power
An external 24 V DC power supply is necessary to supply a fail-safe CPU's L+ and M input terminals (with the arrow symbol pointing into the CPU). In the example, fail-safe SM 24 V DC loads are also connected to the external power supply. Other devices in your system may connect to the external 24 V DC supply. You must ensure that the external supply has sufficient power available. A total external power load calculation is not described in the example. The purpose of the example is to verify sufficient power is available for loads that are supplied directly from the CPU.

The fail-safe CPU in this example provides sufficient 5 V DC current for all add-on modules, but insufficient 24 V DC current for all of the standard digital inputs and outputs. The fail-safe

SMs connect to a 24 V DC external supply which moves their 24 V DC loads off of the CPU power budget calculation.

The example system requires 424 mA at 24 V DC from the fail-safe CPU, but the CPU can provide only 400 mA. This result requires moving at least 24 mA of the 24 V DC CPU load, to the external 24 V DC power supply. A solution would be to move the 24 V DC power connections for the 24 standard relay outputs, from the CPU to the external power supply. This action would reduce the CPU 24 V DC load by 264 mA.

NOTE

The power required to drive the fail-safe CPU's internal relay coils is already allocated. Do not include the internal relay power requirements in a power budget calculation.

Table 1-10 Sample power budget

	5 V DC distributed by internal bus when modules are installed	**24 V DC distributed by connection to fail-safe CPU terminals L+ and M, (identified by arrow pointing away from the fail-safe CPU)**	**24 V DC supplied by connection to external power supply (separate external supply power budget required)**
CPU 1214FC DC/DC/Relay maximum output current	1600 mA	400 mA	Obtain maximum current rating from the external power supply manufacturer
	Minus		
System components	**5 V DC CPU loads**	**24 V DC CPU loads**	**24 V DC external power supply loads**
CPU 1214FC, 14 X 24 V DC		14 standard inputs located on the CPU: 14 * 4 mA = 56 mA	
1 SB 1223, 2 X 24 V DC	50 mA	2 standard inputs located on a signal board: 2 * 4 mA = 8 mA	
1 CM 1241 RS422/485	220 mA		
1 SM 1226 F-DI 16 x 24 V DC	155 mA		Module plus 16 fail-safe inputs (8 paired channels): 130 mA + 16 * 6 mA = 226 mA
1 SM 1226 F-DQ 4X 24 V DC	125 mA		4 fail-safe digital outputs: 170 mA + load current for all 4 P-switches + Vs1/Vs2 load current
1 SM 1226 F-DQ 2 X relay	120 mA		2 fail-safe relay outputs: 300 mA
3 SM 1223 DI 8 x 24 V DC, DQ 8 x Relay	3 * 145 mA = 435 mA	24 standard digital inputs: 3 * 8 * 4 mA = 96 mA 24 standard relay outputs: 3 * 8 * 11 mA = 264 mA	
Total requirements	1105 mA	424 mA	
	Equals		
Current balance	**5 V DC CPU power**	**24 V DC CPU power**	**24 V DC external power**
Current balance total	495 mA	(24 mA)	

4.2.2.3 Calculating your power requirement

Form for calculating your power budget

Use the following table to determine how much power (current) is available from the fail-safe CPU and how much is needed by the central rack modules for your system. Refer to the technical specifications in this manual for the power ratings of your fail-safe CPU model (1212FC (Page 136), 1214FC (Page 145) ,or 1215FC (Page 155)) and the power requirements of the fail-safe digital input and output signal modules (SM 1226 F-DI 16 x 24 V DC (Page 166), SM 1226 F-DQ 4 x 24 V DC (Page 170), or SM 1226 F-DQ 2 x Relay (Page 176)). Refer to the technical specifications in the S7-1200 Programmable Controller System Manual (https://support.industry.siemens.com/cs/ww/en/view/109478121) for details about standard S7-1200 modules.

Table 1-11 CPU power budget

	5 V DC distributed by internal bus when modules are installed	**24 V DC distributed by connection to fail-safe CPU terminals L+ and M, (identified by arrow pointing away from the fail-safe CPU)**	**24 V DC supplied by connection to external power supply (separate external supply power budget required)**
		Minus	
System components	**5 V DC CPU loads**	**24 V DC CPU loads**	**24 V DC external power supply loads**
Total requirements			
		Equals	
Current balance	**5 V DC CPU power**	**24 V DC CPU power**	**24 V DC external power**
Current balance total			

4.2.3 Fail-Safe module electrical characteristics and terminal assignments

Refer to the respective technical specifications chapter for details about electrical characteristics and terminal assignments.

CPU 1212FC	CPU 1214FC	CPU 1215FC
Specifications (Page 136) Wiring diagram (Page 143)	Specifications (Page 145) Wiring diagram (Page 153)	Specifications (Page 155) Wiring diagram (Page 163)

SM 1226 F-DI 16 x 24 VDC	SM 1226 F-DQ 4 x 24 VDC	SM 1226 F-DQ 2 x Relay
Specifications (Page 166) Wiring diagram (Page 169)	Specifications (Page 170) Wiring diagram (Page 175)	Specifications (Page 176) Wiring diagram (Page 181)

4.3 Control system wiring guidelines

4.3.1 Guidelines for grounding and wiring

Proper grounding and wiring of all electrical equipment is important to provide electrical noise protection for your application and the S7-1200. Refer to the technical specifications (Page 117) for the S7-1200 wiring diagrams.

Prerequisites

Before you ground or install wiring to any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

Ensure that you follow all applicable electrical codes when wiring the S7-1200 and related equipment. Install and operate all equipment according to all applicable national and local standards. Contact your local authorities to determine which codes and standards apply to your specific case.

⚠ WARNING

Installing or wiring the S7-1200 or related equipment with power applied could cause electric shock or unexpected operation of equipment.

Failure to disable all power to the S7-1200 and related equipment during installation or removal procedures could result in death, severe personal injury, and damage due to electric shock or unexpected equipment operation.

Always follow appropriate safety precautions and ensure that power to the S7-1200 is disabled before attempting to install or remove the S7-1200 or related equipment.

Always take safety into consideration as you design the grounding and wiring of your S7-1200 system. Electronic control devices, such as the S7-1200, can fail and cause unexpected operation of the equipment that is being controlled or monitored:

- On-board I/O on the fail-safe CPU and signal modules (SM) other than fail-safe SM: Single point dangerous failures of electronics or software can occur on these devices. You should never depend on these devices as the only protection against personal injury or unacceptable property damage.
- Fail-safe SM: Internal dangerous failures can occur on these devices with a probability as reflected in the SIL rating, PFD, and PFH as stated in this manual.
- Each control's installation: Common cause failure threats can occur such as overvoltage, over-temperature, electrical faults, EMC interference, and fire, water, or mechanical damage to the installation.

You must evaluate every control point for the threat level and consequences of failure. Your installation can require safeguards that are independent of the S7-1200 to achieve an appropriate level of risk for personal injury or equipment damage.

⚠ WARNING

Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment.
Such unexpected operations could result in death, severe personal injury, and property damage.
When using fail-safe I/O, design safety-related control functions to account for the probability of faults, including redundancy to achieve an appropriate level of risk for the consequences of failure.
When using standard I/O, always include an emergency stop function, electromechanical overrides, or other redundant safeguards when a failure could cause personal injury or significant property damage.

4.3.2 Grounding an S7-1200 system

Guidelines for grounding the S7-1200

The best way to ground your application is to ensure that all the common and ground connections of your S7-1200 and related equipment are grounded to a single point. This single point should be connected directly to the earth ground for your system.

All ground wires should be as short as possible and should use a large wire size, such as 2 mm^2 (14 AWG).

When locating grounds, consider safety-grounding requirements and the proper operation of protective interrupting devices.

4.3.3 Wiring an S7-1200 system

Guidelines for wiring the S7-1200 system

When designing the wiring for your S7-1200, provide a single disconnect switch that simultaneously removes power from the fail-safe CPU power supply, from all input circuits, and from all output circuits. Provide over-current protection, such as a fuse or circuit breaker, to limit fault currents on supply wiring. Consider providing additional protection by placing a fuse or other current limit in each output circuit.

Install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Do not place low voltage signal wires and communications cables in the same wire tray with AC wires and high energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

NOTE

The standard I/O channels integrated in the S7-1200 fail-safe CPUs are not designed to be used for the fail-safe I/O function

In your project, you can use the integrated fail-safe CPU I/O with standard code blocks, but you must use the S7-1200 fail-safe DI and DQ signal modules as the fail-safe digital I/O channels with safety code blocks.

Use the shortest wire possible and ensure that the wire is sized properly to carry the required current. Refer to the "Wiring Rules for S7-1200 CPUs, SMs, and SBs" table below for further information.

Wire and cable should have a temperature rating 30 °C higher than the ambient temperature around the S7-1200 (for example, a minimum of 85 °C-rated conductors for 55 °C ambient temperature). You should determine other wiring type and material requirements from the specific electrical circuit ratings and your installation environment.

Use shielded wires for optimum protection against electrical noise. Typically, grounding the shield at the S7-1200 gives the best results. You should ground communication cable shields to S7-1200 communication connector shells using connectors that engage the cable shield, or by bonding the communication cable shields to a separate ground. You should ground other cable shields using clamps or copper tape around the shield to provide a high surface area connection to the grounding point.

When wiring input circuits that are powered by an external power supply, include an overcurrent protection device in that circuit. External protection is not necessary for circuits that are powered by the 24 V DC sensor supply from the S7-1200 because the sensor supply is already current-limited.

All S7-1200 modules have removable connectors for user wiring. To prevent loose connections, ensure that the connector is seated securely and that the wire is installed securely into the connector.

To help prevent unwanted current flows in your installation, the S7-1200 provides isolation boundaries at certain points. When you plan the wiring for your system, you should consider these isolation boundaries. Refer to the technical specifications (Page 117) for the amount of isolation provided and the location of the isolation boundaries. Circuits rated for AC line voltage include safety isolation to other circuits. Isolation boundaries between 24 V DC circuits are functional only, and you should not depend on these boundaries for safety.

A summary of wiring rules for the S7-1200 CPUs and SMs is shown below:

Table 1-12 Wiring rules for S7-1200 CPUs, SMs, and SBs

Wiring rules for...	CPU and SM connector	SB connector
Connectible conductor cross-sections for standard wires	2 mm^2 to 0.3 mm^2 (14 AWG to 22 AWG)	1.3 mm^2 to 0.3 mm^2 (16 AWG to 22 AWG)
Number of wires per connection	1 or combination of 2 wires up to 2 mm^2 (total)	1 or combination of 2 wires up to 1.3 mm^2 (total)
Wire strip length	6.4 mm	6.4 mm
Tightening torque* (maximum)	0.56 N-m (5 inch-pounds)	0.33 N-m (3 inch-pounds)
Tool	2.5 to 3.0 mm flathead screwdriver	2.0 to 2.5 mm flathead screwdriver

* To avoid damaging the connector, be careful that you do not over-tighten the screws.

NOTE

Ferrules or end sleeves on stranded conductors reduce the risk of stray strands causing short circuits. Ferrules longer than the recommended strip length should include an insulating collar such that the uninsulated portion of the ferrule is no longer than the maximum wire strip length. Cross-sectional area limits for bare conductors also apply to ferrules.

4.3.4 Guidelines for lamp loads

Guidelines for lamp loads

Lamp loads are damaging to relay contacts because of the high turn-on surge current. This surge current is 10 to 15 times the steady state current for a tungsten filament lamp. A replaceable interposing relay or surge limiter is recommended for lamp loads that are switched a large number of times during the lifetime of the application.

4.3.5 Guidelines for inductive loads

Guidelines for inductive loads

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off. Suppressor circuits protect your outputs from premature failure caused by the high voltage transient that occurs when current flow through an inductive load is interrupted.

In addition, suppressor circuits limit the electrical noise generated when switching inductive loads. High frequency noise from poorly suppressed inductive loads can disrupt the operation of the PLC. Placing an external suppressor circuit so that it is electrically across the load and physically located near the load is the most effective way to reduce electrical noise.

S7-1200 DC outputs include internal suppressor circuits that are adequate for inductive loads in most applications. Since S7-1200 relay output contacts can be used to switch either a DC or an AC load, internal protection is not provided.

A good suppressor solution is to use contactors and other inductive loads for which the manufacturer provides suppressor circuits integrated in the load device, or as an optional accessory. However, some manufacturer provided suppressor circuits may be inadequate for

your application. An additional suppressor circuit may be necessary for optimal noise reduction and contact life.

For AC loads, a metal oxide varistor (MOV) or other voltage clamping device may be used with a parallel RC circuit, but is not as effective when used alone. An MOV suppressor with no parallel RC circuit often results in significant high frequency noise up to the clamp voltage.

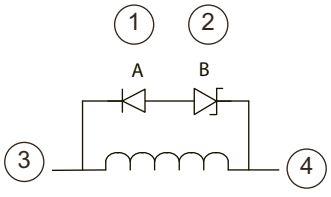
A well-controlled turn-off transient will have a ring frequency of no more than 10KHz, with less than 1KHz preferred. Peak voltage for AC lines should be within +/- 1200 V of ground. The data sheets list voltage thresholds for the internal suppression circuits on DC outputs. (Refer to Appendix A: "Technical specifications" for further information.) External suppression should limit the transient to less than this threshold to ensure that the internal suppression circuit does not attempt to suppress an excessive load.

An external suppression circuit connected directly across the load also avoids the hazard of energizing the load if suppression circuit components fail short.

NOTE

The effectiveness of a suppressor circuit depends on the application and must be verified for your particular usage. Ensure that all components are correctly rated and use an oscilloscope to observe the turn-off transient.

Typical suppressor circuit for DC or relay outputs that switch DC inductive loads



① 1N4001 diode or equivalent

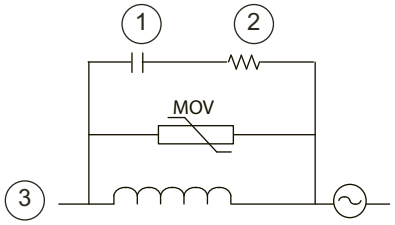
② 8.2 V Zener (DC outputs), 36 V Zener (Relay outputs)

③ Output channel F-DQ (P-switch) or standard DQ output

④ Output channel F-DQ (M-switch) or standard DQ common return

In most applications, the addition of a diode (A) across a DC inductive load is suitable, but if your application requires faster turn-off times, then the addition of a Zener diode (B) is recommended. Be sure to size your Zener diode properly for the amount of current in your output circuit.

Typical suppressor circuit for relay outputs that switch AC inductive loads



Ensure that the working voltage of the MOV is at least 20% greater than the nominal line voltage.

Choose pulse-rated, non-inductive resistors, and capacitors recommended for pulse applications (typically metal film). Verify the components meet

① See table for C value
② See table for R value
③ Output channel

average power, peak power, and peak voltage requirements.

If you design your own suppressor circuit, the following table suggests resistor and capacitor values for a range of AC loads. These values are based on calculations with ideal component parameters. "I rms" in the table refers to the steady-state current of the load when fully ON.

Table 1-13 AC suppressor circuit resistor and capacitor values

Inductive load			Suppressor values		
I rms	**230 V AC**	**120 V AC**	**Resistor**		**Capacitor**
Amps	VA	VA	Ω	W (power rating)	nF
.02	4.6	2.4	15000	.1	15
.05	11.5	6	5600	.25	47
.1	23	12	2700	.5	100
.2	46	24	1500	1	150
0.5	115	60	560	2.5	470
1	230	120	270	5	1000
2	460	240	150	10	1500

[2] **Conditions satisfied by the table values:**
Maximum turn-off transition step < 500 V
Resistor peak voltage < 500 V
Capacitor peak voltage < 1250 V
Suppressor current < 8% of load current (50 Hz)
Suppressor current < 11% of load current (60 Hz)
Capacitor dV/dt < 2 V/µs
Capacitor pulse dissipation : ∫(dv/dt) dt < 10000 V^2/µs
Resonant frequency < 300 Hz
Resistor power for 2Hz max switching frequency
Power factor of 0.3 assumed for typical inductive load

4.4 Maintenance guidelines

Each S7-1200 module and CPU is a factory-assembled unit that contains no user replaceable components or repairable components, except for removable terminal blocks and memory cards. Maintenance of an S7-1200 system consists of the following:

- Observation and response to diagnostic reports from the S7-1200
- Replacement of modules with identified failures
- Replacement of modules at 20 years of operating life
- Inspection and monitoring of the installation environment to ensure continued adherence to all specified operating conditions, to include the following:
  - S7-1200 and field wiring electrically and mechanically secure
  - Ventilation continued as designed for installation
  - Continued protection from moisture, dust, and conductive contamination
  - Voltage of connected circuits in proper range
  - Operating temperature of equipment in proper range

The fail-safe signal modules (SMs) monitor the 24 V DC power supplied at L+ and passivate the module on voltage out-of-range.

The fail-safe SMs monitor internal temperature and passivate the SM on temperature out-of-range.

You must assess your installation safety and determine if you require additional voltage and temperature monitoring.

NOTE

Associated equipment including sensors, actuators, circuit breakers, and surge protectors are subject to wear and typically require periodic inspections or proof tests according to manufacturer's instructions or standards to maintain a consistent level of safety integrity.

User cleaning or decontamination of an S7-1200:

- Only use vacuum or a dry cloth applied to the outside of the assembly.
- Turn the power off before cleaning.

NOTICE
Do not use high pressure forced air or wet/liquid cleaners for user cleaning or decontamination of an S7-1200. High pressure forced air can damage components or carry entrained contaminants. Wet/liquid cleaners of any kind can deposit conductive contamination onto the circuit boards.

Fail-Safe signal module (SM) I/O configuration 5

All connected fail-safe SM I/O must have their operating properties configured by the STEP 7 Safety configuration software. You have the responsibility to ensure that no unconfigured SMs are connected in a fail-safe automation system.

5.1 Configuring fail-safe SM I/O properties

To configure fail-safe SM I/O properties, follow these steps:

1. Select "Device configuration" in the project tree.
2. Place fail-safe I/O devices into your project's "Device view".

NOTE

The fail-safe SM's each use both I's and Q's, even though they may physically only have input channels or only have output channels. The extra bytes carry safety status and data integrity information.

Module	Number of channels	Input (I) bytes required	Output (Q) bytes required
SM 1226 F-DI 16 x 24 V DC	8 - 16 (input)	9	5
SM 1226 F-DQ 4 x 24 V DC	4 (output)	6	6
SM 1226 F-DQ 2 x Relay	2 (output)	6	6

3. Select the image of a fail-safe I/O device (on the Device view or Device overview) and view the module's "Properties" tab.
4. On the **"Properties"** view, select the **"General"** tab.
5. Click on the module properties tree and expand the branches for an I/O module. You can select a module (for example, "F-DI16") and see all the properties. You can also select a module branch (for example, "F-parameters", "DI-parameters", or "Channel parameters") and see a subset of the properties.
6. Select a property in the left-side property tree and then set values in the right-side property fields.
7. A successful compile and download of your hardware configuration to an S7-1200 fail-safe CPU automatically puts your new configuration settings in the I/O modules.

5.2 Configuring common F-parameters

Table 1-14 Common F-parameters

F-parameters	Description	Default	Options
Manual assignment of F-monitoring time	You must select the check box to change F-monitoring time from the central value propagated by the fail-safe CPU.	Check box deselected	Check box: • Selected • Deselected
F-monitoring time [1]	Watchdog timer monitoring safety-related communication between the fail-safe CPU and fail-safe SM (PROFIsafe monitoring time)	150 ms	1 to 65535 ms
F-source address	Unique network-wide address for the fail-safe CPU	1	You can configure the F-source address using the fail-safe CPU parameter "Basis for PROFIsafe addresses".
F-destination address	CPU-wide unique address (usually in descending order, starting with 65534).	-	1 to 65534
Behavior after channel fault	Response by the fail-safe SM to channel faults such as a short-circuit, overload, or discrepancy error.	Passivate channel	Not configurable in the fail-safe SM
Reintegration after channel fault (not available for the SM 1226 F-DQ 2 x Relay)	You have two methods, manual and automatic, to reintegrate your fail-safe SM channels after a channel fault. You can choose to reintegrate in one of three ways: • All channels automatically (no acknowledgement necessary for reintegration) • All channels manually (acknowledgement necessary for reintegration) • Adjustable (channel-by-channel; some channels automatically reintegrated and some channels manually reintegrated)	Adjustable	• Adjustable • All channels automatically • All channels manually

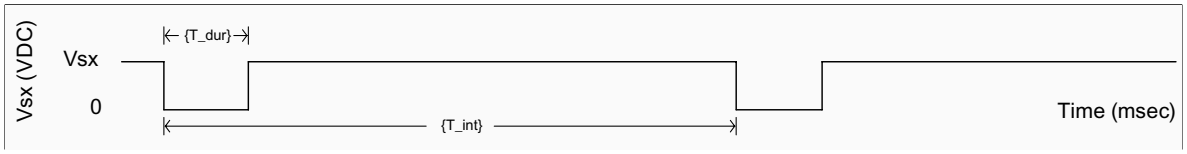
[1] You set the "Default F-monitoring time for central F-IO" in the F-parameters of the fail-safe CPU. STEP 7 uses this number to set the F-monitoring time in each fail-safe SM unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

Refer to the SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for further F-parameter information.

5.3 Configuring SM 1226 F-DI 16 x 24 V DC DI and channel parameters

Table 1-15 SM 1226 F-DI 16 x 24 V DC DI parameters

DI parameters	Description	Default	Options
Short-circuit test	This test creates short duration OFF pulses on the sensor power supplies. Input circuits powered by Vs1 and Vs2 are expected to be OFF during the sensor OFF time. Failure to detect OFF when a sensor supply is OFF indicates a short-circuit to a power source or another fault that prevents the input from properly detecting a "0". Input channels which fail this test are passivated. During the test, the reported process value will not change, so the configured "Duration of short-circuit test" increases the response time. An actual process "0" occurring near the beginning of a test will not be reported to the user program until after the "Duration of short-circuit test" time has elapsed. The check box must be selected to activate the short-circuit test.	Check box deselected	Check box: • Selected • Deselected
Interval for short-circuit test (see T_int in figure below)	This value is the time between the OFF pulses of the sensor supply. Refer to the figure below for further information. Note: The interval must be a minimum of eight times the duration.	25.6 ms	• 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms
Duration of short-circuit test (see T_dur in figure below)	This value is the time that the power supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs. Refer to the figure below for further information. Note: The interval must be a minimum of eight times the duration.	1.6 ms	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms



Vsx Vs1 or Vs2 sensor supplies (VDC)

T_int Short-circuit test interval (time period) between the OFF pulses of the sensor supply

T_dur Short-circuit test OFF pulse time duration (msec)

Table 1-16 SM 1226 F-DI 16 x 24 V DC channel parameters

Channel parameters	Description	Default	Options
Activated	Select the check box to activate the channel. You must activate both required channels before selecting 1oo2. If channels are paired, you must change to 1oo1 and change individually. Deselect the check box and the unused channel is deactivated. If you deactivate a channel, you also deactivate its diagnostic function.	Check box selected	Check box: • Selected • Deselected
Input filters	Digital inputs are filtered to remove contact bounce and short duration noise. This parameter assigns the duration of the filter time.	6.4 ms	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms
Channel failure acknowledge	Controls whether the channel is automatically reintegrated after a fault clears, or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults" (Page 102) for the reintegration procedure.	Manual	• Automatic • Manual
Sensor supply	Assign whether 24 V power is supplied to sensors from a sensor supply output of the module (internal) or from an external power supply (external). Short-circuit tests are not performed for any channel where external power is selected.	External	• Internal • External
Sensor evaluation	Assigns whether channel x input operates individually or is paired with channel x+8 input. **1oo1 evaluation:** One sensor is connected to the module on a single channel. **1oo2 evaluation:** Two input channels are occupied by either: • Two 1-channel sensors • One 2-channel equivalent sensor • One 2-channel non-equivalent sensor If 1oo2 is selected, you must assign the digital input connection type and discrepancy properties.	1oo1 evaluation	• 1oo1 evaluation • 1oo2 evaluation
Type sensor connection	**1 channel**: One sensor is connected to one channel. For "1oo1 evaluation", the type of sensor connection is set read only to "1 channel". **2 channel equivalent** (with equivalent signals): One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair. **2 channel - 3 wire non-equivalent**: One two-channel non-equivalent sensor is connected to the two channels, in a channel pair. **2 channel - 4 wire non-equivalent** One two-channel non-equivalent sensor or two single-channel non-equivalent sensors are connected to the two channels, in a channel pair. Note: Refer to "Digital input applications" (Page 64) for illustrations of connection modes.	1 channel	• 1 channel • 2 channel equivalent • 2 channel - 3 wire non-equivalent • 2 channel - 4 wire non-equivalent

Channel parameters	Description	Default	Options
Discrepancy behavior	A logical difference between the two signals of a 1oo2 input configuration is allowed, without error, for the configured discrepancy time. You can choose whether the reported process value should be "0" or the last valid value during the configured discrepancy time while the signals do not match. If a logical difference in 1oo2 inputs persists for more than the configured discrepancy time, the channel will be passivated and the process value set to 0.	Supply value 0	• Supply value 0 • Supply last valid value
Discrepancy time	The two signals in a 1oo2 input configuration will not change exactly at the same time, due to differences in sensors, contacts, and wiring. The discrepancy time parameter allows you to configure a normally expected duration for a mismatch between signals during transition.	10 ms	5 to 30000 ms
Reintegration after discrepancy error	Assigns whether a zero state must be detected on both 1oo2 channels before a previously declared discrepancy can be cleared.	Test 0-signal not necessary	• Test 0-signal not necessary • Test 0-signal necessary Note: The test 0-signal must be applied for at least 100 ms.

NOTE

Safety program access to 1oo2 input data

For 1oo2 evaluation, two paired input channels (for example, F-DI a0.0 and F-DI b0.0) are connected to one or two sensors. The F-DI performs the discrepancy analysis and sends the result to the safety program, **at the input address of the low-numbered channel** (F-DI a0.0, in the example).

Sensor-actuator response time is increased when you add more input discrepancy time

The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0", but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0' and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides reliable normal operation. Refer to "Response time parameters for the SM 1226 F-DI 16 x 24 VDC" (Page 186) for further information.

Discrepancy time variation with short circuit test

If your process input changes near a short-circuit test, a discrepancy is detected in less time than your configured discrepancy time.

With:

Tdisc = configured discrepancy time

Tsct = configured short circuit test duration

Tfilter = configured input filter time

Tda = actual discrepancy time, time between process signal changes that can be detected as a fault

The range of detected discrepancy time is:

If Tfilter < Tsct: {Tdisc - (Tfilter + Tsct)} <= Tda <= Tdisc

If Tfilter >= Tsct: {Tdisc - (2 x Tsct)} <= Tda <= Tdisc

Your configured discrepancy time should account for this variation to avoid unexpected passivations.

5.4 Configuring SM 1226 F-DQ 4 x 24 V DC DQ and channel parameters

Table 1-17 SM 1226 F-DQ 4 x 24 V DC DQ parameters

DQ parameters	Description	Default	Options
Maximum test period	Assign the time interval between bit pattern tests for F-DQ DC output faults. Functional test bit patterns are applied to the output switches. These tests detect faulted P- or M- output switches and wiring faults that are detectable at the module terminals. Short circuits to other signals or power rails can be detected. Open circuits between the wiring terminals and the load are not detected. If an error is detected on a channel, the test interval is shortened to approx. 1 min. If an error is no longer detected, the configured test interval is used again. A persistent fault is reported to the fail-safe CPU and the affected channels are passivated.	1000 s	• 100 s • 1000 s

Table 1-18 SM 1226 F-DQ 4 x 24 V DC channel parameters

Channel parameters	Description	Default	Options
Activated	Select the check box to activate the channel. Deselect the check box and the unused channel is deactivated. If you deactivate a channel, you also deactivate its diagnostic function.	Check box selected	Check box: • Selected • Deselected
Channel failure acknowledge	Controls whether the channel is automatically reintegrated after a fault clears, or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults" (Page 102) for the reintegration procedure.	Manual	• Automatic • Manual
Maximum readback time	The maximum readback time is a user-configured parameter that assigns the maximum time allowed for an output to reach the new state (ON or OFF) due to a process value change without generating an error. Also, this is the maximum width of a diagnostic test pulse applied to verify that an output can be turned OFF while it is ON. The time of the OFF pulse should be as long as possible, but short enough so that the actuator cannot react.	2.0 ms	1 ms to 400 ms, in 0.1 ms increments
Maximum readback time switch on test	The maximum readback time switch on test is a user-configured parameter that assigns the maximum time for which the P-switch or the M-switch of a channel that is currently in OFF state can be switched ON during a bit pattern	1.0 ms	0.5 ms to 5 ms, in 0.1 ms increments

Channel parameters	Description	Default	Options
	test step. The F-DQ DC tests the P- and M-switches on a channel such that only one switch is turned on at a time. Unless there is a fault in the system (for example, actuator shorted to ground), the actuator is not energized during either the P- or M-switch on tests. Under single fault conditions (either internal or external to the SM), test pulses applied to either the P- or the M-switch of channels in the OFF state can repeatedly energize the actuator. You must select the parameter so that the duration of such pulses is too short to cause the actuator to react and, therefore, cannot have a hazardous effect on the equipment under control.		

⚠ WARNING

In the presence of a single fault, the bit pattern tests can apply energy to the load for a duration up to the configured "Maximum readback time switch on test".
If the load can respond dangerously within the configured readback time, it can respond to bit pattern tests in the presence of a single fault, resulting in death or serious injury to personnel and/or property damage.
Always choose a maximum readback configuration time that is guaranteed not to activate the load.

5.5 Configuring SM 1226 F-DQ 2 x Relay DQ and channel parameters

Table 1-19 SM 1226 F-DQ 2 x Relay DQ parameters

DQ parameters	Description	Default	Options
Relay continuous on time limit	Maximum number of days that the relay can remain continuously on before automatic passivation. Whenever the relay cycles from the de-energized to energized state, the number-of-days calculation begins again. Note: The 30-day default is the maximum test frequency for SIL 3/Category 4 applications. You can extend the test frequency for SIL 2/Category 3 applications for this product to as much as 366 days.	30	1 to 366 days

Table 1-20 SM 1226 F-DQ 2 x Relay channel parameters

Channel parameters	Description	Default	Options
Activated	Select the check box to activate the channel. Deselect the check box and the unused channel is deactivated. If you deactivate a channel, you also deactivate its diagnostic function.	Check box selected	Check box: • Selected • Deselected
Channel failure acknowledge	Controls whether the channel is automatically reintegrated after a fault clears, or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults" (Page 102) for the reintegration procedure.	Manual	Not configurable

Fail-Safe signal module (SM) diagnostics 6

6.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe signal modules (SM). This applies to both sensors and actuators.

The safety function requires that safe state values be applied to the fail-safe signal module (SM) or channel(s) instead of process values (passivation of the fail-safe SM or channel(s)) in the following situations:

- When the fail-safe system is started up
- If SM module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe SM through the PROFIsafe safety protocol (communication error)
- If SM channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-Safe SMs do not remember errors upon power cycle. When the system is powered down and then restarted, any faults still existing are detected again.

Fail-Safe value for fail-safe signal modules

If channels are passivated in fail-safe DI SMs, the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If channels are passivated in the F-DQ DC or F-RLY, the fail-safe system always transfers safe state values "0" to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

Time-out of the PROFIsafe message (F-monitoring time exceeded) passivates all module channels.

Table 1-21 Signal module type and passivation result

Signal module type	Passivation result
SM 1226 F-DI 16 x 24 V DC	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective inputs. • If a channel fault occurs for a 1oo1 configuration, only the affected channel is passivated. For a 1oo2, the channel group of two inputs in the 1oo2 configuration are passivated.
SM 1226 F-DQ 4 x 24 V DC	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective outputs. • Diagnostic evaluations are performed separately for each of the two switches of a channel. Failure detection for one switch leads to passivation of the channel.
SM 1226 F-DQ 2 x Relay	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective outputs. • Diagnostic evaluations are performed separately for each of the two relays of a channel. Failure detection for one relay leads to passivation of the channel.

Response to faults in the fail-safe system

You should prepare maintenance procedures for your system to assure that return to operation after a detected fault is controlled and documented.

The following steps must be performed:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe signal module

A channel or module can be reintegrated after successful diagnostics determine that a fault has cleared.

You can configure reintegration as automatic or manual. You can make this selection on a per channel or module basis in the Device Configuration. Communication errors must always be manually acknowledged.

Channels that you select to be automatically reintegrated are immediately reintegrated when the fault has cleared.

Channels that you select to be manually reintegrated can be acknowledged in your program after the fault has cleared.

The "ACK_REQ" bit for that module goes true to signal that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Some fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

Reintegration after high stress events

High temperature, high voltage, and excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Relays and solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe SM is operated within its specified operating parameters. When an SM has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure may be increased.

⚠ WARNING

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.
Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the SMs, refer to "Fault types, causes, and corrective measures" (Page 110).

At reintegration, the following occurs:

- For a fail-safe DI SM, the process values pending at the fail-safe inputs are provided for the safety program.
- For a fail-safe DQ SM, the output values provided in the safety program are again transferred to the fail-safe outputs.

Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O is not being diagnosed, and is subject to dangerous failure without warning.

If any channel passivation persists for 100 hours, the entire module is passivated and can only be recovered through power cycle.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe SM cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

Do not depend on deactivation or unconfiguration to maintain safe state in any circumstances.

Additional information on passivation and reintegration

For further information about fail-safe SM access, refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

6.2 Fault diagnostics

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe SM, communication with the CPU, or external circuits. Diagnostic information is assigned either to a single channel or to the entire fail-safe SM.

Most diagnostics operate without user selection. You can configure the following diagnostic options:

- Short-circuit testing using the digital input sensor supply can be enabled. The interval and duration of short-circuit tests is configurable.
- The read-back times for 24 V DC digital outputs is configurable.
- The time-out intervals for failures in the safety communication or failure of a safety program to run is configurable.

  Refer to "Fail-Safe signal module (SM) I/O configuration" (Page 94) for a complete description of these options.

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These reports are offered as maintenance and debugging aids, but must be observed and interpreted with caution.

In the presence of single faults, any or all LED indications can be wrong. You should not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages may fail to be delivered, or the numerical event ID or text message can be wrong. You should not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

⚠ WARNING

Diagnostic and status reports through LEDs and text messages are subject to single point failure errors.

Reliance on such reported information to determine that a system or I/O point is in a safely controlled state can result in death, severe personal injury, or property damage.

If the integrity of your fail-safe system is in doubt, you should use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.

6.2.1 Diagnostics performed at start-up

Each fail-safe SM executes self-diagnostics at power-up to assure that the electronics and software meet testable expectations before allowing the SM to participate in process control. If tests are not successful, the SM passivates individual channels or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

The SM 1226 F-DQ 4 x 24 VDC executes tests of the P and M switches as defined by your configured parameters for "Maximum readback time" and "Maximum readback time switch on test" after receiving configuration parameters from the fail-safe CPU at power-up. P and M switch ON tests are sequenced so that normally or in the presence of a single detected fault there is no complete PM circuit to energize the load.

The SM 1226 F-DI 16 x 24 VDC executes tests of the sensor supply at power up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the F-DI also executes a short-circuit test according to your configured parameters after receiving the parameters from the fail-safe CPU at power-up.

The SM 1226 F-DQ 2 x Relay executes tests of the relay coil control and the sense contact read circuit, but limits ON time of relay coil test pulses to much less than the normal pull-in time of the relay. In the absence of faults, the test does not close contacts of any relay. Relay coil tests are sequenced so that in the presence of a single detected fault no more than one of two series relay contacts closes and there is no energy supplied to the load.

6.2.2 Diagnostics by LED display

The fail-safe SMs have the following types of LEDs:

- **Module DIAG LED:**
  - Dual color (green / red) LED indicates the operating state and fault status of the module.
  - Only a single DIAG LED on each fail-safe SM
  - The DIAG LED is green ON if no fault is present and the fail-safe SM is configured.
  - The DIAG LED is flashing green if no fault is present and the fail-safe SM is not configured.
  - The DIAG LED is flashing red as soon as a diagnostic function is triggered by the fail-safe SM.
  - The DIAG LED alternates between flashing red and green when a reintegratable module fault has been cleared, but not yet acknowledged.
  - The DIAG LED continues to flash red when a reintegratable channel fault has been cleared, but not yet acknowledged.
  - The DIAG LED is green ON when all faults have been eliminated and acknowledged.
- **Input/Output Status LED**:
  - Green LED for each input shows the input/output state during normal operation**.**
- **Input/Output Fault LED**:
  - Red LED for each input/output indicates a channel error. If any channel error is present, the DIAG LED is flashing red.
  - The input/output LEDs alternate between flashing red and green when a reintegratable channel fault has been cleared, but not yet acknowledged.

SM 1226 F-DI 16 x 24 V DC

Table 1-22 Module DIAG and 1oo1 input channel LEDs

Description	DIAG LED	Input	
		Fault LED	Status LED
LED color	Green / red	Red	Green
I/O bus power off	○ Off	○ Off	○ Off
Module hardware fault [1]	✶ Flashing red	● On	○ Off
PROFIsafe error	✶ Flashing red	Unaffected	Unaffected
Inconsistent firmware versions between Bus-ASIC and F-µCs	✶ Flashing red	✶ Flashing	○ Off
24 V DC module supply voltage off	✶ Flashing red	○ Off	○ Off
24 V DC module supply voltage too high / too low	✶ Flashing red	● On	○ Off
Sensor supply fault: For inputs affected by the fault	✶ Flashing red	● On	○ Off
Sensor supply fault: For inputs not affected by the fault	✶ Flashing red	Unaffected	○ Input state 0
			● Input state 1
Module successfully configured; no errors	● On green	○ Off	○ Input state 0
			● Input state 1
Not configured	✶ Flashing green	○ Off	○ Input state 0
			● Input state 1
Channel deactivated	● On green	○ Off	○ Input state 0
			● Input state 1
Channel fault; passivated	✶ Flashing red	● On	○ Off
Awaiting reintegration, module fault	✶ / ✶[2] Flashing red and green	✶ / ✶[3] Flashing	
Awaiting reintegration, channel fault	✶ Flashing red	✶ / ✶[3] Flashing	
Firmware update in progress	✶ Flashing green	○ Off	○ Off

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 All channels passivated indicates a module-wide fault occurred. This could be an external condition such as supply voltage low or a detected internal module defect.

2 A single, dual color (green / red) flashing LED

3 Alternating flashing of the separate fault (red) and status (green) LEDs

Table 1-23 Module DIAG and 1oo2 input channel LEDs

Description	DIAG LED	Primary input		Secondary input	
		Fault LED	Status LED	Fault LED	Status LED
LED color	**Green / red**	**Red**	**Green**	**Red**	**Green**
Input state 0 (equivalent)	On green	Off	Off	Off	Off
Input state 1 (equivalent)			On		On
Input state 0 (non-equivalent)			Off		On
Input state 1 (non-equivalent)			On		Off
Discrepancy error	Flashing red	On	Off	On	Off
Discrepancy error resolved; awaiting reintegration	Flashing red	Flashing [1]		Flashing [1]	

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 Alternating flashing of the separate fault (red) and status (green) LEDs

SM 1226 F-DQ 4 x 24 V DC

Table 1-24 Module DIAG and output channel LEDs

Description	DIAG LED	Output	
		Fault LED	Status LED
LED color	**Green / red**	**Red**	**Green**
I/O bus power off	Off	Off	Off
Module hardware fault [1]	Flashing red	On	Off
PROFIsafe error	Flashing red	Unaffected	Off
Inconsistent firmware versions between Bus-ASIC and F-µCs	Flashing red	Flashing	Off
24 V DC module supply voltage off	Flashing red	Off	Off
24 V DC module supply voltage too high / too low	Flashing red	On	Off
Module successfully configured; no errors	On green	Off	Output state 0

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 All channels passivated indicates a module-wide fault occurred. This could be an external condition such as supply voltage low or a detected internal module defect.

2 A single, dual color (green / red) flashing LED

3 Alternating flashing of the separate fault (red) and status (green) LEDs

Description	DIAG LED	Output	
		Fault LED	Status LED
LED color	**Green / red**	**Red**	**Green**
Module successfully configured; no errors	On green	Off	Output state 1
Not configured	Flashing green	Off	Off
Channel deactivated	On green	Off	Off
Channel fault; passivated	Flashing red	On	Off
Awaiting reintegration, module fault	Flashing red and green[2]	Flashing[3]	
Awaiting reintegration, channel fault	Flashing red	Flashing[3]	
Firmware update in progress	Flashing green	Off	Off

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 All channels passivated indicates a module-wide fault occurred. This could be an external condition such as supply voltage low or a detected internal module defect.

2 A single, dual color (green / red) flashing LED

3 Alternating flashing of the separate fault (red) and status (green) LEDs

SM 1226 F-DQ 2 x Relay

Table 1-25 Module and output channel LEDs

Description	DIAG LED	Output	
		Fault LED	Status LED
LED color	**Green / red**	**Red**	**Green**
I/O bus power off	Off	Off	Off
Module hardware fault [1]	Flashing red	On	Off
PROFIsafe error	Flashing red	Unaffected	Off
Inconsistent firmware versions between Bus-ASIC and F-µCs	Flashing red	Flashing	Off
24 V DC module supply voltage off	Flashing red	Off	Off
24 V DC module supply voltage too high / too low	Flashing red	On	Off

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 All channels passivated indicates a module-wide fault occurred. This could be an external condition such as supply voltage low or a detected internal module defect.

2 A single, dual color (green / red) flashing LED

3 Alternating flashing of the separate fault (red) and status (green) LEDs

Description	DIAG LED	Output	
		Fault LED	Status LED
LED color	**Green / red**	**Red**	**Green**
Module successfully configured; no errors	On green	Off	Output state 0
			Output state 1
Not configured	Flashing green	Off	Off
Channel deactivated	On green	Off	Off
Channel fault; passivated	Flashing red	On	Off
Awaiting reintegration, module fault	Flashing red and green [2]	Flashing [3]	
Awaiting reintegration, channel fault	Flashing red	Flashing [3]	
Firmware update in progress	Flashing green	Off	Off

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 All channels passivated indicates a module-wide fault occurred. This could be an external condition such as supply voltage low or a detected internal module defect.

2 A single, dual color (green / red) flashing LED

3 Alternating flashing of the separate fault (red) and status (green) LEDs

6.2.3 Fault types, causes, and corrective measures

The "Fault types, causes, and corrective measures" table below lists the messages of the S7-1200 fail-safe SMs. These messages are displayed in the TIA Portal under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight an individual text line in the diagnostic buffer, the Event ID for that text item is displayed, along with module identity and location that generated the message. You may need to expand the window to see all information.

Table 1-26 Fault types, causes, and corrective measures

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
0x0001	Short-circuit	SM 1226 F-DQ 4 x 24 V DC	A channel problem has been detected where either the P terminal or M terminal is at an unexpected potential.	Short-circuit of the output	Eliminate the short-circuit.
				Short-circuit between channels with different signals	Eliminate the short-circuit.

1 Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

2 Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
0x0001	Short-circuit	SM 1226 F-DQ 4 x 24 V DC	A channel problem has been detected where either the P terminal or M terminal is at an unexpected potential.	Output overload	Eliminate the overload.
				"Maximum readback time switch on test" value is configured too small	Increase "Maximum readback time switch on test" if permissible.
				Short-circuit of output to M	Eliminate the short-circuit.
				Defective output driver	Replace the fail-safe signal module (SM).
0x0005	Overtemperature	All	• Overtemperature at microcomputer • Overtemperature at I/O	Shutdown due to violation of high temperature limit value in the module case	Check the ambient temperature. Once the fault has been eliminated, the power must be switched off and on.
0x004D	PROFIsafe communication error (CRC)	All	Transmission error in data message frame: Data inconsistent (CRC (cyclic redundancy check) error)	Communication interference between the fail-safe CPU and the fail-safe signal module (SM) (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)	• Check the communications connection. • Eliminate the interference.
0x004E	PROFIsafe communication failure (timeout)	All	Monitoring time exceeded for data message frame (timeout)	F-monitoring time exceeded	• Adjust F-monitoring time. • Check Safety program and all other CPU activities for excessive execution or demands: – Interrupts – Ethernet communication – OB scheduling conflicts – Long program paths.
0x0100	Module is defective	All	Internal error	Fail-Safe SM is defective.	Replace the fail-safe SM. [2]
0x0103	Watchdog tripped	All	The watchdog timer in the SM communications processor timed out.	Fail-Safe SM is defective.	Replace the fail-safe SM.
0x0105	Short-circuit to L+	SM 1226 F-DQ 4	The fail-safe SM	Short-circuit to L+	Eliminate the short-circuit.

[1] Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

[2] Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
	Short-circuit to L+	x 24 V DC	detects a channel problem where the P-terminal is unexpectedly at L+ potential.	Short-circuit between channels with different signals	Eliminate the short-circuit.
				Defective output driver	Replace the fail-safe SM.
				"Maximum readback time" value is configured too small.	Increase readback time.
0x0106	Short-circuit to ground	SM 1226 F-DQ 4 x 24 V DC	The fail-safe SM detects a channel problem where the M-switch output terminal is unexpectedly at M potential.	Short-circuit of output to M, ground, or another channel.	Eliminate the short-circuit.
				Defective output driver	Replace the fail-safe SM.
				"Maximum readback time" value is configured too small.	Increase readback time.
0x0300	Discrepancy failure, channel state 0/0	SM 1226 F-DI 16 x 24 V DC	External discrepancy failure: Channel state 0/0 with 1oo2 non-equivalent configuration	• Process signal faulty, sensor may be defective. • Configured discrepancy time too short • Short-circuit • Sensor mechanical activation or alignment out of tolerance	• Check process signal, replace sensor if necessary. • Check the configured discrepancy time. • Check the wiring. • Check that both sensors are mounted and aligned to be activated together.
0x0301	Discrepancy failure, channel state 0/1	SM 1226 F-DI 16 x 24 V DC	External discrepancy failure: Channel state 0/1 with 1oo2 equivalent configuration		
0x0302	Discrepancy failure, channel state 1/0	SM 1226 F-DI 16 x 24 V DC	External discrepancy failure: Channel state 1/0 with 1oo2 equivalent configuration		
0x0303	Discrepancy failure, channel state 1/1	SM 1226 F-DI 16 x 24 V DC	External discrepancy failure: Channel state 1/1 with 1oo2 non-equivalent configuration		
0x0306	Internal sensor supply short-circuit to P	SM 1226 F-DI 16 x 24 V DC	SM provided sensor supply voltage shorted to P	Sensor supply shorted to P	• Eliminate the short-circuit. • Once the fault is eliminated, the power must be switched off and on.

[1] Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

[2] Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
0x0306	Internal sensor supply short-circuit to P	SM 1226 F-DI 16 x 24 V DC	SM provided sensor supply voltage shorted to P	Short-circuit test duration configured too short	Increase short-circuit test duration.
				Failed sensor supply	Replace the fail-safe SM.
0x0307	Overload or internal sensor supply shorted to ground	SM 1226 F-DI 16 x 24 V DC	Internal sensor supply voltage shorted to M, ground, or excessive load on sensor supply	Short-circuit	• Eliminate the short-circuit. • Once the fault has been eliminated, the power must be switched off and on.
				Excessive load on sensor supply	Reduce load on sensor supply.
				Failed sensor supply	Replace the fail-safe SM.
0x030B	Channel failure acknowledgement	All	Channel configured for manual acknowledgement is ready to reintegrate	Manual acknowledgement required	Manually acknowledge correction of channel fault so that reintegration can occur.
0x0311	Frequency too high	SM 1226 F-DQ 4 x 24 V DC SM 1226 F-DQ 2 x Relay	Switching frequency exceeded; readback not in time	Process value from safety program changing too rapidly for SM to follow	• Change Safety program logic to guarantee more time between output changes.
0x0312	Undertemperature	All	• Undertemperature at microcomputers • Undertemperature at I/O	Shutdown due to violation of low temperature limit value in the SM case	• Check the ambient temperature. • Once the fault has been eliminated, the power must be switched off and on.
0x0313	Failure in the input circuit	SM 1226 F-DI 16 x 24 V DC	Internal fault at the read circuit/test circuit	The input SM detects a failure during bit pattern testing of inputs. EMI or SM hardware fault.	• If intermittant, probably due to interference. Eliminate interference. • If persistent, or repeats after efforts to eliminate interference, replace the fail-safe SM.
0x0316	Relay cannot be turned on	SM 1226 F-DQ 2 x Relay	Relay activated, but remains deactivated	Relay is faulty. SM supply voltage too low.	• Check for supply voltage warning messages and supply voltage. • Replace the fail-safe SM.

1 Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

2 Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
0x0317	Relay cannot be turned off (contacts welded)	SM 1226 F-DQ 2 x Relay	Relay deactivated, but remains activated (Relay contact is welded)	Relay is faulty, due to normal wear, excessive load, or unsuppressed inductive load.	• Replace the fail-safe SM. • Check that load current, including inrush, is within specifications. • Check for adequate inductive load suppression and capacitive load inrush limiting. • Check for circuit faults creating excessive load.
0x031C	Input shorted to P	SM 1226 F-DI 16 x 24 V DC	Input shorted to P failure	External wiring or sensor shorts input signal to L+.	Check/correct external short-circuit.
				Input configured for short-circuit detection but wired to external L+	Make wiring and configuration agree.
				Input defective	Replace the fail-safe SM.
0x031D	Output defective	SM 1226 F-DQ 2 x Relay	Relay coil driver defective	Relay or relay driver faulty	Replace the fail-safe SM.
0x031E	Read back failure	SM 1226 F-DQ 4 x 24 V DC	The SM has detected a channel problem where the expected terminal voltage(s) are not reached.	"Maximum readback time" or "Maximum readback time switch on test" configured value is too small.	Increase readback time.
				Output switch failure	Replace the fail-safe SM if output does not respond.
		SM 1226 F-DQ 2 x Relay	Relay state does not agree with commanded value.	Relay faulty	Replace the fail-safe SM.
0x0320	Overload	SM 1226 F-DQ 4 x 24 V DC	Over load condition at the output driver that leads to passivation of the channel	Over load at output	Eliminate over load.

[1] Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

[2] Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Event ID	Diagnostic message	Fail-safe signal module	Description	Possible causes	Corrective measures [1]
0x0321	Supply voltage too high	All	Supply voltage maximum exceeded.	Supply voltage is set too high.	Adjust supply voltage.
0x0322	Supply voltage too low	All	Supply voltage minimum exceeded.	Supply voltage is set too low.	Adjust supply voltage.
0x032C	Failsafe error (0x032C)	SM 1226 F-DQ 2 x Relay	Maximum relay switch on time exceeded.	Safety program did not switch the relay within the configured "Relay continuous on time limit".	• Include in the safety program and process operations an opportunity to turn the relay "OFF" briefly, to allow the module to confirm that the relay is still under control. • Increase the "Relay continuous on time limit'. This value cannot exceed 30 days for SIL 3 applications.

1 Once the fault is eliminated, the fail-safe signal module must be reintegrated (returned to normal state) from passivation into the safety program.

2 Repeated external error conditions coming and going more rapidly than the system can process can lead to a module fatal error and a reported Event ID: 0x0100. One example is a rapidly changing 1oo2 input signal with repeated discrepancy errors. If the F-DI detects and reports errors coming and going more rapidly than the fail-safe CPU can process, the F-DI enters a fatal error state rather than continue to operate with unreported errors. Event ID: 0x0100 should be interpreted in view of other diagnostic reports which may suggest other corrective actions, including parameter adjustments, correction of external control system faults (within 100 hours), and suppression of electromagnetic interference. You must perform a power cycle of the module to recover from a fatal error as reported by Event ID: 0x0100 and some other Event IDs. Diagnostics performed at start-up provide a high level of assurance that any sustained fault is recognized again before process control is resumed.

Electromagnetic interference and diagnostic reports

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not apparently relate to an identifiable device failure, wiring problem, programming or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load in-rush currents.

Technical specifications

A

A.1 General technical specifications

A.1.1 Standards compliance

The S7-1200 Fail-Safe automation system design conforms to the following standards and test specifications. The test criteria for the S7-1200 automation system are based on these standards and test specifications.

Not all S7-1200 models may be certified to these standards, and certification status may change without notification. It is the user's responsibility to determine applicable certifications by referring to the ratings marked on the product. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

Siemens products will generally be in accordance with the latest released standards as of the time of product release. For European Norm (EN) standards, the effective version will be in accordance with listings in the official journal of the European Union. Product certifications including the CE declaration of conformity and certificates from listing agencies cite the exact standards applicable to each certification.

A.1.2 Fail-Safe standards and approvals

All S7-1200 fail-safe CPUs and fail-safe signal modules (SM) are certified by TÜV. The fail-safe CPUs and signal modules are certified to the IEC 61508, EN ISO 13849, and IEC 62061 standards and guidelines for functional safety. For further information, refer to the current Annex 1 of the report for the TÜV certifificate from the Internet.

See also

TÜV certificates (http://support.automation.siemens.com/WW/view/en/49368678/134200)

A.1.3 PROFIsafe compatibility

- PROFIsafe address type 2
- Supports the RIOforFA-Safety profile

A.1.4 Standards and approvals

A.1.4.1 General certifications

CE approval

The S7-1200 Automation System satisfies requirements and safety related objectives according to the EC directives listed below, and conforms to the harmonized European standards (EN) for the programmable controllers listed in the Official Journals of the European Union.

- 2014/35/EU "Electrical equipment designed for use within certain voltage limits" (Low-Voltage Directive)
- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
- 2006/42/EC "Machinery Directive" for S7-1200 safety components (fail-safe modules)

NOTE

Not all S7-1200 products are suitable for potentially explosive atmosphere locations. Only S7-1200 products that are marked with the ATEX symbol are suitable for ATEX classified hazardous locations as marked.

EU declarations of conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
P.O. Box 1963
D-92209 Amberg

The EU declarations of conformity are also available for download from the Siemens Industry Online Support website, under the keyword "Declaration of Conformity".

UK Conformity Assessed marking

The S7-1200 automation system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The S7-1200 automation system meets the requirements and protection targets of the following regulations and related amendments:

- Electrical Equipment (Safety) Regulations 2016 (Low-Voltage)
- Electromagnetic Compatibility Regulations 2016 (EMC)
- Equipment and Protective Systems Intended for use in Potentially Explosive Atmospheres Regulations 2016 (Explosion Protection)
- Regulations on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2012 (RoHS).
- Supply of Machinery (Safety) Regulations 2008 for S7-1200 safety components (fail-safe modules)

UK Declarations of Conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
P.O. Box 1963
D-92209 Amberg

The UK Declaration of Conformity is also available for download from the Siemens Industry Online Support website under the keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc. complying with:

- Underwriters Laboratories, Inc.: UL 508 Listed (Industrial Control Equipment)
- Canadian Standards Association: CSA C22.2 Number 142 (Process Control Equipment)

NOTE

The SIMATIC S7-1200 series meets the CSA standard.
The cULus logo indicates that the S7-1200 has been examined and certified by Underwriters Laboratories (UL) to standards UL 508 and CSA 22.2 No. 142.

cULus HAZ. LOC. approval

Underwriters Laboratories Inc. in accordance with:

- UL 508 (Industrial Control Equipment)
- CANCSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CAN/CSA C22.2 No. 213 (Hazardous Location) APPROVED for use in Class I, Division 2, Group A, B, C, D T3C; Class I, Zone 2, Group IIC T3 Installation Instructions for cULus haz.loc.
- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.

- WARNING – Explosion Hazard – Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

IMPORTANT EXCEPTION: See Technical Specifications for the number of inputs or outputs allowed on simultaneously. Some models are de-rated for Ta = 55 °C.

FM approval



FM Approvals
Approval Standard Class Number 3600, 3611 (ANSI/UL 121201), 3810 (ANSI/UL 61010-1), CSA Standard C22.2 No. 0-10, C22.2 No. 213, C22.2 No. 61010-1
Approved for use in:
Class I, Division 2, Group A, B, C, D, Temperature Class T3C Ta = 55 °C [CA, US]
Class I, Zone 2, Group IIC, Temperature Class T3 Ta = 55 °C [US]
Canadian Class I, Zone 2 Installation per CEC 18-150 [CA]

⚠ WARNING

Substitution of components may impair the suitability for Class I, Division 2 and Zone 2.
Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.
Repair of units should only be performed by an authorized Siemens Service Center.

ATEX approval



According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T3 Gc

UL 21 ATEX 2622X

Special conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with EN IEC 60079-7.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

IECEx approval



According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T3 Gc

IECEx UL 21.0107X

Specific conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in IEC 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with IEC 60079-7.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

UKEX approval



According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T3 Gc

UL 21UKEX2277X

Specific conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with EN 60079-7.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

CCCEx approval



According to GB 3836.3 (Explosive atmosphere - Part 3: Equipment protection by ignition protection type "e")

GB 3836.1 (Explosive atmosphere - Part 1: Equipment - General requirements)

Ex ec IIC T3 Gc

Specific conditions of safety use:

- The equipment shall only be used in an area of not more than polution degree 2, as defined in GB/T 16935.1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with GB 3836.3.
- Transient protection shall be provided that is set at a level not exceeding 140 % of the peak rated voltage value at the supply terminals to the equipment.

Australia and New Zealand - RCM Mark (Regulatory Compliance Mark)



The S7-1200 automation system satisfies requirements of standards to AS/NZS 61000.6.4 and IEC 61000-6-4 (Class A).

Korea Certification



The S7-1200 automation system satisfies the requirements of the Korean Certification (KC Mark). It has been defined as Class A Equipment and is intended for industrial applications and has not been considered for home use.

Eurasian Customs Union approval (Belarus, Kazakhstan, Russian Federation)



EAC (Eurasion Conformity): Declaration of Conformity according to Technical Regulation of Customs Union (TR CU)

Maritime approval

The S7-1200 products are periodically submitted for special agency approvals related to specific markets and applications. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

Classification societies:

- American Bureau of Shipping (ABS): U.S.A.
- Bureau Veritas (BV): France
- Det Norske Veritas (DNV): Norway
- Germanischer Lloyd (GL): German
- Lloyds Register of Shipping (LRS): England
- Nippon Kaiji Kyokai (Class NK): Japan
- Korean Register of Shipping (KR): Korea
- China Classification Society (CCS): China

See also

Safe functional extra low voltage requirement (power supplies and other system components) (Page 81)

A.1.4.2 Industrial environments

The S7-1200 automation system is designed for use in industrial environments.

Table 1-27 Industrial environments

Application field	Emission requirements	Immunity requirements
Industrial	EN 61000-6-4	EN 61000-6-2

A.1.5 Electromagnetic compatibility

Electromagnetic Compatibility (EMC) is the ability of an electrical device to operate as intended in an electromagnetic environment and to operate without emitting levels of electromagnetic interference (EMI) that may disturb other electrical devices in the vicinity.

For safety related functions, additional EMC requirements are applied according to IEC 61326-3-1 and IEC 61326-3-2.

Table 1-28 Immunity per EN 61000-6-2

Electromagnetic compatibility - Immunity per EN 61000-6-2	
EN 61000-4-2 Electrostatic discharge	8 kV air discharge to all surfaces 6 kV contact discharge to exposed conductive surfaces
EN 61000-4-3 Radiated, radio-frequency, electro-magnetic field immunity test	80 to 1000 MHz, 10 V/m, 80% AM at 1 kHz 1.4 to 6.0 GHz, 3 V/m, 80% AM at 1 kHz
EN 61000-4-4 Fast transient bursts	2 kV, 5 kHz with coupling network to AC and DC system power 2 kV, 5 kHz with coupling clamp to I/O
EN 61000-4-5 Surge immunity	AC systems - 2 kV common mode, 1kV differential mode DC systems - 2 kV common mode, 1kV differential mode For DC systems (I/O signals, DC power systems) external protection is required. Refer to "Safe functional extra low voltage requirement (power supplies and other system components)" (Page 81), "Surge immunity" for the recommended protection devices.
EN 61000-4-6 Conducted disturbances	150 kHz to 80 MHz, 10 V RMS, 80% AM at 1kHz
EN 61000-4-11 Voltage dips	AC systems 0% for 1 cycle, 40% for 12 cycles and 70% for 30 cycles at 60 Hz

Table 1-29 Conducted and radiated emissions per EN 61000-6-4

Electromagnetic compatibility - Conducted and radiated emissions per EN 61000-6-4		
Conducted Emissions EN 55016, Class A, Group 1	0.15 MHz to 0.5 MHz	< 79dB (µV) quasi-peak; <66 dB (µV) average
	0.5 MHz to 5 MHz	< 73dB (µV) quasi-peak; <60 dB (µV) average
	5 MHz to 30 MHz	< 73dB (µV) quasi-peak; <60 dB (µV) average
Radiated Emissions EN 55016, Class A, Group 1	30 MHz to 230 MHz	< 40dB (µV/m) quasi-peak; measured at 10 m
	230 MHz to 1 GHz	< 47dB (µV/m) quasi-peak; measured at 10 m
	1 GHz to 3 GHz	< 76dB (uV/m) quasi peak, measured at 10 m

A.1.5.1 Surge immunity

Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. One specification for evaluation of protection from lightning type surges is found in EN 61000-4-5, with operational limits established by EN 61000-6-2. S7-1200 DC CPUs and signal modules require external protection to maintain safe operation when subject to surge voltages defined by this standard.

Listed below are some devices that support the needed surge immunity protection. These devices only provide the protection if they are properly installed according to the manufacturer's recommendations. Devices manufactured by other vendors with the same or better specifications can also be used:

Table 1-30 Devices that support surge immunity protection

Sub-system	Protection device
+24 V DC power	BLITZDUCTOR VT, BVT AVD 24, Part Number 918 422
Industrial Ethernet	DEHNpatch DPA M CLE RJ45B 48, Part Number 929 121
+24 V DC digital inputs	DEHN, Inc., Type DCO SD2 E 24, Part Number 917 988
+24 V DC digital outputs and sensor supply	DEHN, Inc., Type DCO SD2 E 24, Part Number 917 988
Analog IO	DEHN, Inc., Type DCO SD2 E 12, Part Number 917 987
Relay outputs	None required
L - N	DEHNguard® DG M TNS 275 (952 400) DEHNguard® DG MOD 320 (952 013)

A.1.6 Transport and storage conditions

Table 1-31 Transport and storage

Environmental conditions - Transport and storage	
EN 60068-2-2, Test Bb, Dry heat and EN 60068-2-1, Test Ab, Cold	-40 °C to +70 °C
EN 60068-2-30, Test Db, Damp heat	25 °C to 55 °C, 95% humidity
EN 60068-2-14, Test Na, temperature shock	-40 °C to +70 °C, dwell time 3 hours, 5 cycles
EN 60068-2-32, Free fall	0.3 m, 5 times, product packaging
Atmospheric pressure	1140 hPa to 660 hPa (corresponding to an altitude of -1000 m to 3500 m)

A.1.7 Mechanical and climatic ambient conditions

A.1.7.1 Environmental conditions

Table 1-32 Operating conditions

Environmental conditions - Operating	
Ambient temperature range (Inlet Air 25 mm below unit)	0 °C to 55 °C horizontal mounting 0 °C to 45 °C vertical mounting 95% non-condensing humidity
Atmospheric pressure	1140 hPa to 795 hPa (corresponding to an altitude of -1000 m to 2000 m)
Concentration of contaminants	SO_2: < 0.5 ppm; H_2S: < 0.1 ppm; RH < 60% non-condensing
EN 60068-2-14, Test Nb, temperature change	5 °C to 55 °C, 3 K/minute
EN 60068-2-27 Mechanical shock	15 g, 11 ms pulse, 6 shocks in each of 3 axis
EN 60068-2-6 Sinusoidal vibration	DIN rail mount: 3.5 mm from 5 to 8.4 Hz, 1 G from 8.4 to 150 Hz Panel Mount: 7.0 mm from 5 to 8.4 Hz, 2 G from 8.4 to 150 Hz 10 sweeps each axis, 1 octave per minute

A.1.8 Information on protection class, degree of protection, and rated voltages

A.1.8.1 Contamination level and overvoltage category in accordance with IEC 61131-2

The following levels are provided:

- Pollution degree 2
- Overvoltage category: II, unless otherwise noted (See also the Overvoltage Category III section.)

A.1.8.2 Protection class in accordance with EN 61131-2

Protection Class II is provided according to EN 61131-2:

- S7-1200 is open equipment and must be enclosed in additional protection as described in Section 4.1.2: "Guidelines for installing S7-1200 Fail-Safe devices" (Page 74).
- S7-1200 systems including AC power supply or relays which can be connected to AC voltage achieve Class II when installed in a suitable enclosure.
- S7-1200 systems including only connections to SELV / PELV achieve Class III when installed in a suitable enclosure.
- The S7-1200 does not require a protective earth connection. A functional earth connection is provided and is used for non-safety purposes such as interference immunity improvement.

A.1.8.3 Degree of protection IP20

The degree of protection IP20 in accordance with IEC 60529 is provided for all modules of the S7-1200 automation system:

- Protection against contact with standard test finger
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

A.1.8.4 Rated voltages

Rated voltage	Tolerance	Notes
24 V DC	20.4 V DC to 28.8 V DC	Refer to "Safe functional extra low voltage requirement (power supplies and other system components)" (Page 81) for additional requirements of a 24 V DC power source.

When you suddenly apply 24 V DC power to the S7-1200 CPU or digital I/O signal modules (SM), including fail-safe SM, short-term current flows can occur which briefly mimic the effect of "1" signals at process outputs and inputs. Digital outputs can trigger to ON state for approximately 50 microseconds at power application. The SMs deliberately test functional safety P- and M-switch outputs ON at different times for up to the user-configurable "Maximum readback time switch on test" (500 microseconds to 5 ms) during the power up sequence and as a cyclic bit-pattern test. This test pulse can energize the load in the presence of a switch or wiring fault on the opposite side of the load circuit. Such short pulses are typically not a hazard for electromechanical loads, but you must consider the effect. High-speed electronic receiver circuits can detect short pulses and improperly interpret the short pulses as deliberate "1" signals.

⚠ WARNING

Short term current and voltage pulses can occur on 24 V DC I/O circuits near the time that power is applied.

Such short term pulses can cause unexpected activation or position changes in machinery, resulting in death or serious injury to personnel and/or property damage.

If your installation includes receivers which can be responsive to short pulses as described above, you should apply measures such as power sequencing or progressive removal of safety lockouts to assure that unexpected machine operations do not occur.

A.1.9 Reverse voltage protection

Reverse voltage protection circuitry is provided on each terminal pair of +24 V DC power or user input power for CPUs, signal modules (SM), and signal boards (SB). It is still possible to damage the system by wiring different terminal pairs in opposite polarities.

Some of the 24 V DC power input ports in the S7-1200 system are interconnected, with a common logic circuit connecting multiple M terminals. For example, the following circuits are interconnected when designated as "not isolated" in the data sheets: the 24 V DC power supply of the CPU, the power input for the relay coil of an SM, or the power supply for a non-isolated analog input. All non-isolated M terminals must connect to the same external reference potential.

⚠ WARNING

Connecting non-isolated M terminals to different reference potentials will cause unintended current flows that may cause damage or unpredictable operation in the PLC and any connected equipment.

Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.

Always ensure that all non-isolated M terminals in an S7-1200 system are connected to the same reference potential.

A.1.10 DC outputs

Short-circuit protection circuitry is not provided for DC outputs on CPUs, signal modules (SM) and signal boards (SB).

A.1.11 Relay electrical service life

The typical performance data estimated from sample tests is shown below. Actual performance may vary depending upon your specific application. An external protection circuit that is adapted to the load will enhance the service life of the contacts. N.C. contacts have a typical service life of about one-third that of the N.O. contact under inductive and lamp load conditions.

An external protective circuit will increase the service life of the contacts.

Table 1-33 Typical performance data

Data for selecting an actuator				
Continuous thermal current		2 A max.		
Switching capacity and life of the contacts				
	For ohmic load	Voltage	Current	Number of operating cycles (typical)
		24 V DC	2.0 A	0.1 million
		24 V DC	1.0 A	0.2 million
		24 V DC	0.5 A	1.0 million
		48 V AC	1.5 A	1.5 million
		60 V AC	1.5 A	1.5 million
		120 V AC	2.0 A	1.0 million
		120 V AC	1.0 A	1.5 million

Data for selecting an actuator				
	For ohmic load	120 V AC	0.5 A	2.0 million
		230 V AC	2.0 A	1.0 million
		230 V AC	1.0 A	1.5 million
		230 V AC	0.5 A	2.0 million
	For inductive load (according to IEC 947-5-1 DC13/AC15)	Voltage	Current	Number of operating cycles (typical)
		24 V DC	2.0 A	0.05 million
		24 V DC	1.0 A	0.1 million
		24 V DC	0.5 A	0.5 million
		24 V AC	1.5 A	1.0 million
		48 V AC	1.5 A	1.0 million
		60 V AC	1.5 A	1.0 million
		120 V AC	2.0 A	0.7 million
		120 V AC	1.0 A	1.0 million
		120 V AC	0.5 A	1.5 million
		230 V AC	2.0 A	0.7 million
		230 V AC	1.0 A	1.0 million
		230 V AC	0.5 A	1.5 million
Activating a digital input		Possible		
Switching frequency				
	Mechanical	Max. 10 Hz		
	At ohmic load	Max. 1 Hz		
	At inductive load (according to IEC 947-5-1 DC13/AC15)	Max. 0.5 Hz		
	At lamp load	Max. 1Hz		

A.1.12 Internal CPU memory retention

- Lifetime of retentive data and data log data: 10 years
- Power down retentive data, Write cycle endurance: 2 million cycles
- Data log data, up to 2 KB per data log entry, Write cycle endurance: 500 million data log entries

NOTE

Effect of data logs on internal CPU memory

Each data log write consumes at a minimum 2 KB of memory. If your program writes small amounts of data frequently, it is consuming at least 2 KB of memory on each write. A better implementation would be to accumulate the small data items in a data block (DB), and to write the data block to the data log at less frequent intervals.

If your program writes many data log entries at a high frequency, consider using a replaceable SD memory card.

A.1.13 Overvoltage Category III

Relay contacts of the SM 1226 F-DQ 2 x Relay are designed to Overvoltage Category III. You can use them in AC mains circuits without further overvoltage protection.

Relay contact outputs and AC inputs for fail-safe S7-1200 CPUs and standard (non fail-safe) I/O modules do not meet requirements regarding Overvoltage Category III, as applicable to EN 50156-1 conforming equipment (burner applications).

When using the SM 1226 F-DQ 2 x Relay in safety critical circuits of burner applications, you can use the relay contact outputs and AC inputs for fail-safe S7-1200 CPUs and standard (non fail-safe) I/O modules, but only if used in one of the following:

- SELV/PELV circuits
- Circuits connected to the electrical mains with permanent, recognized protection that reduces transients to Overvoltage Category II

Otherwise, the CPU and I/O system, including the SM 1226 F-DQ 2 x Relay, will not meet the Overvoltage Category III requirement for burner applications.

⚠ WARNING

Adjacent relay contacts in the same channel of the SM 1226 F-DQ 2 x Relay are not rated to separate AC line from SELV / PELV.
Death or serious personal injury and damage to machines and equipment can result if SELV/PELV circuits are wired adjacent to high voltage circuits on this module.
The A and B circuits of each output must either be both AC line or both SELV.

A.2 Fail-Safe CPU technical specifications

A.2.1 Fail-Safe CPU additions/exceptions

The following sections discuss exceptions and additions for the CPU 1212FC, CPU 1214FC, and CPU 1215FC that differentiates them from the standard CPU 1212C, CPU 1214C, and CPU 1215C.

A.2.1.1 Areas of application

The S7-1200 fail-safe CPUs are intended for applications including Functional Safety requirements. In addition to the safety program, you can also program standard applications.

A.2.1.2 Restrictions with "READ_DBL" and "WRIT_DBL"

If an F-DB is specified as the target address, a READ_DBL instruction execution fails when reading data from load memory into work memory.

If an F-DB is specified as the target address, a WRIT_DBL instruction execution fails when writing data from work memory to load memory.

A.2.1.3 Restrictions to configuring the retentive behavior of data blocks

The configuration of retentive data blocks is not supported for F-DBs.

This means that the current values of the F-DBs will not be retentive in the event of Power OFF/ON and Restart (STOP-RUN) of the fail-safe CPU. The F-DBs are always set to the initial values from the load memory.

In the F-DBs, for all tags the "Retain" check box is grayed out.

A.2.1.4 Probabilities of failure

Probability of failure values are estimated using standard data tables and calculation methods according to international standards, specifically for the purpose of calculating PFD and PFH values according to IEC 61508:2010 and related functional safety standards. The calculations assume products operated within specifications and repair of diagnosed faults within 100 hours:

	Operation in Low Demand Mode, Average probability of a dangerous failure on demand (PFD_avg)	**Operation in High Demand or Continuous Mode, Average frequency of a dangerous failure per hour (PFH)**	**Proof test interval (Mission time or Useful lifetime)**
S7-1200 fail-safe CPUs	< 2.00E-05	< 1.00E-09 1/h	20 years

A.2.1.5 Web server

Start Page

The S7-1200 fail-safe CPUs display the following additional information on the "Start Page" of the web server:

- STEP 7 Safety version: Version of the TIA Portal Safety package used to download the project
- Safety mode (Enabled/Disabled): Indicates whether or not safety mechanisms for fault detection and fault reaction are activated in the project and safety-related communication using safety message frames is allowed
- Collective F-signature: Signature used to determine changes to any safety components in the project
- Last fail-safe modification: Date/time of last change to the safety components in the project

NOTE

The time displayed for "Last fail-safe modification" depends on the time being correctly set in the PLC when you load the program. Note that the time will not be correct in the PLC if you remove power from the PLC for an extended time before the program is loaded. The BB 1297 Battery Board allows a longer power down without loss of correct time.



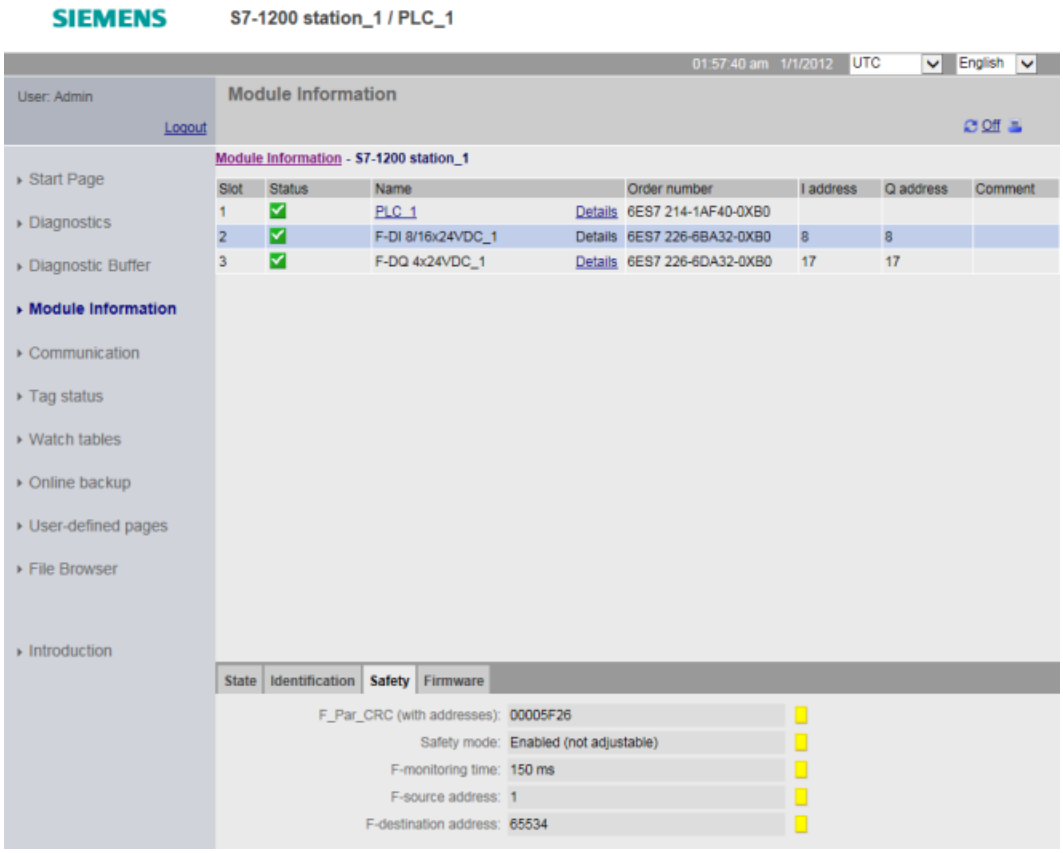
Module Information

Each F-I/O displays the following information on the "Module information" page in the "Safety" tab:

- F_Par_CRC (with addresses) (F-parameter signature): Cyclic redundancy checksum that confirms the integrity of the PROFIsafe message contents and sequence
- Safety mode: All safety mechanisms for fault detection and fault reaction are activated, and safety-related communication using safety message frames is allowed.
- F-monitoring time: The F-monitoring time is the amount of time an SM or CPU waits for a valid current safety message frame before passivating channels.
- F-source address: Unique network-wide address for the fail-safe CPU
- F-destination address: A CPU-wide unique PROFIsafe address for every F-IO used in a safety system

NOTE

If you click an F-I/O module and its "Details" link in the top section, then a "Safety" tab is displayed in the bottom section. In the Safety tab, you can see specific data related to the selected module.



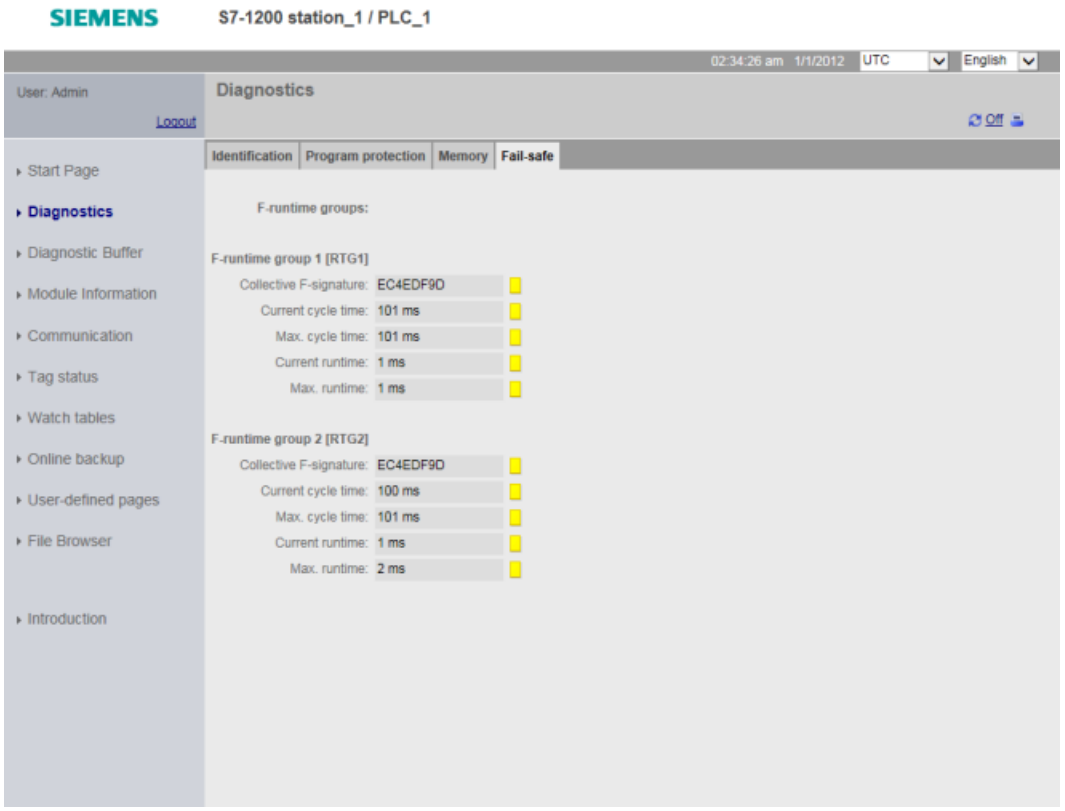
NOTE
You do not have write access to F-blocks.

Diagnostics

F-runtime groups display the following information on the "Diagnostics" page in the "Fail-safe" tab:

- F-runtime group name: Name of group that consists of an F-OB (cycle OB or cyclic interrupt OB) that calls a main safety block (FB or FC). Additional user-specific safety functions must then be called from this main safety block.
- Collective F-signature: Signature used to determine changes to any safety components in the project
- Current cycle time: Time that the CPU requires to complete one PLC scan cycle
- Max. cycle time: Maximum recorded time that the CPU requires to complete one PLC scan cycle
- Current runtime: Time that the CPU requires to execute the user program once; duration of the last scan
- Max. runtime: Maximum recorded time that the CPU requires to execute the user program once

NOTE
If you download a standard program to an S7-1200 fail-safe CPU, the Fail-safe tab (to display runtime groups) is not displayed.



A.2.1.6 Using a memory card with the S7-1200 Fail-Safe CPU

The S7-1200 memory card used as a transfer card is a way to copy a program into the PLC Internal Load Memory (ILM) without a connected TIA Portal. You remove the transfer card after program installation, and subsequent power cycles use the program stored in the ILM.

A memory card used as a program card keeps the PLC program on the card. If you remove the memory card, the ILM is empty, and there is no program in the PLC.

Refer to the "S7-1200 Programmable Controller System Manual" (https://support.industry.siemens.com/cs/ww/en/view/109478121) for general instructions for creating and using transfer cards and memory cards. The S7-1200 fail-safe CPU behavior when using a memory card has some differences from the standard CPU:

- When the S7-1200 fail-safe CPU starts with no memory card and the ILM is empty, the fail-safe CPU's STOP and MAINT LEDs flash for three seconds. Power cycle the CPU. This provides a temporary visual indication that the ILM is empty. The TIA Portal or a memory card must be used to load a user program.
- When the fail-safe CPU starts with a program memory card installed and the ILM is not empty, the fail-safe CPU erases the ILM and then stops, flashing the STOP and MAINT LEDs. This is a visual indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. Continuation and subsequent power cycles load the program from the memory card.
- When the fail-safe CPU starts with an empty memory card installed and the ILM is not empty, the fail-safe CPU copies the program from the ILM to the memory card. The fail-safe CPU then erases the ILM and stops, flashing the STOP and MAINT LEDs. This is an indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. Continuation and subsequent power cycles load the program from the memory card.
- When the fail-safe CPU starts with a transfer memory card installed and the ILM is not empty, the fail-safe CPU erases the ILM and then stops, flashing the STOP and MAINT LEDs. This is a visual indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. Continuation copies the user program from the memory card to the ILM, and then the fail-safe CPU stops, with the STOP LED on and the MAINT LED flashing. At this point, you must remove the transfer memory card and then power cycle or command a memory reset in order to continue. Continuation and subsequent power cycles load the program from the ILM.

Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en), Section 10.4: "Function test of safety program and protection through program identification" for instructions on transferring programs.

⚠ WARNING

Loading an incorrect user program into a fail-safe CPU results in incorrect execution and total or partial loss of the safety function.

Loss of the safety function can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

Follow the instructions as provided in the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* for properly identifying safety programs and controlling how you load programs into a fail-safe CPU.

NOTE

S7-1200 fail-safe CPU successful memory card format

Follow these steps:

1. Insert a memory card into an F-CPU (MAINT LED on F-CPU flashes yellow.)
2. Power cycle the F-CPU. (CPU comes up in STOP mode.)
3. Format the Memory Card from SAT (SAT reports operation completed succesfully. MAINT LED flashes yellow.)
4. Power cycle the F-CPU (CPU flashes RUN/STOP and MAINT yellow continuously. It does NOT stop after three seconds and go to STOP mode.)

A.2.1.7 Backing up and restoring a fail-safe CPU

You have the option of backing up an S7-1200 fail-safe CPU in the same way as a standard S7-1200 CPU. Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) and "S7-1200 Programmable Controller System Manual" (https://support.industry.siemens.com/cs/ww/en/view/109478121) for further information. You can also find information on backing up a CPU in the online help on STEP 7 under "Creating a backup of an S7 CPU".

A.2.1.8 Password for a fail-safe CPU

The password assigned in the fail-safe CPU hardware configuration ("Full access incl. fail-safe (no protection)" must be entered for the fail-safe CPU to perform the following functions:

- Download/delete F-blocks
- Change/delete the password for a fail-safe CPU
- Format the SIMATIC Memory Card in a fail-safe CPU with STEP 7
- Restore the factory settings with STEP 7
- Restore a backup of a fail-safe CPU

NOTE

If neither the safety program nor the fail-safe CPU password is changed by the restore process, you are not prompted for the fail-safe CPU.

A.2.1.9 Configuration control (option handling)

When using fail-safe signal modules (SM) with option handling, configure the fail-safe SMs to reside in the slots closest to the fail-safe CPU. Place all standard SMs after all fail-safe SMs. The Option Handling record must not change the configuration of the fail-safe SMs.

A.2.2 PROFINET interface X1 port pinouts

The S7-1200 fail-safe CPU connects to the PROFINET network using a standard female RJ45 jack. The connector pinout depends on the CPU type.

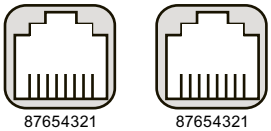
Single-port CPUs

Single-port CPUs (CPU 1212FC and CPU 1214FC) have a standard Ethernet MDI pin configuration as follows:

Pin	Signal name	Description	RJ45 female jack pinout
1	TD+	Transmit data	 X1P1
2	TD-		
3	RD+	Receive data	
4	GND	Ground	
5	GND		
6	RD-	Receive data	
7	GND	Ground	
8	GND		

Dual-port CPUs

The ports of a dual-port CPU (CPU 1215FC) have a standard Ethernet MDI-X pin configuration as follows:

Pin	Signal name	Description	RJ45 female jack pinout
1	RD+	Receive data	 X1P1 X1P2
2	RD-		
3	TD+	Transmit data	
4	GND	Ground	
5	GND		
6	TD-	Transmit data	
7	GND	Ground	
8	GND		

Autonegotiation

If the port's configuration enables autonegotiation, the S7-1200 fail-safe CPU automatically detects the cable type and swaps the transmit/receive lines, if needed. If the port's configuration disables autonegotiation, the CPU also disables this automatic swap. You configure a port's autonegotiation setting in the TIA Portal's port options dialog. This is a port-specific advanced option for the PROFINET interface (X1) of the CPU's properties. Refer to "Configuring the PROFINET port" in Section 11.2.3.4: "Configuring an IP address for a CPU in your project" of the *S7-1200 Programmable Controller System Manual* for further information.

A.2.3 CPU 1212FC

A.2.3.1 General specifications and features

Table 1-34 General

Technical data	CPU 1212FC DC/DC/Relay	CPU 1212FC DC/DC/DC
Article number	6ES7212-1HF40-0XB0	6ES7212-1AF40-0XB0
Dimensions W x H x D (mm)	90 x 100 x 75	
Shipping weight	385 grams	370 grams
Power dissipation	9 W	
Current available (SM and CM bus)	1000 mA max. (5 V DC)	
Current available (24 V DC)	300 mA max. (sensor power)	
Digital input current consumption (24 V DC)	4 mA/input used	

Table 1-35 CPU features

Technical data		Description
User memory (Refer to "General technical specifications (Page 127)", "Internal CPU memory retention".)	Work	150 Kbytes
	Load	2 Mbyte internal, expandable up to SD card size
	Retentive	10 Kbytes
On-board digital I/O		8 inputs/6 outputs
On-board analog I/O		2 inputs
Process image size		1024 bytes of inputs (I)/1024 bytes of outputs (Q)
Bit memory (M)		4096 bytes
Temporary (local) memory		• 16 Kbytes for startup and program cycle (including associated FBs and FCs) • 6 Kbytes for each of the other interrupt priority levels (including FBs and FCs)
Signal modules expansion		2 SMs max.
SB, CB, BB expansion		1 max.
Communication module expansion		3 CMs max.
High-speed counters		Up to 6 configured to use any built-in or SB inputs: (Refer to the *S7-1200 System Manual*. for more information.) • 100/[1]80 kHz (Ia.0 to Ia.5) • 30 /[1]20 kHz (Ia.6 to Ia.7)
Pulse outputs[2]		Up to 4 configured to use any built-in or SB outputs: • 100 kHz (Qa.0 to Qa.3) • 20 kHz (Qa.4 to Qa.5)
Pulse catch inputs		8
Time delay interrupts		4 total with 1 ms resolution
Cyclic interrupts		4 total with 1 ms resolution
Edge interrupts		8 rising and 8 falling (12 and 12 with optional signal board)

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Technical data	Description
Memory card	SIMATIC Memory Card (optional)
Real time clock accuracy	+/- 60 seconds/month
Real time clock retention time	20 days typ./12 days min. at 40 °C (maintenance-free Super Capacitor)

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Table 1-36 Performance

Type of instruction		Execution speed	
		Direct addressing (I, Q and M)	DB accesses
Boolean		0.08 µs/instruction	
Move	Move_Bool	0.3 µs/instruction	1.17 µs/instruction
	Move_Word	0.137 µs/instruction	1.0 µs/instruction
	Move_Real	0.72 µs/instruction	1.0 µs/instruction
Real Math	Add Real	1.48 µs/instruction	1.78 µs/instruction

NOTE
Many variables affect measured times. The above performance times are for the fastest instructions in this category and error-free programs.

A.2.3.2 Timers, counters, and code blocks supported by CPU 1212FC

Table 1-37 Blocks, timers and counters supported by CPU 1212FC

Element		Description
Blocks	Type	OB, FB, FC, DB
	Size	50 Kbytes
	Quantity	Up to 1024 blocks total (OBs + FBs + FCs + DBs)
	Address range for FBs, FCs, and DBs	FB and FC: 1 to 65535 (such as FB 1 to FB 65535) DB: 1 to 59999
	Nesting depth	16 from the program cycle or startup OB 6 from any interrupt event OB
	Monitoring	Status of 2 code blocks can be monitored simultaneously
OBs	Program cycle	Multiple
	Startup	Multiple
	Time-delay interrupt	4 (1 per event)
	Cyclic interrupts	4 (1 per event)
	Hardware interrupts	50 (1 per event)
	Time error interrupts	1
	Diagnostic error interrupts	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	Multiple
	Status	1
	Update	1
	Profile	1

Element		Description
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, 16 bytes per timer
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size dependent upon count type • SInt, USInt: 3 bytes • Int, UInt: 6 bytes • DInt, UDInt: 12 bytes

Table 1-38 Communication

Technical data	Description
Number of ports	1
Type	Ethernet
HMI device	4
Programming device (PG)	1
Connections	• 8 for Open User Communication (active or passive): TSEND_C, TRCV_C, TCON, TDISCON, TSEND, and TRCV • 3 for server GET/PUT (CPU-to-CPU) S7 communication • 8 for client GET/PUT (CPU-to-CPU) S7 communication
Data rates	10/100 Mb/s
Isolation (external signal to logic)	Transformer isolated, 1500 V AC (type test) [1]
Cable type	CAT5e shielded
Interfaces	
Number of PROFINET interfaces	1
Number of interfaces PROFIBUS	0
Interface	
Interface Hardware	
Number of ports	1
Integrated switch	No
RJ-45 (Ethernet)	Yes; X1
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	No
PROFINET IO controller	
Services	
PG/OP communication	Yes
S7 routing	Yes
Isochronous mode	No
Open IE communication	Yes

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data		Description
IRT		No
MRP		No
PROFIenergy		No
Prioritized startup		Yes (max. 16 PROFINET devices)
Number of connectable I/O devices max.		16
Number of IO devices that you can connect for RT, max.		16
Of which are in line, max.		16
Number of IO devices that can be activated/ deactivated simultaneously, max.		8
Update times		The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.
With RT		
Send clock of 1 ms		1 ms to 512 ms
PROFINET IO device		
Services		
PG/OP communication		Yes
S7 routing		Yes
Isochronous mode		No
Open IE communication		Yes
IRT, supported		No
MRP, supported		No
PROFIenergy		Yes
Shared device		Yes
Number of IO controllers with shared device, max.		2
SIMATIC communication		
S7 communication, as server		Yes
S7 communication, as client		Yes
User data per job, max.		See online help (S7 communication, user data size)
Open IE communication		
TCP/IP:		Yes
	Data length, max.	8 KB
	Several passive connections per port, supported	Yes
ISO-on-TCP (RFC1006):		Yes
	Data length, max.	8 KB
UDP		Yes
	Data length, max.	1472 bytes
DHCP		No
SNMP		Yes
DCP		Yes
LLDP		Yes

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Table 1-39 Power supply

Technical data		**CPU 1212FC DC/DC/Relay**	**CPU 1212FC DC/DC/DC**
Voltage range		20.4 V DC to 28.8 V DC	
Line frequency		--	
Input current (max. load)	CPU only	400 mA at 24 V DC	
	CPU with all expansion accessories	1200 mA at 24 V DC	
Inrush current (max.)		12 A at 28.8 V DC	
I^2 t		0.5 A^2 s	
Isolation (input power to logic)		Not isolated	
Ground leakage, AC line to functional earth		--	
Hold up time (loss of power)		10 ms at 24 V DC	
Internal fuse, not user replaceable		3 A, 250 V, slow blow	

Table 1-40 Sensor power

Technical data	**CPU 1212FC DC/DC/Relay**	**CPU 1212FC DC/DC/DC**
Voltage range	L+ minus 4 V DC min.	
Output current rating (max.)	300 mA (short-circuit protected)	
Maximum ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	

A.2.3.3 Digital inputs and outputs

Table 1-41 Digital inputs

Technical data	**CPU 1212FC DC/DC/Relay**	**CPU 1212FC DC/DC/DC**
Number of inputs	8	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 V DC at 4 mA, nominal	
Continuous permissible voltage	30 V DC, max.	
Surge voltage	35 V DC for 0.5 sec.	
Logic 1 signal (min.)	15 V DC at 2.5 mA	
Logic 0 signal (max.)	5 V DC at 1 mA	
Isolation (field side to logic)	707 V DC (type test)	
Isolation groups	1	
Filter times	us settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (max.) (Logic 1 Level = 15 to 26 V DC)	100/80 kHz (Ia.0 to Ia.5) 30 /20 kHz (Ia.6 to Ia.7)	
Number of inputs on simultaneously	8 inputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	

Table 1-42 Digital outputs

Technical data	CPU 1212FC DC/DC/Relay	CPU 1212FC DC/DC/DC
Number of outputs	6	
Type	Relay, mechanical	Solid state - MOSFET (sourcing)
Voltage range	5 to 30 V DC or 5 to 250 V AC	20.4 to 28.8 V DC
Logic 1 signal at max. current	--	20 V DC min.
Logic 0 signal with 10 KΩ load	--	0.1 V DC max.
Current (max.)	2.0 A	0.5 A
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Surge current	7 A with contacts closed	8 A for 100 ms max.
Overload protection	No	
Required external overload protection [1]	10 A maximum must be limited to any common	5 A maximum must be limited to any common
Isolation (field side to logic)	1500 V AC (coil to contact) None (coil to logic)	707 V DC (type test)
Isolation groups	2	1
Isolation (group-to-group)	1500 V AC [2]	--
Inductive clamp voltage	--	L+ minus 48 V DC, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., off to on 3.0 µs max., on to off
Switching delay (Qa.4 to Qa.5)	10 ms max.	5 µs max., off to on 20 µs max., on to off
Maximum relay switching frequency	1 Hz	--
Pulse Train Output rate	Not recommended [3]	100 kHz (Qa.0 to Qa.3) [4], 2 Hz min. 20 kHz (Qa.4 to Qa.5) [4]
Lifetime mechanical (no load)	10,000,000 open/close cycles	--
Lifetime contacts at rated load	100,000 open/close cycles	--
Behavior on RUN to STOP	Last value or substitute value (default value 0)	Last value or substitute value (default value 0)
Number of outputs on simultaneously	6 outputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 150 m unshielded	

1 External overload protection is to limit fire hazard. Overload can damage relay or transistor output.

2 Relay group-to-group isolation separates line voltage from SELV/PELV and separates different phases up to 250 V AC line to ground.

3 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

4 Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

A.2.3.4 Analog inputs

Analog input specifications

Table 1-43 Analog inputs

Technical data	Description
Number of inputs	2
Type	Voltage (single-ended)
Full-scale range	0 to 10 V
Full-scale range (data word)	0 to 27648
Overshoot range	10.001 to 11.759 V
Overshoot range (data word)	27649 to 32511
Overflow range	11.760 to 11.852 V
Overflow range (data word)	32512 to 32767
Resolution	10 bits
Maximum withstand voltage	35 V DC
Smoothing	None, Weak, Medium, or Strong See the table for Step response (ms) for the analog inputs of the CPU.
Noise rejection	10, 50, or 60 Hz
Impedance	≥100 KΩ
Isolation (field side to logic)	None
Accuracy (25 °C / 0 to 55 °C)	3.0% / 3.5% of full-scale
Cable length (meters)	100 m, shielded twisted pair

Step response of built-in analog inputs of the CPU

Table 1-44 Step Response (ms), 0 V to 10 V measured at 95%

Smoothing selection (sample averaging)	Rejection frequency (Integration time)		
	60 Hz	50 Hz	10 Hz
None (1 cycle): No averaging	50 ms	50 ms	100 ms
Weak (4 cycles): 4 samples	60ms	70 ms	200 ms
Medium (16 cycles): 16 samples	200 ms	240 ms	1150 ms
Strong (32 cycles): 32 samples	400 ms	480 ms	2300 ms
Sample time	**4.17 ms**	**5 ms**	**25 ms**

Sample time for the built-in analog ports of the CPU

Table 1-45 Sample time for built-in analog inputs of the CPU

Rejection frequency (Integration time selection)	Sample time
60 Hz (16.6 ms)	4.17 ms
50 Hz (20 ms)	5 ms
10 Hz (100 ms)	25 ms

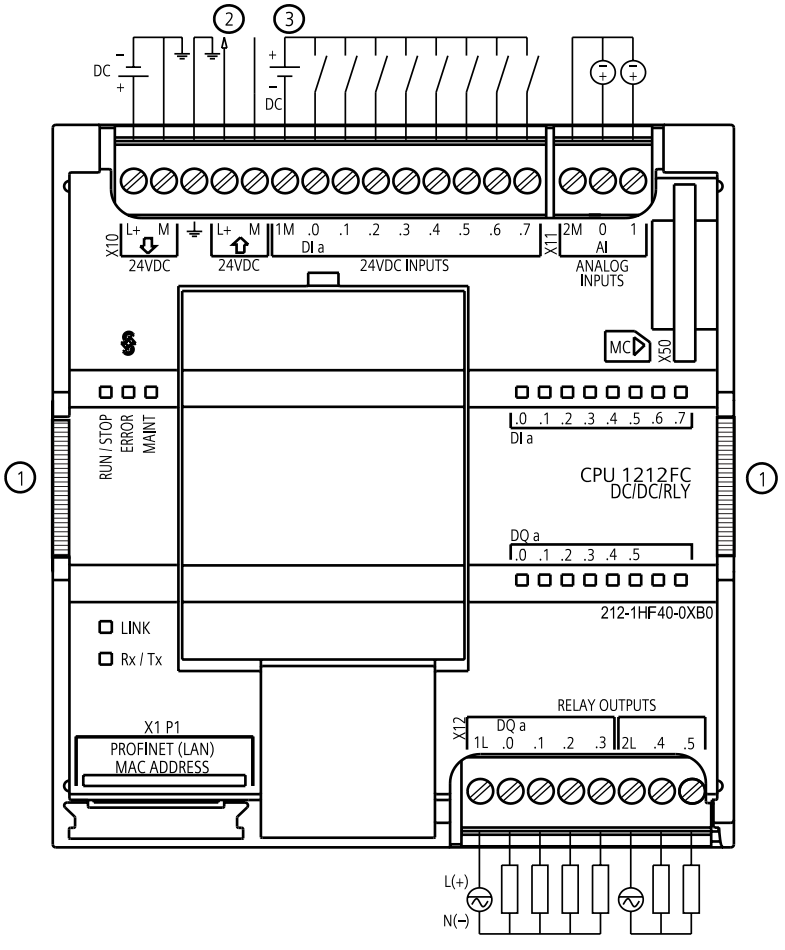
Measurement ranges of the analog inputs for voltage of the CPU

Table 1-46 Analog input representation for voltage of the CPU

System		Voltage Measuring Range	
Decimal	**Hexadecimal**	**0 to 10 V**	
32767	7FFF	11.852 V	Overflow
32512	7F00		
32511	7EFF	11.759 V	Overshoot range
27649	6C01		
27648	6C00	10 V	Rated range
20736	5100	7.5 V	
34	22	12 mV	
0	0	0 V	
Negative values		Negative values are not supported	

A.2.3.5 CPU 1212FC wiring diagrams

Table 1-47 CPU 1212FC DC/DC/Relay (6ES7212-1HF40-0XB0)

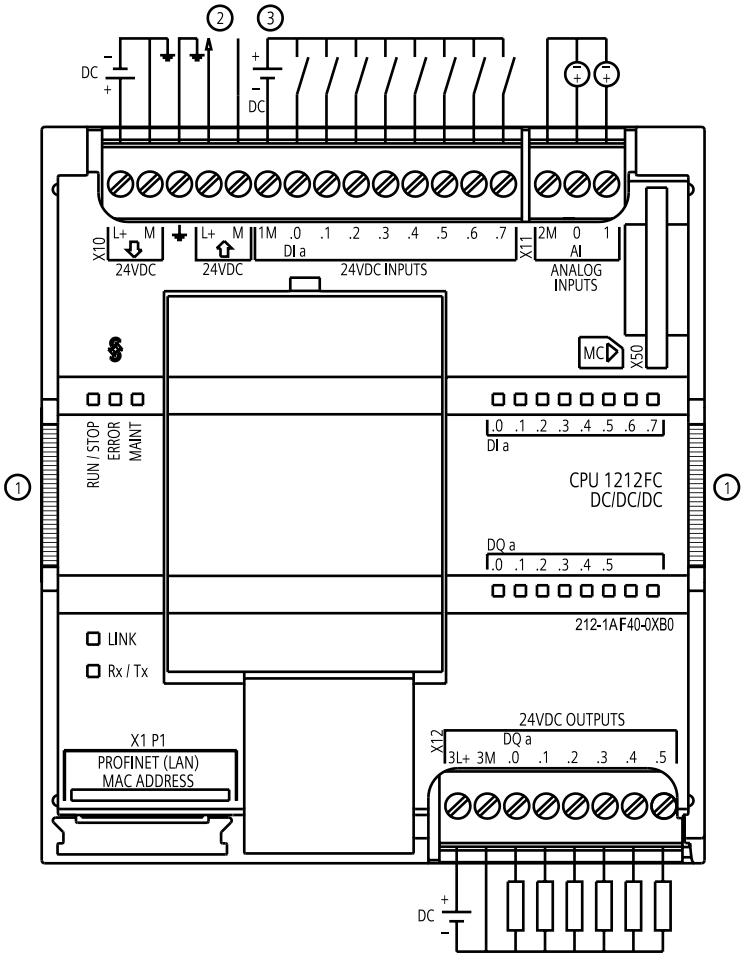


①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".
Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.	

Table 1-48 Connector pin locations for CPU 1212FC DC/DC/Relay (6ES7212-1HF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2 M	1L
2	M / 24 V DC	AI 0	DQ a.0
3	Functional Earth	AI 1	DQ a.1
4	L+ / 24 V DC Sensor Out	--	DQ a.2
5	M / 24 V DC Sensor Out	--	DQ a.3
6	1M	--	2L
7	DI a.0	--	DQ a.4
8	DI a.1	--	DQ a.5
9	DI a.2	--	--
10	DI a.3	--	--
11	DI a.4	--	--
12	DI a.5	--	--
13	DI a.6	--	--
14	DI a.7	--	--

Table 1-49 CPU 1212FC DC/DC/DC (6ES7212-1AF40-0XB0)



①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".
Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.	

Table 1-50 Connector pin locations for CPU 1212FC DC/DC/DC (6ES7212-1AF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2 M	3L+
2	M / 24 V DC	AI 0	3M
3	Functional Earth	AI 1	DQ a.0
4	L+ / 24 V DC Sensor Out	--	DQ a.1
5	M / 24 V DC Sensor Out	--	DQ a.2
6	1M	--	DQ a.3
7	DI a.0	--	DQ a.4
8	DI a.1	--	DQ a.5
9	DI a.2	--	--
10	DI a.3	--	--
11	DI a.4	--	--
12	DI a.5	--	--
13	DI a.6	--	--
14	DI a.7	--	--

NOTE
Unused analog inputs should be shorted.

A.2.4 CPU 1214FC

A.2.4.1 General specifications and features

Table 1-51 General

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Article number	6ES7214-1HF40-0XB0	6ES7214-1AF40-0XB0
Dimensions W x H x D (mm)	110 x 100 x 75	
Shipping weight	435 grams	415 grams
Power dissipation	12 W	
Current available (SM and CM bus)	1600 mA max. (5 V DC)	
Current available (24 V DC)	400 mA max. (sensor power)	
Digital input current consumption (24 V DC)	4 mA/input used	

Table 1-52 CPU features

Technical data		Description
User memory	Work	200 Kbytes
	Load	4 Mbytes internal, expandable up to SD card size

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Technical data		Description
(Refer to "General technical specifications (Page 127), "Internal CPU memory retention".)	Retentive	10 Kbytes
On-board digital I/O		14 inputs/10 outputs
On-board analog I/O		2 inputs
Process image size		1024 bytes of inputs (I)/1024 bytes of outputs (Q)
Bit memory (M)		8192 bytes
Temporary (local) memory		• 16 Kbytes for startup and program cycle (including associated FBs and FCs) • 6 Kbytes for each of the other interrupt priority levels (including FBs and FCs)
Signal modules expansion		8 SMs max.
SB, CB, BB expansion		1 max.
Communication module expansion		3 CMs max.
High-speed counters		Up to 6 configured to use any built-in or SB inputs: (Refer to the *S7-1200 System Manual*. for more information.) • 100/[1]80 kHz (Ia.0 to Ia.5) • 30/[1]20 kHz (Ia.6 to Ib.5)
Pulse outputs[2]		Up to 4 configured to use any built-in or SB outputs: • 100 kHz (Qa.0 to Qa.3) • 20 kHz (Qa.4 to Qb.1)
Pulse catch inputs		14
Time delay interrupts		4 total with 1 ms resolution
Cyclic interrupts		4 total with 1 ms resolution
Edge interrupts		12 rising and 12 falling (16 and 16 with optional signal board)
Memory card		SIMATIC Memory Card (optional)
Real time clock accuracy		+/- 60 seconds/month
Real time clock retention time		20 days typ./12 days min. at 40 °C (maintenance-free Super Capacitor)

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Table 1-53 Performance

Type of instruction		Execution speed	
		Direct addressing (I, Q and M)	DB accesses
Boolean		0.08 µs/instruction	
Move	Move_Bool	0.3 µs/instruction	1.17 µs/instruction
	Move_Word	0.137 µs/instruction	1.0 µs/instruction
	Move_Real	0.72 µs/instruction	1.0 µs/instruction
Real Math	Add Real	1.48 µs/instruction	1.78 µs/instruction

NOTE

Many variables affect measured times. The above performance times are for the fastest instructions in this category and error-free programs.

A.2.4.2 Timers, counters and code blocks supported

Table 1-54 Blocks, timers and counters supported by CPU 1214FC

Element		Description
Blocks	Type	OB, FB, FC, DB
	Size	64 Kbytes
	Quantity	Up to 1024 blocks total (OBs + FBs + FCs + DBs)
	Address range for FBs, FCs, and DBs	FB and FC: 1 to 65535 (such as FB 1 to FB 65535) DB: 1 to 59999
	Nesting depth	16 from the program cycle or startup OB 6 from any interrupt event OB
	Monitoring	Status of 2 code blocks can be monitored simultaneously
OBs	Program cycle	Multiple
	Startup	Multiple
	Time-delay interrupts	4 (1 per event)
	Cyclic interrupts	4 (1 per event)
	Hardware interrupts	50 (1 per event)
	Time error interrupts	1
	Diagnostic error interrupts	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	Multiple
	Status	1
	Update	1
	Profile	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, 16 bytes per timer
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size dependent upon count type • SInt, USInt: 3 bytes • Int, UInt: 6 bytes • DInt, UDInt: 12 bytes

Table 1-55 Communication

Technical data	Description
Number of ports	1
Type	Ethernet
HMI device	4
Programming device (PG)	1
Connections	• 8 for Open User Communication (active or passive): TSEND_C, TRCV_C, TCON, TDISCON, TSEND, and TRCV • 3 for server GET/PUT (CPU-to-CPU) S7 communication • 8 for client GET/PUT (CPU-to-CPU) S7 communication
Data rates	10/100 Mb/s

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description
Isolation (external signal to logic)	Transformer isolated, 1500 V AC (type test) [1]
Cable type	CAT5e shielded
Interfaces	
Number of PROFINET interfaces	1
Number of interfaces PROFIBUS	0
Interface	
Interface Hardware	
Number of ports	1
Integrated switch	No
RJ-45 (Ethernet)	Yes; X1
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	No
PROFINET IO controller	
Services	
PG/OP communication	Yes
S7 routing	Yes
Isochronous mode	No
Open IE communication	Yes
IRT	No
MRP	No
PROFIenergy	No
Prioritized startup	Yes (max. 16 PROFINET devices)
Number of connectable I/O devices max.	16
Number of IO devices that you can connect for RT, max.	16
Of which are in line, max.	16
Number of IO devices that can be activated/ deactivated simultaneously, max.	8
Update times	The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.
With RT	
Send clock of 1 ms	1 ms to 512 ms
PROFINET IO device	
Services	
PG/OP communication	Yes
S7 routing	Yes
Isochronous mode	No

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data		Description
Open IE communication		Yes
IRT, supported		No
MRP, supported		No
PROFIenergy		Yes
Shared device		Yes
Number of IO controllers with shared device, max.		2
SIMATIC communication		
S7 communication, as server		Yes
S7 communication, as client		Yes
User data per job, max.		See online help (S7 communication, user data size)
Open IE communication		
TCP/IP:		Yes
	Data length, max.	8 KB
	Several passive connections per port, supported	Yes
ISO-on-TCP (RFC1006):		Yes
	Data length, max.	8 KB
UDP		Yes
	Data length, max.	1472 bytes
DHCP		No
SNMP		Yes
DCP		Yes
LLDP		Yes

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Table 1-56 Power supply

Technical data		CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Voltage range		20.4 V DC to 28.8 V DC	
Line frequency		--	
Input current (max. load)	CPU only	500 mA at 24 V DC	
	CPU with all expansion accessories	1500 mA at 24 V DC	
Inrush current (max.)		12 A at 28.8 V DC	
$I^2 t$		0.5 $A^2 s$	
Isolation (input power to logic)		Not isolated	
Ground leakage, AC line to functional earth		-	
Hold up time (loss of power)		10 ms at 24 V DC	
Internal fuse, not user replaceable		3 A, 250 V, slow blow	

Table 1-57 Sensor power

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Voltage range	L+ minus 4 V DC min.	
Output current rating (max.)	400 mA (short-circuit protected)	
Maximum ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	

A.2.4.3 Digital inputs and outputs

Table 1-58 Digital inputs

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Number of inputs	14	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 V DC at 4 mA, nominal	
Continuous permissible voltage	30 V DC, max.	
Surge voltage	35 V DC for 0.5 sec.	
Logic 1 signal (min.)	15 V DC at 2.5 mA	
Logic 0 signal (max.)	5 V DC at 1 mA	
Isolation (field side to logic)	707 V DC (type test)	
Isolation groups	1	
Filter times	us settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (max.) (Logic 1 Level = 15 to 26 V DC)	100/80 kHz (Ia.0 to Ia.5) 30/20 kHz (Ia.6 to Ib.5)	
Number of inputs on simultaneously	14 inputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	

Table 1-59 Digital outputs

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Number of outputs	10	
Type	Relay, mechanical	Solid state - MOSFET (sourcing)
Voltage range	5 to 30 V DC or 5 to 250 V AC	20.4 to 28.8 V DC
Logic 1 signal at max. current	--	20 V DC min.
Logic 0 signal with 10 KΩ load	--	0.1 V DC max.
Current (max.)	2.0 A	0.5 A
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Surge current	7 A with contacts closed	8 A for 100 ms max.
Overload protection	No	

1 External overload protection is to limit fire hazard. Overload can damage relay or transistor output.

2 Relay group-to-group isolation separates line voltage from SELV/PELV and separates different phases up to 250 V AC line to ground.

3 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

4 Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

Technical data	CPU 1214FC DC/DC/Relay	CPU 1214FC DC/DC/DC
Required external overload protection [1]	10 A maximum must be limited to any common	5 A maximum must be limited to any common
Isolation (field side to logic)	1500 V AC (coil to contact) None (coil to logic)	707 V DC (type test)
Isolation groups	2	1
Isolation (group-to-group)	1500 V AC [2]	--
Inductive clamp voltage	--	L+ minus 48 V DC, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., off to on 3.0 µs max., on to off
Switching delay (Qa.4 to Qb.1)	10 ms max.	5 µs max., off to on 20 µs max., on to off
Maximum relay switching frequency	1 Hz	--
Pulse Train Output rate	Not recommended [3]	100 kHz (Qa.0 to Qa.3) [4], 2 Hz min. 20 kHz (Qa.4 to Qb.1) [4]
Lifetime mechanical (no load)	10,000,000 open/close cycles	--
Lifetime contacts at rated load	100,000 open/close cycles	--
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Number of outputs on simultaneously	10 outputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 150 m unshielded	

1 External overload protection is to limit fire hazard. Overload can damage relay or transistor output.

2 Relay group-to-group isolation separates line voltage from SELV/PELV and separates different phases up to 250 V AC line to ground.

3 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

4 Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

A.2.4.4 Analog inputs

Table 1-60 Analog inputs

Technical data	Description
Number of inputs	2
Type	Voltage (single-ended)
Full-scale range	0 to 10 V
Full-scale range (data word)	0 to 27648
Overshoot range	10.001 to 11.759 V
Overshoot range (data word)	27649 to 32511
Overflow range	11.760 to 11.852 V
Overflow range (data word)	32512 to 32767
Resolution	10 bits
Maximum withstand voltage	35 V DC
Smoothing	None, Weak, Medium, or Strong See the table for Step response (ms) for the analog inputs of the CPU (Page 152).
Noise rejection	10, 50, or 60 Hz
Impedance	≥100 KΩ

Technical data	Description
Isolation (field side to logic)	None
Accuracy (25 °C / 0 to 55 °C)	3.0% / 3.5% of full-scale
Cable length (meters)	100 m, shielded twisted pair

Step response of built-in analog inputs of the CPU

Table 1-61 Step Response (ms), 0 V to 10 V measured at 95%

Smoothing selection (sample averaging)	Rejection frequency (Integration time)		
	60 Hz	50 Hz	10 Hz
None (1 cycle): No averaging	50 ms	50 ms	100 ms
Weak (4 cycles): 4 samples	60 ms	70 ms	200 ms
Medium (16 cycles): 16 samples	200 ms	240 ms	1150 ms
Strong (32 cycles): 32 samples	400 ms	480 ms	2300 ms
Sample time	**4.17 ms**	**5 ms**	**25 ms**

Sample time for the built-in analog ports of the CPU

Table 1-62 Sample time for built-in analog inputs of the CPU

Rejection frequency (Integration time selection)	Sample time
60 Hz (16.6 ms)	4.17 ms
50 Hz (20 ms)	5 ms
10 Hz (100 ms)	25 ms

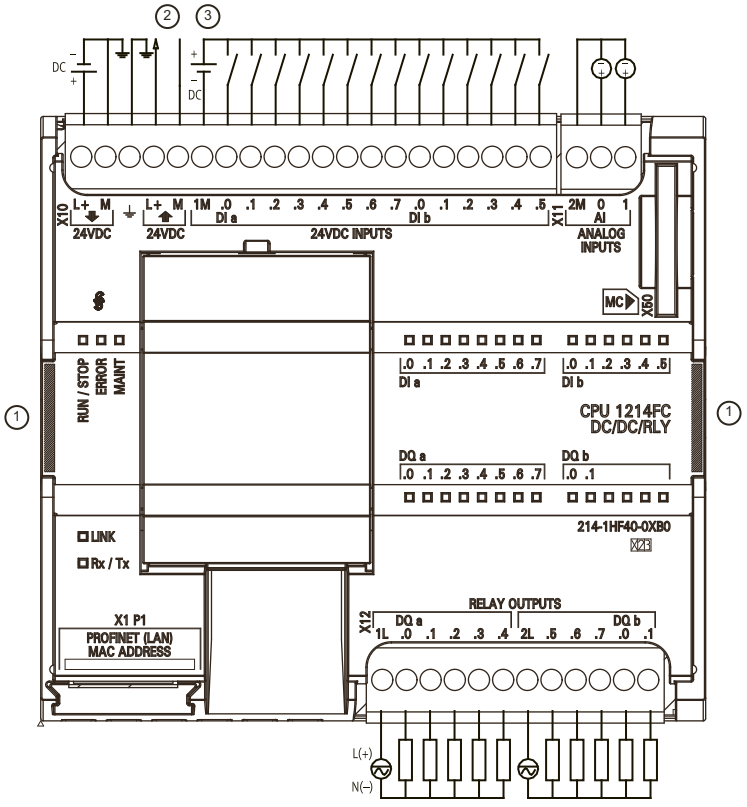
Measurement ranges of the analog inputs for voltage of the CPU

Table 1-63 Analog input representation for voltage of the CPU

System		Voltage Measuring Range	
Decimal	**Hexadecimal**	**0 to 10 V**	
32767	7FFF	11.852 V	Overflow
32512	7F00		
32511	7EFF	11.759 V	Overshoot range
27649	6C01		
27648	6C00	10 V	Rated range
20736	5100	7.5 V	
34	22	12 mV	
0	0	0 V	
Negative values		Negative values are not supported	

A.2.4.5 CPU 1214FC wiring diagrams

Table 1-64 CPU 1214FC DC/DC/Relay (6ES7214-1HF40-0XB0)



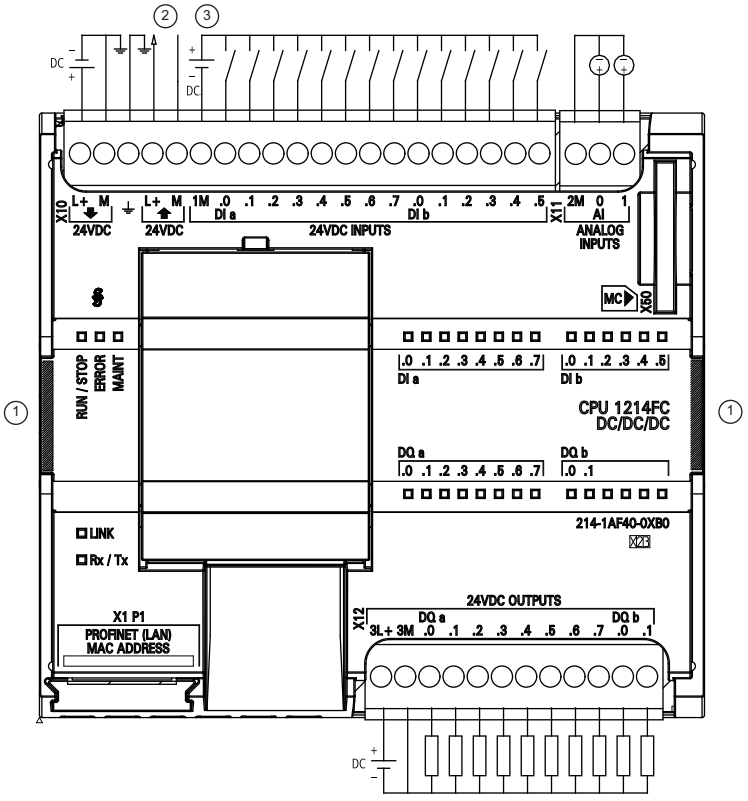
①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".
Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.	

Table 1-65 Connector pin locations for CPU 1214FC DC/DC/Relay (6ES7214-1HF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2 M	1L
2	M / 24 V DC	AI 0	DQ a.0
3	Functional Earth	AI 1	DQ a.1
4	L+ / 24 V DC Sensor Out	--	DQ a.2
5	M / 24 V DC Sensor Out	--	DQ a.3
6	1M	--	DQ a.4
7	DI a.0	--	2L
8	DI a.1	--	DQ a.5
9	DI a.2	--	DQ a.6
10	DI a.3	--	DQ a.7
11	DI a.4	--	DQ b.0
12	DI a.5	--	DQ b.1
13	DI a.6	--	--
14	DI a.7	--	--
15	DI b.0	--	--
16	DI b.1	--	--
17	DI b.2	--	--

Pin	X10	X11 (gold)	X12
18	DI b.3	--	--
19	DI b.4	--	--
20	DI b.5	--	--

Table 1-66 CPU 1214FC DC/DC/DC (6ES7214-1AF40-0XB0)



①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.

Table 1-67 Connector pin locations for CPU 1214FC DC/DC/DC (6ES7214-1AF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2 M	3L+
2	M / 24 V DC	AI 0	3M
3	Functional Earth	AI 1	DQ a.0
4	L+ / 24 V DC Sensor Out	--	DQ a.1
5	M / 24 V DC Sensor Out	--	DQ a.2
6	1M	--	DQ a.3
7	DI a.0	--	DQ a.4
8	DI a.1	--	DQ a.5
9	DI a.2	--	DQ a.6
10	DI a.3	--	DQ a.7
11	DI a.4	--	DQ b.0
12	DI a.5	--	DQ b.1
13	DI a.6	--	--
14	DI a.7	--	-
15	DI b.0	--	--

Pin	X10	X11 (gold)	X12
16	DI b.1	--	--
17	DI b.2	--	--
18	DI b.3	--	--
19	DI b.4	--	--
20	DI b.5	--	--

NOTE
Unused analog inputs should be shorted.

A.2.5 CPU 1215FC

A.2.5.1 General specifications and features

Table 1-68 General

Technical data	CPU 1215FC DC/DC/Relay	CPU 1215FC DC/DC/DC
Article number	6ES7215-1HF40-0XB0	6ES7215-1AF40-0XB0
Dimensions W x H x D (mm)	130 x 100 x 75	
Shipping weight	550 grams	520 grams
Power dissipation	12 W	
Current available (SM and CM bus)	1600 mA max. (5 V DC)	
Current available (24 V DC)	400 mA max. (sensor power)	
Digital input current consumption (24 V DC)	4 mA/input used	

Table 1-69 CPU features

Technical data		Description
User memory (Refer to "General technical specifications (Page 127), "Internal CPU memory retention".)	Work	250 Kbytes
	Load	4 Mbytes, internal, expandable up to SD card size
	Retentive	10 Kbytes
On-board digital I/O		14 inputs/10 outputs
On-board analog I/O		2 inputs/2 outputs
Process image size		1024 bytes of inputs (I)/1024 bytes of outputs (Q)
Bit memory (M)		8192 bytes
Temporary (local) memory		• 16 Kbytes for startup and program cycle (including associated FBs and FCs) • 6 Kbytes for each of the other interrupt priority levels (including FBs and FCs)
Signal modules expansion		8 SMs max.
SB, CB, BB expansion		1 max.
Communication module expansion		3 CMs max.

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Technical data	Description
High-speed counters	Up to 6 configured to use any built-in or SB inputs. (Refer to the *S7-1200 System Manual* for more information.) • 100/[1]80 kHz (Ia.0 to Ia.5) • 30/[1]20 kHz (Ia.6 to Ib.5)
Pulse outputs[2]	Up to 4 configured to use any built-in or SB outputs • 100 kHz (Qa.0 to Qa.3) • 20 kHz (Qa.4 to Qb.1)
Pulse catch inputs	14
Time delay interrupts	4 total with 1 ms resolution
Cyclic interrupts	4 total with 1 ms resolution
Edge interrupts	12 rising and 12 falling (16 and 16 with optional signal board)
Memory card	SIMATIC Memory Card (optional)
Real time clock accuracy	+/- 60 seconds/month
Real time clock retention time	20 days typ./12 days min. at 40 °C (maintenance-free Super Capacitor)

1 The slower speed is applicable when the HSC is configured for quadrature mode of operation.

2 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

Table 1-70 Performance

Type of instruction		Execution speed	
		Direct addressing (I, Q and M)	DB accesses
Boolean		0.08 µs/instruction	
Move	Move_Bool	0.3 µs/instruction	1.17 µs/instruction
	Move_Word	0.137 µs/instruction	1.0 µs/instruction
	Move_Real	0.72 µs/instruction	1.0 µs/instruction
Real Math	Add Real	1.48 µs/instruction	1.78 µs/instruction

NOTE
Many variables affect measured times. The above performance times are for the fastest instructions in this category and error-free programs.

A.2.5.2 Timers, counters and code blocks supported

Table 1-71 Blocks, timers and counters supported by CPU 1215FC

Element		Description
Blocks	Type	OB, FB, FC, DB
	Size	64 Kbytes
	Quantity	Up to 1024 blocks total (OBs + FBs + FCs + DBs)
	Address range for FBs, FCs, and DBs	FB and FC: 1 to 65535 (such as FB 1 to FB 65535) DB: 1 to 59999
	Nesting depth	16 from the program cycle or startup OB 6 from any interrupt event OB
	Monitoring	Status of 2 code blocks can be monitored simultaneously
OBs	Program cycle	Multiple
	Startup	Multiple
	Time-delay interrupts	4 (1 per event)

Element		Description
OBs	Cyclic interrupts	4 (1 per event)
	Hardware interrupts	50 (1 per event)
	Time error interrupts	1
	Diagnostic error interrupts	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	Multiple
	Status	1
	Update	1
	Profile	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, 16 bytes per timer
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size dependent upon count type • SInt, USInt: 3 bytes • Int, UInt: 6 bytes • DInt, UDInt: 12 bytes

Table 1-72 Communication

Technical data	Description
Number of ports	2
Type	Ethernet
HMI device	4
Programming device (PG)	1
Connections	• 8 for Open User Communication (active or passive): TSEND_C, TRCV_C, TCON, TDISCON, TSEND, and TRCV • 3 for server GET/PUT (CPU-to-CPU) S7 communication • 8 for client GET/PUT (CPU-to-CPU) S7 communication
Data rates	10/100 Mb/s
Isolation (external signal to logic)	Transformer isolated, 1500 V AC (type test) [1]
Cable type	CAT5e shielded
Interfaces	
Number of PROFINET interfaces	1
Number of interfaces PROFIBUS	0
Interface	
Interface hardware	
Number of ports	2
Integrated switch	Yes
RJ-45 (Ethernet)	Yes; X1
Protocols	
PROFINET IO controller	Yes
PROFINET IO device	Yes

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description
SIMATIC communication	Yes
Open IE communication	Yes
Web server	Yes
Media redundancy	Yes
PROFINET IO controller	
Services	
PG/OP communication	Yes
S7 routing	Yes
Isochronous mode	No
Open IE communication	Yes
IRT	No
MRP	Yes as MRP client
PROFIenergy	No
Prioritized startup	Yes (max. 16 PROFINET devices)
Number of connectable I/O devices max.	16
Number of IO devices that you can connect for RT, max.	16
Of which are in line, max.	16
Number of IO devices that can be activated/ deactivated simultaneously, max.	8
Update times	The minimum value of the update time also depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.
With RT	
Send clock of 1 ms	1 ms to 512 ms
PROFINET IO device	
Services	
PG/OP communication	Yes
S7 routing	Yes
Isochronous mode	No
Open IE communication	Yes
IRT, supported	No
MRP, supported	Yes
PROFIenergy	Yes
Shared device	Yes
Number of IO controllers with shared device, max.	2
SIMATIC communication	
S7 communication, as server	Yes
S7 communication, as client	Yes
User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
TCP/IP:	Yes
Data length, max.	8 KB

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data		Description
	Several passive connections per port, supported	Yes
ISO-on-TCP (RFC1006):		Yes
	Data length, max.	8 KB
UDP:		Yes
	Data length, max.	1472 bytes
DHCP		No
SNMP		Yes
DCP		Yes
LLDP		Yes

[1] Ethernet port isolation is designed to limit hazard during short-term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Table 1-73 Power supply

Technical data		CPU 1215FC DC/DC/Relay	CPU 1215FC DC/DC/DC
Voltage range		20.4 V DC to 28.8 V DC	
Line frequency		--	
Input current (max. load)	CPU only	500 mA at 24 V DC	
	CPU with all expansion accessories	1500 mA at 24 V DC	
Inrush current (max.)		12 A at 28.8 V DC	
$I^2 t$		0.5 $A^2 s$	
Isolation (input power to logic)		Not isolated	
Ground leakage, AC line to functional earth		-	
Hold up time (loss of power)		10 ms at 24 V DC	
Internal fuse, not user replaceable		3 A, 250 V, slow blow	

Table 1-74 Sensor power

Technical data	CPU 1215FC DC/DC/Relay	CPU 1215FC DC/DC/DC
Voltage range	L+ minus 4 V DC min.	
Output current rating (max.)	400 mA (short-circuit protected)	
Maximum ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	

A.2.5.3 Digital inputs and outputs

Table 1-75 Digital inputs

Technical data	CPU 1215FC DC/DC/Relay	CPU 1215FC DC/DC/DC
Number of inputs	14	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 V DC at 4 mA, nominal	
Continuous permissible voltage	30 V DC, max.	
Surge voltage	35 V DC for 0.5 sec.	

Technical data	**CPU 1215FC DC/DC/Relay**	**CPU 1215FC DC/DC/DC**
Logic 1 signal (min.)	15 V DC at 2.5 mA	
Logic 0 signal (max.)	5 V DC at 1 mA	
Isolation (field side to logic)	707 V DC (type test)	
Isolation groups	1	
Filter times	us settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (max.) (Logic 1 Level = 15 to 26 V DC)	100/80 kHz (Ia.0 to Ia.5) 30/20 kHz (Ia.6 to Ib.5)	
Number of inputs on simultaneously	14 inputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	

Table 1-76 Digital outputs

Technical data	**CPU 1215FC DC/DC/Relay**	**CPU 1215FC DC/DC/DC**
Number of outputs	10	10
Type	Relay, mechanical	Solid state - MOSFET (sourcing)
Voltage range	5 to 30 V DC or 5 to 250 V AC	20.4 to 28.8 V DC
Logic 1 signal at max. current	--	20 V DC min.
Logic 0 signal with 10 KΩ load	--	0.1 V DC max.
Current (max.)	2.0 A	0.5 A
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Surge current	7 A with contacts closed	8 A for 100 ms max.
Overload protection	No	No
Required external overload protection [1]	10 A maximum must be limited to any common	5 A maximum must be limited to any common
Isolation (field side to logic)	1500 V AC (coil to contact) None (coil to logic)	707 V DC (type test)
Isolation groups	2	1
Isolation (group-to-group)	1500 V AC [2]	--
Inductive clamp voltage	--	L+ minus 48 V DC, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., off to on 3.0 µs max., on to off
Switching delay (Qa.4 to Qb.1)	10 ms max.	5 µs max., off to on 20 µs max., on to off
Maximum relay switching frequency	1 Hz	--
Pulse Train Output rate	Not recommended [3]	100 kHz (Qa.0 to Qa.3) [4], 2 Hz min. 20 kHz (Qa.4 to Qb.1) [4]
Lifetime mechanical (no load)	10,000,000 open/close cycles	--
Lifetime contacts at rated load	100,000 open/close cycles	--

Technical data	CPU 1215FC DC/DC/Relay	CPU 1215FC DC/DC/DC
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Number of outputs on simultaneously	10 outputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)	500 m shielded, 150 m unshielded	

1 External overload protection is to limit fire hazard. Overload can damage relay or transistor output.

2 Relay group-to-group isolation separates line voltage from SELV/PELV and separates different phases up to 250 V AC line to ground.

3 For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

4 Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) may improve pulse signal quality and noise immunity.

A.2.5.4 Analog inputs and outputs

Table 1-77 Analog inputs

Technical data	Description
Number of inputs	2
Type	Voltage (single-ended)
Full-scale range	0 to 10 V
Full-scale range (data word)	0 to 27648
Overshoot range	10.001 to 11.759 V
Overshoot range (data word)	27649 to 32511
Overflow range	11.760 to 11.852 V
Overflow range (data word)	32512 to 32767
Resolution	10 bits
Maximum withstand voltage	35 V DC
Smoothing	None, Weak, Medium, or Strong See the table for Step response (ms) for the analog inputs of the CPU (Page 161).
Noise rejection	10, 50, or 60 Hz
Impedance	≥100 KΩ
Isolation (field side to logic)	None
Accuracy (25 °C / 0 to 55 °C)	3.0% / 3.5% of full-scale
Cable length (meters)	100 m, shielded twisted pair

Step response of built-in analog inputs of the CPU

Table 1-78 Step Response (ms), 0 V to 10 V measured at 95%

Smoothing selection (sample averaging)	Rejection frequency (Integration time)		
	60 Hz	50 Hz	10 Hz
None (1 cycle): No averaging	50 ms	50 ms	100 ms
Weak (4 cycles): 4 samples	60 ms	70 ms	200 ms
Medium (16 cycles): 16 samples	200 ms	240 ms	1150 ms
Strong (32 cycles): 32 samples	400 ms	480 ms	2300 ms
Sample time	**4.17 ms**	**5 ms**	**25 ms**

Sample time for the built-in analog ports of the CPU

Table 1-79 Sample time for built-in analog inputs of the CPU

Rejection frequency (Integration time selection)	Sample time
60 Hz (16.6 ms)	4.17 ms
50 Hz (20 ms)	5 ms
10 Hz (100 ms)	25 ms

Measurement ranges of the analog inputs for voltage of the CPU

Table 1-80 Analog input representation for voltage of the CPU

System		Voltage Measuring Range	
Decimal	**Hexadecimal**	**0 to 10 V**	
32767	7FFF	11.852 V	Overflow
32512	7F00		
32511	7EFF	11.759 V	Overshoot range
27649	6C01		
27648	6C00	10 V	Rated range
20736	5100	7.5 V	
34	22	12 mV	
0	0	0 V	
Negative values		Negative values are not supported	

Analog output specifications

Table 1-81 Analog outputs

Technical data	Description
Number of outputs	2
Type	Current
Full-scale range	0 to 20 mA
Full-scale range (data word)	0 to 27648
Overshoot range	20.01 to 23.52 mA
Overshoot range (data word)	27649 to 32511
Overflow range	see footnote [1]
Overflow range data word	32512 to 32767
Resolution	10 bits
Output drive impedance	≤500 Ω max.
Isolation (field side to logic)	None
Accuracy (25 °C / 0 to 55 °C)	3.0% / 3.5% of full-scale
Settling time	2 ms
Cable length (meters)	100 m, shielded twisted pair

[1] In an overflow condition, analog outputs will behave according to the device configuration properties settings. In the "Reaction to CPU STOP" parameter, select either: "Use substitute value" or "Keep last value".

Measurement ranges of the analog outputs for current of the CPU

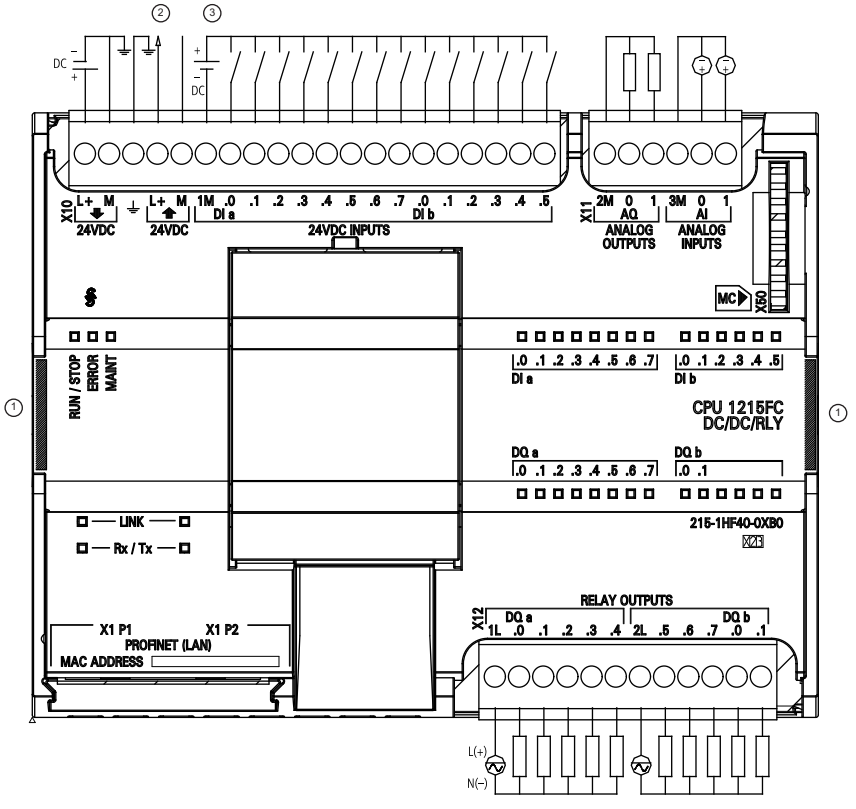
Table 1-82 Analog output representation for current of the CPU

System		Current output range	
Decimal	**Hexadecimal**	**0 mA to 20 mA**	
32767	7FFF	See note 1	Overflow
32512	7F00	See note 1	
32511	7EFF	23.52 mA	Overshoot range
27649	6C01		
27648	6C00	20 mA	Rated range
20736	5100	15 mA	
34	22	0.0247 mA	
0	0	0 mA	
Negative values		Negative values are not supported	

[1] In an overflow condition, analog outputs will behave according to the device configuration properties settings. In the "Reaction to CPU STOP" parameter, select either: "Use substitute value" or "Keep last value".

A.2.5.5 CPU 1215FC wiring diagrams

Table 1-83 CPU 1215FC DC/DC/Relay (6ES7215-1HF40-0XB0)

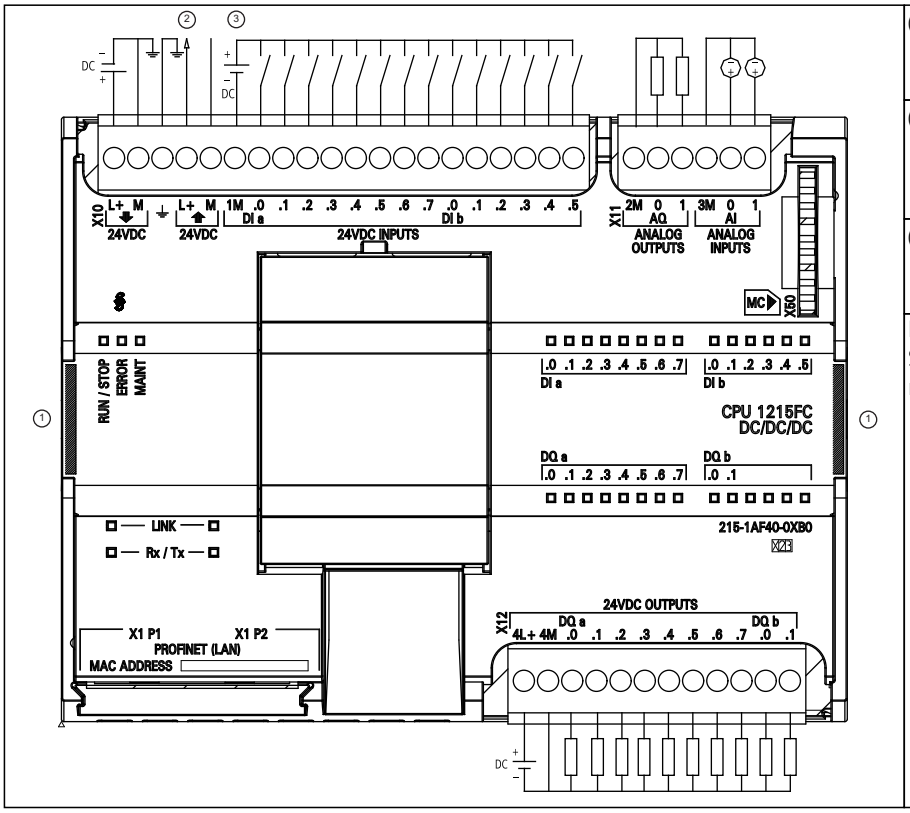


①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".
Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.	

Table 1-84 Connector pin locations for CPU 1215FC DC/DC/Relay (6ES7215-1HF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2M	1L
2	M / 24 V DC	AQ 0	DQ a.0
3	Functional Earth	AQ 1	DQ a.1
4	L+ / 24 V DC Sensor Out	3M	DQ a.2
5	M / 24 V DC Sensor Out	AI 0	DQ a.3
6	1M	AI 1	DQ a.4
7	DI a.0	--	2L
8	DI a.1	--	DQ a.5
9	DI a.2	--	DQ a.6
10	DI a.3	--	DQ a.7
11	DI a.4	--	DQ b.0
12	DI a.5	--	DQ b.1
13	DI a.6	--	--
14	DI a.7	--	--
15	DI b.0	--	--
16	DI b.1	--	--
17	DI b.2	--	--
18	DI b.3	--	--
19	DI b.4	--	--
20	DI b.5	--	--

Table 1-85 CPU 1215FC DC/DC/DC (6ES7215-1AF40-0XB0)



①	The two rectangular areas are yellow. These are only on the fail-safe CPUs.
②	24 V DC Sensor Power Out For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.
③	For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix B, Spare Parts for article number.

Table 1-86 Connector pin locations for CPU 1215FC DC/DC/DC (6ES7215-1AF40-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24 V DC	2 M	4L+
2	M / 24 V DC	AQ 0	4M
3	Functional Earth	AQ 1	DQ a.0
4	L+ / 24 V DC Sensor Out	3M	DQ a.1
5	M / 24 V DC Sensor Out	AI 0	DQ a.2
6	1M	AI 1	DQ a.3
7	DI a.0	--	DQ a.4
8	DI a.1	--	DQ a.5
9	DI a.2	--	DQ a.6
10	DI a.3	--	DQ a.7
11	DI a.4	--	DQ b.0
12	DI a.5	--	DQ b.1
13	DI a.6	--	--
14	DI a.7	--	--
15	DI b.0	--	--
16	DI b.1	--	--
17	DI b.2	--	--
18	DI b.3	--	--
19	DI b.4	--	--
20	DI b.5	--	--

NOTE
Unused analog inputs should be shorted.

A.3 Fail-Safe signal module (SM) technical specifications

A.3.1 Fail-Safe signal modules (SM)

Table 1-87 Fail-Safe signal modules

Signal module model	Digital inputs	Digital outputs	Removable connector
SM 1226 F-DI 16 x 24 V DC	8 x 24 V DC (1oo2), 16 x 24 V DC (1oo1), or a mix	-	Y
SM 1226 F-DQ 4 x 24 V DC	-	4 x 24 V DC	Y
SM 1226 F-DQ 2 x Relay	-	2 x Relay	Y

A.3.2 SM 1226 F-DI 16 x 24 V DC

A.3.2.1 Properties

Article number

6ES7226-6BA32-0XB0

Properties

The SM 1226 F-DI 16 x 24 V DC has the following features:

- 16 inputs (SIL 2/Category 3/PL d), 8 inputs (SIL 3/Category 3 or Category 4/PL e), or a mix
- 24 V DC-rated input voltage
- Suitable for switches and 3/4-wire proximity switches (BEROs)
- Two short circuit-proof sensor supplies, each one for eight inputs
- External sensor supply possible
- Module fault display (DIAG; green and red LED)
- Status display for each input (green LED)
- Fault display for each input (red LED)
- Assignable diagnostics
- Refer to "Fault diagnostics" (Page 105) for a description of LED and diagnostic message functions.

A.3.2.2 User data space

The SM 1226 F-DI 16 x 24 VDC user data space is two bytes (16 bits) of Process value input followed by two bytes of Value status bits.

This is the bit structure for an F-DI configured with input start address 8:

Input terminal	Process value bit	Value status bit
DI a.0	I8.0	I10.0
DI a.7	I8.7	I10.7
DI b.0	I9.0	I11.0
DI b.7	I9.7	I11.7

A.3.2.3 Specifications

Table 1-88 General specifications

Model	SM 1226 F-DI 16 x 24 V DC
Article number	6ES7226-6BA32-0XB0
Dimensions W x H x D (mm)	70 x 100 x 75
Weight	250 grams
Power dissipation	7 W
Current consumption (SM Bus, 5 V DC)	155 mA

Model		**SM 1226 F-DI 16 x 24 V DC**	
Current consumption (24 V DC)		130 mA + 6 mA / input used + any Vs1/Vs2 current used	
Isolation		• Signal terminals on this module are referenced to this module's M terminal and NOT ISOLATED from each other. • Signal terminals on this module are isolated to 707 V DC (type test) from S7-1200 system internal logic and Ground.	
Assigned address area	I/O area for inputs	9 bytes	
	I/O area for outputs	5 bytes	
Maximum achievable safety class	Number of channels	1-channel	2-channel
	In accordance with IEC 61508:2010	SIL 2	SIL 3
	In accordance with EN ISO 13849-1:2015	Category 3, PL d	Category 4, PL e
Fail-safe performance characteristics	Safety Integrity Level (SIL)	SIL 2	SIL 3
	Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg	5e-4	1e-5
	Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH	1e-8	1e-10
	Proof test interval (Mission time or Useful lifetime)	20 years	20 years
	Safety repair time	100 hours	100 hours
Inputs status display		Green LED / channel	
Inputs fault display		Red LED / channel	
Module fault display		Red / Green LED (DIAG)	
Diagnostic information can be displayed		Possible (TIA Portal, HMI, or Web page)	

Table 1-89 Performance

Model	**SM 1226 F-DI 16 x 24 V DC**
T_{cycle_i}: Internal cycle time	8 ms Note: Refer to "Response time parameters for the SM 1226 F-DI 16 x 24 VDC" (Page 186) for further information.

Table 1-90 Power supply (L+, M)

Model	**SM 1226 F-DI 16 x 24 V DC**
Voltage range	20.4 V DC to 28.8 V DC
Surge voltage	35 V DC for 0.5 s
Input current	• 130 mA with no current out of Vs1 and Vs2 • 730 mA with maximum current out of Vs1 and Vs2
Hold up time (loss of power)	1.0 ms at 20.4 V DC
Internal fuse, not user replaceable	2.5 A
Reverse polarity protection	Yes

Table 1-91 Sensor power (Vs1 / Vs2)

Model	**SM 1226 F-DI 16 x 24 V DC**
Number of outputs	2
Voltage range	L+ minus 2.0 V DC minimum

Model		**SM 1226 F-DI 16 x 24 V DC**
Output current rating (maximum)		300 mA
Permissible total current of outputs		600 mA
Short-circuit protection	Selection	Yes
	Operating value	0.7 A to 2.1 A

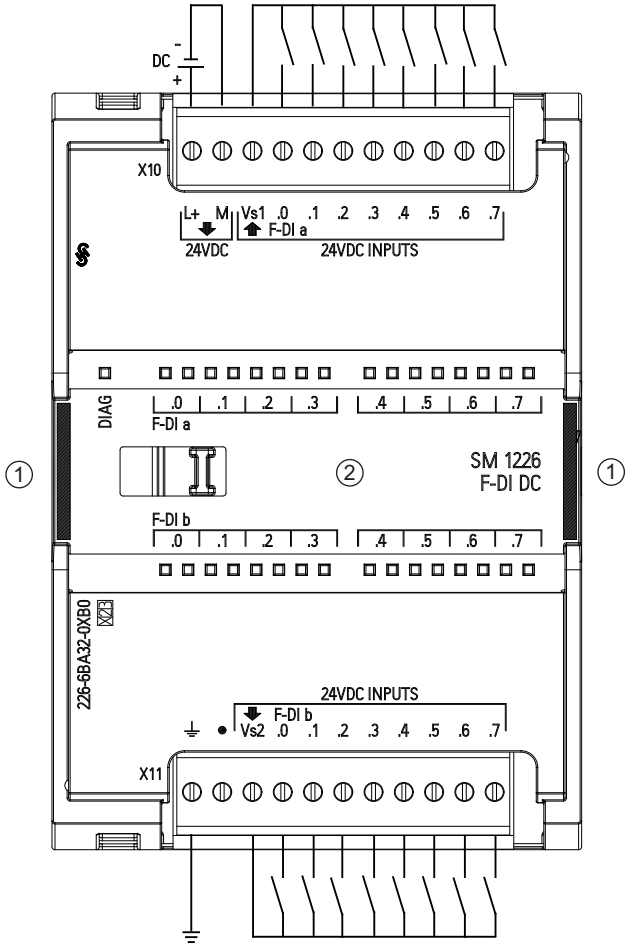
Table 1-92 Digital inputs

Model		**SM 1226 F-DI 16 x 24 V DC**	
Number of inputs	1oo1 evaluation	16 maximum	Note: You can individually assign each pair of inputs "a.x" and "b.x" as a single 1oo2 channel or as two separate 1oo1 channels.
	1oo2 evaluation	8 maximum	
Type		Sink (IEC 61131-2 Type 1)	
Rated voltage		24 V DC at 5 mA, nominal	
Surge voltage		35 V DC for 0.5 s	
Logic 1 signal		15 V DC at 3 mA to 30 V DC at 6 mA	
Logic 0 signal		-30 V DC to 5 V DC	
Connection of 2-wire proximity switch (BERO)	Selection	Not possible	
	Permissible quiescent current	0.5 mA maximum	
Filter times		• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms Note: Refer to "Response time parameters for the SM 1226 F-DI 16 x 24 VDC" (Page 186) for further information.	
Number of inputs on simultaneously		16 inputs at 55 °C horizontal or 45 °C vertical	
Cable length (meters)[1]		• 200 m unshielded with input filter time of 1.6 ms to 12.6 ms • 200 m shielded with input filter time of 0.8 ms to 12.6 s[1]	

[1] With an input delay of 0.8 ms, shielded cables must be used for the digital inputs and the sensor supply.

A.3.2.4 Wiring diagrams

Table 1-93 SM 1226 F-DI 16 x 24 V DC (6ES7226-6BA32-0XB0)



① The two rectangular areas are yellow. These are only on the fail-safe signal modules.
② Two LEDs per input:
- One for channel status: Green (on = input on, off = input off)
- One for channel faults: Red (on = problem/passivated, off = ok, blink = ready to reintegrate (activate))

Note: Refer to "Digital input applications" (Page 64) for alternate applications wiring.

Table 1-94 Connector pin locations for SM 1226 F-DI 16 x 24 V DC (6ES7226-6BA32-0XB0)

Pin	X10	X11
1	L+ / 24 V DC	Functional Earth
2	M / 24 V DC	No connection
3	Vs1 / 24 V DC Sensor Supply Output 1	Vs2 / 24 V DC Sensor Supply Output 2
4	DI a.0	DI b.0
5	DI a.1	DI b.1
6	DI a.2	DI b.2
7	DI a.3	DI b.3
8	DI a.4	DI b.4
9	DI a.5	DI b.5
10	DI a.6	DI b.6
11	DI a.7	DI b.7

A.3.3 SM 1226 F-DQ 4 x 24 V DC

A.3.3.1 Properties

Article number

6ES7226-6DA32-0XB0

Properties

The SM 1226 F-DQ 4 x 24 V DC has the following features:

- Four outputs, P- and M-switching
- 2 A output current
- Rated load voltage 24 V DC
- Suitable for solenoid valves, DC contactors, and indicator LEDs
- Module fault display (DIAG; green and red LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Safety class SIL 3 attainable
- Assignable diagnostics
- Refer to "Fault diagnostics" (Page 105) for a description of LED and diagnostic message functions.

A.3.3.2 User data space

The SM 1226 F-DQ 4 x 24 V DC user data space is four Process value output bits followed by four Value status bits.

This is the bit structure for an F-DQ DC module configured with input start address 8:

Terminal	Process value bit	Value status bit
F-DQ a.0	Q8.0	I8.0
F-DQ a.1	Q8.1	I8.1
F-DQ a.2	Q8.2	I8.2
F-DQ a.3	Q8.3	I8.3

A.3.3.3 Specifications

Table 1-95 General specifications

Model	SM 1226 F-DQ 4 x 24 V DC
Article number	6ES7226-6DA32-0XB0
Dimensions W x H x D (mm)	70 x 100 x 75
Weight	270 grams
Power dissipation	8 W
Current consumption (SM Bus, 5 V DC)	125 mA

Model		**SM 1226 F-DQ 4 x 24 V DC**
Current consumption (24 V DC)		170 mA + load current for all P-switch outputs
Isolation		• Signal terminals on this module are referenced to this module's M terminal and NOT ISOLATED from each other. • Signal terminals on this module are isolated to 707 V DC (type test) from S7-1200 system internal logic and Ground.
Assigned address area	I/O area for inputs	6 bytes
	I/O area for outputs	6 bytes
Maximum achievable safety class	In accordance with IEC 61508:2010	SIL 3
	In accordance with EN ISO 13849-1:2015	Category 4, PL e
Fail-safe performance characteristics	Safety Integrity Level (SIL)	SIL 3
	Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg	1e-5
	Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH	4e-9
	Proof test interval (Mission time or Useful lifetime)	20 years
	Safety repair time	100 hours
Outputs status display		Green LED / channel
Outputs fault display		Red LED / channel
Module fault display		Red / Green LED (DIAG)
Diagnostic information can be displayed		Possible (TIA Portal, HMI, or Web page)

Table 1-96 Performance

Model	**SM 1226 F-DQ 4 x 24 V DC**
T_{cycle_q}: Internal cycle time	8 ms Note: Refer to "Response time parameters for the SM 1226 F-DQ 4 x 24 VDC" (Page 187) for further information.

Table 1-97 Power supply (L+, M)

Model	**SM 1226 F-DQ 4 x 24 V DC**
Voltage range	20.4 V DC to 28.8 V DC
Surge voltage	35 V DC for 0.5 s
Input current	170 mA (does not include current in all P-switch loads)
Hold up time (loss of power)	• None for outputs • 1.0 ms at 20.4 V DC for internal power
Internal fuse, not replaceable	• 1 A for logic power • 7 A common for P-switch outputs F-DQ a.0 and F-DQ a.1 • 7 A common for P-switch outputs F-DQ a.2 and F-DQ a.3
Reverse polarity protection	Yes Note: Refer to "Reverse polarity protection" in the SM 1226 F-DQ 4 x 24 V DC "Digital outputs" table for more information.

Table 1-98 Digital outputs

Model		**SM 1226 F-DQ 4 x 24 V DC**
Number of outputs		4
Type		P- and M-switching
Logic 1 signal at maximum current		L+ minus 2.0 V DC (minimum): • P-switch: L+ minus 1.5 V DC (maximum) • M-switch: 0.5 V DC (maximum)
Logic 1 current		• 2 A nominal • 10 mA to 2.4 A
Lamp load		10 W (maximum)
Logic 0 current (residual)		• P-switch: 0.5 mA, maximum • M-switch: 0.5 mA, maximum
Wire break monitoring		None
Output overload protection: • M-switch • P-switch		Yes, electronic in addition to internal non-replaceable fuse. Threshold equal to or greater than 25 A turns off the switch (M- or P-) that sensed the current. Threshold of 2.4 A to 3.8 A, 400 ms time constant filter, measured at P-switch, turns both switches OFF. 7 A fuse can open for large faults.Note: Refer to "Fuse and electronic overload protection" (Page 172) for more information.
Current per common (maximum)		8 A
Inductive clamp voltage		• M-switch: + 48 V DC referenced to M • P-switch: - 26 V DC referenced to M
Behavior on RUN to STOP		Only 0 (OFF) is allowed
Number of outputs on simultaneously		4 at 55 °C horizontal or 45 °C vertical
Parallel connection of 2 outputs		Not possible
Control of a digital input		Not possible
Switching frequency	With resistive load	30 Hz symmetrical, maximum
	With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz symmetrical, maximum
	With lamp load	10 Hz symmetrical, maximum
Cable length (meters)		• 200 m unshielded • 200 m shielded
Reverse polarity protection		Yes, except loads connected between M-switch and L+ will conduct if M and L+ are reversed. Note: Refer to Digital Output Application Mode 2 (Page 70) for more information.

A.3.3.4 Fuse and electronic overload protection

Overload protection attempts to protect the module from damage from moderate faults in the range of 2.4 A to 15 A at the P switch. Above 15 A on each P-switch fuse, the internal non-replaceable fuse can open. Supply your SM 1226 F-DQ 4 x 24 V DC from a source limited to less than 15 A, or use an external fuse or non-shorting load element to prevent opening of the internal fuse.

The internal electronic limiting causes the channel to passivate and reports as an overload. If no damage results, you can reintegrate the channel after removal of the external fault.

A.3.3.5 Switching of loads

Connecting capacitive loads

Load capacitance can delay the voltage response as seen at the P- and M- switches of the SM 1226 F-DQ 4 x 24 V DC. For a capacitive load with capacitance C across P and M, and a parallel load resistance R, the "Maximum readback time" needs to be longer than 1 time constant (R * C) of the load. This allows enough time for an appreciable voltage change to be seen when you briefly de-energize an energized load during bit pattern testing. If the resulting "Maximum readback time" is too long for your application, you can reduce this time constant by adding parallel resistance across the load to reduce the realized R * C time constant.

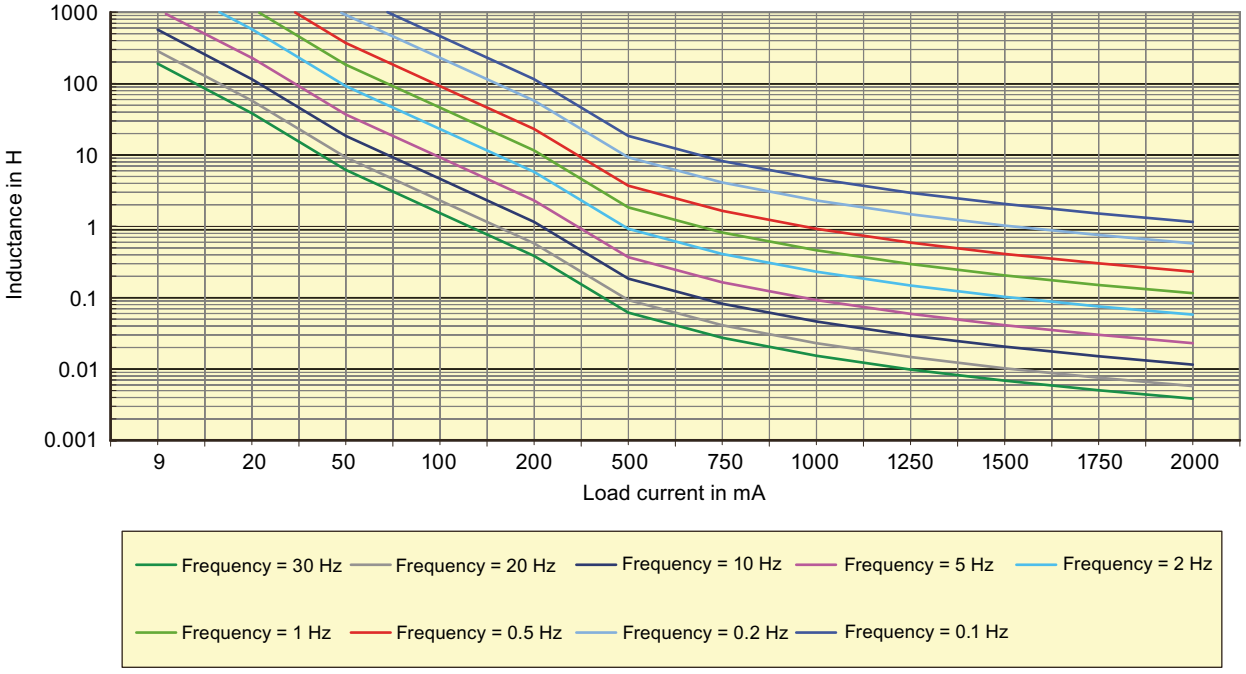
Stray capacitance between the load circuit and ground, M, and P increases the time required for the "Maximum readback time switch on test". When module diagnostics switch "ON" a P or M switch to a de-energized load during bit pattern testing, both sides of the load are driven towards L+ or M, limited by stray capacitance. This effect is typically small.

Your "Maximum readback time switch on test" should be long enough for the load circuit voltage to react, but short enough that if one side of the load faults to P or M, testing of the opposite switch should not cause the load to mechanically react.

Capacitive loads (including power supplies with input capacitors) with low series resistance can have a large inrush current. If you have a large capacitive load, you should add series resistance to reduce the inrush current to reduce the risk of opened fuses or overcurrent fault detection on normal load switch ON events.

Switching of inductive loads

The graph below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the F-DQ DC outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the F-DQ DC output switch. The external suppression must conduct the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression. Refer to "Guidelines for inductive loads" (Page 90) for more information:



WARNING

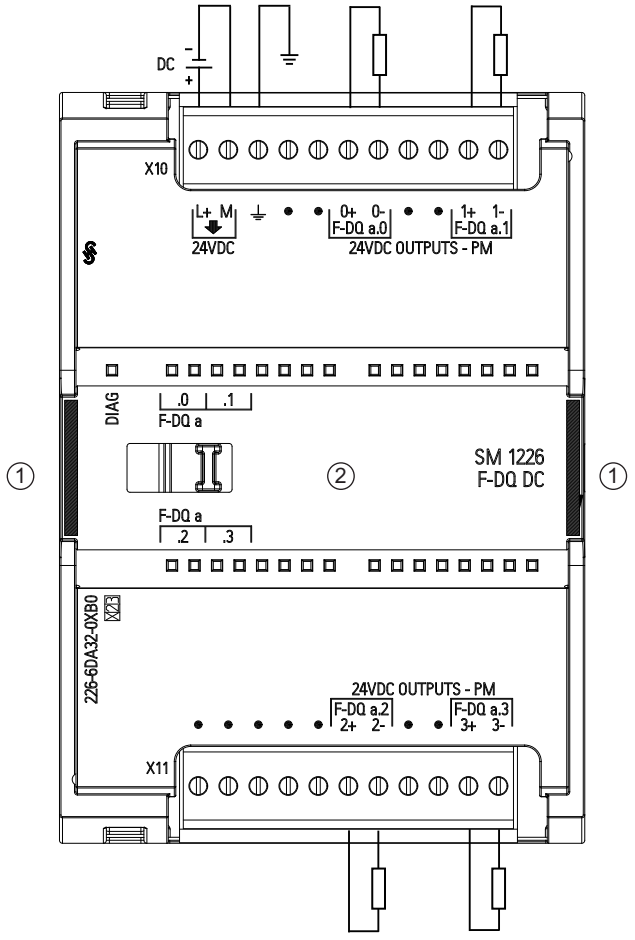
Unsuppressed inductive loads can lead to failures.
The following failures can result:

- Unsuppressed inductive loads can lead to early "stuck-on"' failures of F-DQ DC and F-RLY outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
You should use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.

A.3.3.6 Wiring diagrams

Table 1-99 SM 1226 F-DQ 4 x 24 V DC (6ES7226-6DA32-0XB0)



① The two rectangular areas are yellow. These are only on the fail-safe signal modules.
② Two LEDs per output:
- One for channel status: Green (on = output on, off = output off)
- One for channel faults: Red (on = problem/passivated, off = ok, blink = ready to reintegrate (activate))

Note: Refer to "Digital output applications" (Page 69) for alternate applications wiring.

Table 1-100 Connector pin locations for SM 1226 F-DQ 4 x 24 V DC (6ES7226-6DA32-0XB0)

Pin	X10	X11
1	L+ / 24 V DC	No connection
2	M / 24 V DC	No connection
3	Functional Earth	No connection
4	No connection	No connection
5	No connection	No connection
6	F-DQ a.0+ / P-switch	F-DQ a.2+ / P-switch
7	F-DQ a.0- / M-switch	F-DQ a.2- / M-switch
8	No connection	No connection
9	No connection	No connection
10	F-DQ a.1+ (P-switch)	F-DQ a.3+ (P-switch)
11	F-DQ a.1- (M-switch)	F-DQ a.3- (M-switch)

A.3.4 SM 1226 F-DQ 2 x Relay

A.3.4.1 Properties

Article number

6ES7226-6RA32-0XB0

Properties

The SM 1226 F-DQ 2 x Relay has the following features:

- Two relay outputs (each output switches two circuits)
- 5 A output current
- Rated load voltage 24 V DC or 24 V AC to 230 V AC
- Module fault display (DIAG; green and red LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Safety class SIL3 attainable
- Assignable diagnostics
- Refer to "Fault diagnostics" (Page 105) for a description of LED and diagnostic message functions.

A.3.4.2 User data space

The SM 1226 F-DQ 2 x Relay user data space is two Process value output bits followed by two Value status bits.

This is the bit structure for an F-RLY module configured with input start address 8:

Terminal	Process value bit	Value status bit
F-DQ a.0	Q8.0	I8.0
F-DQ a.1	Q8.1	I8.1

A.3.4.3 Specifications

Table 1-101 General specifications

Model		SM 1226 F-DQ 2 x Relay
Article number		6ES7226-6RA32-0XB0
Dimensions W x H x D (mm)		70 x 100 x 75
Weight		340 grams
Power dissipation		10 W
Current consumption (SM Bus, 5 V DC)		120 mA
Current consumption (24 V DC)		300 mA
Assigned address area	I/O area for inputs	6 bytes
	I/O area for outputs	6 bytes

Model		**SM 1226 F-DQ 2 x Relay**
Maximum achievable safety class	In accordance with IEC 61508:2010	SIL 3
	In accordance with EN ISO 13849-1:2015	Category 4, PL e
Fail-safe performance characteristics	Safety Integrity Level (SIL)	SIL 3
	Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg	1e-5
	Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH	4e-9
	Proof test interval (Mission time or Useful lifetime)	20 years
	Safety repair time	100 hours
Outputs status display		Green LED / channel
Outputs fault display		Red LED / channel
Module fault display		Red / Green LED (DIAG)
Diagnostic information can be displayed		Possible (TIA Portal, HMI, or Web page)

Table 1-102 Performance

Model	**SM 1226 F-DQ 2 x Relay**
T_{cycle_r}: Internal cycle time	8 ms Note: Refer to "Response time parameters for the SM 1226 F-DQ 2 x Relay" (Page 188) for further information.

Table 1-103 Power supply (L+, M)

Model	**SM 1226 F-DQ 2 x Relay**
Voltage range	20.4 V DC to 28.8 V DC
Surge voltage	35 V DC for 0.5 s
Input current	300 mA
Isolation (L+, M to S7-1200 internal logic and Ground)	707 V DC (type test)
Hold up time (loss of power)	• None for outputs • 1.0 ms at 20.4 V DC for internal power with outputs off • 0.5 ms at 20.4 V DC with either output or both outputs on
Internal fuse, not user replaceable	1 A for internal power
Reverse polarity protection	Yes

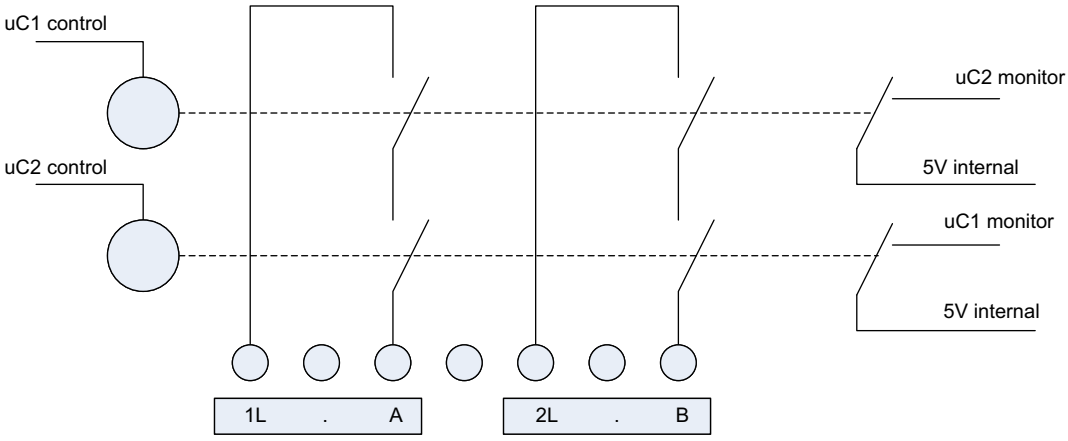
Table 1-104 Digital outputs

Model		**SM 1226 F-DQ 2 x Relay**
Number of outputs		2 (2 circuits per output)
Type		Relay, mechanically linked sense contact monitored internal to module
Voltage range		5 to 30 V DC or 5 to 250 V AC
Output current	Continuous thermal current	5 A maximum per circuit
	Minimum load current	5 mA
Current per common		5 A
Current per module (maximum) – all output circuits		10A at 55 °C horizontal or 45 °C vertical

Model		**SM 1226 F-DQ 2 x Relay**
ON state contact resistance		0.2 Ω maximum when new
Wire break monitoring		None
Short-circuit protection of output		None; external fuse or circuit breaker required. General purpose fuse type gG per IEC 60269, 5A maximum on each circuit. Some application standards require derating.
Overload protection of output		None
Isolation (output circuits to logic)		2200 V AC, rated for Overvoltage Category III
Isolation (output circuits to power supply)		2200 V AC, rated for Overvoltage Category III
Isolation (circuit to circuit on same output)		2200 V AC Note: Circuit-to-circuit isolation (A circuit to B circuit) on the same output is not rated to separate line voltage from SELV / PELV.
Isolation (output to output)		2200 V AC; rated for Overvoltage Category III, including Overvoltage Category III to SELV separation or different phase separation.
Isolation groups		4
Inductive clamp voltage		None; external protection required.
On delay time		Typically 20 ms to both series contacts closed, including 8 ms separation between commands to series contacts
Off delay time		Typically 16 ms to first series contact open, second contact opens approximately 40 ms later.
Behavior on RUN to STOP		Only 0 (OFF) is allowed.
Number of outputs on simultaneously		2
Parallel connection of 2 outputs		Allowed for redundant availability. Do not exceed single relay load rating.
Control of a digital input		With 24 V DC SELV supply
Switching frequency	With resistive load	2 Hz, maximum
	With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz, maximum
	With inductive load in accordance with IEC 60947-5-1, AC15	2 Hz, maximum
	Inductive load in accordance with UL 508	Pilot Duty B300, R300
Cable length (meters)		• 200 m shielded • 200 m unshielded
Reverse polarity protection		No

A.3.4.4 Relay output circuits

The SM 1226 F DQ 2 x Relay has two output channels (F-DQ a.0 and F-DQ a.1). Each channel includes two circuits that switch mechanically-linked contacts at the same time. Each circuit has two contacts in series controlled by independent relay coils. Opening and closing of the series contacts in each circuit is sequenced to avoid common wear-out failures.



Output channel a.0: Two circuits controlled as one process output channel
Refer to the isolation description in the SM 1226 F-DQ 2 x Relay (Page 176) specifications, Digital outputs table.

⚠ WARNING

Adjacent relay contacts in the same channel of the SM 1226 F DQ 2 x Relay are not rated to separate AC line from SELV / PELV.
Death or serious personal injury and damage to machines and equipment may result if SELV/PELV circuits are wired adjacent to high voltage circuits on this module.
The A and B circuits of each output must either be both AC line or both SELV.

A.3.4.5 Switching performance and service life of contacts

Note the "Switching performance and service life of contacts" table below. You should equip Inductive loads with suppression circuits to avoid shortened relay contact life and to avoid excessive switching noise. Refer to "Guidelines for inductive loads" (Page 90) for more information:

Table 1-105 Switching performance and service life of contacts

Resistive load	Voltage	Current	Duty cycle (typical) Normally-Open (NO) contact
For resistive load	24 V DC	5.0 A	0.35 million
		3.0 A	0.5 million
		2.0 A	0.75 million
		1.0 A	1.8 million
		0.5 A	4 million
	230 V AC	5.0 A	0.1 million
		3.0 A	0.15 million
		2.0 A	0.2 million

Resistive load	Voltage	Current	Duty cycle (typical) Normally-Open (NO) contact
For resistive load	230 V AC	1.0 A	0.4 million
		0.5 A	0.8 million
For inductive load to IEC 60947-5-1 DC13/AC15	24 V DC	1.0 A	0.1 million
		0.5 A	0.2 million
	230 V AC	1.0 A	0.2 million
		0.5 A	0.35 million

⚠ WARNING

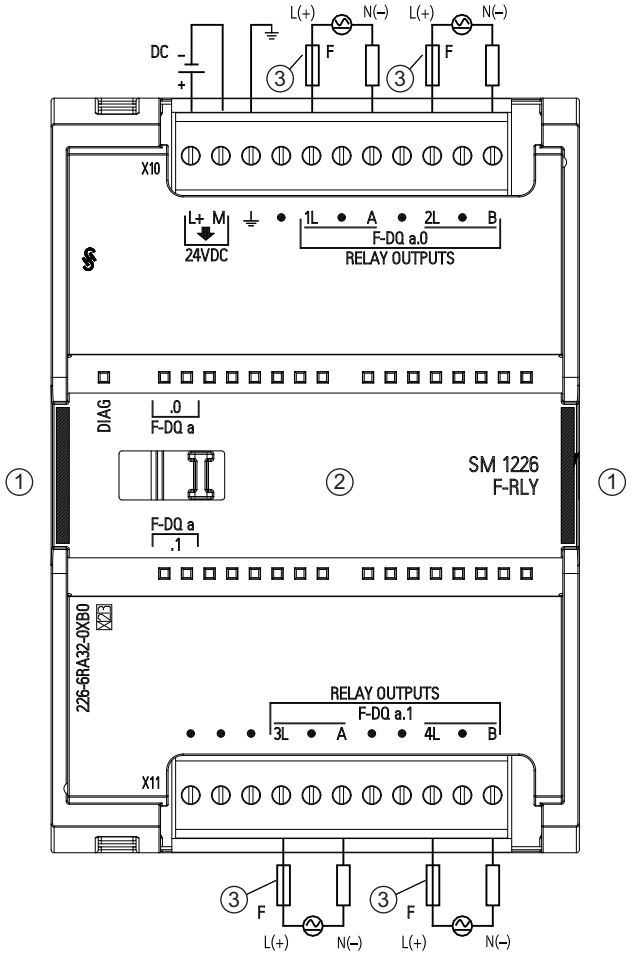
Unsuppressed inductive loads can lead to failures.
The following failures can result from unsuppressed inductive loads:

- Unsuppressed inductive loads can lead to early "stuck-on'" failures of F-DQ and F-relay outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
You should use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.

A.3.4.6 Wiring diagrams

Table 1-106 SM 1226 F-DQ 2 x Relay (6ES7226-6RA32-0XB0)



① The two rectangular areas are yellow. These are only on the fail-safe signal modules.
② Two LEDs per output:
- One for channel status: Green (on = output on, off = output off)
- One for channel faults: Red (on = problem/passivated, off = ok, blink = ready to reintegrate (activate))

③ External fuse
Note: Refer to "Digital output applications" (Page 69) for alternate applications wiring.

⚠ WARNING

External fuse or circuit breaker required
Use a general purpose fuse type gG per IEC 60269, 5A maximum on each circuit. Some application standards require derating to exclude contact welding as a fault.
Failure to follow these installation requirements could result in death, severe personal injury, and property damage.
Always follow these requirements when installing S7-1200 modules.

Table 1-107 Connector pin locations for SM 1226 F-DQ 2 x Relay (6ES7226-6RA32-0XB0)

Pin	X10	X11
1	L+ / 24 V DC	No connection
2	M / 24 V DC	No connection
3	Functional Earth	No connection
4	No connection	3L
5	1L	No connection

Pin	X10	X11
6	No connection	A / DQ a.1
7	A / DQ a.0	No connection
8	No connection	No connection
9	2L	4L
10	No connection	No connection
11	B / DQ a.0	B / DQ a.1

A.4 Companion products

A.4.1 PM1207 power module

The PM1207 is a power supply module for the SIMATIC S7-1200. It provides the following features:

- Input: 120/230 V AC, output: 24 V DC/2.5 A
- Article number: 6ESP332-1SH71-4AA0

For more information about this product and for the product documentation, refer to the product catalog web site for the PM1207 (https://eb.automation.siemens.com/mall/en/de/Catalog/Product/6AG1332-1SH71-4AA0)

Ordering information

B

B.1 Fail-Safe CPUs

Table 1-108 Fail-Safe CPUs

Item		Article number
CPU 1212FC	CPU 1212FC DC/DC/DC	6ES7212-1AF40-0XB0
	CPU 1212FC DC/DC/Relay	6ES7212-1HF40-0XB0
CPU 1214FC	CPU 1214FC DC/DC/DC	6ES7214-1AF40-0XB0
	CPU 1214FC DC/DC/Relay	6ES7214-1HF40-0XB0
CPU 1215FC	CPU 1215FC DC/DC/DC	6ES7215-1AF40-0XB0
	CPU 1215FC DC/DC/Relay	6ES7215-1HF40-0XB0

B.2 Fail-Safe signal modules (SM)

Table 1-109 Fail-Safe signal modules (SM)

Item		Article number
Digital input	SM 1226 F-DI 16 x 24 V DC	6ES7226-6BA32-0XB0
Digital output	SM 1226 F-DQ 4 x 24 V DC	6ES7226-6DA32-0XB0
	SM 1226 F-DQ 2 x Relay	6ES7226-6RA32-0XB0

B.3 Other modules

Table 1-110 Companion products

Item		Article number
Power supply	PM 1207 power supply	6EP1332-1SH71-4AA0

B.4 Spare parts and other hardware

Table 1-111 Expansion cables, simulators, and end retainers

Item		Article number
I/O expansion cable	I/O Expansion cable, 2 mm	6ES7290-6AA30-0XA0
I/O simulator	Simulator (1212FC - 8 position)	6ES7274-1XF30-0XA0
	Simulator (1214FC/1215FC - 14 position)	6ES7274-1XH30-0XA0
Potentiometer module	S7-1200 Potentiometer module	6ES7274-1XA30-0XA0
Ethernet strain relief	Single port RJ45 strain relief, 10/100 Mbit/sec	6ES7290-3AA30-0XA0
	Dual port RJ45 strain relief, 10/100 Mbit/sec	6ES7290-3AB30-0XA0
Spare door kit	CPU 1212FC	6ES7291-1AA30-0XA0
	CPU 1214FC	6ES7291-1AB30-0XA0
	CPU 1215FC	6ES7291-1AC30-0XA0

Item		Article number
Spare door kit	Signal module, 45 mm	6ES7291-1BA30-0XA0
	Signal module, 70 mm	6ES7291-1BB30-0XA0
	Communication module (for use with 6ES72xx-xxx32-0XB0 and 6ES72xx-xxx30-0XB0 modules)	6ES7291-1CC30-0XA0
End Retainer	End Retainer Thermoplastic, 10 mm	8WA1808
	End Retainer Steel, 10.3 mm	8WA1805

B.5 Fail-Safe terminal block spare kits

Table 1-112 Fail-Safe CPUs - Terminal block spare kit

If you have Fail-Safe CPU (article number)	Use this terminal block spare kit (4/pk)		
	Terminal block article number	Equivalent Push-in terminal block article number	Terminal block description
CPU 1212FC DC/DC/DC (6ES7212-1AF40-0XB0)	6ES7292-1BC30-0XA0	6ES7292-2BC30-0XA0	3 pin, gold-plated
	6ES7292-1AH30-0XA0	6ES7292-2AH30-0XA0	12 pin, tin-plated
	6ES7292-1AP30-0XA0	6ES7292-2AP30-0XA0	20 pin, tin-plated
CPU 1212FC DC/DC/Relay (6ES7212-1HF40-0XB0)	6ES7292-1BC30-0XA0	6ES7292-2BC30-0XA0	3 pin, gold-plated
	6ES7292-1AH30-0XA0	6ES7292-2AH40-0XA0	3 pin, gold-plated
	6ES7292-1AP30-0XA0	6ES7292-2AP30-0XA0	12 pin, tin-plated, keyed
CPU 1214FC DC/DC/DC (6ES7214-1AF40-0XB0)	6ES7292-1BC30-0XA0	6ES7292-2BC30-0XA0	3 pin, gold-plated
	6ES7292-1AM30-0XA0	6ES7292-2AM30-0XA0	12 pin, tin-plated
	6ES7292-1AV30-0XA0	6ES7292-2AV30-0XA0	20 pin, tin-plated
CPU 1214FC DC/DC/Relay (6ES7214-1HF40-0XB0)	6ES7292-1BC30-0XA0	6ES7292-2BC30-0XA0	3 pin, gold-plated
	6ES7292-1AM40-0XA0	6ES7292-2AM40-0XA0	12 pin, tin-plated, keyed
	6ES7292-1AV30-0XA0	6ES7292-2AV30-0XA0	20 pin, tin-plated
CPU 1215FC DC/DC/DC (6ES7215-1AF40 0XB0)	6ES7292-1BF30-0XB0	6ES7292-2BF30-0XB0	6 pin, gold-plate
	6ES7292-1AM30-0XA0	6ES7292-2AM30-0XA0	12 pin, tin-plated
	6ES7292-1AV30-0XA0	6ES7292-2AV30-0XA0	20 pin, tin-plated
CPU 1215FC DC/DC/Relay (6ES7215-1HF40 0XB0)	6ES7292-1BF30-0XB01	6ES7292-2BF30-0XB0	6 pin, gold-plated
	6ES7292-1AM40-0XA0	6ES7292-2AM40-0XA0	2 pin, tin-plated, keyed
	6ES7292-1AV30-0XA0	6ES7292-2AV30-0XA0	20 pin, tin-plated

Table 1-113 Fail-Safe signal modules - Terminal block spare kit

If you have Fail-Safe signal module (article number)	Use this Terminal block spare kit (4/pk)		
	Terminal block article number	Equivalent Push-in terminal block article number	Terminal block description
SM 1226 F-DI (6ES7226-6BA32-0XB0)	6ES7292-1AL30-0XA0	6ES7292-2AL30-0XA0	11 pin, tin-plated
SM 1226 F-DQ (6ES7226-6DA32-0XB0)	6ES7292-1AL30-0XA0	6ES7292-2AL30-0XA0	11 pin, tin-plated
SM 1226 F-Relay (6ES7226-6RA32-0XB0)	6ES7292-1AL40-0XA0	6ES7292-2AL40-0XA0	11 pin, tin-plated, keyed

B.6 Programming software

Table 1-114 Programming software

SIMATIC software		Article number
Programming software	STEP 7 Basic V14	6ES7822-0AA04-0YA5
	STEP 7 Professional V14	6ES7822-1AA04-0YA5
	STEP 7 Safety Advanced V14	6ES7833-1FA12-0YA5
	STEP 7 Safety Basic V14	6ES7833-1FB13-0YA5
Visualization software	WinCC Basic V14 SP1	6AV2100-0AA01-0AA0
	WinCC Comfort V14 SP1	6AV2101-0AA01-0AA5
	WinCC Advanced V14 SP1	6AV2102-0AA01-0AA5
	WinCC Professional 512 PowerTags V14 SP1	6AV2103-0DA01-0AA5
	WinCC Professional 4096 PowerTags V14 SP1	6AV2103-0HA01-0AA5
	WinCC Professional max. PowerTags V14 SP1	6AV2103-0XA01-0AA5

Fail-Safe response times

C

C.1 Maximum response time of the system

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced V14: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times" (http://support.automation.siemens.com/WW/view/en/49368678/133100).) Excel file (RT_calculator). Use your configured individual fail-safe SM timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{CYCLE} parameter values given below include an allowance for the fail-safe SM to acquire and deliver PROFIsafe messages in transactions with the S7-1200 I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe SM location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

C.2 Response time parameters for the SM 1226 F-DI 16 x 24 VDC

Maximum Device Acknowledge Time of the SM 1226 F-DI 16 x 24 VDC

T_{DAT_i} 9.44 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the F-DI to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

Maximum response time of the SM 1226 F-DI 16 x 24 VDC

1oo1 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle_i}$

$T_{OFDT_i} = T_{WCDT_i} + T_{scf}$

1oo2 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle_i}$

$T_{OFDT_i} = T_{WCDT_i} + T_{DIS}$

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time of the F-DI from a signal transition at the digital input to the reliable availability of the safety message frame available for the fail-safe CPU request.
T_{OFDT_i}	One Fault Delay Time: Maximum response time for the F-DI to report a channel as passivated.
T_{filter}	Configured "Input filters" time for the channel
T_{DIS}	Discrepancy time: • Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" • Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "0" for 1oo1 channels You should include the expected discrepancy time between your sensor inputs in your external sensor delay. Your configured T_{DIS} contributes to T_{OFDT} as the time delay for the F-DI to passivate the channel due to fault case extension of the discrepancy time. This parameter can be listed separately in the RT_calculator. Do not include T_{DIS} in the value of T_{OFDT} that you enter into the RT_calculator if you enter T_{DIS} as a separate item.
T_{sct}	Time delay for short-circuit test duration: • "0" if no short-circuit test configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in equation for T_{WCDT_i} if short-circuit test is configured.)
T_{scf}	Time delay for short-circuit fault detection: • Configured "Interval for short-circuit test", when operating in high demand or continuous mode and depending on the short-circuit test to achieve your required level of safety integrity • "0" when not depending on the short-circuit test to achieve your required level of safety integrity
T_{cycle_i} 8 ms	Internal cycle time of F-DI

The term "2 x T_{cycle_i}" allows for other input delays to complete just after the beginning of a cycle. The F-DI processes and reports the changed input data on the next cycle.

C.3 Response time parameters for the SM 1226 F-DQ 4 x 24 VDC

Maximum Device Acknowledge Time of the SM 1226 F-DQ 4 x 24 VDC

T_{DAT_q} 12.98 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the F-DQ DC to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

Maximum response time of the SM 1226 F-DQ 4 x 24 VDC

$T_{WCDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle_q}$

$T_{OFDT_q} = T_{WCDT_q}$

Where:

T_{WCDT_q}	Maximum response time of the F-DQ DC from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output
T_{OFDT_q}	One Fault Delay Time: Maximum response time for the F-DQ DC to turn an output OFF upon detection of a channel or module fault.
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel
T_{cycle_q} 8 ms	Internal cycle time of F-DQ DC

The term "2 x T_{cycle_q}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The F-DQ DC processes the changed output request and applies new data to the output switches on the next cycle.

After the F-DQ DC commands the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Minimum permissible OFF time for SM 1226 F-DQ 4 x 24 VDC

The F-DQ DC expects to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than T_{WCDT_q} can cause the channel to passivate.

C.4 Response time parameters for the SM 1226 F-DQ 2 x Relay

Maximum Device Acknowledge Time of the SM 1226 F-DQ 2 x Relay

T_{DAT_r} 11.93 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the F-RLY to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

Maximum response time of the SM 1226 F-DQ 2 x Relay

T_{WCDT_r} **= 30 ms + 2 x** T_{cycle_r}	OFF to ON
T_{WCDT_r} **= 30 ms + 2 x** T_{cycle_r}	ON to OFF, normal transition with no fault
T_{WCDT_r} **= 70 ms + 2 x** T_{cycle_r}	ON to OFF, fault case, last-on/first-off relay in sequenced pair stuck ON

$T_{OFDT_r} = T_{WCDT_r}$

Where:

T_{WCDT_r}	Maximum response time of the F-RLY from the receipt of a safety message frame from the safety program in the fail-safe CPU to the relay contacts fully responding
T_{OFDT_r}	One Fault Delay Time: Maximum response time for the F-RLY to turn an output OFF upon detection of a channel or module fault.
T_{cycle_r} 8 ms	Internal cycle time of F-RLY

The term "2 x T_{cycle_r}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The F-RLY processes the change request and applies new data to the relay on the next cycle.

Minimum permissible OFF time for SM 1226 F-DQ 2 x Relay

The F-RLY expects to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than "T_{min_off}" can cause the channel to passivate.

$T_{min_off} = 2 \times T_{cycle_r} + 150$ ms

SIEMENS
SIMATIC

Automation system S7-1200
Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

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

EU and UK Declaration of Conformity
- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/13683/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/13683/cert?ct=444&ci=5596).

Firmware
You will find the latest firmware versions for the automation system (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/search?t=all&search=S71200&type=Download&lc=zh-WW).

Documentation
The complete documentation for the automation system consists of product information documents, the system manual and the Easy Book. You will find these on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109744173).

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

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.
1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173)**.**

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

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173) and on the nameplate of the device.

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

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Only install products with IP20 degree of protection according to IEC 60529 in enclosures, cabinets, or electrical equipment rooms suitable for the end use that meet at least this degree of protection.

⚠ WARNING

Electric shock due to externally supplied plant units
Even if the main supply to the plant is disconnected, externally supplied plant units can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.
Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Electric shock due to permissible electric potential difference

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

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

⚠ WARNING

Safety functional extra low voltage

The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173) of the fail-safe I/O and in the data sheets of the power supplies to be used.

Use a power supply unit with output voltage that does not exceed 35 V DC even in the event of a fault.

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

Follow the notes and warnings in the respective manual.

Electromagnetic Compatibility

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

Ensure that your automation system is installed in compliance with EMC requirements, as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173) for the product.

NOTICE

Interference emission / Interference immunity

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

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

ATEX-/UKEX device intended for use in hazardous area

If the product is intended for use in a potentially explosive atmosphere (gas/air or gas/dust mixture), observe the special information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173). The intended use (e.g. ATEX zone, degree of protection, temperature class) is indicated on the product (in the declaration of conformity and usually also on the nameplate).

NOTE

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

Safety in potentially hazardous atmospheres
SIMATIC systems are suitable for use in zones with occasional presence of hazardous gas atmospheres (equipment group II, Cat. 3, gases, vapors, mists). You can find information, restrictions and special conditions in the respective system manuals. To avoid damage, determine a suitable installation location and select suitable products. It is mandatory to define the following points before planning your automation system:

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

⚠ WARNING

Explosion hazard
If work in areas with potentially hazardous atmospheres is not carried out correctly, an explosion may occur. Explosions can lead to serious personal injury or damage to the plant.
Only suitably qualified specialists are allowed to plan and perform activities in areas with potentially hazardous atmospheres. In hazardous areas, always de-energize the SIMATIC system before starting activities.

Cleaning
If you need to clean the product, use dry ESD cleaning cloths (observing the protective measures for ESD).
Requirement: All supply voltages present on the device are switched off. Observe the five safety rules for working in and on electrical installations.

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

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

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173).

Functional safety

⚠ WARNING

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

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components. For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173) especially for:

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

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109744173).

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether the firmware version is approved for the respective fail-safe I/O.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

2 Use of radio devices and cell phones

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
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SIEMENS

SIMATIC
S7-1200
S7-1200 Firmware update V4.6
Product Information

Description

This firmware update provides the following feature improvements and functional changes:

- Increased work memory for S7-1200 CPUs:
  - CPU 1211C is now 75 Kbytes.
  - CPU 1212C is now 100 Kbytes.
  - CPU 1214C is now 150 Kbytes.
  - CPU 1215C is now 200 Kbytes.
  - CPU 1217C is now 250 Kbytes.
  - CPU 1212FC is now 150 Kbytes.
  - CPU 1214FC is now 200 Kbytes.
  - CPU 1215FC is now 250 Kbytes.
- The CPU disables SNMP by default.

Follow the links provided below for information on previous firmware update versions:

- V4.5.2 (https://support.industry.siemens.com/cs/ww/en/view/109806180)
- V4.5.1 (https://support.industry.siemens.com/cs/ww/en/view/109800925)
- V4.5.0 (https://support.industry.siemens.com/cs/ww/en/view/109797782)
- V4.4.1 (https://support.industry.siemens.com/cs/ww/en/view/109780308)
- V4.4.0 (https://support.industry.siemens.com/cs/ww/en/view/109773087)
- V4.3.1 (https://support.industry.siemens.com/cs/ww/en/view/109767000)
- V4.3.0 (https://support.industry.siemens.com/cs/ww/en/view/109764327)
- V4.2.3 (https://support.industry.siemens.com/cs/ww/en/view/109760967)
- V4.2.2 (https://support.industry.siemens.com/cs/ww/en/view/109756819)
- V4.2.1 (https://support.industry.siemens.com/cs/ww/en/view/109746398)
- V4.2.0 (https://support.industry.siemens.com/cs/ww/en/view/109741628)
- V4.1.3 (https://support.industry.siemens.com/cs/ww/en/view/109479125)
- V4.1.2 (https://support.industry.siemens.com/cs/ww/en/view/109478025)
- V4.1.1 (https://support.industry.siemens.com/cs/us/en/view/109550831)

Required user action

You can update the CPU firmware using one of the following methods:

- The Web server
- The Online & diagnostics functions of STEP 7
- The SIMATIC Automation Tool
- A SIMATIC Memory Card that contains the firmware update file from the Siemens Industry Online Support site

The S7-1200 System Manual and the SIMATIC Automation Tool User Guide document these methods.
After you apply the CPU firmware update, verify that your application operates as expected.

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Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
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SIMATIC

S7-1200 G2 F-IO

Equipment Manual

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Introduction

1

Purpose of the documentation

The S7-1200 G2 programmable logic controllers (PLCs) can control a variety of automation applications. Compact design, affordable price, and a powerful instruction set make the S7-1200 G2 CPU and IO devices a perfect solution for controlling a wide variety of applications. Together with the TIA Portal configuration and programming tool, you have the flexibility you need to design your automation solutions.

This manual provides information about the S7-1200 G2 Fail-safe IO. It contains information for engineers, programmers, installers, and electricians.

Required basic knowledge

To understand this manual, you need a general knowledge of automation and programmable logic controllers.

Validity of the documentation

This manual describes the S7-1200 G2 Fail-safe IO.

Refer to the technical specifications for each IO device in the S7-1200 G2 Fail-safe family.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

ID link for the digital nameplate



The ID link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product.

The figure shows an example of an ID link for the SM 1226 F-DI 4x, F-DQ 2x, DI 2x.

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

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

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

⚠ WARNING

Risks when using a cellular phone in close proximity to an S7-1200 G2 system
Using a cellular phone in close proximity to an S7-1200 G2 system with cellular and Wi-Fi communications active can cause unpredictable behavior.
To reduce any influence of a cellular phone on the S7-1200 G2 system, and to ensure proper operation of your devices, place the phone in "Airplane mode" to disable cellular and Wi-Fi before bringing the phone into proximity (<10 cm) of the CPU.
Failure to comply with these guidelines can cause damage or unpredictable operation, which could result in death, severe personal injury, and/or property damage.

SiePortal Products & Services

The SiePortal Products & Services page provides the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://sieportal.siemens.com/en-us/products-services?tree=CatalogTree).

Certifications and approvals

Refer to the technical specifications for details on certifications and approvals.

Glossary

The definitions in the glossary provide an easy first reference for understanding the terms in this manual. Some terms have detailed formal definitions in IEC 61508, EN ISO 13849, IEC 61784-3-3, and associated standards. These terms refer to broad safety concepts, for which the standards provide specific details.

1.1 Documentation guide

In addition to this manual, Siemens offers technical information at Siemens Industry Online Support (https://support.industry.siemens.com/cs/start?lc=en-US). You can also find other resources online.

Contact your Siemens distributor or sales office for assistance in answering any technical questions, for training, or for ordering S7 products. Because your sales representatives are technically trained and have specific knowledge about your operations, processes, and industry, as well as the individual Siemens products that you are using, they can provide the fastest and most efficient answers to any problems you might encounter.

Maintaining operational safety of your plant

NOTE

Operators of plants with safety-related features must meet operational safety requirements. Suppliers must also take measures when monitoring products.
To stay up-to-date on the latest operational safety requirements, visit the Siemens Industry Online Support (https://support.industry.siemens.com/cs/start?lc=en-US) site and subscribe to email notifications:
Log onto Industry Online Support. Go to the following links and click "email on update":

- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/products?mfn=ps&pnid=13917&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200 G2/SIMATIC S7-1200 G2 F (https://support.industry.siemens.com/cs/us/en/ps/30068)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

NOTE

To reduce the risks associated with malicious or counterfeit CPUs and modules, use only official sales channels, such as the following:

- SiePortal Products & Services
- Official Siemens distributors
- Country-specific official Siemens sales and distribution channels

NOTE

To reduce the risks associated with compromised CPU or module firmware, only download firmware from the Siemens Industry Online Support website and verify the file integrity against the associated published SHA checksum.

NOTE
To reduce the risk of physical tampering with critical industrial equipment, implement the measures defined in the Operational guidelines (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity/downloads.html).

NOTE
For additional security, the CPU uses firmware encryption. While encryption provides confidentiality of the firmware, the main purpose is to enhance the secure boot process.

1.2 SIMATIC Technical Documentation

S7-1200 G2 and the TIA Portal provide a variety of documentation and other resources for finding the technical information that you require.

- The *S7-1200 G2 Programmable Logic Controller System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109997791) presents an overview of the Siemens Safety software and fail-safe CPUs. However, the focus of the *S7-1200 G2 F-IO Manual* is the S7-1200 G2 Fail-safe IO modules. IO configuration, diagnostics, applications, and technical specifications are emphasized.

  The English version of the *S7-1200 G2 F-IO Manual* is the authoritative (original) language for Functional Safety-related information. All translated manuals refer back to the English manual as the authoritative and/or original source. Siemens identifies the English manual as the authoritative and/or original source in the case of discrepancies between the translated manuals. The *S7-1200 G2 Programmable Logic Controller System Manual* provides specific information about the operation, programming, and the specifications for the complete S7-1200 G2 product family.
- The *S7-1200 G2 F-IO Manual; SIMATIC Safety - Configuring and Programming, Programming and Operating Manual;* and the *S7-1200 G2 Programmable Logic Controller System Manual* are available as electronic (PDF) manuals. You can download or view the electronic manuals from the Siemens Industry Online Support Web site (http://support.industry.siemens.com).
- The TIA Portal Information System provides immediate access to the conceptual information, specific instructions, and error code event IDs that describe the operation and functionality of the programming package and basic operation of SIMATIC CPUs and IO modules.
- The Siemens Industry Online Support Web site (http://support.industry.siemens.com) provides access to the SIMATIC documentation set. Existing documents are available from the Product Support link. With this online documentation access, you can also drag and drop topics from various documents to create your own custom manual.

  You can access online documentation by clicking "mySupport" from the left side of the page and selecting "Documentation" from the navigation choices. To use the mySupport Documentation features, you must sign up as a registered user.

- Siemens also provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, functional examples guide you in your safety applications, and Siemens Training (SITRAIN) classes offer training in safety standards and products, while you can easily calculate your reaction times for fail-safe devices with the RT_calculator file. Visit the following web sites to access these supports:
  - Safety Evaluation Tool (http://www.siemens.com/safety-evaluation-tool)
  - Functional examples (http://www.siemens.com/safety-functional-examples)
  - SITRAIN (http://www.siemens.com/sitrain-safetyintegrated)
  - SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT_calculator) (https://support.industry.siemens.com/cs/ww/en/view/58856512)

TIA Selection Tool

With the TIA Selection Tool (https://support.industry.siemens.com/cs/us/en/view/109767888), you can select, configure, and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

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

SINETPLAN

SINETPLAN (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html), the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

Overview of the SIMATIC Technical Documentation

Here you will find links to technical support and to videos providing an overview of the SIMATIC documentation available in Siemens Industry Online Support:



Industry Online Support International (http://support.industry.siemens.com)



Quick introduction to the technical documentation of automation products (https://support.industry.siemens.com/cs/ww/en/view/109742705)



YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://www.youtube.com/watch?v=TwLSxxRQQsA)

AI-powered online support chat

The "AskSUPport" function (https://support.industry.siemens.com/cs/ww/en/view/109974274) is an advanced AI-controlled platform that gives you access to the powerful knowledge base of the Siemens Support Portal (https://sieportal.siemens.com/en-ww/support). You do not just receive mechanical answers to your questions, but precise, interactive informational material. This allows you to effectively speed up your research and decision processes.

You can also access the entry by means of the "AI powered Online Support Chat" command in the "Help" menu in TIA Portal.

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

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

Refer to the SIMATIC S7-1200 G2 Programmable Logic Controller (https://support.industry.siemens.com/cs/ww/en/view/109997791) System Manual for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

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

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

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

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

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

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

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
The security "Defense in Depth" strategy for the product to support installation, operation, and maintenance	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Guidelines for performing security hardening during installation and maintenance of the product	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Security properties of the product	
Access protection	Note the information on the topic of access protection in the "Protection" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Secure operation	
Recommendations for secure operation	Information on the secure operation of interface modules can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Account management guidelines	You can find Information on access control, user rights, and default accounts in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Security update notifications	You can find Information on security patches for dependent components and operating systems and how to install them in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).

Topics with cybersecurity-relevant information	Reference
Integrity	
Integrity of documentation and other important files	You can find information on how to verify the integrity of documentation and file downloads like firmware updates using checksums on the SiePortal (https://support.industry.siemens.com/cs/ww/en/view/109483101) website.

Guide to S7-1200 G2 F-IO

3

3.1 Hardware and software components

Fail-safe CPUs

You can use any of the following fail-safe CPUs as of FW version V4.1.2 with the S7-1200 G2 F-IO:

- 1212FC
- 1214FC

A fail-safe system requires a fail-safe CPU with fail-safe local I/O and/or fail-safe distributed I/O.

Required software components

You require a STEP 7 V21 Basic / Professional license, which includes STEP 7 Safety Basic as an integral product.

STEP 7 V21 is the configuration and programming software for the SIMATIC Safety fail-safe system. STEP 7 V21 includes the following:

- Support for configuring the fail-safe CPUs and I/O in the hardware and network editor of the TIA Portal
- Support for creating the safety program using LAD and FBD to integrate error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD

You may require a Hardware Support Package (HSP) which corresponds with used devices and their firmware versions. To install an HSP from the TIA Portal, select "Options > Support packages". If downloading from the internet, click "Download from the internet" and enter the MLFB of the F-module to find and install the corresponding HSP.

3.2 Wiring

For information about wiring the S7-1200 G2 F-IO, refer to the *S7-1200 G2 Programmable Logic Controller System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109997791).

Wire temperature rating

Use wire and cable with a temperature rating that is 45 °C higher than the ambient temperature around the S7-1200 G2. Use the specific electrical circuit ratings and the installation environment to determine what other types of wiring and materials are needed.

3.2.1 Safety extra-low voltage requirement (power supplies and other system components)

⚠ WARNING

Operation of fail-safe modules with safe functional extra-low voltage (SELV, PELV) power sources

External connections to communications ports, analog circuits, 24 V DC nominal power supplies, and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards. Failure to do so can result in the module's low voltage circuits becoming hazardous (for example, shock hazard).

The external power supply should limit the maximum voltage to 35 V DC even under fault conditions. Consult the manufacturer's data for the power supplies that you use.

Failure to use an appropriate external power supply can result in death, severe personal injury, and/or property damage.

Maximum applied voltage to S7-1200 G2 Fail-safe devices

- Operational voltage: The fail-safe CPU and fail-safe signal modules operational voltage is 20.4 V DC - 28.8 V DC. Design and testing assure operation of the unit to specifications. You can impose defined transients upon this voltage from defined source impedances per EN 61000-4-2, 61000-4-4, and 61000-4-6, as specified in the data sheet for each product, without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 V DC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 V DC. These power supplies must be specified by the manufacturer to limit the output voltage to 35 V DC or less under fault conditions. Otherwise, external protection must be supplied that will reliably open the circuit or limit the output voltage to less than 35 V DC to the CPU and signal modules.

Surge immunity

The S7-1200 G2 Fail-safe devices are equipped with internal protection for overloads coupled by surge voltage caused by lightning that meets the levels listed under "IEC 61000-4-5 Surge immunity" in the *S7-1200 G2 Programmable Logic Controller* (https://support.industry.siemens.com/cs/ww/en/view/109997791) System Manual. If you need higher limit values, then you need to use external protective circuits, for example a surge filter, between the voltage power supplies and the voltage input of the module to ensure surge immunity for the S7-1200 G2 Fail-safe device. Additionally, you need to use external protection between the I/O and the sensors/actuators to which the module is connected.

You can find more information in the function manual *Designing interference-free controllers* (https://support.industry.siemens.com/cs/ww/en/view/59193566).

Requirements for power supplies in the event of voltage interruption

To ensure adherence to IEC 61131-2, only use power packs/power supply units (https://support.industry.siemens.com/cs/ww/en/) with a main buffering time of at least 10 ms for DC power or 1/2 AC cycle. The port that powers the CPU meets IEC61131-2 rating of PS2 with an interruption time of 10 ms for DC power and 1/2 AC cycle for AC power. Observe the relevant requirement in your product standards (for example, 30 ms for Burner applications according to EN 298) regarding possible voltage interruptions. The latest

information on PS components is available on the Internet (https://support.industry.siemens.com/cs/ww/en/).

⚠ WARNING

Connection and isolation of power supplies and fail-safe module circuits
The power supply M terminals on the fail-safe CPU and the fail-safe SMs must be connected together or isolated as SELV. Failure to do so can result in unexpected operation.
Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to SM isolation boundary.
Unexpected operation can result in death, severe personal injury, and/or property damage.

3.3 Additional rules and regulations for the operation of the S7-1200 G2 with fail-safe modules

3.3.1 Requirements for sensors and actuators for fail-safe modules

When using sensors and actuators in safety-related applications, observe the following general requirements.

⚠ WARNING

Safety-related responsibility
Instrumentation with sensors and actuators bears a considerable safety responsibility. Also bear in mind that sensors and actuators generally require proof-test intervals that are more frequent than the service life of Siemens products, which is generally 20 years.
The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. You can find a listing of values achieved by each F-module in its respective technical specifications.
To achieve the required safety class, suitably qualified sensors and actuators are necessary.
Failure to use suitably qualified sensors and actuators can result in death, severe personal injury, and/or property damage.

Additional sensor requirements

Generally, to achieve SIL 3/Cat. 4/PL e, a single-channel sensor is adequate. However, with a single-channel sensor, the sensor itself must be SIL 3/Cat. 4/PL e capable. Otherwise, two sensors must be used. To achieve SIL 3/Cat. 4/PL e, sensors must be connected to the module using two input channels.

⚠ WARNING

Additional sensor requirements
In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.
Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).
Failure to ensure that sensors are implemented to ensure reliable reaction of the safety program can result in death, severe personal injury, and/or property damage.

Duration requirements for sensor signals

⚠ WARNING

Duration requirements for sensor signals
To ensure the correct detection of the sensor signals by fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.
Failure to ensure that the sensor signals are output for a sufficient duration can result in death, severe personal injury, and/or property damage.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in "Fail-safe response times".

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly turns off outputs that are turned on and turns on particular switches of outputs that are turned off. You can assign the maximum duration of the test pulses (dark and switch-on period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the switch-on or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

Additional requirements for actuators
If the actuators switch voltages greater than 24 V DC (for example, 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).
This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.
Failure to provide proper electrical isolation can result in death, severe personal injury, and/or property damage.

Technical specifications of sensors and actuators

Refer to the technical specifications for each F-module to assist you in selecting sensors and actuators.

3.3.2 Crosstalk of digital input/output signals

Readback errors could occur on the F-DQ channels if the fail-safe digital output signals and fail-safe digital input signals are routed through a single cable.

Capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply test of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line could result in crosstalk to other non-activated output or input channels. This could then lead to a response of the readback circuit in these channels. The module detects a cross circuit/short-circuit, which leads to safety-related tripping.

To remedy this situation, do the following:

- Separate cables for fail-safe DQ modules and non-fail-safe DQ modules.
- Separate cables for F-DQ channels and F-DI channels.
- Couple relays or diodes in the outputs.
- Disable the sensor supply test if safety class requirements allow it.

Magnetic crosstalk

An inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

To remedy this situation, do the following:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

SM 1226 F-DI 4x / F-DQ 2x 2A PPM / DI 2x, 24VDC

4

4.1 Properties

Article number

6ES7226-6ME50-0XB0

View of the module



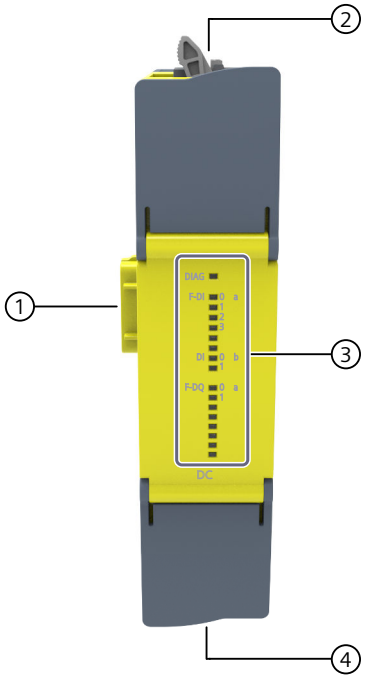
Properties

The SM 1226 F-DI 4x, F-DQ 2x, DI 2x module has the following technical properties:

- Four 24 V DC fail-safe input channels, which can be configured as up to four fail-safe 1oo1 (1 out of 1) process inputs, up to two fail-safe 1oo2 (1 out of 2) process inputs, or as combinations thereof
- Two 24 V DC fail-safe output channels, which can be configured to operate in either PP or PM mode
- Two 24 V DC standard input channels

4.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the SM 1226 F-DI 4x, F-DQ 2x, DI 2x module:



① Bus connector
② F-DI / DI connectors
③ LED displays for channel status/fault/DIAG
④ F-DQ connectors

4.3 Functions

4.3.1 Module functions

4.3.1.1 Overview

The module supports the following functions:

Module

- Firmware update
- Identification and maintenance data I&M0

Fail-safe

- Fail-safe digital inputs
- Fail-safe digital outputs
- Embedded safety functions

Standard

- Standard digital inputs

4.3.2 Fail-safe functions

4.3.2.1 Fail-safe digital inputs

The fail-safe digital inputs are rated for connection to 24 V DC sensors/switches and have an IEC61131 Type 1 input rating.

The fail-safe module has four sensor supply outputs that can power external sensors (inputs). You can configure each fail-safe digital input to provide sensor supply or external power to any channel.

You can integrate these sensors directly as inputs into safety functions that are embedded within this F-module to control F-outputs. By configuring the F-inputs in this way, you can achieve faster reaction times when these sensors are used by the embedded Emergency Stop and/or Internal Evaluation safety functions.

Inputs and test circuit

The fail-safe digital inputs consist of four input channels (F-DI x.0 to x.3). You can configure these inputs as four 1oo1 inputs (SIL 2/Cat. 3/PL d), two 1oo2 inputs (SIL 3/Cat. 3 or Cat. 4/PL e), or combinations of 1oo1 and 1oo2 inputs.

Connections	Input channel pairs
X10	0 and 2, 1 and 3

One microcontroller monitors inputs 0 and 1, and the other microcontroller monitors inputs 2 and 3. The corresponding channels (0, 2) and (1, 3) each form a 1oo2 channel group. The first of the two fail-safe inputs conveys the signal in a 1oo2 configuration. For example, if you wire x.0 and x.2 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal appears at only the x.0 input when you close or open the circuit for both. This also applies to the channel quality.

When you configure a channel group as 1oo2, the two microcontrollers must sense an appropriate input change within a configured time. Otherwise, the module reports a discrepancy error.

If you use a sensor supply output to provide power to a sensor, you can enable short-circuit testing. The short-circuit test checks for shorts to 24 V DC on your inputs by periodically pulsing the sensor output off and verifying that the associated input is off. The sensor supply can also detect shorts to 24 V DC and ground on the sensor supply itself. The short-circuit test also detects cross-connected shorts between sensor supplies and inputs.

4.3.2.2 Fail-safe digital outputs

The fail-safe digital outputs are for use in fail-safe applications and are suitable for various actuators, including solenoid valves, DC contactors, and indicator LEDs. The two fail-safe digital outputs have PP- or PM-switching that are rated for connections to 24 V DC actuators with up to a 2.0 A rating. The fail-safe SM digital outputs use the supply voltage 2L+.

Outputs

The fail-safe digital outputs consist of two output channels (F-DQ x.0, x.1). You can use each output for SIL 3, Cat. 4, PL e applications (including dark test disabled for 48 hours).

Connections	Output channels
X11	0 and 1

Each output consists of three switches:

- Two P-switches (in series) connect 24 V DC positive (L+) through the load.
- An M-switch connects the load to M or to a 24 V DC return.

When the output is in PM mode, there are two connection points (wires). There is one wire for the P-switch and one wire for the M-switch. When the output is in PP mode, there is one connection point (wire). This single wire goes in the P-switch.

The fail-safe digital outputs use two microcontrollers to implement the safety function. One microcontroller controls one P-switch, while the other microcontroller controls the other P-switch and the M-switch. There is feedback from each of these switches to the opposite microcontroller. The feedback verifies that the output switches are operating properly and in the commanded state.

You can configure a "Max. readback time" in STEP 7 device configuration ("F-I/O parameters" > "Output parameters") that specifies the maximum amount of time that the output channel waits for the voltage to respond when the process value changes. The higher the capacitance of the connected load, the higher your set value for "Max. readback time" must be.

The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. Your configured "Max. readback time" sets the duration of the "OFF" test pulse. Your configured "Max. readback time switch on test" sets the duration of the "ON" test pulse. Choose short enough durations to not affect your load. You can disable the "OFF" test pulse with the "Disable dark test for 48 hours" parameter or with the "Disable dark test" parameter. If you select the "Disable dark test" parameter, you can only use the output for SIL 2, Cat. 3, PL d applications.

The module can detect a broken wire or missing load only when the output PV is "OFF" and the load is wired in PM mode.

4.3.2.3 Embedded safety functions (ESFs)

The fail-safe module can perform additional important safety functions with local I/O, such as Emergency Stop and Internal Evaluation. Additionally, you can chain these safety functions together by use of their internal logic results. When using the ESFs, you can achieve significantly faster reaction times.

The module provides two configurable Emergency Stop safety functions and two configurable Internal Evaluation safety functions.

When using ESFs, the module can override the process value from the F-CPU to "0" if the module invokes an ESF. Additionally, when the F-CPU sets the module's output(s) to "1" and the module clears the invocation of the ESF, the module stops overriding the output. This

allows the F-CPU to resume controlling the process value to the output(s). The following table explains this principle:

Table 1-115 ESF truth table

F-CPU PV	ESF State	ESF PV Override	Output State	Description
0	Invoked	Override to 0	0	The ESF is overriding the process value from the F-CPU to "0".
0	Not invoked	No override	0	The F-CPU is in full control of the output(s).
1	Invoked	Override to 0	0	The ESF is overriding the process value from the F-CPU to "0".
1	Not invoked	No override	1	The F-CPU is in full control of the output(s).

The ESFs provide significantly faster reaction times because the module no longer solely depends upon the F-CPU to set the output(s) to "0". This eliminates the F-CPU safety program overhead and communication overhead from the total reaction time (Page 94) to turn the output off.

NOTE

The numbered inputs for the ESFs, such as "Input #1" or "Emergency Stop 0", which are configurable in STEP 7 device configuration under "General > Safety Functions", do not correlate to the physical inputs of the fail-safe module.

Emergency Stop (Estop)

The module's Estop function is a safety measure used to de-energize the desired machine function(s). When activated in STEP 7 through Device configuration under "Safety Functions" > "Emergency Stop" and subsequently downloaded, the module begins to evaluate the configured Estop input to determine the state of the Estop button.

When the module detects that the Estop button is pressed, the module overrides the process value provided from the F-CPU to "0". The configured Estop output is de-energized in this state. If the Estop "Stop category" parameter is configured for delayed deactivation, the output remains energized from the configured Estop "Delay time" before the module overrides the process value to "0".

When the module detects that the Estop button has been reset, the user acknowledgement process is initiated if the Estop "Acknowledge necessary" is set to "Manually using rising edge". The module sets the "Acknowledge requested output" in the process image to "1", indicating that the Estop is ready to be acknowledged. You can then perform acknowledgement with the configured "Acknowledge input" by setting it from "0" to "1".

Once acknowledgement is complete, the module removes the override of the process value from the F-CPU.

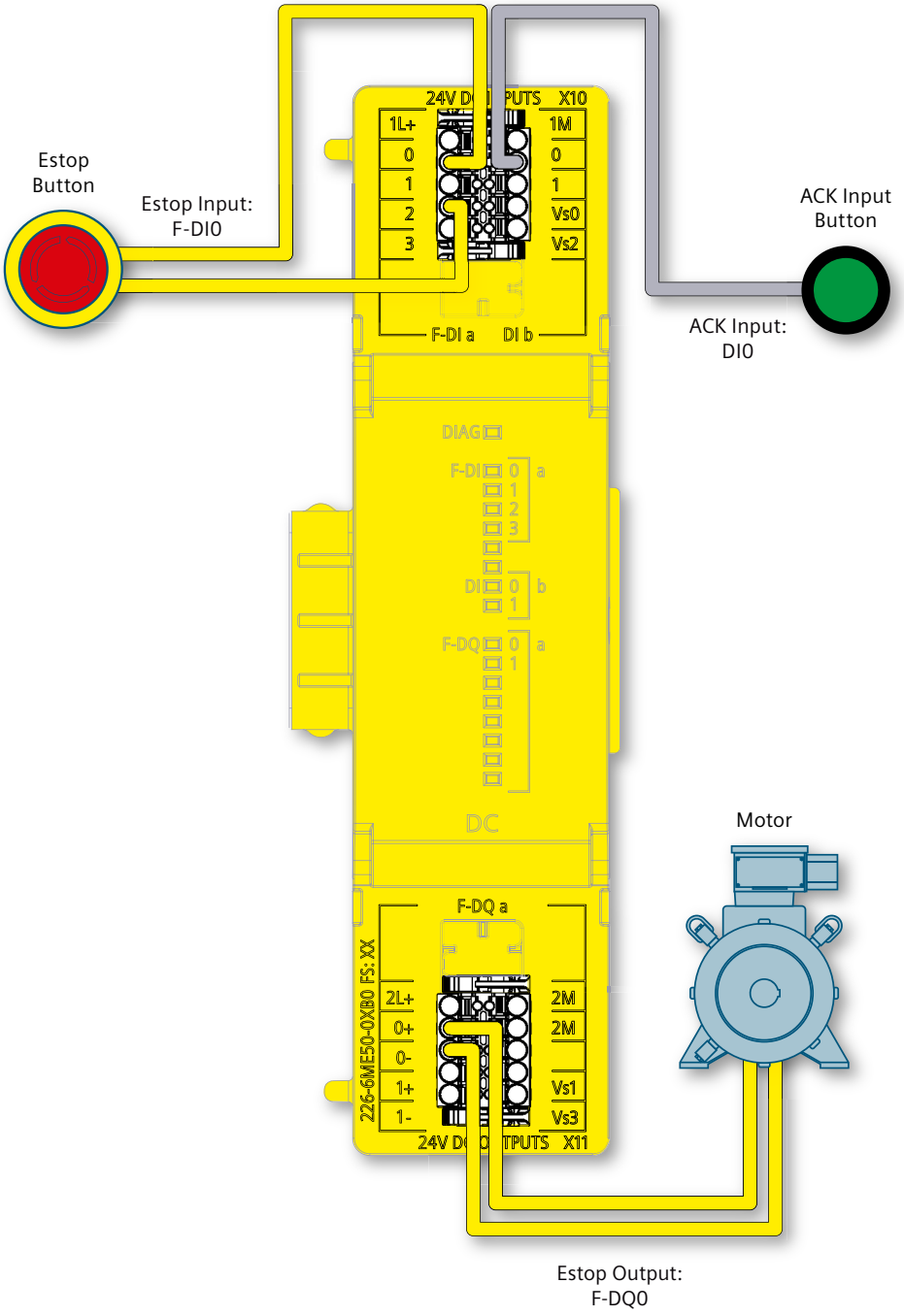


Figure 1-11 A motor controlled by the module's Estop with local I/O for acknowledgement process

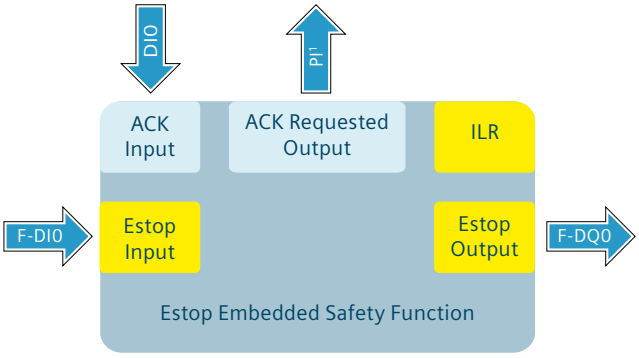


Figure 1-12 Visualization of module parameter assignment

[1]Process Image

Internal Evaluation (IE)

The module's IE function is a safety measure used to immediately de-energize the desired machine function(s). When activated in STEP 7 through Device configuration under "Safety Functions" > "Internal Evaluation" and subsequently downloaded, the module begins to evaluate the configured IE input(s) to determine the state of the connected sensor(s) and/or chained safety functions.

The IE safety function performs a Boolean "AND" operation on the configured input(s).

If the evaluation of the configured input(s) evaluates to "0", the module invokes the safety function and overrides the process value from the F-CPU to "0" to de-energize the configured output(s).

If the evaluation of the configured input(s) evaluates to "1", then the module does not override the configured output(s).

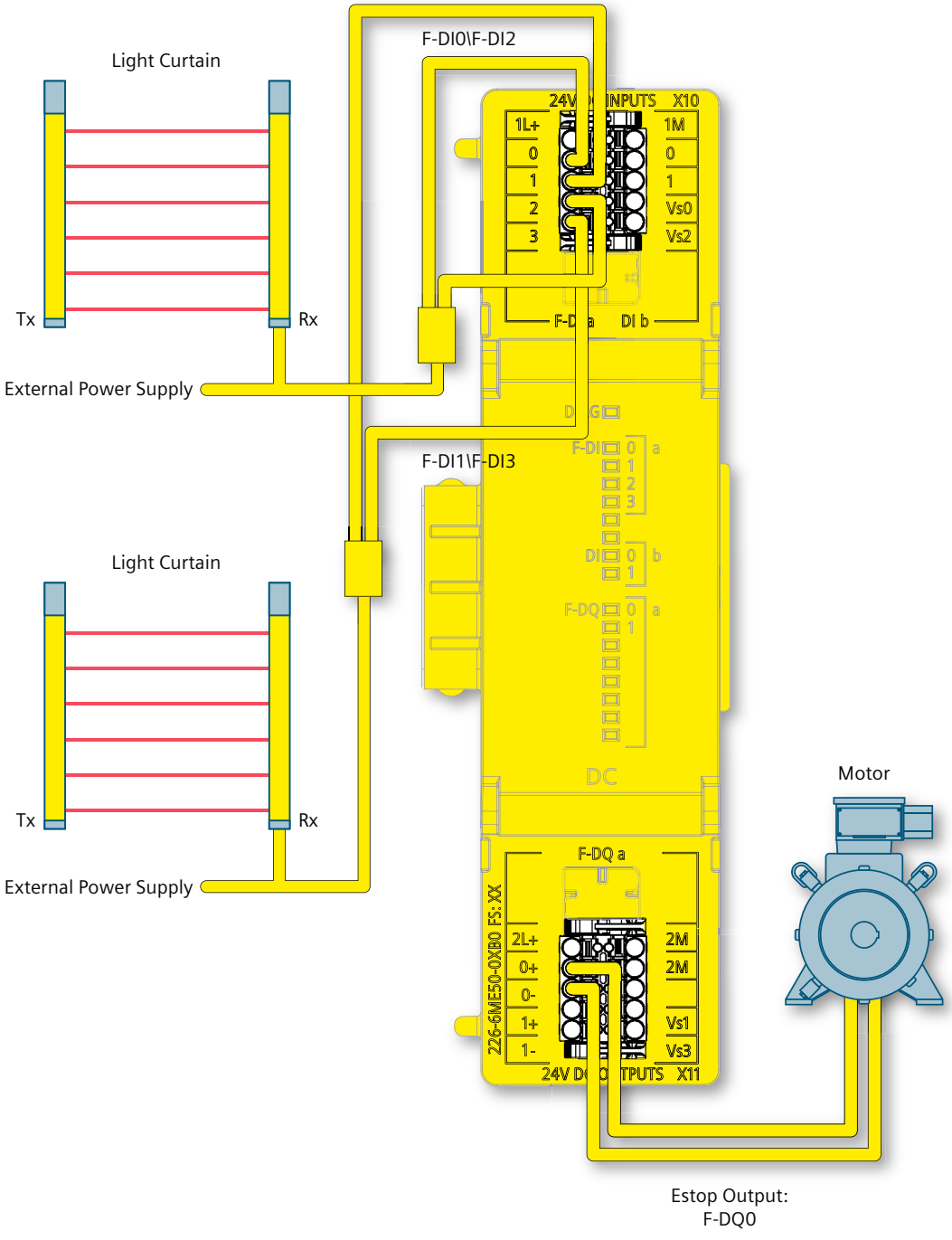


Figure 1-13 A motor controlled by the module's internal evaluation using light curtains

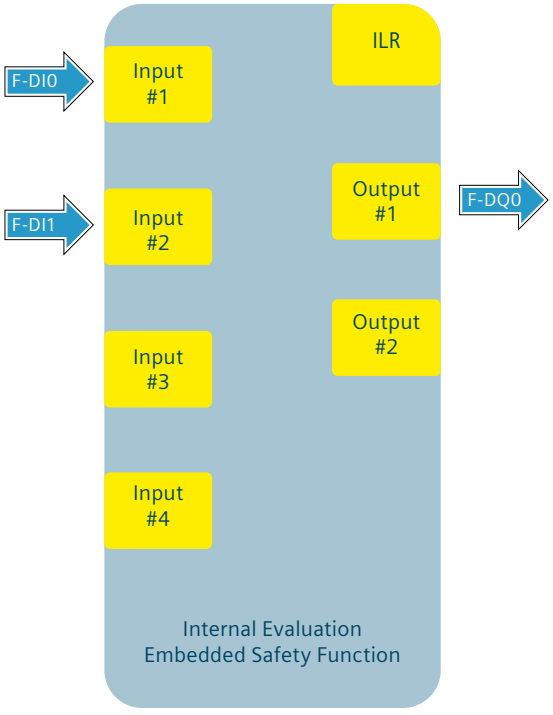


Figure 1-14 Visualization of module parameter assignment

Embedded safety function chaining

The module allows for chaining of embedded safety function outputs to safety function inputs.

In addition to applying the evaluation result of the ESFs to the configured output(s), each ESF provides the result of its evaluation as an Internal Logic Result (ILR). The ILR for each ESF is accessible at all times through the process image and as an input to another ESF.

You create an ESF chain by configuring the input(s) of an ESF to the ILR of another ESF. You can configure these ESF chains in different ways.

NOTE

You must not create a circular dependency within an ESF chain. A circular dependency occurs when the ILR of an ESF is used in another ESF that precedes it. If the module detects that you have configured a circular dependency, it generates a parameter error.

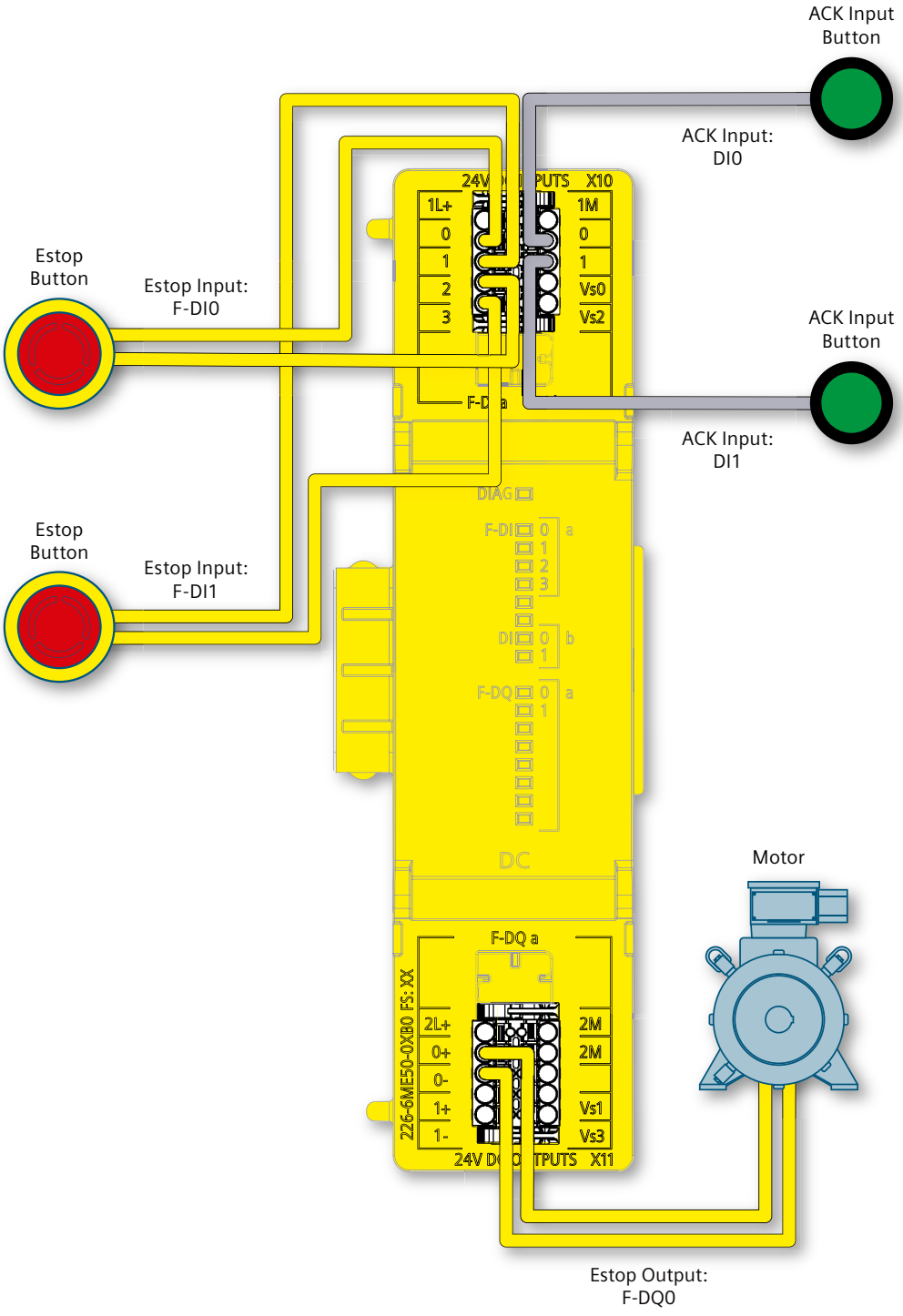


Figure 1-15 A motor controlled by the module's internal evaluation using two Estops

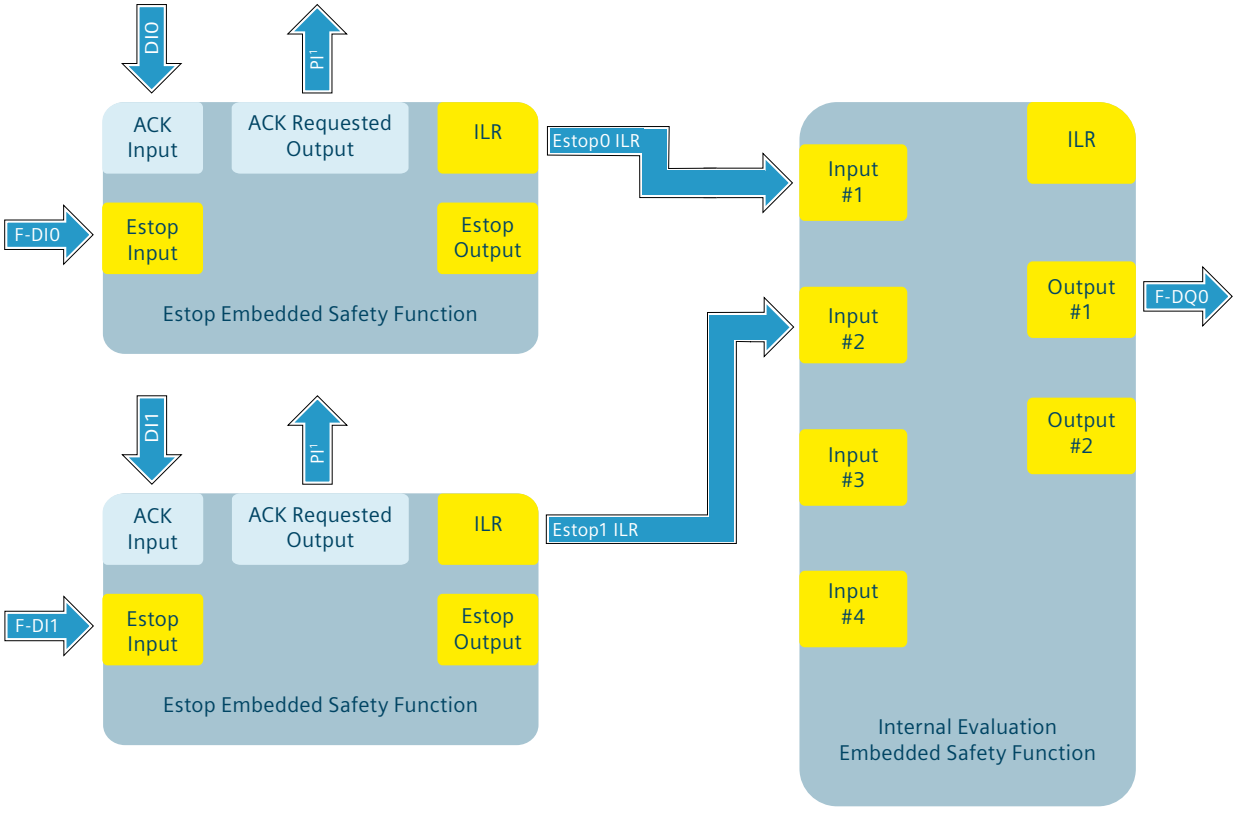


Figure 1-16 Visualization of module parameter assignment

[1] Process Image

4.3.3 Standard functions

4.3.3.1 Standard digital inputs

The standard digital inputs are rated for connection to 24 V DC sensors/switches and have an IEC 61131-2 Type 1 input rating.

Inputs and test circuit

The standard DI consists of two channels (DI x.0 and x.1).

Connectors	Input channel
X10	0 and 1

⚠ WARNING

Standard port safety ratings
Standard DI channels have no safety ratings and are not functionally safe. They should not be used in place of fail-safe I/O.
You must ensure that the appropriate I/O are used for your intended application.
Attempting to use standard I/O in place of fail-safe I/O in a safety related context could result in death, severe personal injury, and/or property damage.

4.4 Fail-safe IO

4.4.1 Parameters/address space

You use the STEP 7 Safety configuration software to configure the operating properties of all connected fail-safe SM I/O. You have the responsibility to ensure that no unconfigured SMs are connected in a fail-safe automation system.

⚠ WARNING

Configuring an F-System with mixed I/O
You cannot put an S7-1200 G2 Fail-safe system that provides safety-related functions into operation after installation or modification until after you successfully validate the safety-related functionality, as the fail-safe channels are potentially unsafe.
An S7-1200 G2 Fail-safe system that provides both safety-related functions and standard (non-safety-related) functions must not be put into operation in order to use the standard functions before you successfully validate the safety-related functions, even if all fail-safe signal modules go to the error state and thus, remain safe.
Failing to take proper precautions could result in death, severe personal injury, and/or property damage.

Configuring module I/O properties

To configure the fail-safe module's properties, follow these steps:

1. Select "Device configuration" for your module from the project tree.
2. Place the fail-safe module into your project's "Device view".

NOTE
The fail-safe module uses both I's and Q's. There are extra bytes allocated at the end of the address space that carry safety status and data integrity information.

Number of channels	Address (I/Q)	Bytes required
4 (fail-safe input) 2 (fail-safe output)	I Q	12 6

3. Select the image of the fail-safe module and view the module's "Properties" tab.
4. On the **"**Properties**"** view, select the **"**General**"** tab.
5. Click the module properties tree and expand the branches for the fail-safe module. You can select a module and see all the properties. You can also select a module branch (for example, "F-parameters", "DI-parameters", or "Channel parameters") and see a subset of the properties.
6. Select a property and set values in the appropriate fields.
7. A successful compile and download of your Device configuration to an S7-1200 G2 F-CPU automatically puts your new configuration settings in the I/O modules.

4.4.1.1 F-parameters

Parameters

You must configure the PROFIsafe addresses (F-destination address and F-source address) to the F-module before you put it into operation as follows:

- Configure the F-source address using the "Central F-source addresses" parameter in the Device configuration of the F-CPU.
- Configure the F-destination address using the "F-destination address" parameter in the Device configuration of each fail-safe module.
- Download the Device configuration to the F-CPU.

You can find further information on F-parameters such as the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address), F-parameter signature (with or without addresses) and the F-I/O DB in the *SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual*. (http://support.automation.siemens.com/WW/view/en/54110126/0/en)

The following table shows the F-parameters for the fail-safe module:

Table 1-116 Configurable F-parameters

Channel	Value range	Default	Scope
Manual assignment of F-monitoring time	• Unchecked • Checked	Unchecked	Module
F-monitoring time	16 to 65535	150 ms (disabled)	Module
F-source address	1 to 65534	1 (always disabled)	Module

Channel	Value range	Default	Scope
F-destination address	1 to 65534	65534	Module
F-parameter signature (with addresses)	0 to 65535	Always disabled	Module
F-parameter signature (without addresses)	0 to 65535	Always disabled	Module
Behavior after channel fault	• Passivate the entire module • Passivate channel	Passivate channel	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	All channels manually	Module
RIOforFA safety	-	Always disabled	Module
PROFIsafe mode	-	Always disabled	Module
PROFIsafe protocol version	-	Always disabled	Module
F-I/O DB manual number assignment	• Unchecked • Checked	Unchecked	Module
F-I/O DB number	• Fixed value, if DB manual number assignment is disabled • Value can be edited by user, if DB manual number assignment is enabled	Fixed value	Module
F-I/O DB name	-	Always disabled	Module

Explanation of the F-parameters

The following explanations describe parameters that you can set in STEP 7 Device configuration under "F-I/O parameters" > "F-parameters":

Behavior after channel fault

You can specify whether the entire F-module is passivated or only the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use the "Reintegration after channel fault" parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Set this parameter in the STEP 7 dialog of the fail-safe module as follows:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". You can specify the reintegration type of the respective channel with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.4.1.2 F-DI

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "F-I/O parameters" > "DI parameters" for the F-DI of the module:

Table 1-117 Configurable F-DI parameters

Parameter	Value range	Default	Scope
Sensor supply			
Short-circuit test	• Unchecked • Checked	Checked	Module
Duration of short-circuit test	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms	3.2 ms	Module
Startup time of sensor after short-circuit test	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms	3.2 ms	Module
Channel Group Settings			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation: – 2 channel - 4 wire equivalent – 2 channel - 3 wire non-equivalent – 2 channel - 4 wire non-equivalent	1oo2 evaluation, 2 channel - 4 wire equivalent	Channel
Discrepancy behavior	• Supply last valid value • Supply value 0	Supply value 0	Channel
Discrepancy time	5 ms to 30000 ms in 1 ms steps	500 ms	Channel
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	Channel
Channel Settings			
Activated	• Unchecked • Checked	Checked	Channel
Input filter	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms	3.2 ms	Channel

Parameter	Value range	Default	Scope
Channel failure acknowledge	• Manual • Automatic	Manual	Channel
Sensor supply	• Sensor supply 0 • Sensor supply 1 • Sensor supply 2 • Sensor supply 3 • External sensor supply	• Sensor supply x (where "x" is the respective channel number)	Channel

Explanation of the F-DI parameters

The following explanations describe parameters that you can set in STEP 7 Device configuration under "F-I/O parameters" > "DI parameters":

Short-circuit test

You can enable the short-circuit detection for the sensor supplies and the fail-safe input channels configured to use a sensor supply. Short-circuit test only applies to one activated single sensor supply at a time.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply.

The short-circuit test switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Duration of short-circuit test". When the sensor supply is turned back on, the module waits to evaluate the sensor signal until the sensor has powered on and the sensor signal has stabilized. The length of the startup time for the sensor is equivalent to the configured "Startup time of sensor after short-circuit test" parameter.

If the module detects a short-circuit, the fault is reported to the F-CPU and the entire module can be passivated.

The following short-circuits are detectable:

- Short-circuit of input to L+
- Short-circuit of the input to another channel when it has a "1" signal
- Short-circuit of the sensor supply to L+
- Short-circuit of the sensor supply to ground
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If you disable the short-circuit test, you must make your wiring short-circuit and cross-circuit proof or select a sensor evaluation type (discrepancy, nonequivalent) which can detect the cross circuits using discrepancy.

During the execution time (duration of short-circuit test + startup time of sensor after short-circuit test + input filter) of the short-circuit test, the state of the input before the start of the short-circuit test is provided. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

Duration of short-circuit test

You can specify the duration of the test pulse applied to the sensor supply when you select the check box "Short-circuit test".

This value is the time that the sensor supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs.

Short-circuit evaluations are dependent upon customer-selected input filter times. The means that you must take care to ensure that input filter time selections are appropriately chosen. These must be faster that the selected duration of short-circuit test settings; otherwise, the module might not detect potential sensor supply and/or input short-circuit errors because of inappropriate filter times.

Startup time of sensor after short-circuit test

You can specify the startup time after the short-circuit test completes when you select the check box "Short-circuit test".

This value is the time that the module waits to evaluate the sensor signal after it has powered on and the sensor signal has stabilized. This duration must be long enough to allow your sensor time to power on.

Sensor evaluation

You can specify signal evaluation and wiring definitions. These selections correspond with the various application mode wiring examples.

You can assign whether “channel n” input operates individually (1oo1) or is paired with its companion channel "n+2" input (1oo2).

1oo1 evaluation: One sensor is connected to the module on a single channel.

1oo2 evaluation: Two input channels are occupied by either:

- **2 channel - 4 wire equivalent**: One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair.
- **2 channel - 3 wire non-equivalent**: One two-channel non-equivalent sensor is connected to the two channels, in a channel pair.
- **2 channel - 4 wire non-equivalent**: One two-channel non-equivalent sensor or two single-channel non-equivalent sensors are connected to the two channels, in a channel pair.

If you select a 1oo2 evaluation mode, you can assign the discrepancy properties.

When you select the channel group as 1oo2, STEP 7 enables the parameters in the first channel of the group and disables the parameters in the second channel of the group. The second channel derives its parameter values from the first channel's parameter values. When you select the channel group as 1oo1, STEP 7 enables all of the parameters in both channels.

NOTE

Safety program access to 1oo2 input data

For 1oo2 evaluation, two paired input channels (for example, F-DI 0 and F-DI 2) are connected to one or two sensors. The F-DI module performs the discrepancy analysis and sends the result to the safety program at the input address of the low-ordered channel of the pair (in the above example, F-DI 0).

Discrepancy behavior

A 1oo2 input configuration allows a logical difference between the two signals, without error, for the configured discrepancy time. You assign the value that is supplied during a discrepancy to the safety program in the F-CPU between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

NOTE

Sensor-actuator response time is increased when you add more input discrepancy time
The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0" but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0" and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides normal operation. Refer to "Maximum fault reaction time for 1oo2 fail-safe digital input discrepancy errors (Page 91)" for further information.

Discrepancy time

The two signals in a 1oo2 input configuration will not change at exactly the same time, due to differences in sensors, contacts, and wiring. You can configure a maximum expected duration for a mismatch between signals during transition.

Discrepancy evaluations and other diagnostic evaluations are dependent upon customer-selected input filter times. These evaluations occur using input samples generated after input filtering is complete. This means that you must take care to ensure that input filter time selections are appropriately chosen. These must be faster than selected discrepancy time evaluations; otherwise, the module might not detect potential 1oo2 input discrepancy differences because of inappropriate filter times.

Reintegration after discrepancy error

You can assign whether a zero state must be detected on both 1oo2 inputs before a previously declared discrepancy can be reintegrated.

"Test 0-signal necessary"
If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels for a duration of at least 100 ms.

If you are using non-equivalent sensors, which means you have set "Sensor evaluation" to a non-equivalent mode, a 0-signal must be present at the low-order channel of the channel pair, and a 1-signal must be present at the high-order channel of the channel pair for a duration of at least 100 ms.

"Test 0-signal not necessary"
If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists between the two relevant input channels.

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

Input filter

The module filters the digital inputs to remove contact bounce and noise. This parameter assigns the duration of the filter time. As the filter time increases, the reaction times of the digital inputs also increase.

Channel failure acknowledge

You can specify in the F-Parameters (Page 32) whether the channel is automatically reintegrated after a fault clears or requires a manual acknowledgement. Refer to "Reactions to faults" for the reintegration procedure.

Sensor supply

You can assign whether to supply 24 V DC power to sensors from the module's integrated sensor supply (internal) or from an external power supply (external).

Short-circuit tests are not performed for any channel where external power is selected.

4.4.1.3 F-DQ

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "F-I/O parameters" > "DQ parameters" for the F-DQ of the module:

Table 1-118 Configurable F-DQ parameters

Channel	Value range	Default	Scope
Maximum test period	• 100 s • 1000 s	1000 s	Module
Channel settings			
Activated	• Unchecked • Checked	Checked	Module
Operating mode of the output	• PM-switching mode • PP-switching mode	PM-switching mode	Module
Channel failure acknowledge	• Manual • Automatic	Manual	Module
Max. readback time	1.0 ms to 400.0 ms in 0.1 ms increments	2.0 ms	Module
Max. readback time switch on test	0.5 ms to 5.0 ms in 0.1 ms increments	1.0 ms	Module

Channel	Value range	Default	Scope
Diagnosis: Wire break	• Unchecked • Checked	Unchecked	Module
Disable dark test for 48 hours	• Unchecked • Checked	Unchecked	Module
Disable dark test (max. SIL2, CAT3, PLd)	• Unchecked • Checked	Unchecked	Module

Explanation of the F-DQ parameters

The following explanations describe parameters that you can set in STEP 7 Device configuration under "F-I/O parameters" > "DQ parameters":

Maximum test period

You can assign the time interval between bit pattern tests for F-DQ DC outputs to a value of either 100 seconds or 1000 seconds.

The module applies test pulses to the output switches. These tests detect faulted P- or M-output switches and wiring faults. Short circuits to other signals or power rails can be detected by the module.

If the module detects an error on a channel, the test interval shortens to 60 seconds. If an error is no longer detected on any output channel, the configured test interval is used again.

A detected fault is reported to the fail-safe CPU, and the affected channels or the module is passivated according to the configured selection of the "Behavior after channel fault" parameter.

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

NOTE

Suspension of 2L+ undervoltage

Whenever you disable all output channels, you do not need to power 2L+. Undervoltage reporting is suspended for 2L+.

Operating mode of the output

You can specify whether the output channel is wired and whether it operates as a PM or PP output.

Channel failure acknowledge

You can specify in the F-Parameters (Page 32) whether the channel is automatically reintegrated after a fault clears or requires a manual acknowledgement. Refer to "Reactions to faults" for the reintegration procedure.

Max. readback time

You can configure a "Max. readback time" that specifies the maximum amount of time that the output channel waits for the voltage to respond when the process value changes. If any P- or M-switch does not reach the expected voltage within the readback time, the module passivates the output channel.

Your configured "Max. readback time" also sets the duration of the "OFF" test pulse during the bit pattern test. Choose a short enough duration where your load will not be affected.

The module does not apply new process values to the output channels while a test pattern is being applied to the outputs. This means that a higher "Max. readback time" increases the response time of the fail-safe module.

⚠ WARNING

Short-circuit (cross-circuit) detection might not be possible for high frequency signals
Through the configured "Max. readback time", short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured "Max. readback time") Hz cannot be detected by the module (50:50 sampling ratio).
You must take this into consideration for your application and respective requirements of your product standards.
Short-circuits (cross-circuits) to an output of the same module are recognized regardless of the frequency of the output channel.
You can adjust the maximum readback time to change the frequency of the signal that can be detected.
Short-circuits of high frequency signals that are undetected can result in death, severe personal injury, and/or property damage.

The parameter also effects the short-circuit detection (cross-circuit) with a "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time"

Siemens recommends that you set the "Max. readback time" as low as possible because the fault response time is extended by the configured value for this parameter; however, you must set this value to a high enough value where the module will not passivate the output channel as a result of your connected load.

You determine the readback time required for your actuator with the diagram in "Switching of loads (Page 96)".

If the capacitance of the actuator is not known, it might be necessary for you to determine the value for the "Max. readback time" by trial and error. This might also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time" so that the output channel can be read back correctly, but your actuator does not respond during a bit-pattern test sequence.
- For verification, use the process value "0" with a minimum duration that corresponds to the "Maximum test period" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated, the "Max. readback time" is too small for the connected capacitive load. The discharge cannot take place within the configured "Max. readback time". Increase the "Max. readback time".

If you have set the "Max. readback time" to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacitance is outside the permitted range.

Max. readback time switch on test

You can configure the "Max. readback time switch on test", which specifies the duration of the "ON" test pulse for any P- or M-switch during the bit pattern test. You must choose a short enough duration that does not affect your load.

Any pulse during the bit pattern test does not generate a light pulse in the absence of faults.

Any pulse during the bit pattern test under fault conditions can result in a light pulse, which can energize the load if the "Max. readback time switch on test" is long enough to affect the load.

Wire break

You can enable or disable wire break testing. The module can detect a broken wire or missing load only when the output PV is "OFF" and the load is wired in PM mode.

Disable dark test for 48 hours

You can select the checkbox to disable dark testing for 48 hours for a channel.

When you deactivate a channel's bit pattern dark testing for 48 hours, its process value is monitored for signal changes. If the channel's process value is "1" for 48 consecutive hours, the channel is included in an immediate output pattern test. If the test is successful, the 48-hour timer restarts. If the channel's process value is "0" at any point during the 48-hour period, a complete output pattern test is performed including the respective channel and, upon successful completion, the 48-hour timer restarts. If an entire output pattern test including the respective channel does not complete successfully, the 48-hour timer does not restart.

A complete pattern test including dark testing for the respective channel(s) is required to establish proper SIL 3, Cat. 4, PL e behavior.

If you select the disable dark test for 48 hours for any channel(s) and a short-circuit or readback error is detected upon the demand of the safety function for any other channel, such as where a P- or M-switch controlling the load fails to open when commanded, a channel error is declared for each channel where you have enabled the disable dark test for 48 hours parameter.

NOTE

Unused switches

The above requirement does not apply to unused switches, such as the M-switch in a PP output configuration, as they do not control the load. As a result, errors on unused switches do not result in channel passivation. Therefore, errors detected on unused switches do not result in any passivation of channels selected for disabling dark test for 48 hours.

If channel(s) that you configured for disabled dark testing for 48 hours are passivated by the module as a result of failures from other channels, reintegration can occur once you have resolved all relevant errors from the other channel(s). When all the other channel(s) become available for reintegration, all channel(s) configured for disabled dark testing for 48 hours also become available for reintegration.

Disable dark test (max. SIL2, CAT3, PLd)

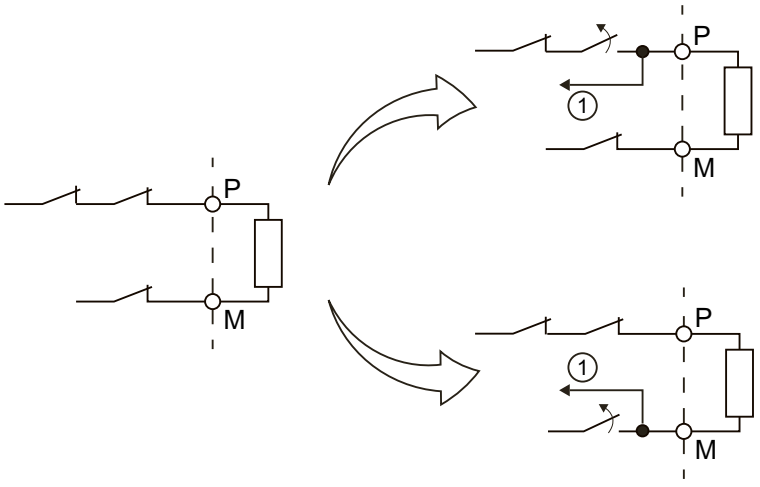
You can select the check box to disable dark testing for a channel.

Dark tests are switch-off tests which occur during an output bit-pattern test sequence.

For a dark test, one of the output channel's switches is briefly turned OFF while the output channel is active (output signal "1"). As a result, current flow through the output is interrupted for a short time. A sufficiently slow actuator does not respond to this and remains switched on.

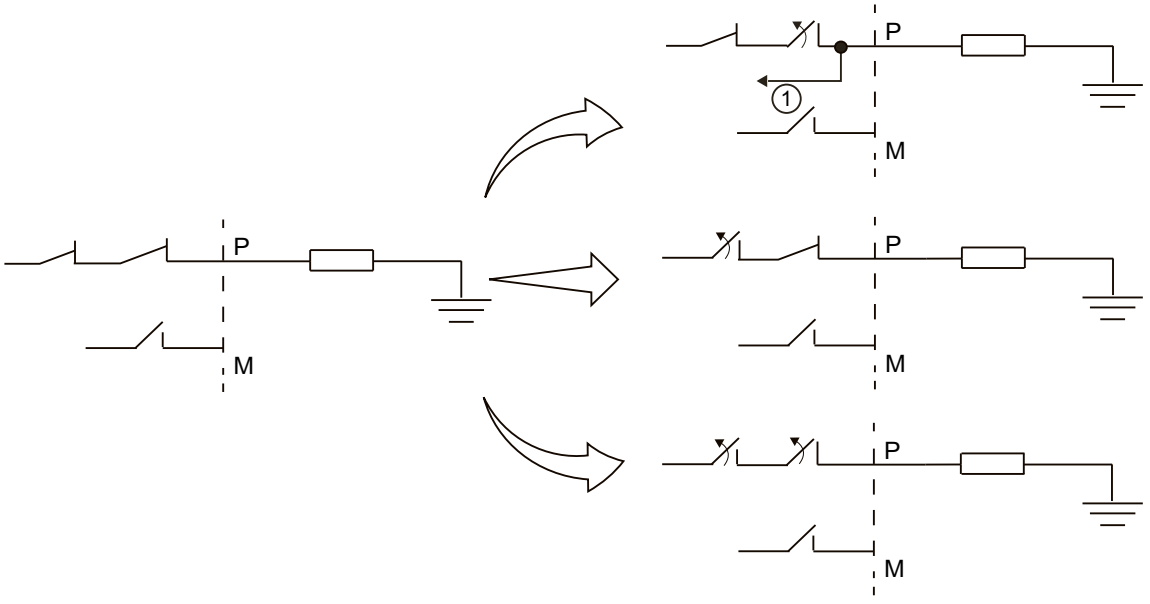
When the dark test is disabled on an output channel, the parameter "Max. readback time" is only relevant for the process value change.

Dark testing of a channel operates in the same manner for both PM- and PP-switching.



① Readback

Figure 1-17 Functional principle of the dark test (PM-switching)



① Readback

Figure 1-18 Functional principle of the dark test (PP-switching)

Test pulses of the dark test

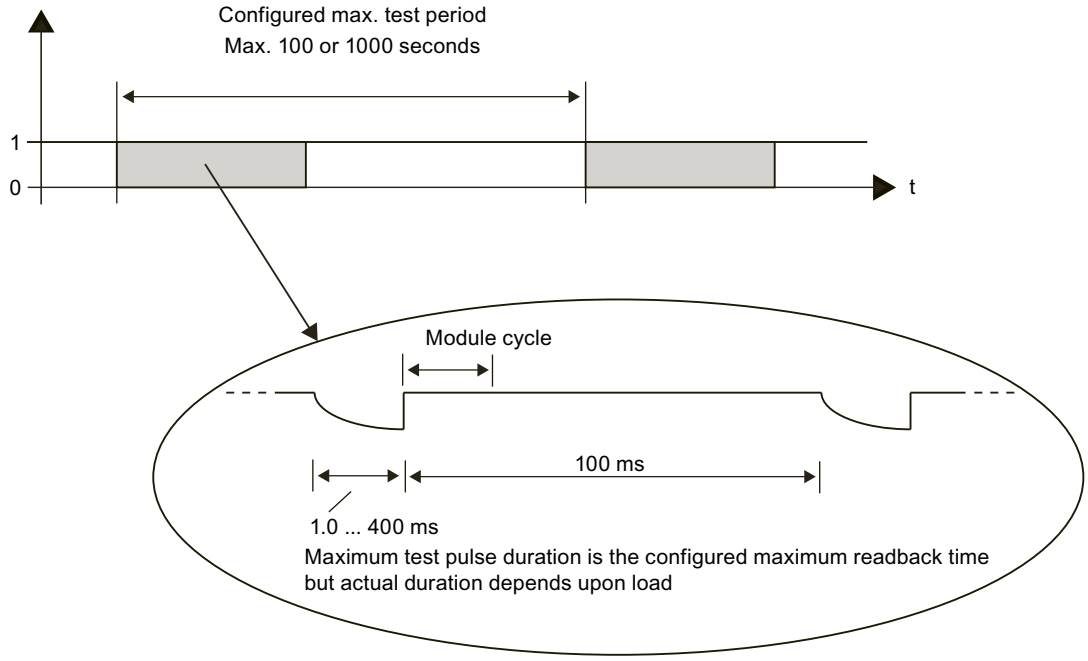


Figure 1-19 Test pulses of the dark test

You configure the time between output bit pattern test sequences to either 100 or 1000 seconds. Each output bit pattern test sequence includes multiple test pulses. The interval between two test pulses is at least 100 ms.

To prevent an unwanted reaction of the actuator to a dark test, you can also permanently disable the dark test individually for each F-output channel.

A capacitive load that does not meet the load curve (Page 96) can result in a passivation of the output in case of a process value change or switch-on test, even if the dark test is disabled.

With the dark test permanently disabled, you can only reach up to SIL 2/Cat. 3/PL d.

⚠ WARNING

Loss of SIL 2/Cat. 3/PL d rating, loss of output control due to potential undetected faults
SIL 2/Cat. 3/PL d requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. With the dark test disabled, an output that is turned on for more than 1 year might not be able to be turned off. This could result in an accumulation of undetected faults.
Ensure the "0" signal has a duration of at least 2 seconds. It is not enough to simply turn off the supply or load voltage of the F-module and turn it on again.
If control of an output is lost due to potential undetected faults, death, severe personal injury, and/or property damage can result.

⚠ WARNING

Reduction of short-circuit detection
When you use the function "Disable dark test", cross-circuits between channels with "1" signal are not detected. An undetected accumulation of faults could result in unexpected operation.
You must take this into consideration for your application and respective requirements of your product standards.
You must also take into consideration the respective requirements of your product standards regarding error detection time.
Unexpected operation can result in death, severe personal injury, and/or property damage.

I/O address parameters

The following table shows the parameters that you can set to specify F-input and F-output starting image register addressing:

Table 1-119 Configurable I/O address parameters

Parameter	Value range	Default
Input addresses		
Start address	0 to 1023	Calculated
End address	N/A	Calculated
Organization block	"---"	"---"
Process image	"---"	"---"
Output addresses		
Start address	0 to 1023	Calculated
End address	N/A	Calculated
Organization block	"---"	"---"
Process image	"---"	"---"

4.4.1.4 Embedded Safety Functions (ESF)

Estop

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Emergency Stop" for the Estop of the module:

Table 1-120 Configurable Estop parameters

Channel	Value range	Default	Scope
Emergency Stop activated	• Checked • Unchecked	Unchecked	Module
Stop category	• 0 (Immediate deactivation) • 1 (Delayed deactivation)	0 (Immediate deactivation)	Module

Channel	Value range	Default	Scope
Emergency Stop input	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • "Emergency Stop x result" (where "x" is the Emergency Stop) • "Internal Evaluation #0 result" • "Internal Evaluation #1 result" • "None"	"None"	Module
Emergency Stop output	• F-DQ 0 • F-DQ 1 • "None"	"None"	Module
Delay time	500 ms to 7200000 ms (2 hours) in 1 ms steps	500 ms	Module
Acknowledge necessary	• "Manually using rising edge" • "Automatic"	"Manually using rising edge"	Module
Type of manual acknowledgement	• "Either process image or local I/O" • "Local I/O only" • "Process image only"	"Either process image or local I/O"	Module
Acknowledge input	• DI 0 • DI 1 • F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • "None"	"None"	Module

Explanation of the Estop parameters

The following explanations describe parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Emergency Stop":

Emergency Stop activated

You can enable or disable the Emergency Stop function.

Stop category

You can set the Estop to either deactivate the fail-safe output immediately, or after a configured delay time.

Emergency Stop input

You can select the F-input address that serves as the Estop input. You can also select the Internal Logic Result of another ESF as the input.

NOTE

Using the same input causes a compiler warning
Do not use the same input for both the "Emergency Stop input" and the "Acknowledge input". Doing so results in a compiler warning.

Emergency Stop output

You can select the F-output address that serves as the Estop output. When you configure this parameter, the Estop functions are able to override the respective F-CPU's output PV only to "0".

Delay time

If the Stop category is configured for "Delayed deactivation", you can configure the time delay for how long the module waits before turning the output off when the Emergency Stop function has been invoked.

Acknowledge necessary

You can select the acknowledgement type that returns the safety function to service, whether manual acknowledgement is required or acknowledgment is automatic.

Type of manual acknowledge

You can define the type of permissible manual acknowledgement from the following options:

- Either process image or local I/O: Performed using either approach
- Local I/O only: Performed using the acknowledge input specified by "Acknowledge Input"
- Process image only: Performed using the process image "ESTOP ACK" and "ACK REQ" bits

Acknowledge input

You can select the DI or F-input address that serves as the Acknowledge Input. You cannot, however, select an input already configured for Emergency Stop input.

NOTE

Using the same input causes a compiler warning
Do not use the same input for both the "Emergency Stop input" and the "Acknowledge input". Doing so results in a compiler warning.

Internal Evaluation (IE)

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Internal Evaluation" for the IE of the module:

Table 1-121 Configurable IE parameters

Channel	Value range	Default	Scope
Activated	• Checked • Unchecked	Unchecked	Module
Input #1	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DI 0 • DI 1 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation) • "None"	"None"	Module
Input #2	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DI 0 • DI 1 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation) • "None"	"None"	Module
Input #3	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DI 0 • DI 1 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation) • "None"	"None"	Module

Channel	Value range	Default	Scope
Input #4	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DI 0 • DI 1 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation) • "None"	"None"	Module
Output #1	• F-DQ 0 • F-DQ 1 • "None"	"None"	Module
Output #2	• F-DQ 0 • F-DQ 1 • "None"	"None"	Module

Explanation of the IE parameters

The following explanations describe parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Internal Evaluation":

Activated

You can either enable or disable the IE.

Input selection

You can select the standard DI addresses or F-input addresses which serve as the IE inputs. You can also select the Internal Logic Result of another ESF as the input.

NOTE

Using the same address causes a compiler warning

Do not select two inputs with the same address. Doing so results in a compiler warning.

NOTE

Fail-safe input requirement

When choosing inputs for the IE, at least one of the enabled inputs must be fail-safe. Failure to do so results in a compilation error.

When chaining together ESFs, all inputs must be fail-safe.

Output selection

You can select the F-output addresses which serve as the IE outputs.

NOTE

Using the same address causes a compiler warning

Do not select two outputs with the same address. Doing so results in a compiler warning.

4.4.1.5 Address space

The table below shows the number of I and Q bytes required for each available PROFIsafe profile:

PROFIsafe profile	Input (I) bytes required	Output (Q) bytes required
V2.4	11	5
V2.6.1	12	6

4.4.1.6 Control and feedback interfaces

Assignment of the control interface

Your safety program uses the control interface to influence the behavior of the module.

The following table shows the assignment of the control interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
QB x	0	0	ESTOP 1 ACK	ESTOP 0 ACK	0	0	F-DQ 0.1	F-DQ 0.0
QB x + 1-4 (PS)	PROFIsafe trailer (V2.4)							
QB x + 1-5 (PS)	PROFIsafe trailer (V2.6.1)							

Explanations of the control interface

Byte	Bit	Control bit/value	Explanation
QB x	0	F-DQ 0.0	The process value (PV) of fail-safe digital output channel 0.
	1	F-DQ 0.1	The process value (PV) of fail-safe digital output channel 1.
	4	ESTOP 0 ACK	The ESTOP 0 ACK bit is used to acknowledge the reset of the Emergency Stop. Not used when you configure Emergency Stop 0's "Type of manual acknowledgement" for "Local I/O only".
	5	ESTOP 1 ACK	The ESTOP 1 ACK bit is used to acknowledge the reset of the Emergency Stop. Not used when you configure Emergency Stop 1's "Type of manual acknowledgement" for "Local I/O only".
QB x + 1-4 (PS)	1-4	PROFIsafe trailer (V2.4)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.4.
QB x + 1-5 (PS)	1-5	PROFIsafe trailer (V2.6.1)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.6.1.

Assignment of the feedback interface

Your safety program receives current values and status information from the module by means of the feedback interface.

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IB x	0	0	0	0	F-DI 0.3 or 0 (SIL 3)	F-DI 0.2 or 0 (SIL 3)	F-DI 0.1	F-DI 0.0
IB x +1	0	0	ESTOP 1 Internal Logic Result (ILR)	ESTOP 0 Internal Logic Result (ILR)	Int. Eval. 1 Internal Logic Result (ILR)	Int. Eval. 0 Internal Logic Result (ILR)	ESTOP 1 ACK REQ	ESTOP 0 ACK REQ
IB x +2	ESTOP #1 Status	ESTOP #1 Status	ESTOP #1 Status	ESTOP #1 Status	ESTOP #0 Status	ESTOP #0 Status	ESTOP #0 Status	ESTOP #0 Status
IB x +3	0	0	0	0	CQ F-DI 0.3 or 0 (SIL 3)	CQ F-DI 0.2 or 0 (SIL 3)	CQ F-DI 0.1	CQ F-DI 0.0
IB x +4	0	0	0	0	0	0	0	0
IB x +5	0	0	0	0	0	0	0	0
IB x +6	0	0	0	0	0	0	CQ F-DQ 0.1	CQ F-DQ 0.0
IB x +7-10 (PS)	PROFIsafe trailer (V2.4)							
IB x +7-11 (PS)	PROFIsafe trailer (V2.6.1)							

Explanations of the feedback interface

Byte	Bit	Control bit/value	Explanation
IB x	0	F-DI 0.0	The process value (PV) of fail-safe digital input channel 0.
	1	F-DI 0.1	The process value (PV) of fail-safe digital input channel 1.
	2	F-DI 0.2, or 0 (SIL 3)	The process value (PV) of fail-safe digital input channel 2. Not used when you configure the input channel pair for 1oo2 evaluation.
	3	F-DI 0.3, or 0 (SIL 3)	The process value (PV) of fail-safe digital input channel 3. Not used when you configured the input channel pair for 1oo2 evaluation.
IB x +1	0	ESTOP 0 ACK REQ	The Acknowledge Input state of Emergency Stop 0. Not used when you configure Emergency Stop 0's "Type of manual acknowledgement" for "Local I/O only".
	1	ESTOP 1 ACK REQ	The Acknowledge Input state of Emergency Stop 1. Not used when you configure Emergency Stop 1's "Type of manual acknowledgement" for "Local I/O only".
	2	Internal Eval. 0 Internal Logic Result (ILR)	The internal logic result from the execution of the Internal Evaluation 0 ESF.
	3	Internal Eval. 1 Internal Logic Result (ILR)	The internal logic result from the execution of the Internal Evaluation 1 ESF.
	4	ESTOP 0 Internal Logical Result (ILR)	The internal logic result from the execution of the Emergency Stop 0 ESF.
	5	ESTOP 1 Internal Logical Result (ILR)	The internal logic result from the execution of the Emergency Stop 1 ESF.
IB x +2	0	ESTOP #0 Status	The ESF reports one of the following status codes:
	1		
	2		

Byte	Bit	Control bit/value	Explanation
IB x +2	3	ESTOP #0 Status	• "1" - The module detects the acknowledge input as on when the Emergency Stop is not awaiting manual acknowledgement. • "2" - The module detected the acknowledge input as on when the Emergency Stop began awaiting manual acknowledgement; the module must detect a rising edge on the acknowledge input for acknowledgement to occur. • "3" - The module detects that the DIQ channel assigned as the Emergency Stop's acknowledge requested output has been incorrectly configured as an input channel; you must configure the DIQ channel as an output for the acknowledge requested output. More than one status code might be present at a given time; however, only one is represented in the process image. Therefore, the status code with the highest priority is returned. Any other status codes are retained such that if a higher priority status code is cleared, the lower priority status code is presented.
	4 5 6 7	ESTOP #1 Status	The ESF reports one of the following status codes: • "1" - The module detects the acknowledge input as on when the Emergency Stop is not awaiting manual acknowledgement. • "2" - The module detected the acknowledge input as on when the Emergency Stop began awaiting manual acknowledgement; the module must detect a rising edge on the acknowledge input for acknowledgement to occur. • "3" - The module detects that the DIQ channel assigned as the Emergency Stop's acknowledge requested output has been incorrectly configured as an input channel; you must configure the DIQ channel as an output for the acknowledge requested output. More than one status code might be present at a given time; however, only one is represented in the process image. Therefore, the status code with the highest priority is returned. Any other status codes are retained such that if a higher priority status code is cleared, the lower priority status code is presented.
IB x +3	0	CQ F-DI 0.0	The channel quality (value status) of fail-safe digital input channel 0. This represents the channel quality (value status) of input channel pair 0/2 when you configure the input channel pair for 1oo2 evaluation.
	1	CQ F-DI 0.1	The channel quality (value status) of fail-safe digital input channel 1. This represents the channel quality (value status) of input channel pair 1/3 when you configure the input channel pair for 1oo2 evaluation.
	2	CQ F-DI 0.2, or 0 (SIL 3)	The channel quality (value status) of fail-safe digital input channel 2. Not used when the input channel pair is configured for 1oo2 evaluation.
	3	CQ F-DI 0.3, or 0 (SIL 3)	The channel quality (value status) of fail-safe digital input channel 3. Not used when the input channel pair is configured for 1oo2 evaluation.
IB x +6	0	CQ F-DQ 0.0	The channel quality (value status) of fail-safe digital output channel 0.
	1	CQ F-DQ 0.1	The channel quality (value status) of fail-safe digital output channel 1.
IB x +7-10 (PS)	0-6	PROFIsafe trailer (V2.4)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.4.
IB x +7-11 (PS)	0-7	PROFIsafe trailer (V2.6.1)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.6.1.

Evaluating the value status

The channel quality (value status) bits provide information regarding the validity of the channel quality (value status):

- Bit = 1: Corresponding process value is valid.
- Bit = 0: Channel is passivated.

4.4.2 Interrupts/diagnostic alarms

4.4.2.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

The safety function requires that safe state values be applied to the fail-safe channel(s) instead of process values. This results in passivation of the fail-safe module or channel(s) in the following situations:

- When the fail-safe system starts up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, any faults still existing are detected again.

Fail-safe value for fail-safe modules

If digital input channels are passivated, the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If digital output channels are passivated, the fail-safe system always transfers safe state values ("0") to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

NOTE
In the F-DI 4/F-DQ 2/DI 2 Properties > F-IO parameters > F-parameters > "Behavior after channel fault" field, if you select "Passivate the entire module", a single channel fault results in passivation of all channels.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates the entire module.

Table 1-122 Module signal type and passivation result

Module signal type	Passivation of channel result	Passivation of module result
Fail-safe digital inputs	For a 1oo1 input channel: • The passivated channel reports a diagnostic. • The module reports the safe state value "0" for the affected channel's process and quality values. For a 1oo2 input channel pair: • The passivated channel, as well as the other input channel in the channel pair, report a diagnostic.[1] • The module reports the safe state value of "0" for the low-order input channel pair's process and quality values. The high-order input always reports "0".	For a 1oo1 input channel: • The passivated channel reports a diagnostic. • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels. For a 1oo2 input channel pair: • The passivated channel, as well as the other input channel in the channel pair, report a diagnostic.[1)] • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels.
Fail-safe digital outputs	• The passivated channel reports a diagnostic. • The F-CPU substitutes the safe state value "0" for the affected channel's process and quality values.	• The passivated channel reports a diagnostic. • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels.

[1] A discrepancy error between two inputs in a channel pair results in one diagnostic. The diagnostic's message indicates which type of discrepancy occurred (0/0, 0/1, 1/0, or 1/1).

Response to faults in the fail-safe system

Prepare maintenance procedures for your system to ensure that returning the safety function to operation after a detected fault is controlled and documented.

Perform the following steps:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe module

A channel or module can be reintegrated into an operational state after diagnostics determine that a fault has cleared successfully.

You can configure reintegration as automatic or manual. You can make this selection on a per-channel basis in the Device configuration. Module-wide errors, such as PROFIsafe communication errors or supply voltage errors, are always manually reintegrated. Fatal diagnostic errors require a power cycle to reintegrate.

Automatic

Channels that you select to be automatically reintegrated immediately become operational when the fault has cleared.

Manual

Channels that you select to be manually reintegrated are acknowledged after the fault has cleared.

The "ACK_REQ" bit for the module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

Reintegration after high stress events

High temperature, high voltage, and excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure may be increased.

⚠ WARNING

Reintegration of a channel or module with an undetected fault

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics. Undetected faults can result in unexpected operation.

After any reported fault, follow the steps outlined in this chapter and in safety standards applicable to your system to assure that you understand the reason for the fault and how to take corrective action before reintegration.

Reintegration of a faulty system can result in unexpected operation, which can cause death, severe personal injury, and/or property damage.

For a list of faults for the module, refer to "Fault types, causes, and corrective measures".

After reintegration, the following occurs:

- For a fail-safe digital input, the process values pending at the fail-safe inputs are provided for the safety program.
- For a fail-safe digital output, the output values provided in the safety program are again transferred to the fail-safe outputs.

Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. Respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O are not being diagnosed and are subject to dangerous failure without warning.

If any error persists for 100 hours, the module issues a fatal diagnostic error and can only be recovered by power cycling.

If a repair within 100 hours is not possible, take passivated fail-safe outputs out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating CPU Safety program logic that can result in activation of a safety function output.

Do not depend upon channel or module passivation to maintain safe state for more than 100 hours.

Do not depend upon channel deactivation or removal of the module from Device configuration to maintain safe state in any circumstances.

⚠ WARNING

Unintentional activation of F-I/O module with fail-safe output

If a fail-safe output is passivated for a period longer than the safety repair time (> 100 hours) and the fault remains uncorrected, an F-output could be activated unintentionally due to a second fault, placing the F-system in a dangerous state.

Even though it is highly unlikely that such Device faults occur, you must prevent the unintentional activation of a fail-safe output by using measures for the physical circuits or other organizational measures. Some possibilities are the shutdown of the power supply to the affected F-module or taking the outputs out of service. Required measures are often standardized for operations with defined design and risk reduction principles. For all other situations, necessary measures must be defined and approved.

Unintentional activation of an F-output can result in death, severe personal injury, and/or property damage.

Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the "*SIMATIC Safety - Configuring and Programming, Programming and Operating Manual*" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

4.4.2.2 Fault diagnostics

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe module, in communication with the CPU, or in external circuits. Diagnostic information is assigned either to a single channel or to the entire fail-safe device.

Most diagnostics operate without user selection. You can configure the following diagnostic options in STEP 7 Device configuration under "F-I/O parameters":

- Short-circuit testing using the digital input sensor supplies, as well as the duration and startup time of the short-circuit tests for each sensor supply
- Discrepancy times for 1oo2 digital inputs
- The readback times for 24 V DC digital outputs
- The timeout intervals for failures in the safety communication or failure of a safety program to run
- Wire break testing when the output is wired in PM mode and the output is off
- Disabling of Dark testing of the digital outputs (max. SIL 2, Cat. 3, PL d)

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These measures are offered as maintenance and debugging aids, but must be observed and interpreted with caution.

In the presence of single faults, any or all LED indications can be wrong. You should not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages can fail to be delivered, or the numerical event ID or text message can be wrong. You should not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

⚠ WARNING

Diagnostic and status reports and single point failure errors

Diagnostic and status reports through LEDs and text messages are subject to single point failure errors. These are not sufficient for determining a safety-controlled state.

If the integrity of your fail-safe system is in doubt, you should use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.

Relying solely upon such reported information to determine that a system or I/O point is in a safety-controlled state can result in death, severe personal injury, and/or property damage.

Diagnostics performed at start-up

Each fail-safe module executes self-diagnostics at power-up to ensure that the electronics and software operate as expected before allowing the module to participate in process control. If tests are not successful, the module passivates the affected channel or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

The SM 1226 F-DI 4x, F-DQ 2x, DI 2x executes tests for its digital input sensor supplies at power-up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the module also executes a short-circuit test according to your configured parameters after receiving the parameters from the fail-safe CPU at power-up.

The SM 1226 F-DI 4x, F-DQ 2x, DI 2x also executes tests for its digital outputs of the P- and M-switches as defined by your configured parameters for "Max. readback time" and "Max.

readback time switch on test" after receiving configuration parameters from the fail-safe CPU at power-up. P- and M-switch ON tests are sequenced so that there is no energy applied to the load in the absence of faults.

Diagnostics by LED display

Fail-safe modules have the following types of LEDs:

- **Module DIAG LED:**
  - The DIAG LED is green ON if no fault is present and the fail-safe module is configured.
  - The DIAG LED is flashing green if no fault is present and the fail-safe module is not configured.
  - The DIAG LED is flashing red as soon as a diagnostic function is triggered by the fail-safe module.

    NOTE

    The DIAG LED continues to flash red when a reintegratable channel fault has been cleared, but not yet acknowledged.

  - The DIAG LED alternates between flashing red and green when a reintegratable module fault has been cleared, but not yet acknowledged.
  - The DIAG LED is red ON when inconsistent hardware and/or firmware versions are present.
- **Input/Output Status LED**:
  - Green LED for each input shows the input/output state during normal operation**.** If the input is ON, the LED is green.
- **Input/Output Fault LED**:
  - Red LED for each input/output indicates a channel error. If any channel error is present, the DIAG LED is flashing red.

    The input/output LEDs alternate between flashing red and green when a reintegratable channel fault has been cleared, but not yet acknowledged.

LED states for module and channel behaviors

Table 1-123 Fail-safe module LEDs

Description	DIAG	F-Input channel		F-Output channel	
	Green / Red	Red	Green	Red	Green
Module / System Fault[2]	Blinking (red)[3]	On	Off	On	Off
Not configured, includes undervoltage, overvoltage of 1L+ and 2L+ when not configured[2]	Blinking (green)[3]	Off	Input state	Off	Off
States after you successfully configure the module					
Channel deactivated	N/A	Off	Input state	Off	Off
No channel faults	On (green)	Off	Input state	Off	Output state
Channel faults	Blinking (red)[3]	On	Off	On	Off
Awaiting manual reintegration after channel fault	Blinking (red)[3]	Blinking[1]	Blinking[1]	Blinking[1]	Blinking[1]
Awaiting manual reintegration of channels after 1L+/2L+ voltage too high or too low	Blinking (red/green)[1]	Blinking[1]	Blinking[1]	Blinking[1]	Blinking[1]

Description	DIAG	F-Input channel		F-Output channel	
	Green / Red	Red	Green	Red	Green
Awaiting reintegration after PROFIsafe communication error (detected by host)	Blinking (red/green)[1]	Off	Input state	Off	Off
1L+ module supply voltage too high/too low	Blinking (red)[3]	On	Off	On[4]	Off
2L+ module supply voltage too high/too low	Blinking (red)[3]	On	Off	On[4]	Off
PROFIsafe communication error (detected by module)	Blinking (red)[3]	Off	Input state	Off	Off
Identification of the F-module when assigning the PROFIsafe address	Off	Off	Blinking[3]	Off	Blinking[3]
PROFIsafe address does not match the configured PROFIsafe address	Off	On	Off	On	Off
Firmware Update	N/A	Off	Off	Off	Off
Inconsistent FW versions and/or HW revisions between TPS and uCs	Blinking (red)[3]	Blinking, all channels	Off	Blinking, all channels	Off

Table 1-124 LED states for 24V supply behaviors

Description	DIAG	F-Input channel		F-Output channel	
	Green / Red	Red	Green	Red	Green
24V module 1L+ off, 24V module 2L+ off	Off	Off	Off	Off	Off
24V module 1L+ on, 24V module 2L+ on	Off	Off	Off	Off	Off
24V module 1L+ on, 24V module 2L+ off	Blinking (red)[3 5]	On	Off	On[4]	Off
24V module 1L+ on, 24V module 2L+ on	Off	Off	Input state	Off	Output state

Table 1-125 LED states for sensor supply behaviors

Description	DIAG	F-Input channel	
	Green / Red	Red	Green
Sensor supply fault, for inputs affected by the fault	Blinking (red)[3]	On	Off
Sensor supply fault, for inputs not affected by the fault	Blinking (red)[3]	Off	Input state

Table 1-126 LED states for 1oo1 input channels

Description	DIAG	F-Input channel	
	Green / Red	Red	Green
Input state 0	N/A	Off	Off
Input state 1	N/A	Off	On
Channel fault	Blinking (red)[3]	On	Off
Channel fault resolved, awaiting integration	Blinking (red)[3]	Blinking[1]	Blinking[1]

Table 1-127 LED states for 1oo2 input channels

Description	DIAG	Primary input		Secondary input	
	Green / Red	Red	Green	Red	Green
Input state 0 (equivalent)	N/A	Off	Off	Off	Off
Input state 1 (equivalent)	N/A		On		On
Input state 0 (non-equivalent)	N/A		Off		On
Input state 1 (non-equivalent)	N/A		On		Off
Discrepancy error	Blinking (red)[3]	On	Off	On	Off
Discrepancy error resolved, awaiting reintegration	Blinking (red)[3]	Blinking[1]	Blinking[1]	Blinking[1]	Blinking[1]

[1] Alternating blinking of red and green LED, for channels awaiting reintegration (blinking frequency: 2 Hz)

[2] Desired behavior Deviations under certain conditions, due to technical constraints, are acceptable.

[3] Blinking frequency (2.0 Hz)

[4] Assuming channels are activated

[5] Unless all outputs are deactivated and 24V 2L+ is low

Fault types, causes, and corrective measures

The table below lists the messages of the S7-1200 G2 Fail-safe I/O modules. These messages are displayed in the TIA Portal under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight a diagnostic buffer entry, the Event ID for that text item is displayed, along with the module identity and location that generated the message. You might need to expand the window to see all of the information.

Table 1-128 Fault types, causes, and corrective measures

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0001	Short-circuit	Fail-safe digital outputs	Short-circuit on one of the switches in the output	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			"Max. readback time switch on test" value is configured too small.	Increase "Max. readback time switch on test" if permissible.
			Defective output driver	Replace the fail-safe module.
0x0005	Overtemperature	Module	Excessive heat within the module	Check the ambient temperature. Once the fault has been eliminated, the power must be switched off and on.
			Excessive heat within the environment surrounding the module	
0x0006	Wire break	Fail-safe digital outputs	No load is connected to the PM output.	Check the wiring between the affected output channel and the load.
			Output is configured as a PM output, but not wired as a PM output.	Check that the affected output channel is wired in PM mode.
			Too small of a load is detected.	Change the output load.
			There is a fault in the external circuitry.	Deactivate the "Wire break" diagnostic

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0006	Wire break	Fail-safe digital outputs	A PM output load with reverse voltage protection could cause a wire break diagnostic.	Provide a small reverse current path through the PM load.
0x0009	Error	Module	Hardware version of the module is set to "0" due to an internal error.	Replace module.
0x0010	Parameter error	Module	i-Parameter CRC error	Check the communications connection or eliminate any electrical interference.
			Invalid F-parameters, I-parameters, and/or parameter CRCs were configured and downloaded to the module.	Resolve the invalid parameters and perform another download.
			A different F-Source and/or F-Destination address has been downloaded and does not match what had been previously assigned to the module.	Assign consistent source and destination fail-safe addresses to the module.
0x004D	PROFIsafe communication error (CRC)	Module	Communication interference between the fail-safe CPU and the fail-safe module (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)	Check the communications connection.
				Eliminate the interference.
0x004E	PROFIsafe communication failure (timeout)	Module	F-monitoring time exceeded. Transmission error: timeout (watchdog time 1 or 2 elapsed)	Adjust F-monitoring time.
				Check Safety program and all other CPU activities for excessive execution or demands: • Interrupts • OB scheduling conflicts • Long program paths
0x004F	User acknowledgement request of channel failures	Module	Fail-safe module awaits an acknowledge of channel failures.	Acknowledge channel failures.
0x0100	Module is defective	Module	Fail-safe module is defective.	Replace the fail-safe module.
0x0103	Watchdog tripped	Module	Fail-safe module is defective.	Replace the fail-safe module.
0x0105	Short-circuit to L+	Fail-safe digital outputs	Short-circuit to L+	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			Defective output driver	Replace the fail-safe module.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0105	Short-circuit to L+	Fail-safe digital outputs	"Max. readback time" value is configured too small.	Increase readback time.
0x0106	Short-circuit to ground	Fail-safe digital outputs	Short-circuit to M	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			Defective output driver	Replace the fail-safe module.
			"Max. readback time" value is configured too small.	Increase readback time.
0x011B	Invalid/inconsistent firmware present	Module	Inconsistent firmware version may occur between Bus ASIC firmware and/or fail-safe microcontroller firmware if the firmware update was interrupted.	The firmware update operation should be repeated.
0x013E	Diagnostic event queue overflow	Module	This can happen if channel errors come and go quickly (for example, discrepancy errors when automatically acknowledged).	Examine the diagnostics buffer to see what errors are occurring, then address the relevant issues.
0x0300	Discrepancy failure, channel state 0/0	Fail-safe digital inputs	Process signal faulty, sensor may be defective Configured discrepancy time too short Short-circuit Sensor mechanical activation or alignment out of tolerance	Check process signal, replace sensor if necessary. Check the configured discrepancy time. Check the wiring. Check that both sensors are mounted and aligned to be activated together.
0x0301	Discrepancy failure, channel state 0/1	Fail-safe digital inputs		
0x0302	Discrepancy failure, channel state 1/0	Fail-safe digital inputs		
0x0303	Discrepancy failure, channel state 1/1	Fail-safe digital inputs		
0x0306	Sensor supply short-circuit to P	Fail-safe digital inputs	Sensor supply shorted to P	Eliminate the short-circuit.
			Short-circuit test duration configured too short	Increase short-circuit test duration.
			Failed sensor supply	Replace the fail-safe module.
0x0307	Sensor supply short-circuit to ground	Fail-safe digital inputs	Short-circuit	Eliminate the short-circuit.
			Excessive load on sensor supply	Reduce load on sensor supply.
			Failed sensor supply	Replace the fail-safe module.
0x0311	Frequency too high	Fail-safe digital outputs	Process value from safety program changing too rapidly for module to follow.	Change safety program logic to guarantee more time between output changes.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0312	Undertemperature	Module	The ambient temperature is too cold.	Check the ambient temperature. After the fault has been eliminated, the power must be cycled.
0x0313	Failure in the input circuit	Fail-safe digital inputs	The module has detected a failure in the input circuitry during diagnostic testing.	If intermittent, possibly due to interference. Eliminate interference. If persistent, or repeats after efforts to eliminate interference, replace the fail-safe module.
0x031C	Input shorted to P	Fail-safe digital inputs	External signal for input or sensor supply shorted to L+	Check/correct external short-circuit.
			Input configured for internal sensor supply with short-circuit detection enabled, but wired to external L+	Make wiring and configuration agree.
			Input defective	Replace the fail-safe module.
0x031E	Read back failure	Fail-safe digital outputs	"Max. readback time" or "Max. readback time switch on test" configured value is too small.	Increase readback time or readback switch on test time.
			Output switch failure	Replace the fail-safe module if output does not respond.
0x0320	Overload	Fail-safe digital outputs	Excessive load on output	Reduce the current demand on the output.
0x032F	Module is defective	Module	Fail-Safe module is defective.	Replace the fail-safe module.
0x0321	Supply too high	Module	Supply is set too high.	Adjust 1L+ and/or 2L+ voltage.
0x0322	Supply too low	Module	Supply is set too low.	Adjust 1L+ and/or 2L+ voltage.

Electromagnetic interference and diagnostic reports

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not apparently relate to an identifiable device failure, wiring problem, programming or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load in-rush currents.

4.5 Standard IO

4.5.1 Parameters/address space

4.5.1.1 DI

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "Input parameters" > "Digital inputs" for the standard DI of the module:

Table 1-129 Configurable standard DI parameters

Parameter	Value range	Default	Scope
Channel Settings			
Input filters	• 0.2 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms	6.4 ms	Channel

I/O address parameters

The following table shows the parameters that you can set for addressing of the standard DI of the module:

Table 1-130 Configurable standard DI address parameters

Parameter	Value range	Default	Scope
Start address	0 to 1023	Calculated	Channel
End address	N/A	Calculated	Channel
Organization block	• "--- (Automatic Update)" • List of available OBs	"--- (Automatic Update)"	Channel
Process image	• "Automatic Update" • List of available PIPs • "None"	"Automatic Update"	Channel

Explanation of DI parameters

The following explanation describes the parameter that you can set in STEP 7 Device configuration under "Input parameters" > "Digital inputs":

Input filters

You can parameterize the standard input filter setting which applies to both channels.

4.5.1.2 Address space

The table below shows the number of I and Q bytes required:

Input (I) bytes required	Output (Q) bytes required
1	0

4.5.1.3 Feedback interface

Assignment of the feedback interface

Your safety program receives current values and status information from the module by means of the feedback interface.

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IB x	0	0	0	0	0	0	DI 0.1	DI 0.0

Explanations

Byte	Bit	Control bit/value	Explanation
IB x	0	DI 0.0	The process value (PV) of digital input channel 0.
	1	DI 0.1	The process value (PV) of digital input channel 1.

Applications

5

This chapter presents typical application examples for connection of fail-safe input channels and output channels, with a statement of the safety performance (SIL/Cat./PL) that is possible for each example.

The PLC system typically contributes only a small part of the total probability of dangerous failure. The probability of dangerous failures of the sensors and actuators will typically be far larger than the PFH/PFD of the PLC system. Faults in the wiring system can also be a substantial contributor.

To achieve a targeted level of safety performance for each safety function, you must do the following:

- Choose an appropriate architecture.
- Choose sensors and actuators that are appropriately rated.
- Provide a safety program that meets the requirements of the safety function.
- Provide diagnostics and proof tests to maintain the ratings of the sensors and actuators.
- Use wiring installation practices, diagnostics, and proof tests to assure wiring integrity.
- Control operating and maintenance procedures for the lifetime of the installation.

The S7-1200 G2 Fail-safe system provides a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each S7-1200 G2 Fail-safe component is stated assuming no field proof test within the lifetime of the product. Sensors and actuators typically require regular proof tests to maintain an expected level of safety performance.

The reaction time of each safety function depends upon the reaction time of each component, including the sensor, the PLC system, and the actuator. "Fail-safe response times" gives further information on delay times through the PLC components. You must choose PLC parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to total delay from safety demand input to safe actuator response, you must consider these additional time-related factors:

- To be assured of a safety response, a safety signal from the fail-safe input sensor must last long enough to be seen by the safety program, which varies based upon your configured input filter, the duration of short-circuit test, and startup after short-circuit test is completed times.
- The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is functional and under independent control. The OFF test pulse duration can be as long as your configured "Max. readback time". The ON test pulse duration can be as long as your configured "Max. readback time switch on test". For a given output, the ON test pulse is only provided to one of the P- or M- switches at a time, but in the presence of a single fault this could apply energy to your load. Make sure that your actuator does not respond to an OFF signal up to the "Max. readback time" or to an ON signal up to the "Max. readback time switch on test".

- The fail-safe digital outputs verify that any transition of the output process value reaches the expected state within the configured "Max. readback time". When an output process value transition occurs, your program must wait the configured "Max. readback time" before changing the output process value again. If the output does not reach the expected state in the configured "Max. readback time", the output channel passivates.

⚠ WARNING

Safety performance depends upon your design and continued maintenance
S7-1200 G2 F-CPUs and fail-safe signal modules provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.
You must choose all components of your installation and complete your design and maintenance according to accepted safety standards and practices to achieve your required level of safety.
Failure to comply with these guidelines can result in death, severe personal injury, and/or property damage.

5.1 Digital input applications

Consider the application modes below along with the features of the fail-safe module as described in the product overview (Page 20).

You configure each channel as a 1oo1 or as part of a 1oo2 evaluation pair. The corresponding channels from input bytes "a" (a.0, a.2), (a.1, a.3) form 1oo2 channel groups. Within this restriction, you can assign 1oo1 and 1oo2 in any order.

Short-circuit testing requires use of the internal sensor supply. Each input can optionally have its own Vs supply. If you enable the short-circuit test, and your inputs are configured as 1oo2, sensors used with the 1oo2 pair are configured with the same parameters. All channels you configured for internal sensor supply will be subject to the same short-circuit test. You configure a test duration and sensor startup time.

The sensor supply is monitored to detect short-circuit or overload. It is cycled on each power up to assure control and readback are working, and the sensor supply continuously monitors the readback. You configure a discrepancy time to identify unacceptable differences between 1oo2 inputs. You configure a filter time for each channel or each 1oo2 pair.

Achieving SIL 2/Cat. 3/PL d in 1oo1 configuration

You can achieve SIL 2/Cat. 3/PL d in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach SIL 2/Cat. 3/PL d by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failure, unless additional measures are applied.

Achieving SIL 3/Cat. 4/PL e in 1oo2 configuration

You can achieve SIL 3/Cat. 4/PL e in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Cat. 4.
- The duplicated external wiring of 2 sensors to 2 input points is vulnerable to accumulated fault dangerous failure, unless additional measures are applied.

The F-DI is recommended for SIL 3/Cat. 4/PL e only when 1oo2 evaluation is selected. A single high-integrity sensor can be rated up to SIL 3/Cat. 4/PL e, but it should be wired and configured for 1oo2 evaluation for the channel to achieve SIL 3/Cat. 4/PL e.

5.1.1 Selecting the digital input application

Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

You can choose a digital input application based upon your functional and safety-related needs when wiring inputs. The applications and their achievable safety ratings are described in the table below:

Table 1-131 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Sensor supply	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
1	Internal	1oo1 evaluation	Single input	1 channel	2/3/d	
2	External					
3	Internal	1oo2 evaluation	Two inputs	2 channel equivalent	3/3/e	3/4/e
4	External				3/3/d	
5	Internal				3/3/e	3/4/e
6	External				3/3/e	
7	Internal			2 channel - 3 wire non-equivalent	3/3/e	3/4/e
8	External				3/3/e	
9	Internal			2 channel - 4 wire non-equivalent	3/3/e	3/4/e
10	External				3/3/e	

⚠ WARNING

Incorporation into SIL 2 and SIL 3 applications
To incorporate an Application Mode into a SIL 2 or SIL 3 rated application, the sensor must be an appropriately qualified device for that SIL level. Failure to use an appropriately qualified device can prevent your safety application from reaching a sufficient safety rating, which increases the probability of dangerous failures occurring.
Use sensors that are appropriately qualified devices: either SIL 3 or SIL 2 with Systematic Capability rules defined in IEC 61508-2:2010 observed (sufficient independence in design and application or SC3).
Dangerous failures could result in death, severe personal injury, and/or property damage.

5.1.2 F-DI Applications 1 and 2: 1oo1 evaluation of a single sensor

F-DI application mode 1

This Application Mode features a single one-channel sensor using 1oo1 evaluation and an internal sensor supply.

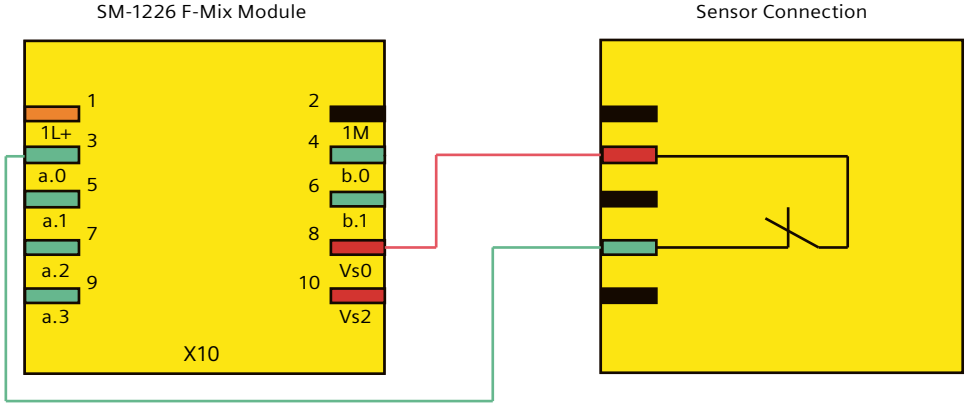


Figure 1-20 F-DI Application Mode 1

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	Assignable, sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 2

This Application Mode features a single one-channel sensor using 1oo1 evaluation and an external sensor supply.

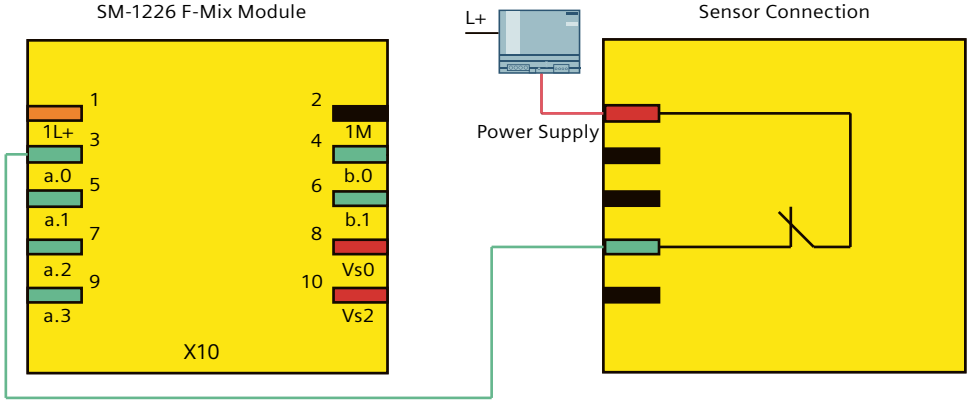


Figure 1-21 F-DI Application Mode 2

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	External

5.1.3 F-DI Applications 3 and 4: 1oo2 equivalent evaluation of a single sensor

F-DI application mode 3

This Application Mode features a single two-channel sensor using 1oo2 equivalent evaluation and an internal sensor supply.

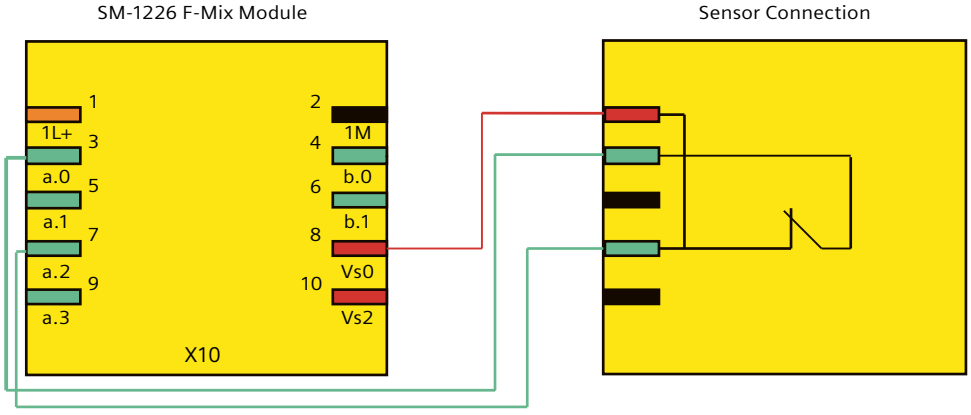


Figure 1-22 F-DI Application Mode 3

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire equivalent
Sensor supply	Assignable, sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 4

This Application Mode features a single two-channel sensor using 1oo2 equivalent evaluation and an external sensor supply.

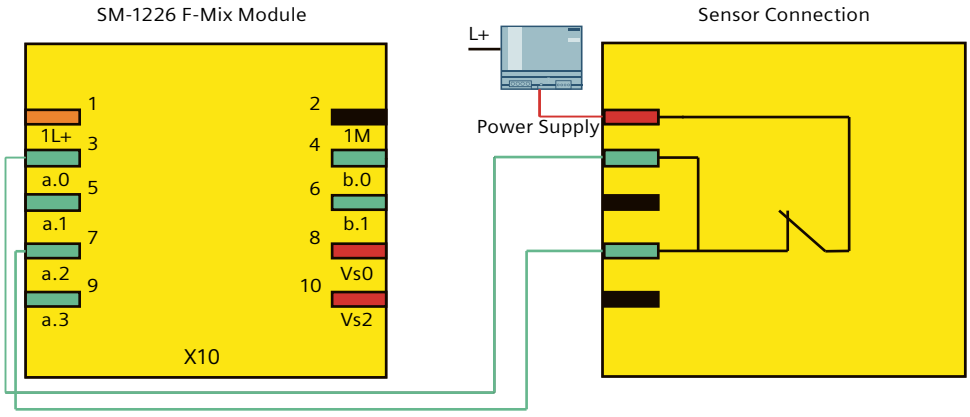


Figure 1-23 F-DI Application Mode 4

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire equivalent
Sensor supply	External

5.1.4 F-DI Applications 5 and 6: 1oo2 evaluation of a mechanically-coupled two-channel sensor

F-DI application mode 5

This Application Mode features a single two-channel sensor, with two mechanically-coupled contacts, using 1oo2 equivalent evaluation and internal sensor supplies.

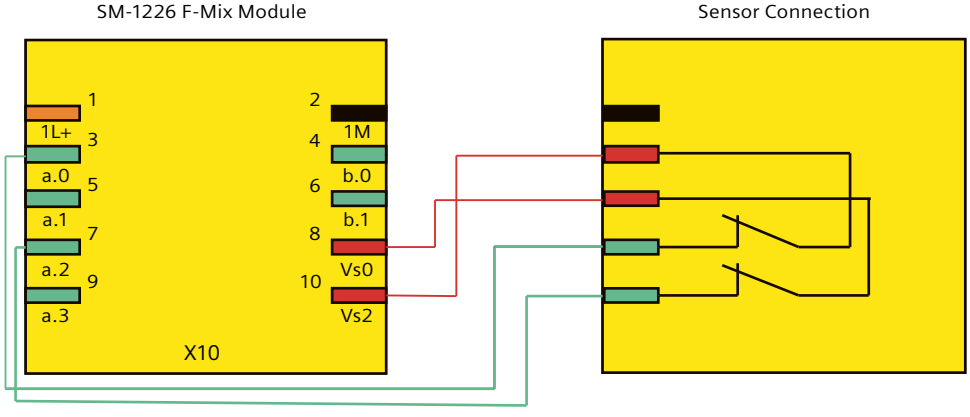


Figure 1-24 F-DI Application Mode 5

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire equivalent
Sensor supply	Assignable, sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 6

This Application Mode features a single two-channel sensor, with two mechanically-coupled contacts, using 1oo2 equivalent evaluation and external sensor supplies.

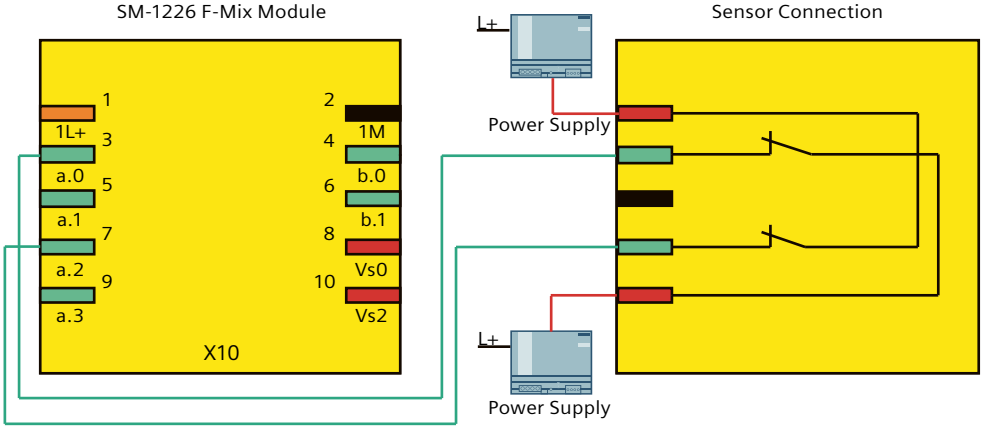


Figure 1-25 F-DI Application Mode 6

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire equivalent
Sensor supply	External

5.1.5 F-DI Applications 7 and 8: 1oo2 evaluation of a single 3 wire non-equivalent sensor

F-DI application mode 7

This Application Mode features a single two-channel sensor using 1oo2, 3-wire non-equivalent evaluation and an internal sensor supply.

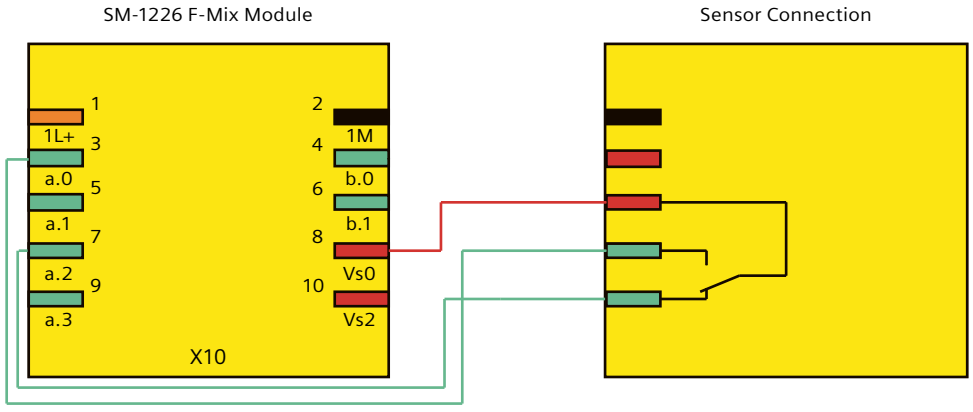


Figure 1-26 F-DI Application Mode 7

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 3-wire non-equivalent
Sensor supply	Assignable, sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 8

This Application Mode features a single two-channel sensor using 1oo2, 3-wire non-equivalent evaluation and an external sensor supply.

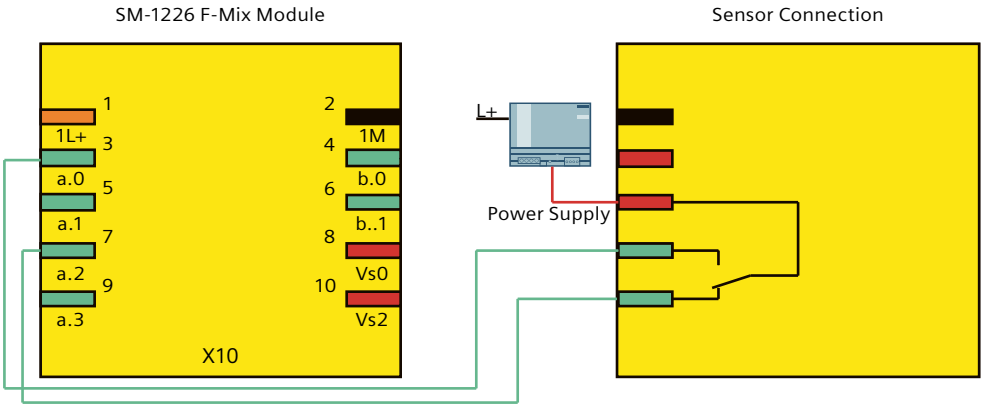


Figure 1-27 F-DI Application Mode 8

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 3-wire non-equivalent
Sensor supply	External

5.1.6 F-DI Applications 9 and 10: 1oo2 non-equivalent evaluation of a non-equivalent single channel sensor

F-DI Application Mode 9

This Application Mode features a single two-channel sensor using 1oo2, 4-wire non-equivalent evaluation and internal sensor supplies.

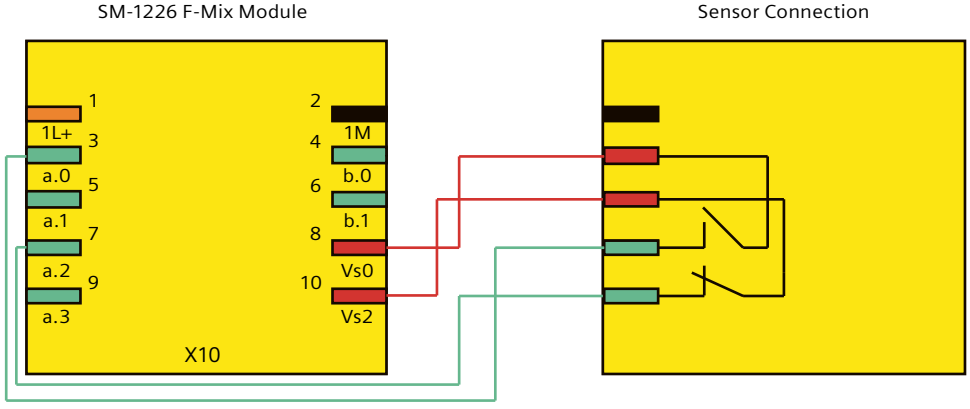


Figure 1-28 F-DI Application Mode 9

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire non-equivalent
Sensor supply	Assignable, sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI Application Mode 10

This Application Mode features a single two-channel sensor using 1oo2, 4-wire non-equivalent evaluation and external sensor supplies.

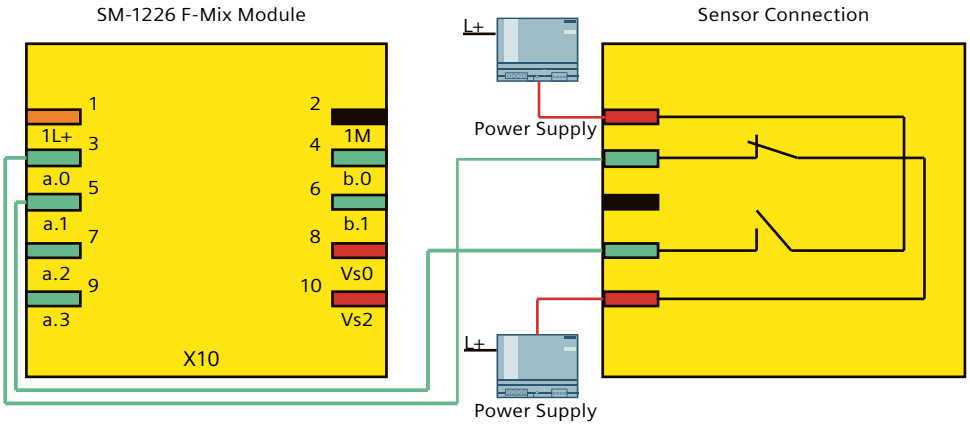


Figure 1-29 F-DI Application Mode 10

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2-channel 4-wire non-equivalent
Sensor supply	External

5.2 Digital output applications

Consider the application modes presented here along with the features of the fail-safe module as described in the product overview (Page 20).

The F-DQ DC separately controls current flow in the P (24 V to load) and M (load to common) sides of the circuit. The voltage at each P- and M- switch is read back to confirm proper state. The P- and M- switches are regularly tested with short ON and OFF pulses to confirm control. You must configure readback times that allow the external voltage to respond but do not cause your load to physically respond.

Internal current limiting as described in the data sheet may be sufficient in combination with your 24 V DC supply, but you must consider whether additional current limits or fuses are necessary. Refer to "Specifications".

All applications shown are capable of reaching SIL 3/Cat. 4/PL e (including dark test disable for 48 hours). To reach Category 4, external contactors must be SIL-rated with sense contacts. You must read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs, but external feedback inputs can also be standard inputs.

5.2.1 Selecting the digital output application

You can choose a digital output application based upon your functional and safety-related needs when wiring outputs. The table below describes these applications:

Application	Description
1	Wiring a load directly to a digital PM output
2	Wiring a load directly to a digital PP output
3	Using two relays to control an actuator, relays are connected between output and supply rail
4	Using two relays to control an actuator, relays are connected between output and supply rail
5	Using separate relays to control an actuator, relays are connected in parallel across two outputs

5.2.2 F-DQ Application 1: Wiring a load directly to a digital PM output

This Application Mode features directly connecting a load to the P- and M- outputs of one channel.

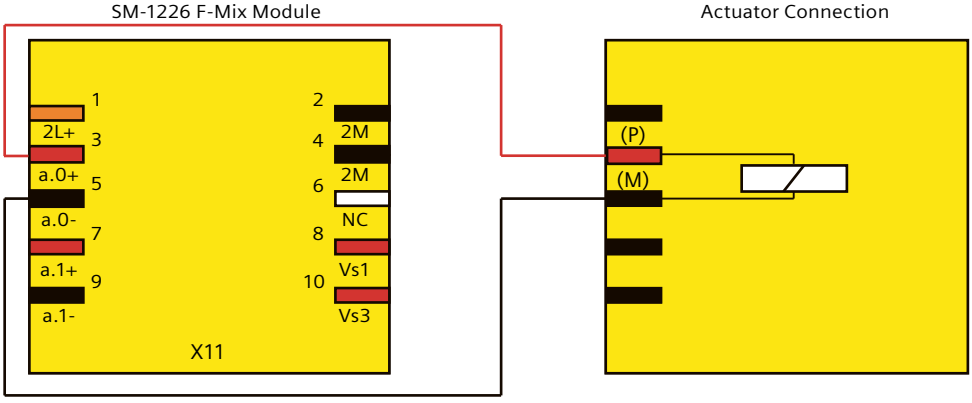


Figure 1-30 F-DQ Application Mode 1

5.2.3 F-DQ Application 2: Wiring a load directly to a digital PP output

This Application Mode features directly connecting a load to the P-output of one channel, which consists of two P-switches internally.

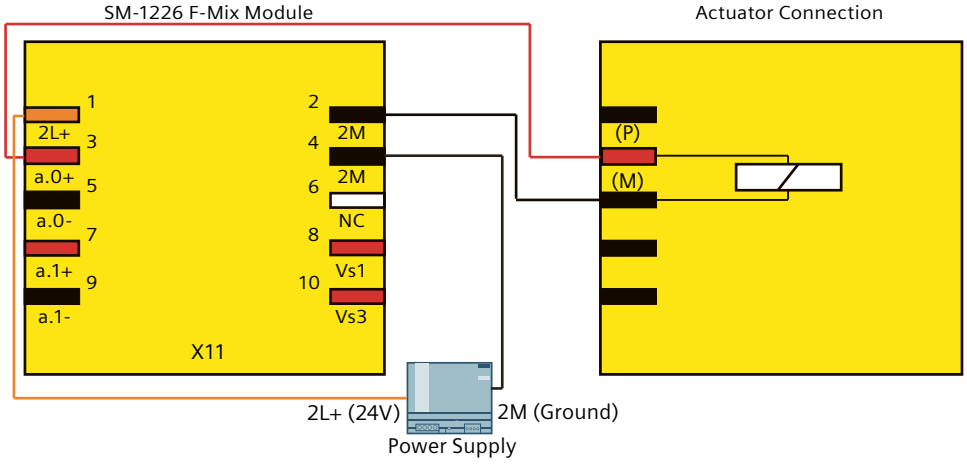


Figure 1-31 F-DQ Application Mode 2

The purpose of the additional wiring connection of the load back to the module's 2M terminal is potential fault mitigation. Without the additional connection, the module could be left in a floating condition with no reference to ground if a disruption to the first 2M (Ground) connection occurs. This disruption could cause the actuator to become energized by the current which could flow through the module from L+ to Px.0, a current greater than the OFF state leakage current for the module. Therefore, achieving safety ratings for SIL 3/Cat. 4/PL e requires an additional connection from the load to the module's M terminal.

F-DQ application mode 2, alternative wiring

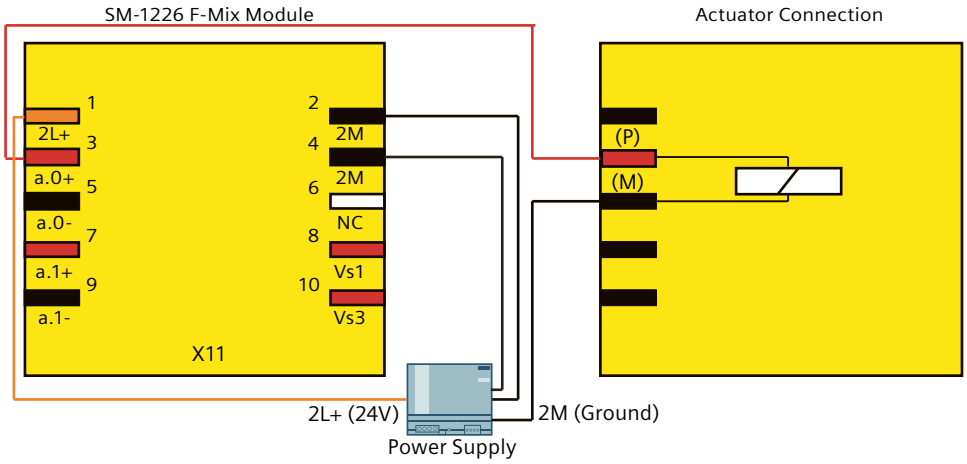


Figure 1-32 F-DQ Application Mode 2, alternative wiring

If the load is wired to the M (Ground) of the power supply, redundant connections are required from the power supply return to the module's 2M terminals for potential fault mitigation. Without the additional connections, ground disruptions could result in the module being left in a floating condition with no reference to ground.

It is possible that current flowing thru L+ to Px.0 which is greater than the OFF state leakage current specified in this manual could energize the module. Redundant connections are required to the module's 2M terminals in order to achieve safety ratings for SIL 3/Cat. 4/PL e.

WARNING

Connecting loads to ground in PP mode
When connecting the load to the ground of the power supply unit when a channel is in PP mode, the maximum residual current at signal "0", which is specified in the technical specifications, cannot be maintained if a single ground line is interrupted. Unexpected current flow can result.
You must run two ground lines between the power supply unit and the module for safety reasons to achieve SIL 3/Cat. 4/PL e.
Unexpected current flow can enable the output, resulting in death, severe personal injury, and/or property damage.

F-DQ application mode 2, Cat. 3/PL d wiring

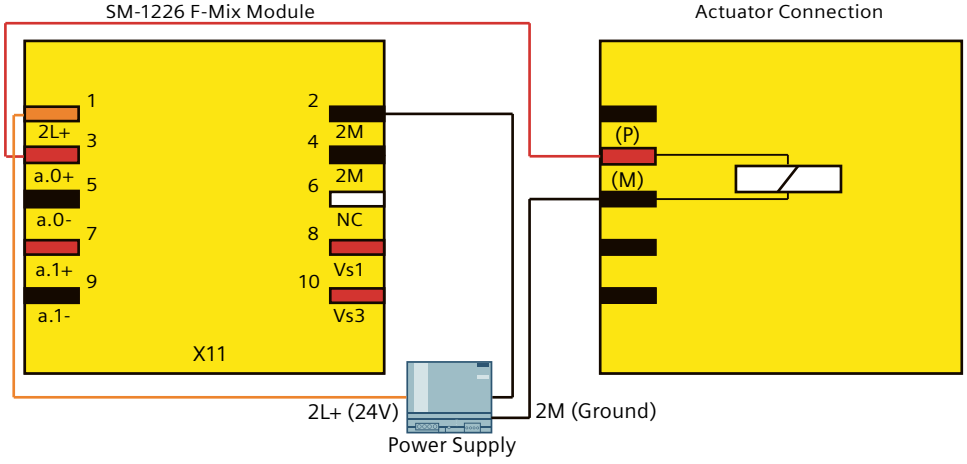


Figure 1-33 F-DQ Application Mode 2: Category 3

If a disruption occurs while the M (Ground) of the power supply is connected to the module's 2M terminal, the module could be left in a floating condition with no reference to ground.

It is possible that current flowing through the module from L+ to Px.0 which is greater than the OFF state leakage current specified in this manual could energize the actuator. Since there is no redundant ground, the configuration can only achieve a SIL 3/Cat. 3/PL d safety rating.

5.2.4 F-DQ Application 3: Using two relays to control an actuator, relays are connected between output and supply rail

This Application Mode features controlling a load by means of the series-connected normally open contacts of two relays. The coil of one relay is connected between the P-output of a channel and M, while the coil of the other relay is connected between the M-output of the same channel and L+.

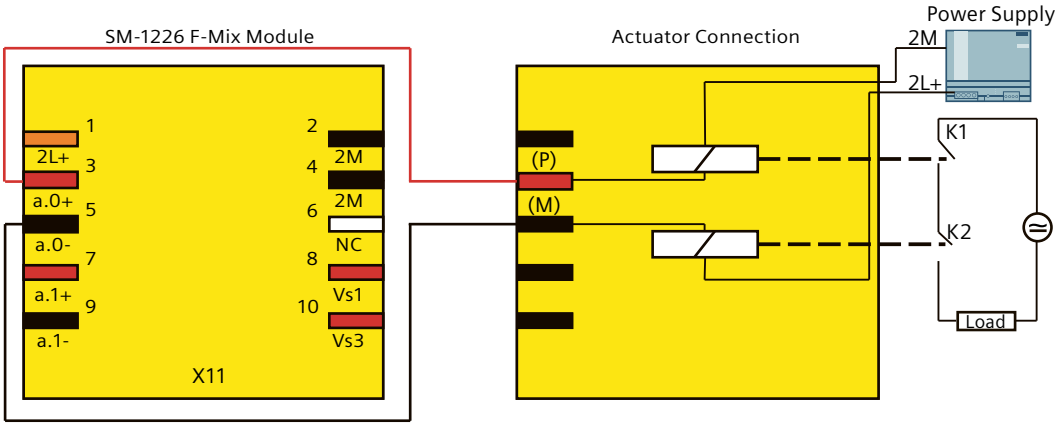


Figure 1-34 F-DQ Application Mode 3

NOTE

This configuration achieves SIL 3/Cat. 4/PL e only if the following conditions are fulfilled:

- The relay status is checked by means of a separate digital input.
- The wiring is adequately protected against shorts between the P and M outputs, as the actuator cannot be switched off if such a fault occurs.

5.2.5 F-DQ Application 4: Using two relays to control an actuator, relays are connected in parallel across one output

This Application Mode features controlling a load by means of series-connected, normally-open contacts of two relays. The coils of both relays are connected in parallel across the outputs of one channel.

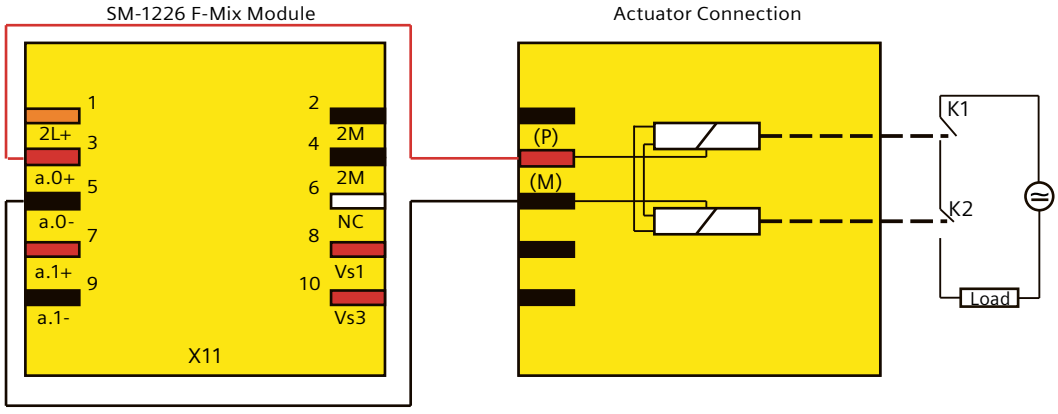


Figure 1-35 F-DQ Application Mode 4

NOTE

This configuration achieves SIL 3/Cat. 4/PL e only if the relay status is checked by means of a separate digital input.

NOTE

This configuration is the preferred way of controlling an actuator by means of relays in a safety-related application, as it avoids the problems associated with F-DQ Application Mode 1 regarding short circuits between the P and M outputs.

5.2.6 F-DQ Application 5: Using separate relays to control an actuator, relays are connected in parallel across two outputs

This Application Mode features controlling a load by means of series-connected, normally-open contacts of two relays. The coil of each relay is connected across the PM output of a unique output channel. Both outputs are independent of each other and are independently controlled and enabled from the safety program.

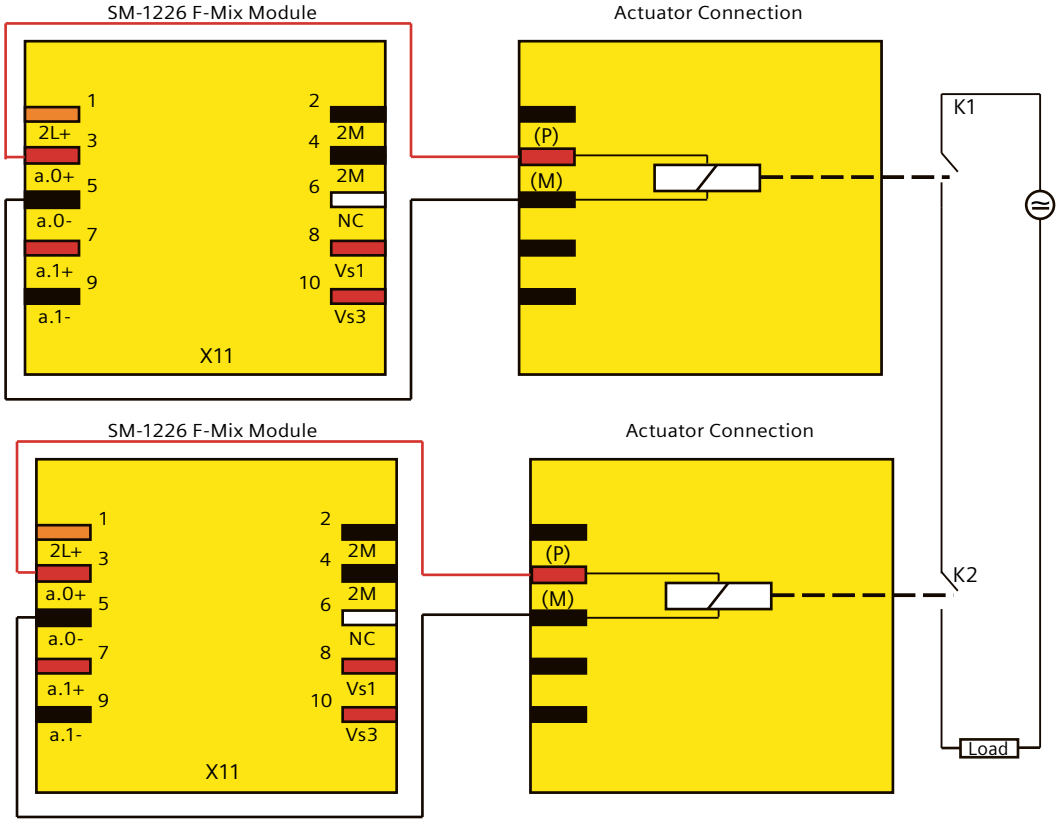


Figure 1-36 F-DQ Application Mode 5

NOTE

This configuration achieves SIL 3/Cat. 4/PL e only if the relay status is checked by means of a separate digital input.

Technical specifications

A

A.1 General technical specifications

Standards compliance

The S7-1200 G2 F-IO design conforms with the following standards and test specifications. The test criteria for the S7-1200 G2 F-IO are based on these standards and test specifications.

Note that not all S7-1200 G2 F-IO are certified to these standards, and certification status can change without notification. It is your responsibility to determine applicable certifications by referring to the ratings marked on the product. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

All S7-1200 G2 Fail-safe signal modules (SM) are certified by TÜV SÜD. The fail-safe signal modules are certified to the IEC 61508, EN ISO 13849, and IEC 62061 standards and guidelines for functional safety. For further information, refer to the current associated Annex of the report for the TÜV SÜD certificate (https://support.industry.siemens.com/cs/document/109825198/information-on-t%C3%BCv-certification?dti=0&lc=en-WW) for the F-CPU (https://support.industry.siemens.com/cs/ww/en/view/109978389) and the F-I/O (https://support.industry.siemens.com/cs/ww/en/view/109825424).

The following specifications are those which differ from those in the *S7-1200 G2 Programmable Logic Controller System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109997791) (A5E52923928).

Industrial environments

The S7-1200 G2 F-IO are designed for use in industrial environments.

Table 1-132 Industrial environments

Application field	Emission requirements	Immunity requirements
Industrial	EN 61000-6-4	EN 61000-6-2

Environmental conditions

The following environmental conditions are those which differ from those in the *S7-1200 G2 Programmable Logic Controller System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109997791).

Table 1-133 Climatic ambient conditions

Environmental conditions – Climatic ambient operating conditions (OTH4)	
Ambient temperature (Inlet Air 25 mm below unit)	Horizontal Mounting: 0 °C to 40 °C Max. specifications 0 °C to 60 °C With derating
	Vertical Mounting: 0 °C to 40 °C Max. specifications 0 °C to 50 °C With derating
	95% non-condensing humidity
	Derating method may change from device to device. See each device for derating method.
EN 60068-2-14, Test Nb (Temperature change)	0 °C to 60 °C, dwell time 3 hours, 5 cycles

Electromagnetic compatibility

Electromagnetic Compatibility (EMC) is the ability of an electrical device to operate as intended in an electromagnetic environment and to operate without emitting levels of electromagnetic interference (EMI) that can disturb other electrical devices in the vicinity.

Table 1-134 Immunity

Electromagnetic compatibility - Immunity per EN 61000-6-2	
EN 61000-4-2 Electrostatic discharge	8 kV air discharge to all surfaces 6 kV contact discharge to exposed conductive surfaces
EN 61000-4-3 Radiated, radio-frequency, electromagnetic field immunity test	80 MHz to 1000 MHz, 10 V/m, 80% AM (1 kHz) 1.4 GHz to 6 GHz, 3 V/m, 80% AM (1 kHz)
EN 61000-4-4 Fast transient bursts	2 kV, 5 kHz with coupling network to AC and DC system power 2 kV, 5 kHz with coupling clamp to I/O
EN 61000-4-5 Surge immunity	AC systems - 2 kV common mode, 1 kV differential mode DC systems - 1 kV common mode, 0.5 kV differential mode
EN 61000-4-6 Conducted disturbances	150 kHz to 80 MHz, 10 V RMS, 80% AM at 1 kHz

Table 1-135 Emissions

Electromagnetic compatibility - Conducted and radiated emissions per EN 61000-6-4		
Conducted emissions DC power ports	0.15 MHz to 0.5 MHz	< 89 dBµV quasi-peak, < 76 dBµV average
	0.5 MHz to 30 MHz	< 83 dBµV quasi-peak, < 70 dBµV average
Radiated emissions	30 MHz to 230 MHz	< 40 dBµV/m quasi-peak at 10 m
	230 MHz to 1000 MHz	< 47 dBµV/m quasi-peak at 10 m
	1000 MHz to 3000 MHz	< 76 dBµV/m peak, < 56 dBµV/m average at 3 m
	3000 MHz to 6000 MHz	< 80 dBµV/m peak, < 60 dBµV/m average at 3 m

DC outputs

Short-circuit protection circuitry is provided for fail-safe DC outputs.

Probabilities of failure

Quantitative safety properties like PDF and PFH are estimated using standard data tables and calculation methods according to international standards, including IEC 61508, ISO 13849, and IEC 61131-6.

The values are based upon the assumption of continuous full nominal load, nominal voltage, and 60 °C equipment ambient temperature.

A.2 SM 1226 F-DI 4x, F-DQ 2x, DI 2x

Table 1-136 General specifications

Technical data		**SM 1226 F-DI 4x, F-DQ 2x, DI 2x**
Article number		6ES7226-6ME50-0XB0
Dimensions W x H x D		30 x 125 x 100 mm
Weight (Product/Shipping)		177 grams / 214 grams
Power dissipation		6.0 W
Current consumption (bus)		80 mA max. (5 V DC)
Current consumption (24 V DC)		42 mA (1L+) plus 45 mA (2L+) plus 6 mA / input used plus any V_{S0} to V_{S3} current used plus load current for all P-switch outputs
Rated supply voltage		24 V DC
Supply voltage range		20.4 to 28.8 V DC
Reverse supply voltage protection		Yes
Highest safety class achievable in safety mode		
Performance level according to ISO 13849-1		PLd (F-DI single-channel, F-DQ with Dark test disabled), PLe (F-DI two-channel, F-DQ including Dark test disabled for 48 hours)
Category according to ISO 13849-1		Cat. 3 (F-DI single-channel, F-DQ with Dark test disabled), Cat. 4 (F-DI two-channel, F-DQ including Dark test disabled for 48 hours)
SIL according to IEC 61508		SIL 2 (F-DI single-channel, F-DQ with Dark test disabled), SIL 3 (F-DI two-channel, F-DQ including Dark test disabled for 48 hours)
Probability of failure (for service life of 20 years and repair time of 100 hours)		Altitude <= 5000 m
	Low demand mode: PFDavg in accordance with SIL2	<2.00E-04 F-DI; <2.00E-04 F-DQ
	Low demand mode: PFDavg in accordance with SIL3	<3.00E-05 F-DI; <3.00E-05 F-DQ

[1] Operating temperature range using maximum voltages and maximum specifications

Technical data		**SM 1226 F-DI 4x, F-DQ 2x, DI 2x**
	High demand/continuous mode: PFH in accordance with SIL2	<5.00E-09 1/h F-DI; <6.00E-09 1/h F-DQ
	High demand/continuous mode: PFH in accordance with SIL3	<5.00E-10 1/h F-DI; <5.00E-09 1/h F-DQ
Operating Environment		Horizontal Mounting 0 °C to 60 °C[1]
		Vertical Mounting 0 °C to 50 °C[1]
		95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-137 Digital inputs

Technical data	**SM 1226 F-DI 4x, F-DQ 2x, DI 2x**
Number of inputs	Fail-safe: 2 (1oo2), 4 (1oo1), or a mix Standard: 2
Type	Sink (IEC 61131-2 Type 1)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC at 6 mA
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times	Fail-safe: 0.8, 1.6, 3.2, 6.4, and 12.8 ms (selectable individually) Standard: 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms (selectable together)
Diagnostics	Fail-safe: Yes Standard: No
Number of sensor supplies	4
Sensor supply current	0.5 A max. per sensor supply / 1.0 A max. for all sensor supplies
Cable length	500 m shielded, 300 m unshielded
Cable size	AWG 24 to 16 (0.2 mm^2 to 1.5 mm^2)

Table 1-138 Digital outputs

Technical data	**SM 1226 F-DI 4x, F-DQ 2x, DI 2x**
Number of outputs	2, in 1 isolation group of 2 outputs
Type	PM-switching or PP-switching
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	2L+ minus 2 V (2L+ minus 1.5 V P-switch; 0.5 V M-switch)
Current	10 mA to 2 A
Lamp load	10 W
Leakage current per point	0.5 mA P-switch; 0.5 mA M-switch
Short-circuit protection	Yes, electronic per point; 10 A threshold

[1] For burner applications, the unshielded cable length is a maximum of 10 m.

Technical data	**SM 1226 F-DI 4x, F-DQ 2x, DI 2x**
Overload protection	Yes, electronic per point; 4 A threshold measured at P-switch for more than 0.5 s
Isolation (field side to logic)	707 V DC (type test)
Current per common	4 A max.
Inductive clamp voltage	Typ. -74 V (typ. -26 V P-switch; typ. +48 V M-switch)
Control of a digital input	Yes in PP mode No in PM mode
Parallel outputs for redundant load control	No
Parallel outputs for increased load	No
Diagnostics	Yes
Switching frequency	
with resistive load, max.	30 Hz
with inductive load, max.	0.1 Hz
on lamp load, max.	10 Hz
Cable length	500 m shielded, 30 m unshielded[1]
Cable size	AWG 24 to 16 (0.2 mm^2 to 1.5 mm^2)

[1] For burner applications, the unshielded cable length is a maximum of 10 m.

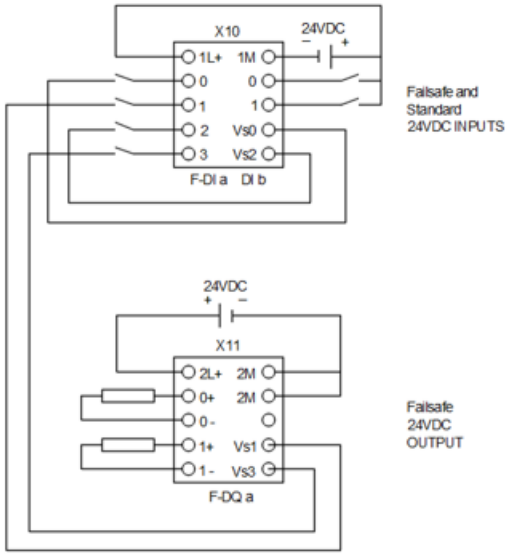
See also

Response time parameters for the SM 1226 F-DQ 2 x Relay (Page %getreference)

A.3 Wiring diagram for the SM 1226 F-DI 4x, F-DQ 2x, DI 2x

The wiring diagram and pin connector locations are shown below:

SM 1226 F-DI 4x, F-DQ 2x, DI 2x



X10: Upper user wiring terminal (gray, no keying)

Signal	Pin #		Signal
1L+	1	2	1M
F-DI a.0	3	4	DI b.0
F-DI a.1	5	6	DI b.1
F-DI a.2	7	8	V_{S0}
F-DI a.3	9	10	V_{S2}

X11: Lower user wiring terminal (gray, no keying)

Signal	Pin #		Signal
2L+	1	2	2M
F-DQ a.0+ (P)	3	4	2M
F-DQ a.0- (M)	5	6	
F-DQ a.1+ (P)	7	8	V_{S1}
F-DQ a.1- (M)	9	10	V_{S3}

Ordering information

B

B.1 Fail-safe signal modules (SM)

Table 1-139 Fail-safe signal modules (SM)

Item		Article number
Digital input / output	SM 1226 F-DI 4 x 24 V DC, F-DQ 2 x 24 V DC, DI 2 x 24 V DC	6ES7226-6ME50-0XB0

B.2 Fail-safe terminal block spare kits

Table 1-140 Fail-safe signal modules - Terminal block spare kit

If you have Fail-safe signal module (article number)	Use this Terminal block spare kit (4/pk)	
	Terminal block article number	Terminal block description
SM 1226 F-DI 4 x 24 VDC, F-DQ 2 x 24 VDC, DI 2 x 24 VDC (6ES7226-6ME50-0XB0)	6ES7292-2AK50-0XA0	10 position, tin-plated, gray

You can order the following components as accessories:

- Connectors
- Cables

For more information on parts and accessories, refer to the S7-1200 G2 System Manual (https://support.industry.siemens.com/cs/ww/en/view/109997791).

Fail-safe response times

C

C.1 Maximum response time of the system

This section shows the response times of the F-DI 4/F-DQ 2/ DI 2 Fail-safe module. The response times are included in the calculation of the F-system response time.

Times required for the calculation

T_{cycle} 7 ms	Firmware cycle time: This is the maximum internal cycle time of the fail-safe module.
T_{DAT_i} 12 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the fail-safe module to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

You assign the "Max. readback time" and "Max. readback time switch on test" settings in STEP 7.

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times" (http://support.automation.siemens.com/WW/view/en/49368678/133100).) Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{cycle} parameter values include an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

C.2 Input response time parameters

Maximum reaction time for 1oo1 fail-safe digital inputs

$T_{WCDT_i} = (2 \times T_{cycle}) + T_{filter} + T_{sct} + T_{stup}$

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the availability of the PROFIsafe message frame for request from the fail-safe CPU.
T_{filter}	Configured "Input filter" time for the channel
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "Duration of short-circuit test" + "Input filter" time if short-circuit test is configured (Confirmation: "Input filter" can occur twice in the equation for T_{WCDT_i} if the short-circuit test is configured).
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test is configured • Duration of the startup time

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

Maximum reaction time for 1oo2 fail-safe digital inputs

$T_{WCDT_i} = (2 \times T_{cycle}) + T_{filter}$ + SUM (T_{sct} primary input, T_{sct} secondary input) + SUM (T_{stup} primary input, T_{stup} secondary input)

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the availability of the PROFIsafe message frame for request from the fail-safe CPU.
T_{filter}	Configured "Input filter" time for the channel
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filter" time if short-circuit test is configured (Confirmation: "Input filter" can occur twice in the equation for T_{WCDT_i} if the short-circuit test is configured).
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test is configured • Duration of the startup time

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

Maximum fault reaction time for 1oo2 fail-safe digital input discrepancy errors

$T_{OFDT_i} = (2 \times T_{cycle}) + T_{filter} + T_{dis} + MAX (SUM (T_{sct}$ primary input, T_{stup} primary input, T_{sct} secondary input, T_{stup} secondary input), $T_{cycle})$

An activated short-circuit test summation must be included for each activated sensor supply.

Where:

T_{OFDT_i}	One Fault Delay Time: Maximum response time for the F-DI 1oo2 channel to report as passivated
T_{filter}	Fixed "Input filter" time for the channel
T_{dis}	Discrepancy time: • Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" • Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filter" time if short-circuit test is configured (Confirmation: "Input filter" can occur twice in the equation for T_{OFDT_i} if the short-circuit test is configured.)
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test configured • Duration of the startup time

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

The term "MAX (SUM (T_{sct} primary input, T_{stup} primary input, T_{sct} secondary input, T_{stup} secondary input), T_{cycle})" includes an additional T_{cycle} to ensure that the minimum amount of time for a complete firmware cycle is included. This applies to situations where the summation of the short-circuit times is less than the duration of a firmware cycle.

Maximum fault reaction time for external short-circuit errors on the fail-safe digital inputs

$T_{OFDT_isc} = (2 \times T_{cycle}) + T_{filter} + T_{scf}$

Where:

T_{OFDT_isc}	One Fault Maximum Delay Time: Maximum delay time to passivate an F-DI channel with an external short-circuit.
T_{filter}	Configured "Input filter" time for the channel
T_{scf}	T_{base} + MAX (T_{fmax} - T_{othr}, 0): The total time interval for short-circuit testing for all channels whose short-circuit test is enabled • T_{base} = SUM (T_{dur}): Where T_{dur} is the total test duration for all channels where short-circuit testing is enabled, including both short-circuit test durations and sensor startup times • $T_{othr} = T_{base}$ - MAX (T_{dur}): The total test duration for all channels other than the channel with the largest duration • T_{fmax} = MAX (T_{filter}) + 1: Maximum filter of all channels where short-circuit testing is enabled

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

C.3 Output response time parameters

Maximum reaction time for the fail-safe digital outputs

$T_{WCDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{WCDT_q}	Maximum response time of the F-DQ DC from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output
T_{rb}	Configured "Max. readback time" for the channel
T_{rb_swon}	Configured "Max. readback time switch on test" for the channel

The term "2 x T_{cycle}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

After the F-DQ DC commands the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Maximum fault reaction time for the fail-safe digital outputs

$T_{OFDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{OFDT_q}	One Fault Delay Time: Maximum response time for the F-DQ DC to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Max. readback time" for the channel
T_{rb_swon}	Configured "Max. readback time switch on test" for the channel

The term "2 x T_{cycle}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

Maximum fault reaction time for the fail-safe digital outputs with the Dark Test disabled

$T_{OFDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{OFDT_q}	One Fault Delay Time: Maximum response time for the F-DQ DC to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Max. readback time" for the channel
T_{rb_swon}	Configured "Max. readback time switch on test" for the channel

The term "2 x T_{cycle}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

NOTE
When dark testing is disabled for a given output, particular channel faults for this output might not be detected until a process value change occurs from "1" to "0". When dark testing is disabled and the process value is "1" for a given channel, the various safety measures do not manipulate the respective output switches.

C.4 ESF response time parameters

Maximum reaction time for an embedded safety function using a standard input

$T_{WCDT_SDI_FDQ} = T_{rb} + T_{filter}$
Where:

$T_{WCDT_SDI_FDQ}$	Worst Case Delay Time: Maximum response time from a transition of a standard input to a reaction of a fail-safe digital output
T_{rb}	Configured "Max. readback time" for the channel
T_{filter}	Configured "Input filters" time for the standard channel

After the F-DQ commands the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Maximum reaction time for an embedded safety function using a fail-safe input

The maximum reaction time for an embedded safety function with or without chaining dependencies is as follows:

$T_{WCDT_FDI_FDQ} = MAX\ (T_{WCDT\ (1oo1),}\ T_{WCDT\ (1oo2)}) + MAX\ (T_{WCDT_q})$
Where:

MAX ($T_{WCDT(1oo1),}\ T_{WCDT(1oo2)}$) applies to each input used within the respective embedded safety function. Each input is calculated separately and the maximum time applied.

T_{WCDT_q} applies to each output used within the respective embedded safety function. Each output is calculated separately and the maximum time applied.

After the F-DQ commands the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Maximum fault reaction time for an embedded safety function

The maximum fault reaction time for an embedded safety function with or without chaining dependencies is as follows:

$T_{_OFDT_ESF}$ = MAX ($T_{OFDT(1oo1)}$, $T_{OFDT(1oo2)}$) + MAX (T_{OFDT_q})

Where:

T_{OFDT_esf}	One Fault Delay Time: Maximum response time for the safety function to turn an output OFF. Refer to the individual $_{OFDT}$ fault reaction time calculations for detailed information.

MAX ($T_{OFDT(1oo1)}$, $T_{ODFT(1oo2)}$)T_{WCDT_q} applies to each input used within the respective embedded safety function. Each input is calculated separately and the maximum time applied.

T_{OFDT_q} applies to each output used within the respective embedded safety function. Each output is calculated separately.

Switching of loads

D

D.1 Connecting capacitive loads

If a fail-safe module is interconnected with loads that require little current and have capacitance, it is important that the readback time parameters are set to a large enough value to allow the capacitive load time to charge or discharge. If the value is too small, the module could issue a diagnostic error due to the load not responding with the correct process value in time. To avoid this, you must calculate appropriate readback time values. This ensures that your load does not respond to test pulses but has sufficient time to react to changes of the process value. Load capacitance can delay the diagnostic voltage response at the P- and M-switches of the fail-safe module's digital outputs. The pattern testing of this module requires the voltage at the P- and M-switches to be nearly zero across the load whenever the process value is "1".

You can place a diode between the P-switch and the capacitive load. This ensures that when the output is turned off, the voltage on the capacitor is not present at the P-switch during diagnostic testing. Typically, this diode is built into power supplies with input capacitors that have reverse voltage protection implemented. Using an additional diode can greatly reduce the "Max. readback time". The reduced "Max. readback time" allows the load to operate normally (load stays ON) during diagnostic testing. Alternatively, you can change the parameterization of a channel to not perform dark testing by selecting the check box for the "Disable dark test (max. SIL2, CAT3, PLd)" parameter.

Stray capacitance between the load circuit/wiring and ground, as well as between M and P, can increase the time needed for the "Max. readback time switch on test". During module diagnostics when the P- or M-switch is turned on to a load that is not powered during bit pattern testing, both sides of the load are influenced by stray capacitance. This effect is typically minor, but it is important for the "Max. readback time switch on test" duration to be long enough for the load circuit voltage to react, yet short enough that if one side of the load connects to P or M, the testing of the opposite switch does not cause the load to react.

Capacitive loads with low series resistance, including power supplies with input capacitors, can experience large inrush current. To avoid this, you should add series resistance to reduce inrush on large capacitive loads. Doing so reduces inrush current and minimizes risk of blown fuses or overcurrent fault detection during normal load switch-on events.

D.2 Switching of inductive loads

The diagram below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the fail-safe module digital outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the fail-safe module digital output switch. External suppression conducts the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression.

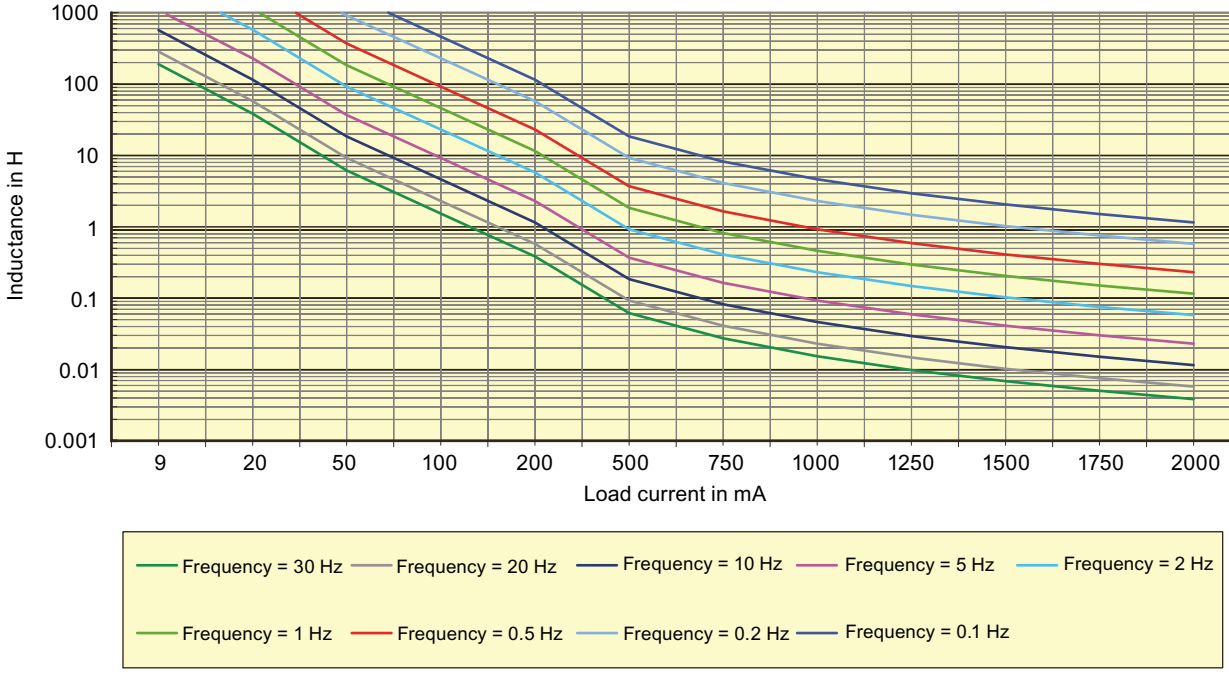


Figure 1-37 Switching of inductive loads depending on the load current and switching frequency

NOTE

Minimum permissible OFF time for fail-safe digital outputs

The fail-safe module's digital outputs expect to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than T_{WCDT_q} can cause the channel to passivate.

⚠ WARNING

Failures of unsuppressed inductive loads
The following failures can result from a lack of suppression of inductive loads:

- Unsuppressed inductive loads can lead to early "stuck-on"' failures of the Fail-safe module digital outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads. For more information on using suppressor circuits, refer to the *S7-1200 G2 Programmable Logic Controller System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109997791).
Failure to observe proper precautions can result in death, severe personal injury, and/or property damage.

SIEMENS

SIMATIC

S7-1200 G2 Programmable Logic Controller

System Manual

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Introduction

1

1.1 General information

Purpose of the documentation

The S7-1200 G2 programmable logic controllers (PLCs) can control a variety of automation applications. Compact design, affordable price, and a powerful instruction set make the S7-1200 G2 CPU and modules a perfect solution for controlling a wide variety of applications. Together with the STEP 7 configuration and programming tool (Page 93), you have the flexibility you need to design your automation solutions.

This documentation provides information about the S7-1200 G2 CPU and modules. It contains information for engineers, programmers, installers, and electricians.

Required basic knowledge

To understand this documentation, you need a general knowledge of automation and programmable logic controllers.

Validity of the documentation

This documentation applies to the S7-1200 G2 CPU family and G2 modules.

Refer to the technical specifications (Page 337) for each CPU and module in the S7-1200 G2 family.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

ID link for the digital nameplate



The ID link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product.

The figure shows an example of an ID link for the CPU 1212C AC/DC/RLY.

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

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

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

Industry Mall

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

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

Certifications and approvals

Refer to the technical specifications (Page 337) for details on certifications and approvals.

Glossary

The definitions in the glossary provide an easy first reference for understanding the terms in this documentation.

1.2 Maintaining operational safety of your plant

NOTE

Operators of plants with safety-related features must meet operational safety requirements. Suppliers must also take measures when monitoring products.
To stay up-to-date on the latest operational safety requirements, visit the Siemens Industry Online Support (https://sieportal.siemens.com/en-ww/support) site and subscribe to email notifications:

1. Follow one of the links below:
   - SIMATIC S7-1200 G2/SIMATIC S7-1200 G2 F (https://support.industry.siemens.com/cs/us/en/ps/30068)
   - Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
   - STEP 7 TIA Portal (https://support.industry.siemens.com/cs/ww/en/ps/14667)
2. To subscribe to notifications, select "email on update".

NOTE

To reduce the risks associated with malicious or counterfeit CPUs and modules, use only official sales channels, such as the following:

- Siemens Industry Mall
- Official Siemens distributors
- Country-specific official Siemens sales and distribution channels

NOTE

To reduce the risks associated with compromised CPU or module firmware, only download firmware from the Siemens Industry Online Support website and verify the file integrity against the associated published SHA checksum.

NOTE

To reduce the risk of physical tampering with critical industrial equipment, implement the measures defined in the Operational guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html).

NOTE

For additional security, the CPU uses firmware encryption. While encryption provides confidentiality of the firmware, the main purpose is to enhance the secure boot process.

1.3 S7-1200 G2 documentation guide

S7-1200 G2 and the TIA Portal provide a variety of documentation and other resources for finding the technical information that you require.

- The S7-1200 G2 Programmable Logic Controller System Manual provides specific information about the operation, programming, and the specifications for the complete S7-1200 G2 product family.

  The system manual is available on Siemens Industry Online Support (https://support.industry.siemens.com/) in multiple display formats and languages.
- The TIA Portal Information System provides access to the conceptual information and specific instructions that describe the operation and functionality of the programming package and basic operation of SIMATIC CPUs.
- You can also follow or join product discussions on the Service & Support technical forum (https://support.industry.siemens.com/tf/ww/en/?Language=en&siteid=csius&treeLang=en&groupid=4000002&extranet=standard&viewreg=WW&nodeid0=34612486). These forums allow you to interact with various product experts.
  - Forum for S7-1200 G2 (https://support.industry.siemens.com/tf/ww/en/threads/237?title=simatic-s7-1200&skip=0&take=10&orderBy=LastPostDate+desc)
  - Forum for TIA Portal (https://support.industry.siemens.com/tf/ww/en/threads/243?title=step-7-tia-portal&skip=0&take=10&orderBy=LastPostDate+desc)
- The SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming Manual (http://support.automation.siemens.com/WW/view/en/54110126/0/en) provides information about configuring and programming fail-safe PLCs.

Contact your Siemens distributor or sales office for assistance in answering any technical questions, for training, or for ordering S7 products. Because sales representatives are technically trained and have knowledge about your operations, process and industry, as well as about the Siemens products that you are using, they can provide efficient answers to problems you might encounter.

System manual updates

When needed, changes and supplements to released system manuals are available in a system manual update document. These updates take precedence over the system manual. You can find the latest system manual updates on Siemens Industry Online Support (https://support.industry.siemens.com/)

1.4 SIMATIC Technical Documentation

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

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

Overview of the SIMATIC Technical Documentation

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

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

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

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

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

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

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

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

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

Updating the documentation

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

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

mySupport

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

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

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

Application examples

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

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

1.5 Tool support

Tools

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

TIA Selection Tool

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

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

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

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

SIMATIC Automation Tool

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

The SIMATIC Automation Tool offers a wide range of functions:

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

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/us/en/view/109986787)

PRONETA

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

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

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

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

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

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

SINETPLAN

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

The advantages at a glance

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

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

Industrial cybersecurity

2

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

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

NOTE

Security-relevant changes to software or devices are documented in the section New properties/functions (Page 28).

2.1 Cybersecurity information

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

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

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

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

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

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

2.2 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction (Page 15) section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

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

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

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

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

2.3 Basic information on industrial cybersecurity

2.3.1 Definition of industrial cybersecurity

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

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (for example, due to the destruction of data or denial of service (DoS))

2.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices that do not have their own security functions

- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

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

2.4 Integrated security concept and security strategies

2.4.1 Comprehensive security concept "Defense in Depth"

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

Productivity and know-how are protected on 3 levels:

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

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

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

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

You can also visit the download center (https://cert-portal.siemens.com/operational-guidelines-industrial-security.pdf?ste_sid=0d5cc2df23db50211d4d0a3c7653cba7) to obtain more information on the topic of industrial cybersecurity. The "Operational Guidelines", for example, provide recommendations on basic security measures for secure machine and plant operation in an industrial environment.

2.4.2 Security management

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

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

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

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

Siemens will provide you with information and support. Subscribe to the Security feeds (https://www.siemens.com/cert) for information on vulnerabilities. Register with mySiePortal (https://sieportal.siemens.com/en-ww/mysieportal) and create filters to be notified when important information is published. The procedure is described in the section Notification of security updates (Page 22). Consider using Siemens Cybersecurity Services.

Responsibility in the digital supply chain

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

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

Employee awareness

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

- Secure handling of USB devices
- Encrypted communication
- Use of VPN
- Rules for passwords and use of access
- Setting up two-factor authentication
- Educating employees about the dangers posed by malware, phishing, social engineering and other factors

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

Maintaining the security concept through updates

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

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

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

Recommendations:

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

Always keep technology and knowledge up to date.

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

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

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

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

Continuously monitoring the security situation

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

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and resolve security vulnerabilities in a targeted manner.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network

- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: for example, network segmentation, firewalls, VPN, DMZ (demilitarized zones)

2.5 Operational application environment and security assumptions

2.5.1 Intended use

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

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

Operational reliability and intended use

Before using your product, read the introductory information about operational guidelines and intended use. Also read the Technical Specifications for your components of your system.

2.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

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

Threat and Risk Assessment

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

Network security concepts

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

Access control concepts

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

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

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

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

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

2.6 Security properties of the devices

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

2.7 Secure operation of the system

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

2.7.1 Hardening measures

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

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which a restrictive user and rights management system is implemented.

2.7.2 Secure configuration

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

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

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

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

2.7.3 Access control

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

- Use a restrictive user and rights management system, for example, for accessing the CPUs and TIA Portal.
- Refer to the information about password management in the section Protection (Page 176) and in the STEP 7 online help (TIA Portal).

See also

Password management (Page 36)

2.7.4 Handling of sensitive data

Data protection information

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

This means for the products in this system:

Products with user management save user names and passwords to manage access rights. User names are also saved in logging alarms. These logging alarms are provided with a time stamp and stored in the internal cache of the CPU. They can be forwarded to a central syslog server. You can find more information in the section Syslog messages (Page 42).

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

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

Information on the secure removal of data from the CPU, interface module and SIMATIC Memory Card is provided in the section Secure decommissioning (Page 31).

Storage of security-relevant data

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

Also observe the section Sensitive data (Page 39).

2.7.5 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

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

You can find more information in the following:

- The section Firmware update (https://sieportal.siemens.com/su/blqEr)
- The section Notification of security updates (Page 30)

2.7.6 Notifications about security vulnerabilities (Siemens Security Advisories)

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

Siemens ProductCERT

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

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

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

On this page, you will also find all the required information on how to deal with vulnerabilities:

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

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

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

2.7.7 Data backup

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

2.7.8 Security checks

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

File Integrity Guidelines describe the prescribed procedure for integrity checks.

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

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

2.7.9 Secure decomissioning

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

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

2.7.9.1 Securely removing data

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

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

Secure erasure of data from the CPU and SIMATIC Memory Card

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

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

1. Format the SIMATIC Memory Card.

   The formatting deletes all contents from the SIMATIC Memory Card.

   Formatting with STEP 7:

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

   Formatting using the display of a CPU:

   – In the display of the CPU, select the menu "Settings" > "Card functions" > "Format card" and confirm with OK.

2. Restore the factory settings of the CPU.

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

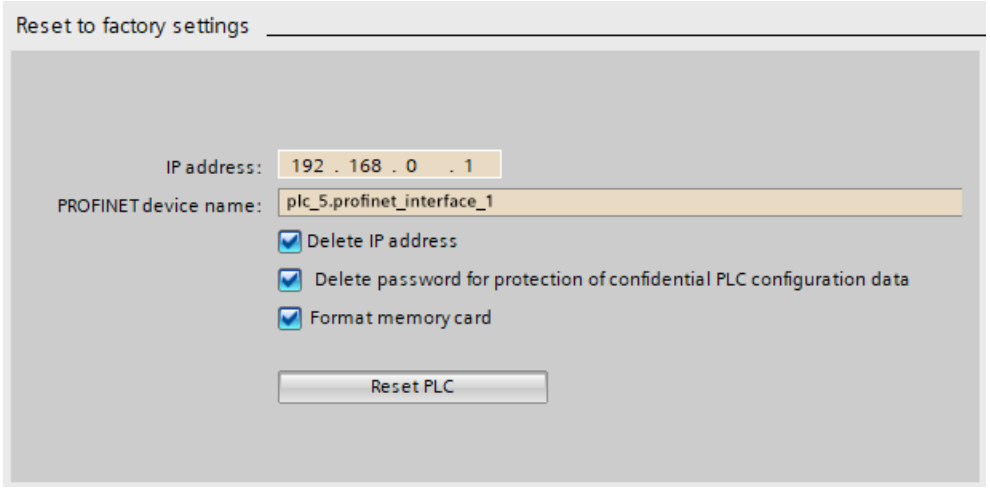


Figure 1-38 Resetting the CPU to factory settings

NOTE

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

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

For more information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (https://docs.tia.siemens.cloud/access?ft:originId=HWCDiagenUS_20.00.00.00_release&ft:clusterIdHWCDiag).

NOTE

If you no longer plan to use the SIMATIC Memory Card after formatting it, destroy it before disposing of it.
A secure destruction method is to shred the card to such a degree that it cannot be reconstructed. For this, you can also use a waste disposal service that specializes in data storage medium destruction.

Secure erasure of data from the interface module

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

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

Follow these steps in the order given:

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

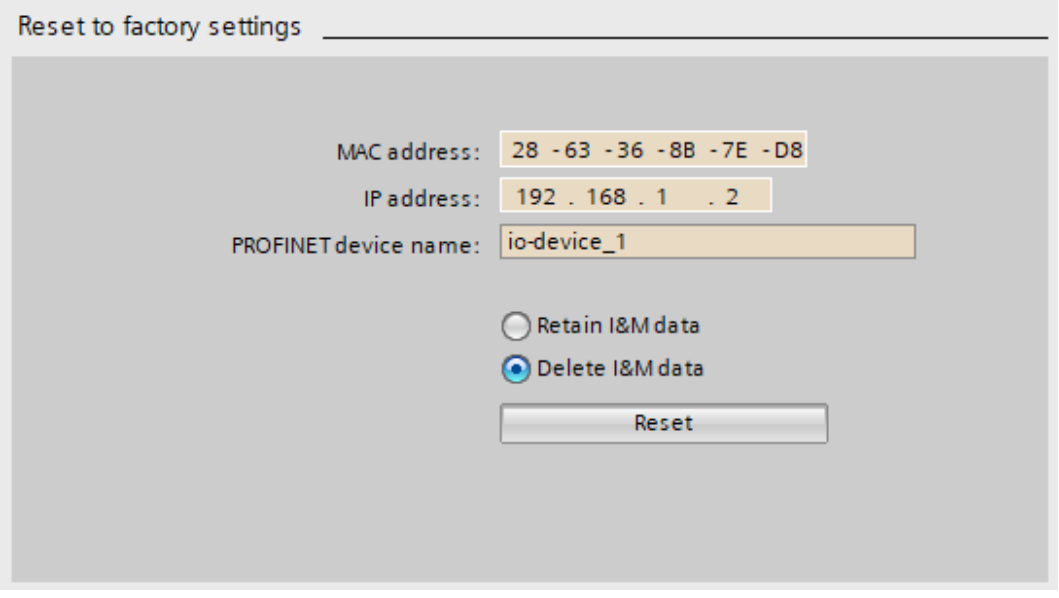


Figure 1-39 Resetting an interface module to factory settings

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

For more information on resetting the interface module to factory settings, refer to the section Resetting an interface module to factory settings (https://docs.tia.siemens.cloud/access?ft:originId=HWCDiagenUS_20.00.00.00_release&ft:clusterIdHWCDiag).

NOTE

STEP 7 ≥ V19

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

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

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

2.7.9.2 Recycling and disposal

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

NOTE

Recycler Guides

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

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

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

2.8 Secure operation of the engineering software

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

2.9 Secure operation of the CPUs

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

2.9.1 Secure configuration

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

2.9.2 User management and access control

2.9.2.1 Administration of user accounts

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

Take the following security measures:

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

You can find information on creating and managing user accounts in the Protection (https://docs.tia.siemens.cloud/access?ft:originId=./100365717643/100365717643_enUS.htm&ft:clusterId./100365717643/100365717643.htm) section under "User management" and in the online help for STEP 7 (TIA Portal).

2.9.2.2 Assigning secure passwords

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

- Therefore, always change the default passwords during commissioning and use different passwords for different users, functions and devices.
- When changing the password, do not use passwords (or parts of passwords) that were used in the past.
- Also, change passwords for functions you don't personally use to prevent misuse of such unused functions.
- Always keep your passwords confidential and ensure that only authorized individuals have access to the respective passwords.
- Go over the required minimum password length and use a mixture of lower- and upper-case letters, numbers and characters.

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

Overview of all components and functions with password protection

Components and functions with password protection	Comment
SIMATIC S7 app	See section SIMATIC S7 app (https://www.siemens.com/global/en/products/software/mobile-apps/simatic2go.html)
Syslog (with certificate protection)	See section Syslog messages (Page 42)
CPU	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
OPC UA	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section OPC UA communication
SNMP Community-String (similar to a password)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section SNMP
Secure communication (with certificate protection)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
Web server	See the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109977246)

2.9.2.3 Password management

- You can find comprehensive recommendations for creating secure passwords in the Industrial security Configuration Manual (https://support.industry.siemens.com/cs/us/en/view/109974047).
- Establish guidelines for assigning passwords and intervals for password changes.
- Settings for checking password policies when passwords are assigned or changed can be configured in the TIA Portal. For more information, please refer to the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
- Modify and reset the password for protecting confidential configuration data.
  You can find information on the following topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925):
  - Description of how to change the password
  - Description of how to delete or reset the password
  - Description of how to assign the password via a SIMATIC Memory Card
- Access to a password-protected CPU can be configured through the display, if the CPU has a display; see section Using the display to set additional password protection.
- For user management and access control, use the Local/central user management (https://docs.tia.siemens.cloud/access?ft:originId=./100365717643/100365717643_enUS.htm&ft:clusterId./100365717643/100365717643.htm).
- Using a password provider: In STEP 7, you can set up a password provider; see section Know-how protection (https://docs.tia.siemens.cloud/access?ft:originId=ProgBlockProtectionenUS_20.00.00.00_release&ft:clusterIdProgBlockProtection).

- In addition, you can use commercially available password management programs.

Setting password protection without engineering system

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

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

You can find more information about the available methods of the web server's Web API in the Web server (https://support.industry.siemens.com/cs/ww/en/view/109977246) Function Manual.

2.9.2.4 Setting protection levels

For detailed information about setting up protection levels for the CPU and assigning user authorizations, refer to the section Configuring access protection for the CPU (https://docs.tia.siemens.cloud/access?ft:originId=./11627607179/171587178635_enUS.htm&ft:clusterId./ 11627607179/171587178635.htm) and the STEP 7 online help (TIA Portal).

2.9.2.5 Certificate management

You can create, assign and manage certificates with TIA Portal for the following functions of the CPUs:

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

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

2.9.3 Protection functions

Integrated protection functions of the CPU protect against unauthorized access.

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

A description of the protection functions and their activation can be found in the section Protection (https://docs.tia.siemens.cloud/access?ft:originId=ProgCPU15enUS_20.00.00.00_release&ft:clusterIdProgfCPU15).

2.9.4 Signed firmware update for CPUs

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

Principle of the signed firmware updates for CPUs

Firmware updates for CPUs contain a digital signature.

The digitally signed firmware update files are available for download on the Siemens Support Web page (https://sieportal.siemens.com/su/blqEr).

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

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

The procedure for carrying out firmware updates for CPUs is described in the section Firmware update (https://support.industry.siemens.com/cs/ww/en/view/109988293/185156409355).

Diagnostics alarms and remedy

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

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

In case of firmware update rejection, proceed as follows:

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

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109483101).

2.9.5 Secure Boot for CPUs

Secure Boot

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

Principle of "Secure Boot" for CPUs

CPUs verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before their startup.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to the signed firmware update for CPUs (Page 38), Secure Boot prevents a manipulation of the firmware by a physical intervention into the CPU.

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

2.9.6 Secure communication/OPC UA

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

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

2.9.7 Sensitive data

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

Sensitive data	Comment	Where can I find more information?
Confidential configuration data (private keys, passwords/access data)	Protection by using a strong password	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Protection of confidential configuration data
User management data	-	Protection (https://docs.tia.siemens.cloud/access?ft:originId=ProgCPU15enUS_20.00.00.00_release&ft:clusterIdProgfCPU15) section STEP 7 online help

Sensitive data	Comment	Where can I find more information?
Configuration of CPUs and interface modules	Protection through PROFINET Security Class 1	Function manual PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Blocks (data blocks, logic blocks)	Know-how protection, copy protection, write protection	Protection (https://docs.tia.siemens.cloud/access?ft:originId=ProgBlockProtectionenUS_20.00.00.00_release&ft:clusterIdProgBlockProtection) section
Data deemed sensitive by the operator	Backups, other configuration data, analysis data	Backing up and restoring the CPU configuration (https://docs.tia.siemens.cloud/access?ft:originId=ProgOnlineBackupenUS_20.00.00.00_release&ft:clusterIdProgOnlineBackup) section

2.9.8 Backups and data backups

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

Backup of a STEP 7 project:

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

You can find more information in the section Backing up and restoring the CPU configuration (https://docs.tia.siemens.cloud/access?ft:originId=ProgOnlineBackupenUS_20.00.00.00_release&ft:clusterIdProgOnlineBackup).

2.9.9 Additional protective measures for network security

In addition to the protective measures described in this manual, you can find information on network security and network components for protection against unauthorized access in the Network security section of the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

See also

SIMATIC CP 1243-1 (https://sieportal.siemens.com/su/blYx6)

2.9.10 Using a Web server

The CPUs have an integrated Web server.
It comes with built-in security features:

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

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

Information about potential risks when using Web servers can be found in the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109977246).

2.9.11 Recording security events

Syslog storage

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

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

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

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

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

You can find more information in the section Syslog messages (Page 42).

Connection to a SIEM system

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

2.9.12 Syslog messages

Using syslog messages

International standards and national regulations for the IT security of automation components require, for example, the ability to log safety-related events.

Syslog (System Logging) is an IETF standard protocol (RFC 5424) for the transfer of recorded events and meets this requirement. A CPU records the following events, for example:

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

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

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

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

Forwarding to a syslog server

You can transfer syslog messages to a server, for example, SINEC INS. The syslog messages are transferred to the syslog server via the syslog protocol. The syslog server saves all syslog messages from its connected devices. Messages of system and network events are stored centrally in a storage location in the syslog server. At the syslog server interface, you can view the collected syslog messages and thereby determine the source of potential security risks or problems.

Syslog messages are sent to the syslog server via port 514 (UDP) or port 6514 (TLS over TCP) by default.

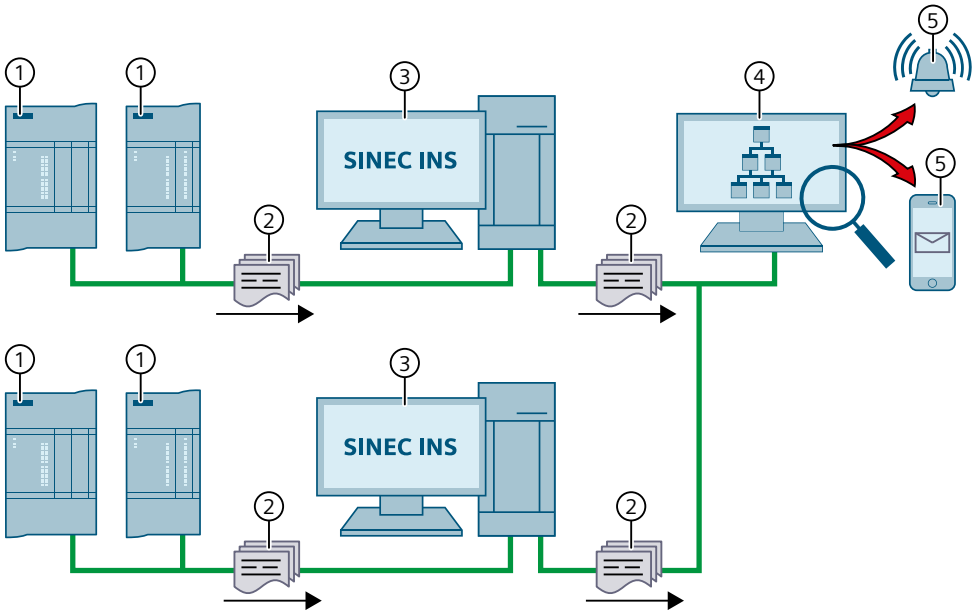
NOTE

If you are using UDP as the transport protocol, the data is transmitted unencrypted. Authentication is also omitted with UDP.

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

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

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



① CPUs
② Syslog messages
③ Syslog server, for example, SINEC INS
④ SIEM system
⑤ Notify user

More information

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

You can find information on the structure of syslog messages in the Structure of the Syslog messages (Page 46) section.

2.9.12.1 Transfer of the syslog messages to a syslog server

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

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

Transmitting syslog messages via a TLS connection

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

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

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

Message in the diagnostics buffer of the CPU

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

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

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

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

Requirements

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

- STEP 7 as of version V20
- S7-1200 G2 CPU as of FW version V1.0
- A project has been created in STEP 7
- The device or network view of STEP 7 is open

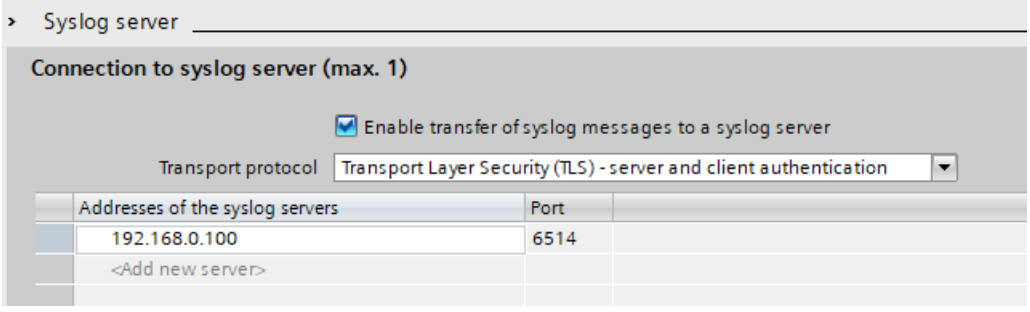
Procedure

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

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

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

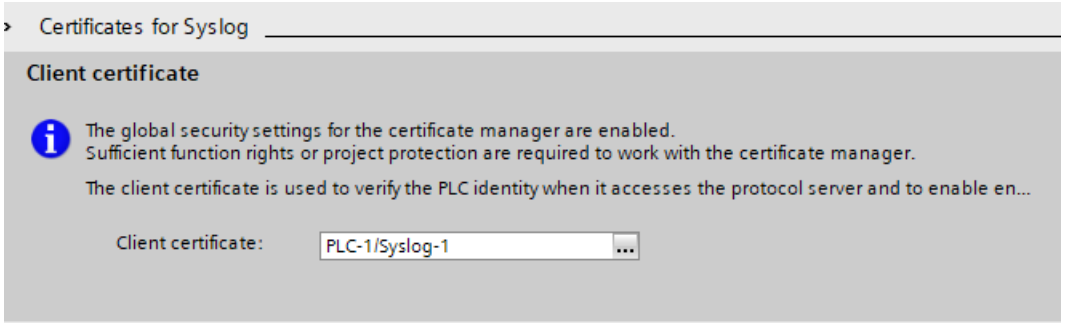
Result: You have configured the transfer of syslog messages to a syslog server.



Selecting the client certificate

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

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



Selecting the server authentication

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

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

NOTE

No authentication with automatically accepted server certificates
If you enable the "Automatically accept server certificates during runtime" option, a server does not need to authenticate itself. This means that the CPU can also connect to unknown servers that could represent a security risk.
Only select this option during commissioning or in a protected environment.

2.9.12.2 Structure of the Syslog messages

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

- HEADER
- STRUCTURED-DATA
- MSG (Message)

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

Structure of the HEADER element

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

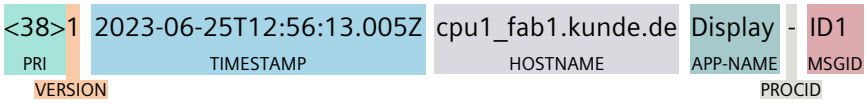


Figure 1-40 Example: HEADER of the syslog message of a CPU

The following table describes the parameters in the prescribed order.

Parameter	Description
PRI	PRI encodes the priority of the syslog message, divided into Severity (severity of the message) and Facility (origin of the message). The PRI value is formed as follows: • PRI = Facility x 8 + Severity Possible values: • Severity – 0 = Emergency: system is unusable – 1 = Alert: action must be taken immediately – 2 = Critical: critical conditions – 3 = Error: error conditions – 4 = Warning: warning conditions – 5 = Notice: normal but significant condition – 6 = Informational: informational messages – 7 = Debug: debug-level messages • Facility – 1 = User-level messages – 2 = Mail system – 3 = System daemons – 4 = Security/authorization messages – 5 = Messages generated internally by syslog – 6 = Line printer subsystem – 7 = Network news subsystem – 8 = UUCP subsystem – 9 = Clock daemon – 10 = Security/authorization messages – 11 = FTP daemon – 12 = NTP subsystem – 13 = Log audit – 14 = Log alert A CPU does not use all of the listed severity/facility values.
VERSION	Version number of the syslog specification.
TIMESTAMP	The device sends the time stamp in the format "2023-06-25T12:56:13.005Z" as UTC time without time zone and correction for daylight-saving/standard time.
HOSTNAME	Contains the name or the IP address (PROFINET interface X1) of the device or system from which the syslog message has been sent. IPv4 address according to RFC1035: Bytes in decimal representation: XXX.XXX.XXX.XXX IPv6 address according to RFC4291 Section 2.2 "-" is output if information is missing.
APP-NAME	Contains the component (device part or application) from which the message has been generated. "-" is output if information is missing.
PROCID	The process ID serves to clearly identify the individual processes, for example during analysis and troubleshooting. "-" is output if information is missing.
MSGID	ID to identify the message. "-" is output if information is missing.

Structure of the STRUCTURED-DATA element

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

- More information about the syslog message
- Application specific information

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

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

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

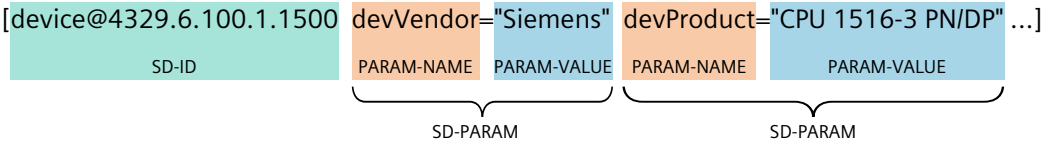


Figure 1-41 Example: SD ELEMENT of the syslog message of a CPU

Structure of the MSG element

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

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

More information

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

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

2.10 Secure operation of interface modules

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

2.10.1 Data integrity for interface modules

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

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

Data integrity for interface modules

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

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

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

Principle

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

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

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

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

I&M data

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

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

NOTE

Requirements for calculating the CRCs

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

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

Example:

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

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

The structure of the I&M data 0 to 4 is described in the section Record structure for I&M data (https://docs.tia.siemens.cloud/access?ft:prettyUrl=simatic_s7_1500_et_200mp_manual_collection_enus_20/basic-information/simatic-drive-controller/commissioning/identification-and-maintenance-data/record-structure-for-i-m-data).

Spare parts scenario

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

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

2.10.2 Signed firmware update for interface modules

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

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

Principle of the signed firmware update for interface modules

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

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

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

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

You still have all the options for firmware updates, as described in the Firmware update (https://docs.tia.siemens.cloud/access?ft:originId=HWCDiagenUS_20.00.00.00_release&ft:clusterIdHWCDiag) section, when performing signed firmware updates for modules. If the firmware update was not successful, the module will continue to run with the previous firmware.

Diagnostics alarms and remedy

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

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

You can find more information in the section on diagnostics alarms in the equipment manual for the respective module.

In case of firmware update rejection, proceed as follows:

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

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109483101).

2.10.3 Secure Boot for interface modules

Secure Boot

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

Information on whether your interface module supports Secure Boot is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of "Secure Boot" for interface modules

Interface modules verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before being executed.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to signed firmware updates for interface modules, Secure Boot also prevents manipulation of the firmware through physical intervention in the interface module.

Secure Boot is integrated into the interface module and cannot be deactivated for security reasons.

NOTE

Longer startup duration of the interface module
The signature verification of Secure Boot significantly extends the startup time of the interface module. You can find time specifications in the Equipment Manual of the interface module, in the Technical specifications section.

LED display on the interface module

If the Secure Boot verification results in an invalid signature, the LEDs RUN, ERROR, and MAINT on the interface module will flash. In this case, you need to replace the interface module.

2.11 Secure operation of I/O modules

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

2.11.1 Data integrity for I/O modules

Data integrity for I/O modules

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

Principle

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

You can find more information on the principle of data integrity and I&M4 data in the section Data integrity for interface modules (Page 49).

Spare parts scenario

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

- CHK_STATIC_SUBS
- CHK_OVERALL_SUBS
- CHK_OVERALL

You can find the structure of I&M data in the section Record structure for I&M data (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/basic-information/simatic-drive-controller/commissioning/identification-and-maintenance-data/record-structure-for-i-m-data).

2.11.2 Signed firmware update for I/O modules

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

Signed firmware update for I/O modules

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

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

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 51) applies.

2.12 Secure operation of power supply modules

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

2.12.1 Signed firmware update for system power supplies (PS)

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

Signed firmware update for system power supplies (PS)

Firmware updates for system power supplies (PS) can contain a digital signature. Information on whether your power supply module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

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

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 51) applies.

Product overview

3

3.1 Introducing the S7-1200 G2 PLC

The S7-1200 G2 PLC family is Generation 2 of the S7-1200 and offers a significantly narrower footprint than the first generation. The CPU and devices provide the flexibility and power to control a wide variety of automation applications. The configuration and programming software is STEP 7 within the TIA Portal framework. If you have used the STEP 7 configuration and programming software (Page 93) with other CPU families, take note of compatibility information (Page 169).

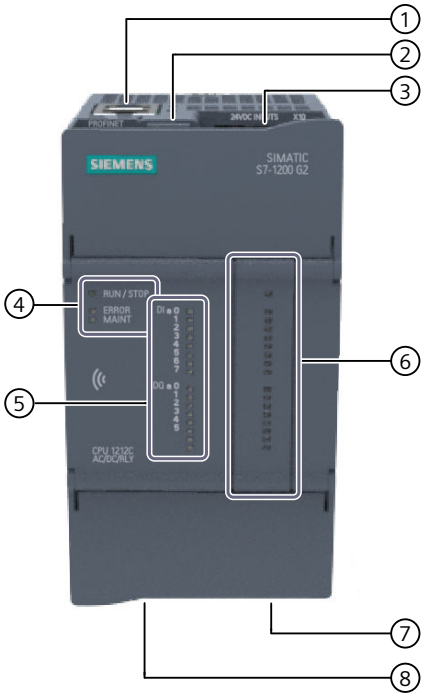
The CPU combines the following elements and more in a compact housing to create a powerful controller:

- A microprocessor
- An integrated power supply
- Input and output circuits
- Built-in PROFINET
- High-speed counters
- Standard and Advanced Motion Control

The S7-1200 G2 firmware adds new functionality and supports most of the previous S7-1200 functionality, with noted differences. (Page 59)

After you download your program, the CPU contains the logic required to monitor and control the devices in your application. The CPU monitors the inputs and changes the outputs according to the logic of your user program, which can include Boolean logic, counting, timing, complex math operations, motion control, and communications with other intelligent devices.

The CPU provides a built-in PROFINET interface with two ports for communication over a PROFINET network. You can connect additional Input, Output, and Communication modules (Page 57) to support larger automation applications.



① PROFINET interface with two ports, X1 (on the top of the CPU)
② Memory card slot, X50 (behind the door)
③ Removable input connector, X10 (behind the door)
④ Status LEDs for the CPU
⑤ Status LEDs for the on-board I/O
⑥ Optional plug-in expansion board, X300 (for CPUs with two slots, X300 and X301)
⑦ Removable output connector, X11 (behind the door, on the bottom of the CPU)
⑧ Power connector, X80 (behind the door, on the bottom of the CPU)

Several security features help protect access to both the CPU and the control program:

- Password protection that allows you to configure access to the CPU functions.
- "know-how protection" to hide the code within a specific block.
- Protection of confidential PLC configuration data
- Secure PG/PC and HMI communication
- Secure boot

You configure these security features in STEP 7. The TIA Portal Information System describes the types of security configurations.

For detailed information about a specific CPU or device, see the technical specifications (Page 337).

3.2 S7-1200 G2 modules and boards

You can connect expansion boards and expansion modules to the CPU to increase its functionality. The following types are available: Communication boards (CBs), Signal boards (SBs), Battery boards (BBs), Communication modules (CMs), Communication processors (CPs), and Signal modules (SMs).

Expansion boards

A variety of plug-in expansion boards are available for use with the S7-1200 G2 system:

- Communication boards (CBs)
- Signal boards (SBs)
- Battery boards (BBs)

You can add CBs, such as the RS485, to increase the communication capability of a CPU.

You can add SBs to increase the digital and analog I/O capability.

You can add a BB to provide long-term backup of the CPU's real-time clock.

NOTE

BBs do not have a removable communication port or I/O wiring connector feature like CBs and SBs.

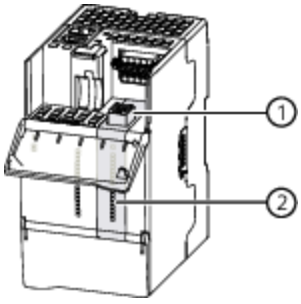
All S7-1200 G2 CPUs support plug-in expansion boards:

- The 1212 CPUs support one plug-in expansion board.
- The 1214 CPUs support two plug-in expansion boards.

NOTE

You can use any combination of plug-in expansion boards in a 1214C or 1214FC CPU, but you cannot use two BBs at the same time. Only one BB can be used. You cannot configure more than one BB for any S7-1200 G2 CPU the TIA Portal. All S7-1200 G2 CPUs support one BB.

In the following diagram, the plug-in expansion board is highlighted, and its key features are labeled:

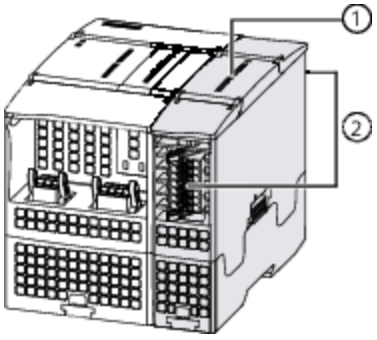


① Removable communication port or I/O wiring connector (This feature is not present on BBs.)
② Status LEDs

Communication modules (CMs) and Communication processors (CPs)

CMs and CPs add communication options to the system, such as RS232/422/485 and Ethernet connectivity. You connect CMs and CPs to the right side of a CPU or CM. All S7-1200 G2 CPUs support up to three communication devices, CMs and CPs, in any combination.

In the following diagram, a CM or CP is highlighted, and its key features are labeled:



① Status LEDs
② Removable communication connector

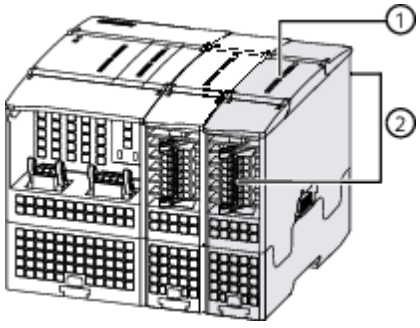
Signal modules (SMs)

SMs add additional functionality to the system, such as digital and analog I/O capability. Connect SMs to the right side of a CPU, CM, CP, or SM. The number of supported expansion modules depends on the CPU:

- The 1212 CPUs support up to six expansion modules (CMs, CPs, and SMs).
- The 1214 CPUs support up to ten expansion modules (CMs, CPs, and SMs).

To determine the number of SMs you can use in a system, subtract the number of CMs or CPs from the maximum number of expansion modules supported. For example, if you use three CMs or CPs with a 1212 CPU, you can use three SMs.

In the following diagram, the SM is highlighted, and its key features are labeled:



① Status LEDs
② Removable I/O wiring connector

3.3 Features

The S7-1200 G2 PLC (Page 55) provides the following features:

- Savings in Installation and wiring (Page 61) space
- Faster execution times
- Near Field Communication (NFC) (Page 299) application for mobile device access to the CPU
- Two expansion board slots (Page 57) for 1214 CPU models, one slot for 1212 CPU models
- Dual Ethernet ports for all CPU models
- Enhanced security
- 8 HSCs (High Speed Counters)
- 8 pulse generators for use as PTOs (Pulse Train Outputs) or for PWM (Pulse Width Modulation)
- Additional error OBs (Page 101)
- Basic, standard, and advanced motion control features (Page 302)
- Support for Real-Time PROFINET and Isochronous Real-Time PROFINET communication
- Ability for CPU can to act as an I-device with PROFIEnergy functionality
- Support for Media Redundancy for Planned Duplication (MRPD) (Page 249) and Media Redundancy Protocol (MRP) (Page 248)
- Support for 31 PROFINET devices (Page 203)
- User-configurable alarms
- Web server (Page 300)
- Support for DHCP and DNS (Page 228)
- Work memory reporting as code work memory and data work memory
- Power budget calculation tool in TIA Portal
- 8MB of internal load memory
- 20KB of retentive memory
- System logging (Page 42)
- Support for users and roles (Page 150)
- SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/ww/en/view/109750245)
- OPC UA server (Page 257)
- Backup and restore capability (Page 336)

Refer to the Technical Specifications (Page 337) for more information.

Differences from the S7-1200 family

The S7-1200 G2 PLC (Page 55) provides features and differences from the S7-1200 PLC as described in Comparison to S7-1200 (Page 475).

3.4 What's new?

The following features are new with this release:

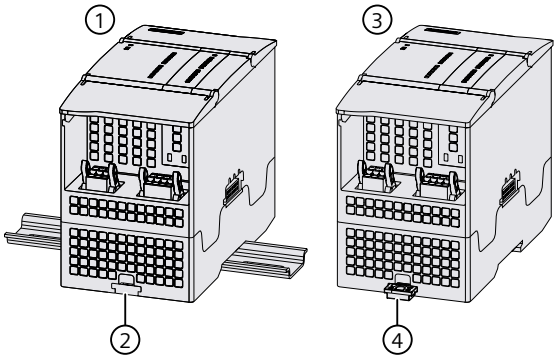
- OPC UA server (Page 257)
- System web pages for the Web server (Page 300)
- Additional modules:
  - Battery Board (BB) 1297 (Page 457)
  - Communication Processor (CP) 1243-1 G2 Ethernet (Page 458)
  - Input Simulators (8 position and 14 position) (Page 464)
  - Signal Module (SM) 1223 DI 16x24VDC / DQ 16xrelay (Page 403)
  - Signal Module (SM) 1223 DI 16x24VDC / DQ 16x24VDC Sink (Page 401)
  - Signal Module (SM) 1223 DI 16x24VDC / DQ 16x24VDC (Page 398)
- Additional spare parts:
  - CB PtP terminal block (Page 469)
  - CM PtP terminal block (Page 469)
- Support for central users on UMC server (Page 150)
- Backup and Restore (Page 336)
- Modbus TCP redundancy instructions (Page 295)
- PROFINET security class 1 (Page 203)
- Communication load default of 20% (Page 122)
- Support for a nesting depth of 26 hierarchical levels of Structs
- Support for Pulse Train Outputs (PTOs) in Motion control (https://docs.tia.siemens.cloud/access?ft:originId=./84171825419/86376357131_enUS.htm)
- Additional Motion Control (Page 302) functionality
- Enhanced support for S7-1200 G2 Near Field Communication (NFC) (Page 299)

Installation and wiring

4

4.1 Installation guidelines

You can install an S7-1200 G2 either on a standard DIN rail or on a panel, and you can orient the S7-1200 G2 either horizontally or vertically. The small size of the S7-1200 G2 allows you to make efficient use of space.



① DIN rail installation
② DIN rail clip in latched position
③ Panel installation
④ DIN rail clip in extended position for panel mounting

The S7-1200 G2 family provides a variety of expansion modules that you can use to increase the capabilities of the CPU with additional I/O or other communication protocols. For detailed information on a specific module, see the technical specifications (Page 337).

Electrical equipment standards classify the SIMATIC S7-1200 G2 system as Open Equipment. You must install the S7-1200 G2 in a housing, cabinet, or electric control room. Only allow authorized personnel access to the housing, cabinet, or electric control room.

Provide a dry environment for installation of the S7-1200 G2. SELV/PELV circuits provide protection against electric shock in dry locations.

Provide appropriate mechanical strength, flammability protection, and stability protection for open equipment in your location according to applicable electrical and building codes.

Conductive contamination due to dust, moisture, and airborne pollution can cause operational and electrical faults in the PLC.

If you locate the PLC in an area where conductive contamination might be present, protect the PLC in an enclosure with appropriate protection rating. IP54 is one rating for electronic equipment enclosures in dirty environments and might be appropriate for your application.

⚠ WARNING

Risks associated with improper installation
Improper installation of the S7-1200 G2 can result in electrical faults or unexpected operation of machinery.
You must follow all instructions for installation and maintenance of a proper operating environment to ensure that the equipment operates safely.
Electrical faults or unexpected machine operation can result in death, severe personal injury, and/or property damage.

Separating S7-1200 G2 devices from heat, high voltage, and electrical noise

When configuring the layout of S7-1200 G2 devices in a panel, always do the following:

- Separate the devices that generate high voltage and high electrical noise from the low-voltage, logic-type devices such as the S7-1200 G2.
- Place electronic-type devices in the cooler areas of the cabinet away from heat-generating devices to reduce exposure to high-temperatures and extend the operating life of the devices.
- Avoid placing low-voltage signal wires and communications cables in the same tray with AC power wiring and high-energy, rapidly-switched DC wiring when routing wiring for the devices.

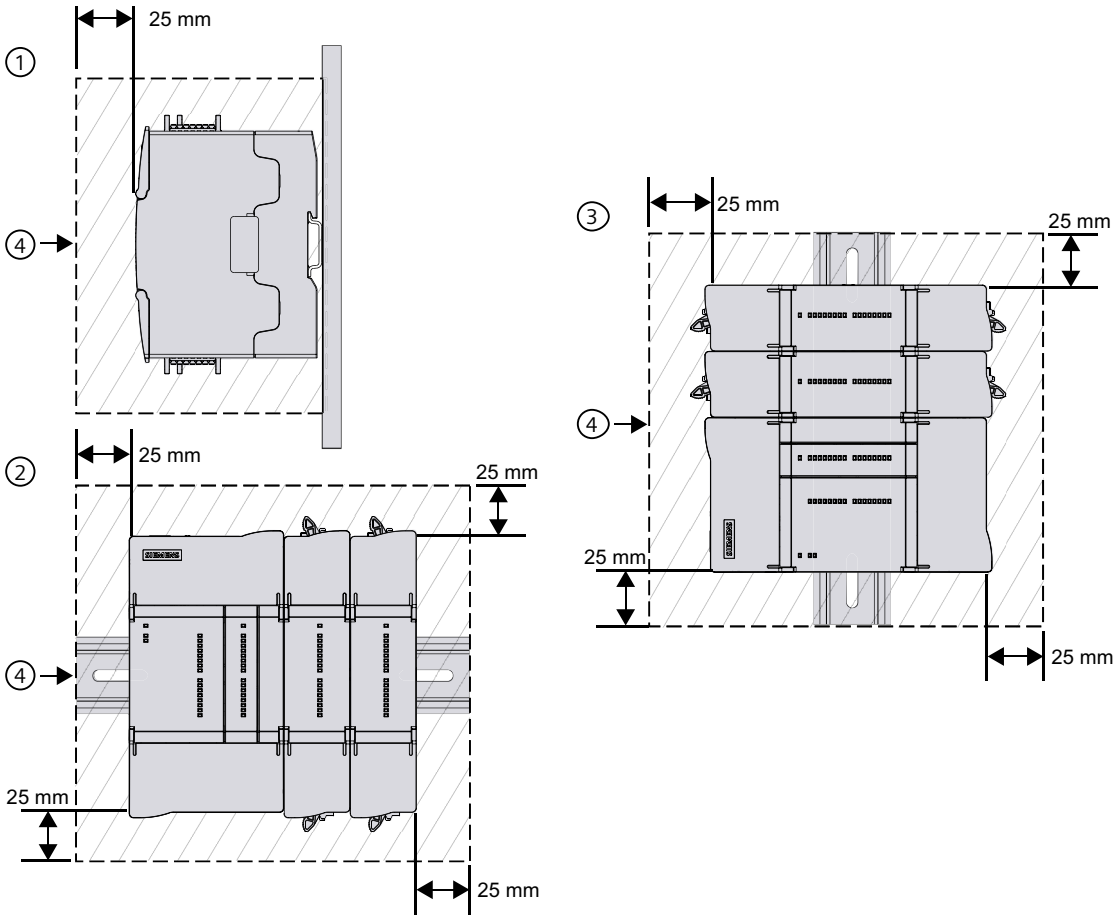
Providing adequate clearance for cooling and wiring

The design of S7-1200 G2 devices provides for natural convection cooling. For proper cooling, allow at least 25 mm of clearance above, below, and on both sides of the system. Also, allow at least 25 mm of depth between the front of the modules and the inside of the enclosure.

⚠ CAUTION

Effect of vertical mounting on allowable ambient temperature
Vertical mounting reduces the maximum allowable ambient temperature.
Orient a vertically mounted S7-1200 G2 system as shown in the following figure: the CPU, when vertically mounted, is at the bottom with its left side down. Ensure that the S7-1200 G2 system is mounted correctly.
Improper installation of a vertically mounted system can result in personal injury.

When planning your layout for the S7-1200 G2 system, allow enough clearance for the wiring and communications cable connections.



① Side view
② Horizontal installation
③ Vertical installation
④ Clearance area

4.2 Safety information

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

⚠ WARNING

Risk of electrocution when installing or removing devices
Installing or wiring the S7-1200 G2 or related equipment with power applied could cause electric shock or unexpected operation of equipment.
Always follow appropriate safety precautions and ensure that power is disabled to the S7-1200 G2 or related equipment before attempting to install or remove any devices.
Failure to disable all power to the S7-1200 G2 and related equipment during installation or removal procedures could result in death, severe personal injury, and/or property damage due to electric shock or unexpected equipment operation.

Always ensure that whenever you replace or install an S7-1200 G2 device you use the correct module or equivalent device.

Always be sure to follow the guidelines for grounding (Page 83).

⚠ WARNING

Risks associated with replacing S7-1200 G2 devices

Incorrect installation of an S7-1200 G2 module can cause the program in the S7-1200 G2 to function unpredictably.

Use the same model, orientation, and order when replacing an S7-1200 G2 device.

Failure to do so can cause unexpected equipment operation resulting in death, severe personal injury, and/or property damage.

⚠ WARNING

Installing or removing devices in a flammable or combustible atmosphere

Disconnecting equipment in a flammable or combustible atmosphere can cause a fire or an explosion.

Do not disconnect equipment in a flammable or combustible atmosphere; follow appropriate safety precautions when working in a flammable or combustible atmosphere.

A fire or explosion can result in death, serious injury, and/or property damage.

NOTICE

Risks associated with electrostatic discharge

Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable.

To protect the memory card and receptacle from electrostatic discharge, do the following:

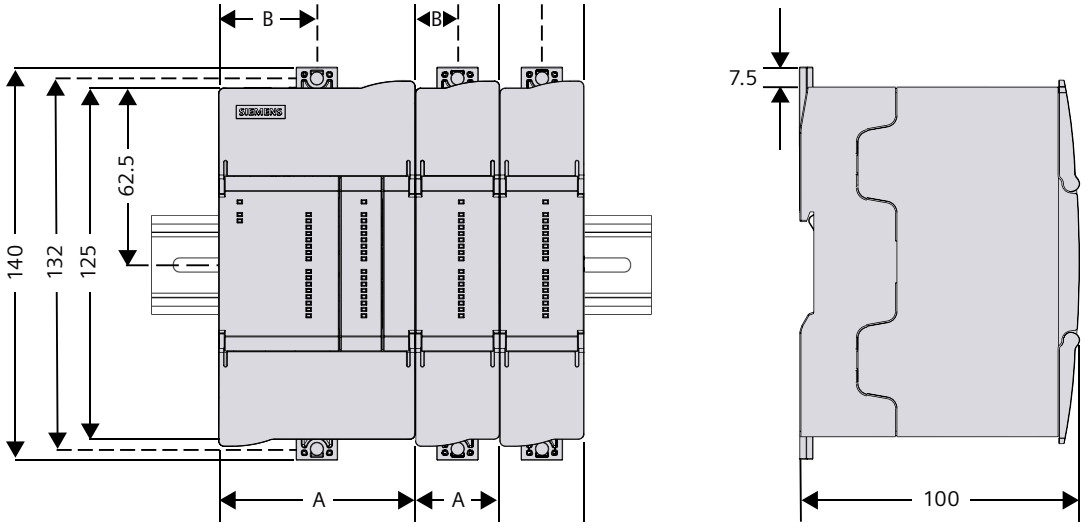
- Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card.
- Store the memory card in a conductive container.

Receptacle or memory card malfunction can result in property damage.

4.3 Mounting dimensions

Use the following mounting dimensions to ensure proper device installation. All mounting dimensions are shown in millimeters (mm).

CPU 1212C



CPU 1214C

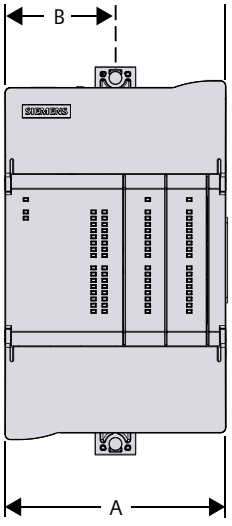


Table 1-141 Mounting dimensions (mm)

S7-1200 G2 Devices		Width A (mm)	Width B (mm)
CPUs[1]	CPU 1212C (AC/DC/Rly, DC/DC/Rly, and DC/DC/DC)	70	35
	CPU 1214C (AC/DC/Rly, DC/DC/Rly, and DC/DC/DC)	80	40
Fail-safe CPUs[1]	CPU 1212FC (DC/DC/Rly, and DC/DC/DC)	70	35
	CPU 1214FC (DC/DC/Rly, and DC/DC/DC)	80	40

[1] If you plan to use an input simulator, you must have extra clearance. See the Input simulators section of the Technical specifications chapter for specific dimensions.

S7-1200 G2 Devices		Width A (mm)	Width B (mm)
Signal modules	SM 1221 (16 DI 24V)	30	15
	SM 1222 (16 DQ 24V and 16 Rly)	30	15
	SM 1223 (8 DI / 8 DQ, 8 DI / 8 Rly)	30	15
	SM 1223 (16 DI / 16 DQ, 16 DI / 16 Rly, 16 DI / 16 DQ Sink)	50	25
	SM 1223 (8 DI / 8 DQ, 8 DI / 8 Rly, 16 Rly, 16 DI / 16 DQ Sink, and 16 DI / 16 DQ)	30	15
	SM 1231 (8 AI)	30	15
	SM1232 (8 AQ)	30	15
	SM 1233 (4 AI / 4 AQ)	30	15
	SM 1231 (8 TC and 4 RTD)	30	15
Communication modules	CM 1241 (RS485/232/422)	30	15
Communication processors	CP 1243-1 G2 Ethernet	30	15

[1] If you plan to use an input simulator, you must have extra clearance. See the Input simulators section of the Technical specifications chapter for specific dimensions.

Each CPU, SM, and CM supports mounting on either a DIN rail or on a panel. Use the DIN rail clips on the module to secure the device on the rail. These clips also snap into an extended position to provide screw mounting positions to mount the unit directly on a panel.

Always be sure to follow the guidelines for grounding (Page 83).

See also

Input simulators (Page 464)

4.4 Providing power for the CPU

All S7-1200 G2 CPUs have an internal power supply that provides power to the CPU, any expansion modules or boards, and the 24 V DC Sensor power output.

You can connect any of the following to the CPU:

- Signal boards
- Communication modules
- Signal modules

Plug-in expansion boards, such as signal boards (SBs), install into the front of the CPU.

Communication modules (CM) and signal modules (SM) are installed to the right of the CPU. You can connect a CM to the right of a CPU or another CM. You can connect an SM to the right of a CPU, CM, or another SM.

The maximum number of expansion modules allowed for each CPU can be found in the Technical specifications (Page 337) under the CPU's General specifications and features.

For more information on expansion modules, see S7-1200 G2 modules (Page 57).

All S7-1200 G2 CPUs have a power budget calculator (Page 161) in the STEP 7 project. Select the CPU in Device view and navigate to the General tab > System power supply > Power segment overview to view the Power consumption per module and the Summary for the hardware configuration. When the chosen hardware configuration exceeds the available power budget, a compile warning is given.

Some of the 24 V DC power input ports in the PLC system are interconnected with a logic common circuit connecting multiple M terminals. The CPU 24 V DC power supply input, the SM relay coil power input, and a non-isolated analog power supply input are examples of circuits that are interconnected when designated as not isolated in the data sheets. All non-isolated M terminals must connect to the same external reference potential.

⚠ WARNING

Risks with connecting non-isolated M terminals to different reference potentials
Connecting non-isolated M terminals to different reference potentials causes unpredictable current flows. Unpredictable current flows can cause PLC damage or abnormal PLC and equipment operation.
Always ensure that all non-isolated M terminals in a PLC system are connected to the same reference potential.
PLC damage or abnormal PLC and equipment operation can cause death, severe personal injury, and/or property damage.

Each CPU supplies DC power:

- Each CPU has a 24 V DC sensor supply that can supply 24 V DC for local input points, for relay coils on the expansion modules, or for other requirements. If your 24 V DC power requirements exceed the budget of the sensor supply, you can add an external 24 V DC power supply to your system. You must manually connect the external 24 V DC supply to the input points or relay coils on the expansion modules.

  ⚠ WARNING

  Risks with parallel connections
  Connecting an external 24 V DC power supply in parallel with the CPU's DC sensor supply can result in a conflict between the two supplies as each seeks to establish its own preferred output voltage level.
  When using the CPU's DC sensor supply in conjunction with an additional external 24 V DC power supply, they must not be wired in parallel.
  Doing so could cause unpredictable operation of the PLC system, resulting in death, severe personal injury, and/or property damage.

Maximum applied voltage to S7-1200 G2 Fail-safe devices

When providing power for the S7-1200 G2 Fail-safe CPUs, you must observe the following:

- Operational voltage: The operational voltage of the fail-safe CPUs and fail-safe SMs is 20.4 V DC - 28.8 V DC. Design and testing assure operation of the unit to specifications. Defined transients from defined source impedances per EN 61000-4-2, 61000-4-4, and 61000-4-6, as specified in the data sheet for each product, can be imposed on this voltage without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 V DC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 V DC. The manufacturer must specify these power supplies to limit the output voltage to 35 V DC or less under fault conditions. Otherwise, you must supply external protection that reliably opens the circuit or limits the output voltage to less than 35 V DC to the fail-safe CPU and fail-safe SMs.

- Immunity to surge voltages (Page 337): To meet the product standard for burner controls (EN 298), the wiring must be equipped with external protection against coupled surge voltages caused by lightning. For more information, refer to the function manual "*Designing interference-free controllers* (https://support.industry.siemens.com/cs/ww/en/view/59193566)".

Requirements for power supplies in the event of voltage interruption

To ensure adherence to IEC 61131-2, only use power packs/power supply units with a main buffering time of at least 10 ms for DC power or 1/2 AC cycle. The port that powers the CPU meets IEC61131-2 rating of PS2 with an interruption time of 10 ms for DC power and 1/2 AC cycle for AC power. Observe the relevant requirement in your product standards (for example, 30 ms for Burner applications according to EN 298) regarding possible voltage interruptions. The latest information on PS components is available on the Internet (https://support.industry.siemens.com/).

⚠ WARNING

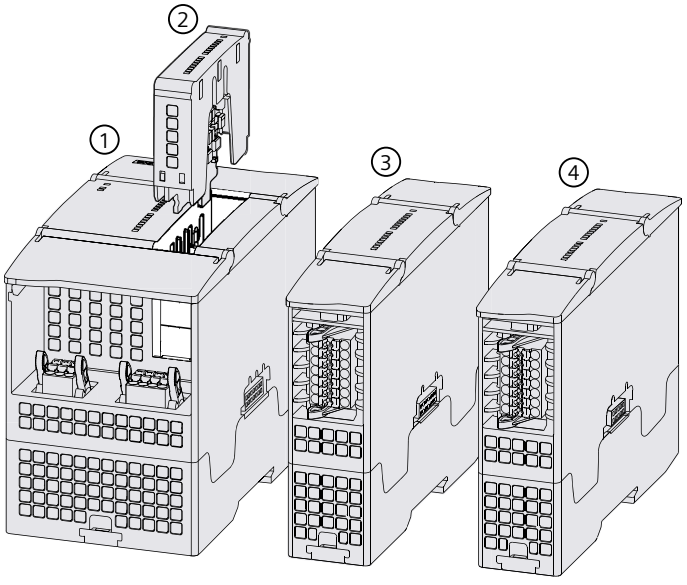
All power supply and fail-safe SM circuits must be connected together to a common voltage reference or must be isolated SELV circuits.

The power supply M terminals on the fail-safe CPU and the fail-safe SMs must be connected together or isolated as SELV. Failure to do so can result in unexpected machine or process operation.

Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to SM isolation boundary.

Unexpected machine or process operation can result in death or serious injury to personnel, and/or damage to equipment.

4.5 Expansion capability of the CPU



① Central processing unit (CPU)
② Expansion board
③ Communication module (CM), if used
④ Signal module (SM)

4.6 Installation and removal procedures

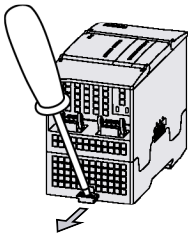
4.6.1 Installing and removing a CPU

You can install the S7-1200 G2 CPU on a DIN rail or a panel.

Installing the CPU on a DIN rail

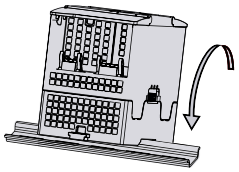
To install the CPU on a DIN rail, follow these steps:

1. Install the DIN rail; secure the rail to the mounting panel every 75 mm.
2. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
3. Use an M3 screwdriver to extend the lower DIN rail clip on the CPU to allow it to fit over the rail.

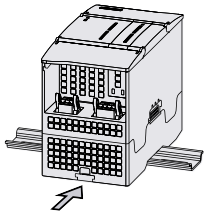


4. Hook the CPU over the top of the DIN rail.

5. Rotate the CPU down into position on the rail.



6. Push in the lower DIN rail clip to secure it to the rail.

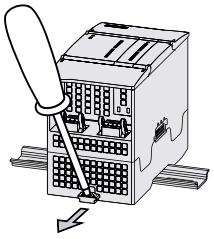


NOTE
Using DIN rail stops can be helpful if the CPU is in an environment with high vibration potential or if the CPU has been installed vertically. Use an end bracket (8WA1808 or 8WA1805) on the DIN rail to ensure that the modules remain connected.

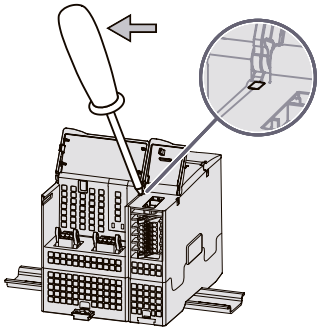
Removing the CPU from a DIN rail

To remove the CPU from a DIN rail, follow these steps:

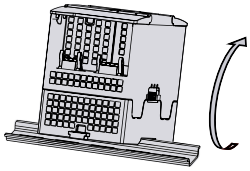
1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Disconnect the I/O connectors, wiring (Page 77), and cables from the CPU.
3. Use an M3 screwdriver to extend the lower DIN rail clip on the CPU to release it from the rail.



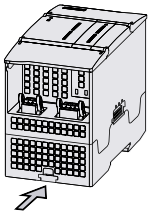
4. If the CPU is connected to an SM or CM, place an M3 screwdriver between the CPU and connected module; gently pry left to disconnect the CPU.



5. Rotate the CPU up and off the rail and remove the CPU from the system.



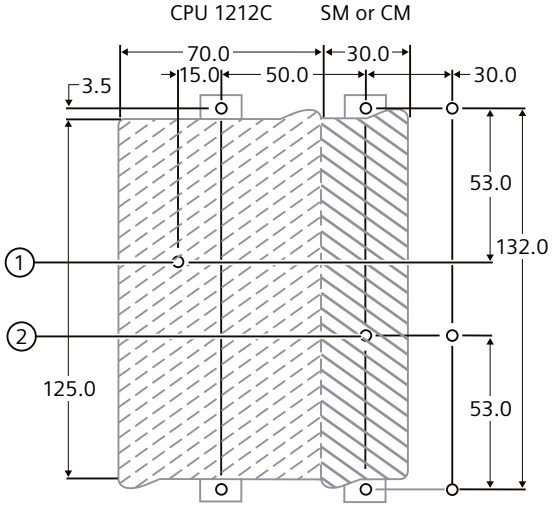
6. Push in the DIN rail clip to protect it from damage.

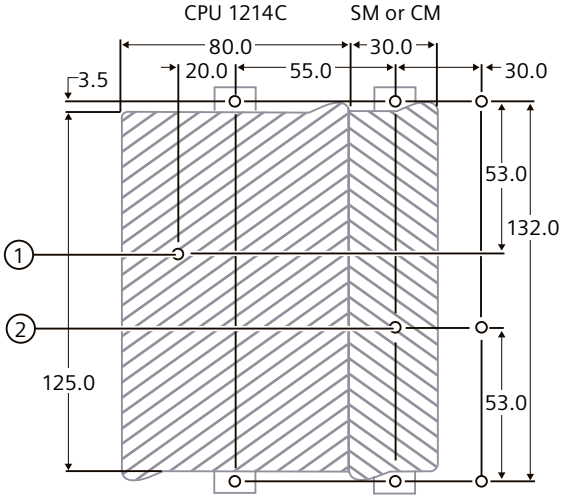


Installing the CPU on a panel

To install the CPU on a panel, follow these steps:

1. Locate, drill, and tap the mounting holes (M4), using the dimensions shown in the diagrams below.
2. Using the Guidelines for grounding (Page 83), install an M4 pan head stainless steel screw with a star washer into the panel at the grounding screw locations shown below.
3. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
4. Use a screwdriver to extend the upper and lower DIN rail clips on the CPU.
5. Secure the module to the panel, using a Pan Head M4 screw with spring and flat washer; apply the appropriate torque to compress the spring washer.





① CPU grounding screw

② SM or CM grounding screw

All measurements are shown in millimeters.

4.6.2 Installing and removing expansion modules

Installing and removing a CM or SM

You can connect a CM to a CPU or to another CM. Connect any CMs before installing any SMs. You can connect an SM to a CPU, CM, or SM.

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

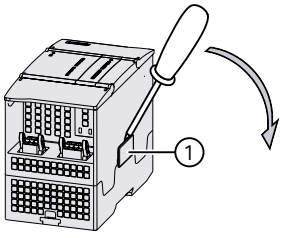
⚠ WARNING

Installation or removal of S7-1200 G2 devices with power applied
Installation or removal of S7-1200 G2 or related equipment with the power applied can cause electric shock or unexpected operation of equipment.
Always follow appropriate safety precautions and ensure that power to the S7-1200 G2 is disabled before attempting to install or remove S7-1200 G2 CPUs or related equipment.
Failure to disable all power to the S7-1200 G2 and related equipment during installation or removal procedures can result in death, severe personal injury and/or property damage due to electric shock or unexpected equipment operation.

Installing a CM or SM

To install an CM or SM, follow these steps:

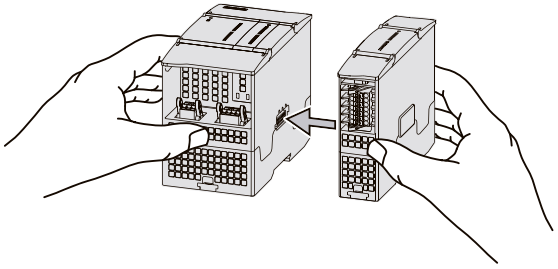
1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Remove the bus cover from the right side of the CPU or module. Insert a screwdriver into the slot above the bus cover, gently pry the cover loose, and remove it. Retain the cover for reuse.



① Bus cover

3. If you are installing the module on a DIN rail extend the lower DIN rail clip, hook the module over the top of the rail, and rotate the module down into place.

4. Align the bus connector and the posts of the module with the holes of the CPU or module, and firmly press the units together until the posts snap into place.

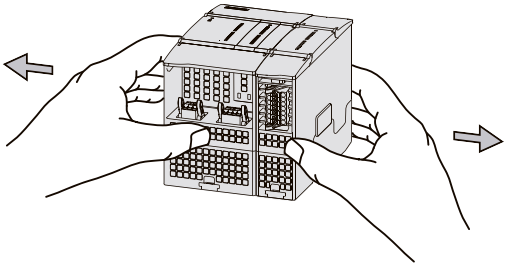


5. If you are DIN Rail mounting, push the lower DIN rail clip in to secure the module. If you are panel mounting, screw the module to the panel.

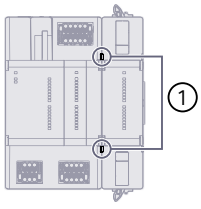
Removing a CM or SM

To remove an CM or SM, follow these steps:

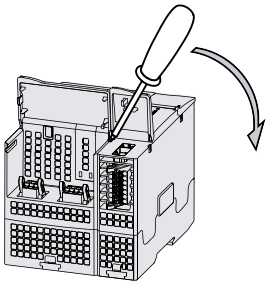
1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Remove the I/O connectors and all wiring and cables from the module.
3. If the module is mounted on a DIN rail, use an M3 screwdriver to extend the lower DIN rail clip on the module. If the module is panel mounted, remove the mounting screws from the upper and lower DIN rail clips to release it from the panel.
   Note: In some cases, it may be necessary to loosen other devices mounted to the left or right to create room to disconnect the device you wish to remove.
4. Separate the module from the CPU or module using one of the following methods:
   • Grasp the units and pull them apart.



   • Place an M3 screwdriver in the provided slot under the doors and pry the devices apart.



① Slots for screwdriver



5. Remove the module(s) from the DIN rail or panel; if removing a module(s) from a DIN rail, rotate it up and off the rail.
6. Push in the DIN rail clips on the modules you are removing to protect them from damage.

4.6.3 Installing and removing expansion boards

Installing or removing an SB

You can install one plug-in expansion board to CPU 1212 and two plug-in expansion boards of any type to CPU 1214.

Before you install or remove any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

⚠ WARNING

Installation or removal of S7-1200 G2 devices with power applied

Installation or removal of S7-1200 G2 or related equipment with the power applied can cause electric shock or unexpected operation of equipment.

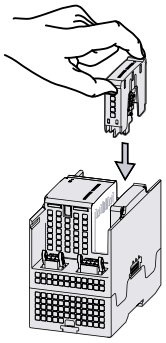
Always follow appropriate safety precautions and ensure that power to the S7-1200 G2 is disabled before attempting to install or remove S7-1200 G2 CPUs or related equipment.

Failure to disable all power to the S7-1200 G2 and related equipment during installation or removal procedures can result in death, severe personal injury and/or property damage due to electric shock or unexpected equipment operation.

Installing an SB

To install an SB, follow these steps:

1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Remove the upper and lower doors from the CPU.
3. Grasp the top and bottom of the existing blank board cover or plug-in expansion board, and pull away from the CPU to remove it. (If you are installing an SB into a newly purchased CPU, retain the preinstalled blank board cover after removing it from the CPU.)

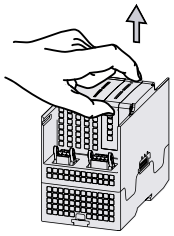


4. Insert the plug-in expansion board into the vacant slot and press down on it until it clicks into place.
5. Replace the upper and lower doors.

Removing an SB

To remove an SB, follow these steps:

1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Remove the upper and lower doors from the CPU.
3. Grasp the top and bottom of the plug-in expansion board and pull away from the CPU to remove it.



4. Insert the desired plug-in expansion board into the vacant slot and press down on it until it clicks into place. (If no SB is required, reinsert the blank board cover that came with the CPU.)
5. Replace the upper and lower doors.

⚠ WARNING

Risks associated with leaving a plug-in expansion board slot empty
Leaving a plug-in expansion board slot empty can expose the internal elements of the CPU to environmental contaminants like moisture, dust, or debris that can damage or shorten the lifespan of the CPU.
Do not leave a plug-in expansion board slot empty. If you are not installing a new SB, reinsert the blank board cover. (Blank board covers are preinstalled in the CPU at the time of purchase.)
Damage to the CPU can cause equipment malfunction. Equipment malfunction can potentially result in property damage, severe personal injury, or death.

4.6.4 Removing and installing terminal block connectors

Removing and installing a CPU, CM, or SM terminal block connector

All S7-1200 G2 devices provide removable connectors to make connecting the wiring easy. For more information on how to wire connectors, see Wiring procedures (Page 85).

Installation risks with terminal block connectors in relay signal modules

You can incorrectly install a CPU's high voltage 6, 8, or 12 pin terminal block connector into a relay digital signal module and a CPU's high voltage 6 or 8 pin terminal block connector into an relay analog signal module.

The existing keying on the CPU's high voltage terminal block connectors does not prevent you from installing them into the following relay signal modules:

Signal modules (SMs)	Article number
SM 1222 DQ 16xRelay (Page 392)	6ES7222-5HH50-0XB0
SM 1223 DI 8x24VDC / DQ 8xRelay (Page 396)	6ES7223-5PH50-0XB0
SM 1231 AI 8x14bit (Page 405)	6ES7231-4HF50-0XB0
SM 1232 AQ 8x14bit (Page 408)	6ES7232-4HF50-0XB0
SM 1233 AI 4x14bit / AQ 4x14bit (Page 410)	6ES7233-4HF50-0XB0

⚠ WARNING

Risk of electrocution with improper terminal block installation

If you install a 6, 8, or 12 pin high voltage connector from a relay CPU into one of the relay SMs listed above, hazardous levels of voltage can occur on the DIN rail and connected machinery.

Ensure that the terminal block connector and the connector receptacle on the device have the same number of pins before installing the terminal block connector, and that both levers of the connector are in the locked position before restoring power to the system.

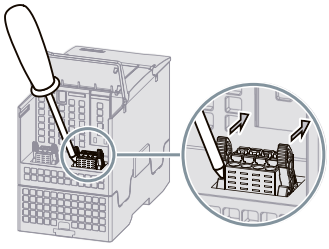
Death, severe personal injury, and property damage can result if you install a relay CPU's 6, 8, or 12 pin high voltage connector into one of the relay SMs listed above.

Removing a CPU, CM, or SM terminal block connector

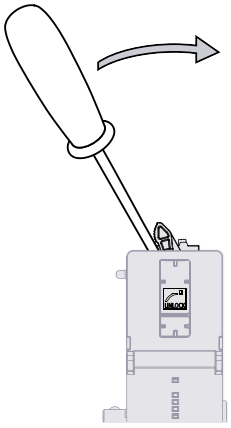
To remove an CPU, CM, or SM terminal block connector, follow these steps:

1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Use a screwdriver to release the terminal block connector levers or firmly press them in the direction shown below.

   CPU removal:



   CM or SM removal:



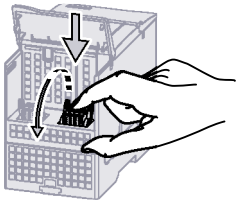
3. Grasp the connector and remove it from the CPU, CM, or SM.

Installing a CPU, CM, or SM terminal block connector

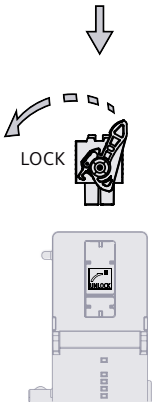
To install an CPU, CM, or SM terminal block connector, follow these steps:

1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Align the terminal block connector with the pins on the unit; for the SM and CM you can use the symbol marked on the unit to identify proper orientation of the connector.
3. Press firmly down on the center of the terminal block connector until it snaps into place. (The levers will rotate and lock into place as you press down.)

   CPU installation:



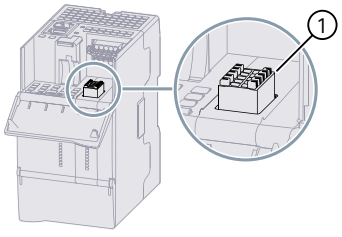
CM or SM installation:



4. Make sure that the terminal block connector is properly aligned and in the locked position.

Removing and installing an SB terminal block connector

The terminal block connector for an SB is behind the top door of the CPU, as shown below.

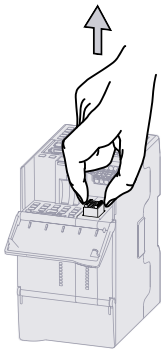


① SB terminal block connector

Removing an SB terminal block connector

To remove an SB terminal block connector, follow these steps:

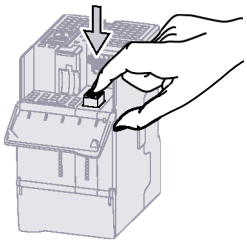
1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Firmly grasp the terminal block connector and pull away from the CPU.



Installing an SB terminal block connector

To install an SB terminal block connector, follow these steps:

1. Ensure that the CPU and all S7-1200 G2 equipment are powered down.
2. Align the terminal block connector with the pins on the unit.
3. Press down firmly on the center of the terminal block connector until it snaps into place.



4.7 Wiring guidelines and procedures

4.7.1 Safety considerations

Proper grounding and wiring of all electrical equipment are important to help ensure the optimum operation of your system and to provide additional electrical noise protection for your application and the S7-1200 G2. Refer to the technical specifications (Page 337) for the S7-1200 G2 wiring diagrams.

Prerequisites

Before grounding or installing wiring to any electrical device, ensure that the power to that device is off. Also, ensure that the power to any related equipment is off.

⚠ WARNING

Risk of electrocution when installing or removing devices
Installing or wiring the S7-1200 G2 or related equipment with power applied could cause electric shock or unexpected operation of equipment.
Always follow appropriate safety precautions and ensure that power is disabled to the S7-1200 G2 or related equipment before attempting to install or remove any devices.
Failure to disable all power to the S7-1200 G2 and related equipment during installation or removal procedures could result in death, severe personal injury, and/or property damage due to electric shock or unexpected equipment operation.

Always consider safety when designing the grounding and wiring for the S7-1200 G2 system. Follow all applicable electrical codes when wiring the S7-1200 G2 and related equipment. Install and operate all equipment according to all applicable national and local standards. Contact your local authorities to determine which codes and standards apply to your specific case.

⚠ WARNING

Risk of unexpected equipment operation
Control devices can fail in unsafe conditions, resulting in unexpected equipment operation. Use an emergency stop function, electromechanical overrides, or other redundant safeguards that are independent of the S7-1200 G2.
Unexpected operation can result in death, severe personal injury and/or property damage.

4.7.2 Guidelines for isolation

S7-1200 G2 AC power supply boundaries and I/O boundaries to AC circuits provide safe separation between AC line voltages and low voltage circuits. These boundaries include double or reinforced insulation, or basic plus supplementary insulation, according to various standards. Components which cross these boundaries such as optical couplers, capacitors, transformers, and relays have been approved as providing safe separation. Only circuits rated for AC line voltage include safety isolation to other circuits. Isolation boundaries between 24 V DC circuits are functional only. Do not depend on these boundaries for safety.

The sensor supply output, communications circuits, and internal logic circuits of an S7-1200 G2 with included AC power supply are sourced as SELV (safety extra-low voltage) according to EN 61131-2.

To ensure safe operation, you must power the external connections to the following items from approved sources that meet the requirements of SELV/PELV, Class 2, Limited Voltage, or Limited Power according to various standards:

- Communications ports

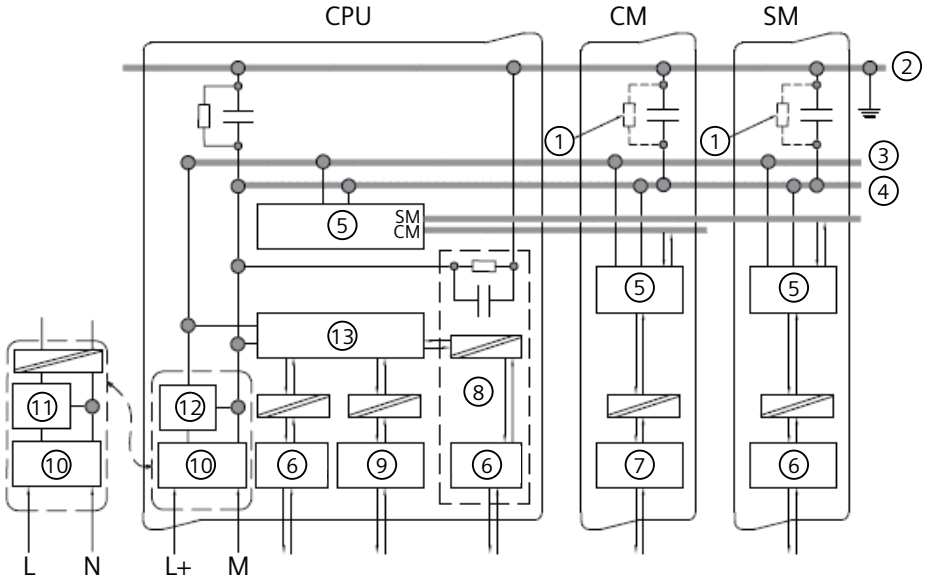
  The CPU meets isolation requirements between the ports and internal circuits (1500 V AC) according to IEEE 802.3, Chapter 27.5.3, Environment B. Therefore, do not connect LAN or LAN segments of different environments (for example, Environment A and B according to IEEE 802.3) to the dual ports of S7-1200 G2 CPUs.
- Analog circuits
- 24 V DC nominal power supply
- Digital I/O circuits

⚠ WARNING

Risk of electrocution with use of non-isolated or single insulation supplies
Using non-isolated or single insulation supplies can cause circuits that are normally safe to the touch, like communications circuits and low voltage sensor wiring, to carry hazardous levels of voltage.
Do not use non-isolated or single insulation supplies to supply low voltage circuits from an AC line.
Only use high voltage to low voltage power converters that are approved as sources of touch safe, limited voltage circuits.
Using non-isolated or single insulation supplies can cause unexpected electric shock resulting in death, severe personal injury, and/or property damage.

The following figure shows a simplified representation of the relationships of the S7-1200 G2 automation system. The electrical tie between Functional Earth and M on a G2 CPU is also represented in the figure.

The Functional Earth and Power supply common in all G2 CPUs are coupled with a series resistor and paralleled capacitor.



① Resistor (not present on all models)
② Din rail or panel
③ Bus 5V power
④ Bus common
⑤ Bus connection
⑥ Process electronics
⑦ Serial communication interface
⑧ Signal board
⑨ PN communication interfaces (always 2 per CPU)
⑩ Filter
⑪ AC power
⑫ DC power
⑬ Electronics

4.7.3 Guidelines for grounding

Ground all S7-1200 G2 and related equipment connections (common and ground) to a single point. Always connect this single point directly to the earth ground of the system.

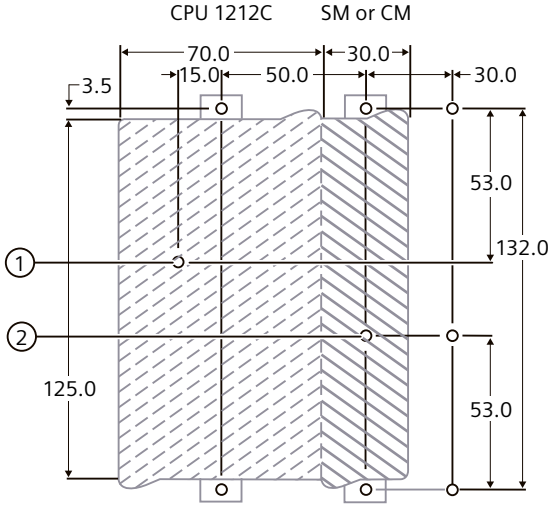
Use the shortest ground wire possible; use a large wire size, such as 2.5 mm^2 (14 AWG).

When using shielded cables, always connect the cable shields to the ground at both ends to reduce low and high frequency interference.

When locating grounds, consider safety-grounding requirements and the proper operation of protective interrupting devices.

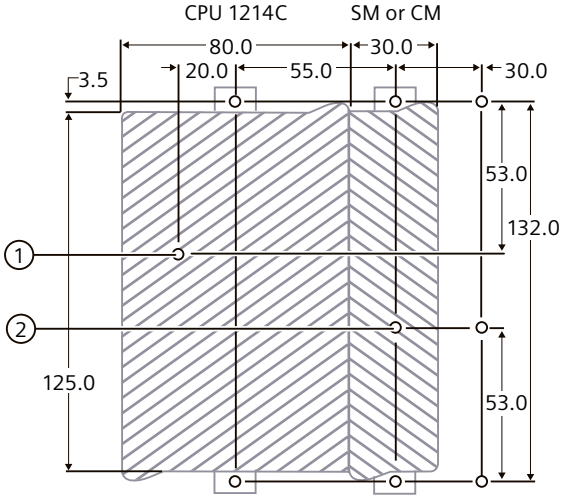
When the S7-1200 G2 is mounted to a DIN rail, the units use a spring to make proper ground connection to the DIN rail. Ensure that the DIN rail is properly grounded to the system's single point ground.

When the S7-1200 G2 is mounted to a panel, it is required to place an M4 pan head stainless steel screw with a star washer into the panel at the locations shown below. This screw will allow the units ground spring to make proper electrical contact with the panel. Ensure that the panel is properly grounded to the system's single point ground.



① CPU grounding screw

② SM or CM grounding screw



All measurements are shown in millimeters.

4.7.4 Guidelines for wiring

When designing the wiring for the S7-1200 G2, provide a single disconnect switch that simultaneously removes power from the S7-1200 G2 CPU power supply, from all input circuits, and from all output circuits. Provide over-current protection, such as a fuse or circuit breaker, to limit fault currents on supply wiring. Consider providing additional protection by placing a fuse or other current limit in each output circuit.

Install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Avoid placing low-voltage signal wires and communications cables in the same wire tray with AC wires and high-energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

Use the shortest wire possible and ensure that the wire is sized properly to carry the required current. Use properly sized copper ferrule sleeves to terminate the wire into the connector.

Use wire and cable with a temperature rating that is 45 °C higher than the ambient temperature around the S7-1200 G2. Use the specific electrical circuit ratings and the installation environment to determine what other types of wiring and materials are needed.

To reduce electrical noise, use shielded wires.

In addition to using shielded wires, you can do the following to further reduce electrical noise:

- Connect the shield to the ground at both ends of the cable.
- Ground other cable shields using clamps or copper tape around the shield to provide a high surface area connection to the grounding point.

When wiring input circuits that are powered by an external power supply, include an overcurrent protection device in that circuit. External protection is not necessary for circuits

that are powered by the 24 V DC sensor supply from the S7-1200 G2 because the sensor supply is already current-limited.

All S7-1200 G2 modules have removable connectors for user wiring. To prevent loose connections, ensure that the connector is seated properly, locked in place, and that the wire is installed securely into the connector.

To help prevent unwanted current flows in your installation, the S7-1200 G2 provides isolation boundaries at certain points. When planning the wiring for the system, consider these isolation boundaries. Refer to the technical specifications (Page 337) for the amount of isolation provided and the location of the isolation boundaries. Circuits rated for AC line voltage include safety isolation to other circuits. Isolation boundaries between 24 V DC circuits are functional only; do not depend on these boundaries for safety.

A summary of Wiring rules for the S7-1200 G2 CPUs, CMs, SMs, SBs, and CBs is shown below:

Table 1-142 Wiring rules for S7-1200 G2 CPUs, CMs, SMs, SBs, and CBs

Wiring rules for...	**CPU, CM, and SM connector**	**SB and CB connector[1]**
Connection technology	**Push in**	**Push in**
Connectible conductor cross-sections for standard wires	0.2 mm^2 to 1.5 mm^2 (24 AWG to 16 AWG)	0.2 mm^2 to 0.8 mm^2 (24 AWG to 18 AWG)
Number of wires per connection	1 wire or combination of 2 wires in a double copper ferrule sleeve up to 1.5 mm^2 (total)	1 wire or combination of 2 wires up to 0.8 mm^2 (total)
Wire stripping length (Use copper ferrule sleeves for secure electric connection)	9 to 10 mm	7 mm

[1] Recommended ferrule sizes for SBs and CBs are listed in the Techincal specifications for each board.

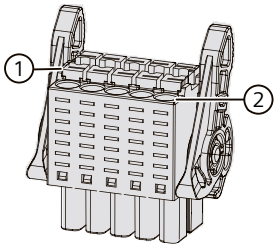
NOTE

Use copper ferrule sleeves on stranded conductors to reduce the risk of stray strands causing short circuits. Ferrules longer than the recommended strip length must include an insulating collar to prevent shorts due to side movement of conductors. Cross-sectional area limits for bare conductors also apply to ferrules.

4.7.5 Wiring and unwiring terminal block connectors

Removable terminal block connectors are used to wire S7-1200 G2 CPUs and modules.

All S7-1200 G2 removable terminal block connectors have the following parts:



① Spring release
② Push-in terminal

There are various types and sizes of terminal block connectors. For CPU, CM, and SM terminal block connectors, the color of the terminal block lock handle and spring release indicates the type of connector. For example, an orange handle and release indicates a high voltage

connector. The color used on the connector matches the color of the terminal block header on the CPU or module.

The CPU, CM, and SM terminal block connectors also have openings where you can insert a 1 mm multimeter test probe to check the voltage.

For details on the terminal block connectors used in a specific CPU or module, refer to the wiring diagram of the device in the Technical specifications (Page 337). Information on terminal block spare kits can be found in Ordering information (Page 469).

NOTE

PLCs require correct wiring to ensure safety and proper operation.
When replacing the terminal block in your S7-1200 G2 CPU or module, it is important that you use the correct terminal block and correct wiring source for your module.
The G2 removable terminal block is designed to prevent you from accidentally placing a high voltage wired terminal block into a low voltage module, or from placing a special voltage wired terminal block into a normal voltage module.

Installation risks with terminal block connectors in relay signal modules

You can incorrectly install a CPU's high voltage 6, 8, or 12 pin terminal block connector into a relay digital signal module and a CPU's high voltage 6 or 8 pin terminal block connector into an relay analog signal module.

The existing keying on the CPU's high voltage terminal block connectors does not prevent you from installing them into the following relay signal modules:

Signal modules (SMs)	Article number
SM 1222 DQ 16xRelay (Page 392)	6ES7222-5HH50-0XB0
SM 1223 DI 8x24VDC / DQ 8xRelay (Page 396)	6ES7223-5PH50-0XB0
SM 1231 AI 8x14bit (Page 405)	6ES7231-4HF50-0XB0
SM 1232 AQ 8x14bit (Page 408)	6ES7232-4HF50-0XB0
SM 1233 AI 4x14bit / AQ 4x14bit (Page 410)	6ES7233-4HF50-0XB0

⚠ WARNING

Risk of electrocution with improper terminal block installation
If you install a 6, 8, or 12 pin high voltage connector from a relay CPU into one of the relay SMs listed above, hazardous levels of voltage can occur on the DIN rail and connected machinery.
Ensure that the terminal block connector and the connector receptacle on the device have the same number of pins before installing the terminal block connector, and that both levers of the connector are in the locked position before restoring power to the system.
Death, severe personal injury, and property damage can result if you install a relay CPU's 6, 8, or 12 pin high voltage connector into one of the relay SMs listed above.

Wiring rules

For wire size requirements and wire stripping length, refer to Wiring rules for S7-1200 G2 CPUs, SMs, SBs and CBs (Page 84).

Solid or stranded wire can be used. With stranded wire, Siemens recommends using ferrules of an appropriate size.

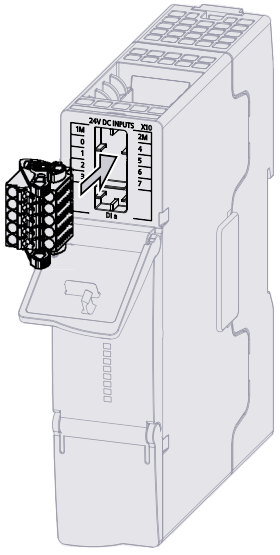
Wiring terminal block connectors

When wiring a removable terminal block connector, use a wire stripping tool to remove the plastic coating from the section of the wire that you are inserting into the connector.

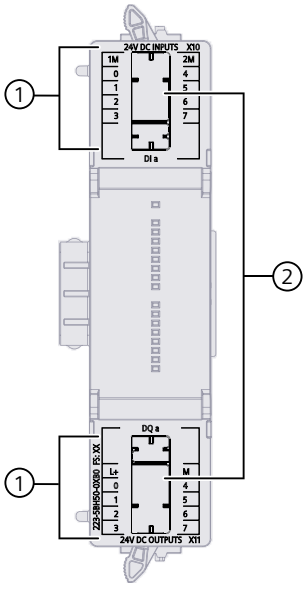
If using stranded wire, you might also need a 0.4 to 2.0 mm flat head screwdriver and a crimping tool.

To wire the removable terminal block connector of a CPU or expansion module, follow these steps:

1. Disconnect the CPU and all S7-1200 G2 equipment from electrical power.
2. Remove the terminal block connector from the CPU or module as described in Removing and installing S7-1200 G2 terminal block connectors (Page 77).
3. If wiring a CM or SM, place the terminal block connector into the wiring slot on the front of the module. (Skip this step if you are wiring a CPU or SB.)



Unlike the removable terminal block connectors on a CPU or SB, each expansion module has wiring slots with pin assignments located on the front of the module. Use these slots when wiring an expansion module.



① Pin assignments
② Wiring slots

4. Strip the end of the wire(s) to the length specified in Wiring rules for S7-1200 G2 CPUs, SMs, SBs and CBs (Page 84).

NOTE
When using stranded wire, for best results, attach a ferrule to the end of the wire and crimp the end using a crimping tool. Do not attach a ferrule to solid wire. It is not necessary to use ferrules when using solid wire.

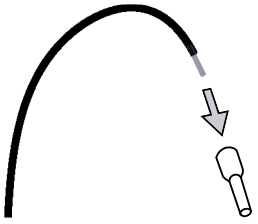
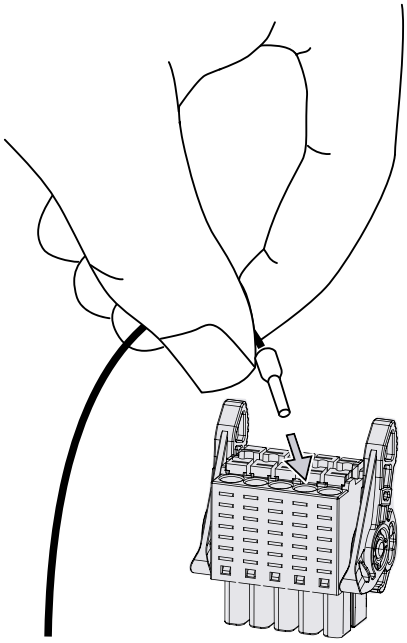
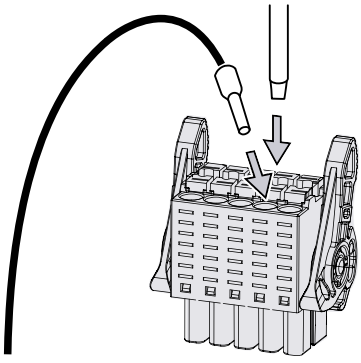


Figure 1-42 How to attach a ferrule to stranded wire

5. Use your hand to press the wire(s) into the push-in terminal,



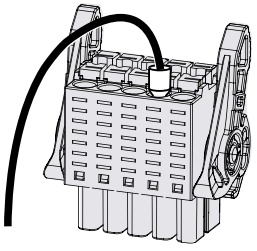
or use a 0.4 to 2.0 mm flathead screwdriver to press down on the spring release and insert the wire(s) into the push-in terminal.



NOTE

Pressing down on the spring release opens the teeth inside the connector and makes it easier to insert the wire. Once a wire is inserted into the push-in terminal, the teeth hold the wire in place.

6. Once all wires are inserted and secure, install the terminal block connector as described in Removing and installing S7-1200 G2 terminal block connectors (Page 77).

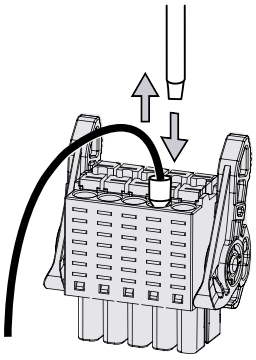


Unwiring terminal block connectors

Use a 0.4 to 2.0 mm flat head screwdriver to unwire the removable terminal block connector.

To unwire the removable terminal block connector of a CPU or expansion module, follow these steps:

1. Disconnect the CPU and all S7-1200 G2 equipment from electrical power.
2. Remove the terminal block connector from the CPU or module as described in Removing and installing S7-1200 G2 terminal block connectors (Page 77).
3. Using a 0.4 to 2.0 mm flathead screwdriver, press down on the spring release and remove the wire and ferrule from the push-in terminal.



4.7.6 Guidelines for inductive loads

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off. Suppressor circuits protect your outputs from premature failure caused by the high voltage transient that occurs when current flow through an inductive load is interrupted.

In addition, suppressor circuits limit the electrical noise generated when switching inductive loads. High frequency noise from poorly suppressed inductive loads can disrupt the operation of the PLC. Placing an external suppressor circuit so that it is electrically across the load and physically located near the load is the most effective way to reduce electrical noise.

S7-1200 G2 DC outputs include internal suppressor circuits that are adequate for inductive loads in most applications. Internal protection is not provided for relay outputs because you can use S7-1200 G2 relay output contacts to switch either a DC or an AC load.

Consider using inductive loads with integrated suppression circuitry. However, for some applications, manufacturer-provided suppressor circuits are inadequate. You can use an additional suppressor circuit to further protect the PLC output.

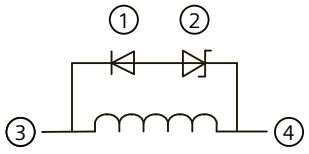
Consider using a metal oxide varistor (MOV), parallel RC circuit, or a combination of both for AC loads. A MOV suppressor with no parallel RC circuit often results in significant high frequency noise up to the clamp voltage.

A well-controlled turn-off transient will have a ring frequency of no more than 10 kHz, with less than 1 kHz preferred. Peak voltage for AC lines must be within +/- 1200 V of ground. Negative peak voltage for DC loads using the PLC internal suppression will be ~40 V below the 24 V DC supply voltage. External suppression must limit the transient to within 36 V of the supply to unload the internal suppression.

NOTE

The effectiveness of a suppressor circuit depends on the application; you must verify a suppressor circuit is suitable for your particular usage. Ensure that all components are correctly rated. Use an oscilloscope to observe the turn-off transient.

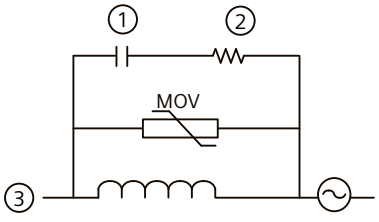
Typical suppressor circuit for DC or relay outputs that switch DC inductive loads



① 1N4001 diode or equivalent
② 8.2 V Zener (DC outputs), 36 V Zener (Relay outputs)
③ Output point
④ M, 24 V reference

In most applications, the addition of a diode (1) across a DC inductive load is suitable, but if your application requires faster turn-off times, then the addition of a zener diode (2) is recommended. Be sure to size your zener diode properly for the amount of current in your output circuit.

Typical suppressor circuit for relay outputs that switch AC inductive loads



① See table for C value
② See table for R value
③ Output point

Ensure that the working voltage of the metal oxide varistor (MOV) is at least 20% greater than the nominal line voltage.

Choose pulse-rated, non-inductive resistors, and capacitors recommended for pulse applications (typically metal film). Verify the components meet average power, peak power, and peak voltage requirements.

If you design your own suppressor circuit, the following table suggests resistor and capacitor values for a range of AC loads. These values are based on calculations with ideal component parameters. I rms in the table refers to the steady-state current of the load when fully ON.

Table 1-143 AC suppressor circuit resistor and capacitor values

Inductive load			**Suppressor values**		
I rms	230 V AC	120 V AC	Resistor		Capacitor
Amps	VA	VA	Ω	W (power rating)	nF
0.02	4.6	2.4	15000	0.1	15
0.05	11.5	6	5600	0.25	47
0.1	23	12	2700	0.5	100
0.2	46	24	1500	1	150
0.5	115	60	560	2.5	470
1	230	120	270	5	1000
2	460	240	150	10	1500

[2] **Conditions satisfied by the table values:**
Maximum turn-off transition step < 500 V
Resistor peak voltage < 500 V
Capacitor peak voltage < 1250 V
Suppressor current < 8% of load current (50 Hz)
Suppressor current < 11% of load current (60 Hz)
Capacitor dV/dt < 2 V/µs
Capacitor pulse dissipation : ∫(dv/dt) dt < 10000 V^2/µs
Resonant frequency < 300 Hz
Resistor power for 2 Hz max switching frequency
Power factor of 0.3 assumed for typical inductive load

4.7.7 Guidelines for lamp loads

Lamp loads, including LED lamp loads, are damaging to relay contacts because of the high turn-on surge current. This surge current will nominally be 10 to 15 times the steady state current for a Tungsten lamp. A replaceable interposing relay or surge limiter is recommended for lamp loads that will be switched a large number of times during the lifetime of the application.

4.8 Maintenance and repair

The components of the S7-1200 G2 automation system are maintenance-free.

NOTE
Only the manufacturer can carry out repairs to the components of the S7-1200 G2 automation system.

PLC concepts, configuration, and programming 5

5.1 TIA Portal

The Totally Integrated Automation Portal (TIA Portal) is an engineering framework for implementing automation solutions. The TIA Portal includes STEP 7 for PLC programming and configuration. You use STEP 7 to configure CPUs and modules (Page 151) and for programming your application logic (Page 170).

TIA Portal provides an extensive information system.

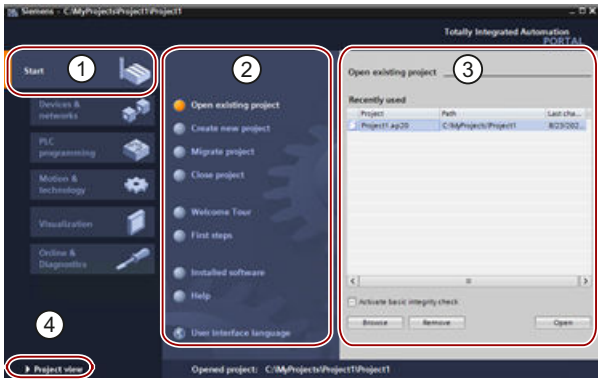
5.2 Different views in the TIA Portal

The TIA Portal provides two different views of the project that you use for your control application:

- Portal view: A task-oriented set of portals that are organized on the functionality of the tools
- Project view: A project-oriented view of the elements within the project

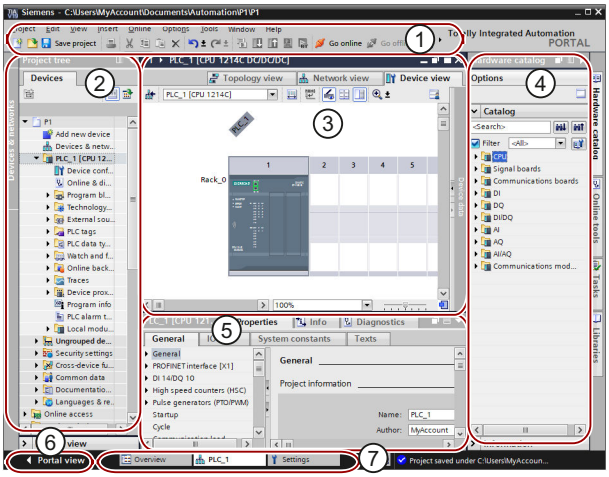
Choose which view helps you work most efficiently. With a single click, you can toggle between the Portal view and the Project view.

Portal view



① Portals for the different tasks
② Tasks for the selected portal
③ Selection panel for the selected action
④ Switch to Project view

Project view



① Menus and toolbar
② Project tree navigator
③ Work area
④ Task cards
⑤ Inspector window
⑥ Selector to change to the Portal view
⑦ Editor bar

With these components in one place, you have easy access to every aspect of your project. The work area consists of three tabbed views:

- Device view: Displays the device that you have added or selected and its associated modules
- Network view: Displays the CPUs and network connections in your network
- Topology view: Displays the PROFINET topology of the network including devices, passive components, ports, interconnections, and port diagnostics

Each view also enables you to perform configuration tasks. The inspector window shows the properties and information for the object that you have selected in the work area. As you select different objects, the inspector window displays the properties that you can configure. The inspector window includes tabs that allow you to see diagnostic information and other messages.

By showing all of the editors that are open, the editor bar helps you work more quickly and efficiently. To toggle between the open editors, simply click one of the open editors. You can also arrange two editors to appear together, arranged either vertically or horizontally. This feature allows you to drag and drop between editors.

5.3 Using the TIA Portal Information System

The TIA Portal Information System has extensive information about configuring and programming PLCs. In the TIA Portal Information System, refer to Help on the Information System (https://docs.tia.siemens.cloud/access?ft:originId=./11251439499/75833983499_enUS.htm&ft:clusterId./11251439499/75833983499.htm) for usage information.

When searching for information about the S7-1200 G2, note the following:

- When filtering a search on devices, S7-1200 G2 is not available as a device selection. Filtering by S7-1500 would be the closest match to S7-1200 G2 information.
- When using context-sensitive help in the TIA Portal, if the tooltip does not include S7-1200 G2, then choose the S7-1500 topic.

This system manual for the S7-1200 G2 Programmable Logic Controller provides additional information on configuration, programming, and program execution.

5.4 Program structure

5.4.1 Structure of a STEP 7 user program

The S7-1200 G2 CPU supports the following types of code blocks that allow you to create an efficient structure for your user program:

- Organization blocks (OBs) (Page 101) define the structure of the program. Some OBs run at startup. Some run continuously when the CPU is running your process. Some run under specific conditions.
- Data blocks (DBs) (Page 129) store data that can be used by the program blocks. Refer to "Data types (https://docs.tia.siemens.cloud/access?ft:originId=./65883487371/65883487371_enUS.htm&ft:clusterId./65883487371/65883487371.htm)" in the TIA Portal Information System for descriptions of the data types that STEP 7 provides.
- Functions (FCs) and function blocks (FBs) contain the program code that corresponds to specific tasks. FCs and FBs can be called from an OB or from another FC or FB. Each FC or FB provides a set of input and output parameters for sharing data with the calling block. An FB also uses an associated data block (called an instance DB) to maintain the data values for that instance of the FB call. You can call an FB multiple times, each time with a unique instance DB. Calls to the same FB with different instance DBs do not affect the data values in any of the other instance DBs.

An S7-1200 G2 F-CPU supports the following types of code blocks that allow you to create an efficient structure for your safety program:

- F-I/O data blocks are automatically generated by the safety program when you configure an F-I/O.
- Fail-safe organization blocks (F-OBs) define the structure of the safety program. The F-OB calls the main safety block in an F-Runtime Group (F-RTG); this group contains F-blocks that you create or that are inserted from the project or global libraries, as well as those which are added automatically by the safety program. You can manage F-RTGs in the Safety Administration Editor (SAE). There can be either one or two F-RTGs.

- Fail-safe data blocks (F-DBs) store data that can be used by the safety program blocks.
  - F-shared data blocks are data blocks that contain all data shared between the safety program and the F-subsystems.
  - F-runtime group information data blocks are created by the safety program when you create an F-runtime group. These blocks provide information on the F-runtime group and on the safety program.
- Fail-safe functions (F-FCs) and Fail-safe function blocks (F-FBs) contain the program code that corresponds specifically to safety tasks. F-FCs and F-FBs can be called from an F-OB or from another F-FC or F-FB. Each F-FC or F-FB contains instructions from either the project or global library and can call other created F-FBs or F-FCs to structure the user safety program.

NOTE

Onboard standard I/O channels not used for fail-safe I/O function
In your STEP 7 project, you can configure the onboard I/O of the F-CPU with standard code blocks, but these I/O are not safety I/O. You can only use F-I/O to accomplish safety tasks by configuring the fail-safe I/O channels with safety blocks.

To learn more about the code blocks which structure the safety program, refer to the "SIMATIC Safety - Configuring and Programming" manual (https://support.industry.siemens.com/cs/us/en/view/54110126).

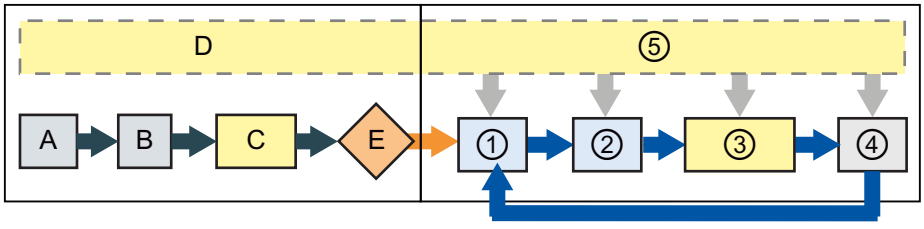
5.4.2 Execution of the user program

Execution of the user program begins with one or more optional startup OBs (Page 102) that execute once upon entering RUN mode. Execution then continues with configured program cycle OBs (Page 102) that execute cyclically. You can also associate an OB with an interrupt event, which can be either a standard event or an error event. These OBs execute whenever the corresponding standard or error event occurs.

Operating modes

The CPU has three modes of operation: STOP mode, STARTUP mode, and RUN mode. Status LEDs on the front of the CPU indicate the current mode of operation.

- In STOP mode, the CPU handles any communication requests (as appropriate) and performs self-diagnostics. The CPU does not execute the user program. Automatic updates of the process image do not occur. You can download a project to the CPU.
- In STARTUP and RUN modes, the CPU performs the tasks shown in the following figure:



STARTUP

A	Copies the state of the physical inputs to I memory
B	Initializes the Q output (image) memory area with either zero or the last value. Zeroes PN outputs
C	Initializes non-retentive M memory and data blocks to their initial value and enables configured cyclic interrupt and time of day events. Executes the startup OBs.
D	Stores any interrupt events into the queue to be processed after entering RUN mode
E	Enables the writing of Q memory to the physical outputs

RUN

①	Writes Q memory to the physical outputs
②	Copies the state of the physical inputs to I memory
③	Executes the program cycle OBs and updates the output values in the process image output area
④	Performs self-test diagnostics
⑤	Processes interrupts and communications during any part of the scan cycle

You can download some parts of a project in RUN mode (Page 323).

Restart of fail-safe system

The operating modes of the SIMATIC Safety system differ from those of the standard system only in terms of the restart characteristics.

When you switch a fail-safe CPU from STOP to RUN mode, the standard user program restarts in the usual way. When you restart the safety program, the fail-safe system initializes all data blocks with the F-Attribute with values from load memory. This is comparable to a cold restart.

Process image update and process image partitions

The CPU updates local digital and analog I/O points synchronously with the scan cycle using an internal memory area called the process image. The process image contains a snapshot of the physical inputs and outputs (the physical I/O points on the CPU, signal board, and signal modules).

You can configure I/O points to be updated in the process image every scan cycle or when a specific event interrupt occurs. You can also configure an I/O point to be excluded from process image updates. For example, your process might only need certain data values when an event such as a hardware interrupt occurs. By configuring the process image update for these I/O points to be associated with a partition that you assign to a hardware interrupt OB, you avoid having the CPU update data values unnecessarily every scan cycle when your process does not need a continual update.

For controlling whether your process updates I/O points automatically on every scan cycle, or upon the triggering of events, the S7-1200 G2 provides 32 process image partitions. The first process image partition, PIP0, is designated for I/O that is to be automatically updated every scan cycle, and is the default assignment. You can use the remaining partitions, PIP1 through PIP31, for assigning I/O process image updates to various interrupt events. You assign I/O to process image partitions in Device Configuration and you assign process image partitions to interrupt events when you create interrupt OBs (Page 101) or edit OB properties (Page 101).

By default, when you insert a module in the device view, STEP 7 sets its I/O process image update to "Automatic update". For I/O configured for "Automatic update", the CPU handles the data exchange between the module and the process image area automatically during every scan cycle.

To assign digital or analog points to a process image partition, or to exclude I/O points from process image updates, follow these steps:

1. View the Properties tab for the appropriate device in Device configuration.
2. Expand the selections under "General" as necessary to locate the desired I/O points.
3. Select "I/O addresses".
4. Optionally select a specific OB from the "Organization block" drop-down list.
5. From the "Process image" drop-down list, change "Automatic update" to a PIP from PIP1 through PIP31 or None. A selection of "None" means that you can only read from and write to this I/O using immediate instructions. To add the points back to the process image automatic update, change this selection back to "Automatic update".

You can immediately read physical input values and immediately write physical output values when an instruction executes. An immediate read accesses the current state of the physical input and does not update the process image input area, regardless of whether the point is configured to be stored in the process image. An immediate write to the physical output updates both the process image output area (if the point is configured to be stored in the process image) and the physical output point. Append the suffix ":P" to the I/O address if you want the program to immediately access I/O data directly from the physical point instead of using the process image.

NOTE

Use of process image partitions

If you assign I/O to one of the process image partitions PIP1 - PIP31, and do not assign an OB to that partition, then the CPU never updates that I/O to or from the process image. Assigning I/O to a PIP that does not have a corresponding OB assignment is the same as assigning the process image to "None".

You can read a physical input directly with an immediate read instruction, or write to the physical output with an immediate write instruction. The CPU does not update the process image.

The CPU supports distributed I/O for PROFINET (Page 209) networks.

5.4.3 Startup configuration and processing

Startup configuration

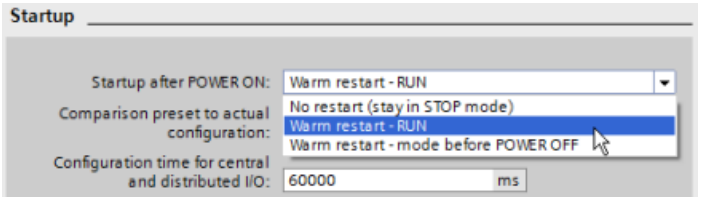
The CPU supports a warm restart for entering the RUN mode. The CPU initializes all non-retentive system and user data at warm restart, and retains the values of all retentive user data.

Warm restart does not include a memory reset. A memory reset clears all work memory, clears retentive and non-retentive memory areas, copies load memory to work memory, and sets outputs to the configured "Reaction to CPU STOP". A memory reset does not clear the diagnostics buffer or the permanently saved values of the IP address.

You can configure the "startup after POWER ON" setting of the CPU. This configuration item appears under the "Device configuration" for the CPU under "Startup". Upon powering up, the CPU performs a sequence of power-up diagnostic checks and system initialization. During system initialization, the CPU deletes all non-retentive bit (M) memory and resets all non-retentive DB contents to the initial values from load memory. The CPU retains retentive bit (M) memory and retentive DB contents and then enters the appropriate operating mode. Certain detected errors prevent the CPU from entering the RUN mode. The CPU supports the following configuration choices:

- No restart (stay in STOP mode)
- Warm restart - RUN

- Warm restart - mode prior to POWER OFF



NOTICE
Risks associated with repairable faults The CPU can enter STOP mode due to repairable faults, such as the following: – Failure of a replaceable signal module – Temporary faults, such as power line disturbance or erratic power up event Such conditions can result in property damage. If you have configured the CPU to "Warm restart - mode prior to POWER OFF", the CPU goes to the operating mode that the CPU was in prior to the loss of power or fault. If the CPU was in STOP mode at the time of power loss or fault, the CPU goes to STOP mode on power up. The CPU stays in STOP mode until the CPU receives a command to go to RUN mode. If the CPU was in RUN mode at the time of power loss or fault, the CPU goes to RUN mode on the next power up. The CPU goes to RUN mode providing the CPU detects no errors that would inhibit a transition to RUN mode. Configure CPUs that you intend to operate independently of a STEP 7 connection to "Warm restart - RUN". This startup mode sets the CPU to return to RUN mode on the next power cycle.

Startup processing

See Execution of the user program (Page 97) for the processing sequence during startup.

Each startup OB includes startup information that helps you determine the validity of retentive data and the time-of-day clock. You can program instructions inside the startup OBs to examine these startup values and to take appropriate action.

The CPU also performs the following tasks during the startup processing:

- Interrupts are queued but not processed during the startup phase
- No cycle time monitoring is performed during the startup phase
- Configuration changes to HSC (high-speed counter), PTO (pulse train output), and PtP (point-to-point communication) modules can be made in startup
- Actual operation of HSC, PTO, and point-to-point communication modules only occurs in RUN

After the execution of the startup OBs finishes, the CPU goes to RUN mode and processes the control tasks in a continuous scan cycle.

Changing the operating mode

You can use the "STOP" or "RUN" commands (Page 299) from the online tools of the TIA Portal to change the current operating mode. You can also include an STP instruction in your program to change the CPU to STOP mode. Other tools provide a means to change the operating mode as well.

5.4.4 Processing the scan cycle in RUN mode

For each scan cycle, the CPU performs processing as described in Execution of the user program (Page 97).

The CPU handles interrupt events that are enabled according to priority in the order in which they occur. For interrupt events, the CPU reads the inputs, executes the OB, and then writes the outputs, using the associated process image partition (PIP), if applicable.

The system guarantees that the scan cycle will be completed in a time period called the maximum cycle time; otherwise a time error event is generated.

- Each scan cycle begins by retrieving the current values of the digital and analog outputs from the process image and then writing them to the physical outputs of the CPU, SB, and SM modules configured for automatic I/O update (default configuration). When a physical output is accessed by an instruction, both the output process image and the physical output itself are updated.
- The scan cycle continues by reading the current values of the digital and analog inputs from the CPU, SB, and SMs configured for automatic I/O update (default configuration), and then writing these values to the process image. When a physical input is accessed by an instruction, the value of the physical input is accessed by the instruction, but the input process image is not updated.
- After reading the inputs, the user program is executed from the first instruction through the end instruction. This includes all the program cycle OBs plus all their associated FCs and FBs. The program cycle OBs are executed in order according to the OB number with the lowest OB number executing first.

Communications processing occurs periodically throughout the scan, possibly interrupting user program execution (https://support.industry.siemens.com/cs/de/en/view/59193558/158758826123).

Self-diagnostic checks include periodic checks of the system and the I/O module status checks.

Interrupts can occur during any part of the scan cycle, and are event-driven. When an event occurs, the CPU interrupts the scan cycle and calls the OB that was configured to process that event. After the OB finishes processing the event, the CPU resumes execution of the user program at the point of interruption.

5.4.5 Organization blocks (OBs)

Organization blocks (OBs) control the execution of the user program.

The program cycle OB contains your main program. You can include more than one program cycle OB in your user program. During RUN mode, the program cycle OBs execute at the lowest priority level (Page 117) and can be interrupted by all other event types. The CPU executes the program cycle OBs in a continuous cycle known as the "program cycle" or "scan cycle". This cyclic processing is the normal type of processing used for programmable logic controllers. For many applications, the entire user program is located in a single program cycle OB.

Specific events in the CPU trigger the execution of other organization blocks. OBs cannot call each other. The startup OB runs when you start the CPU. It does not interrupt the program cycle OB. The CPU executes the startup OB before going to RUN mode.

Other OBs, called interrupt OBs, run when associated events or errors occur. These OBs interrupt the execution of the program cycle OBs.

An FC or FB cannot call an OB. Only an event such as a diagnostic interrupt or a time delay can start the execution of an OB. The CPU handles OBs according to their respective priority classes (Page 117), with higher priority OBs executing before lower priority OBs.

5.4.5.1 Program cycle OB

Program cycle OBs execute cyclically while the CPU is in RUN mode. The main block of the program is a program cycle OB. This is where you place the instructions that control your program and where you call additional user blocks. You can have multiple program cycle OBs, which the CPU executes in numerical order. Main (OB 1) is the default.

Program cycle events

The program cycle event happens once during each program cycle (or scan). During the program cycle, the CPU writes the outputs, reads the inputs and executes program cycle OBs. The program cycle event is required and is always enabled. You might have no program cycle OBs, or you might have multiple program cycle OBs. After the program cycle event occurs, the CPU executes the lowest numbered program cycle OB (usually "Main" OB 1). The CPU executes the other program cycle OBs sequentially (in numerical order) within the program cycle. Program execution is cyclical such that the program cycle event occurs at the following times:

- When the last startup OB finishes execution
- When the last program cycle OB finishes execution

You can delay the next program cycle after the program cycle OB finishes by configuring a minimum cycle time in the device configuration

Table 1-144 Start information for a program cycle OB

Input	Data type	Description
Initial_Call	Bool	True for initial call of the OB
Remanence	Bool	True if retentive data are available

5.4.5.2 Startup OB

Startup OBs execute one time when the operating mode of the CPU changes from STOP to RUN, including powering up in the RUN mode and in commanded STOP-to-RUN transitions. After completion, the main "Program cycle" begins executing. Refer to "Startup processing" in Startup configuration and processing (Page 99)

The Startup OBs support the following startup data bits:

Table 1-145 Startup locations supported by the startup OB

Input	Data Type	Description
LostRetentive	Bool	This bit is true if the retentive data storage areas have been lost
LostRTC	Bool	This bit is true if the time-of-day clock (real-time clock) has been lost

5.4.5.3 Time delay interrupt OB

Time delay interrupt OBs execute after a time delay that you configure.

Time delay interrupt events

You configure time delay interrupt events to occur after a specified delay time has expired from the beginning of execution of the SRT_DINT instruction. You assign the delay time with the SRT_DINT instruction. The time delay events interrupt the program cycle to execute the corresponding time delay interrupt OB. You can attach only one time delay interrupt OB to a time delay event. The CPU supports 20 time delay events.

Table 1-146 Start information for a time delay interrupt OB

Input	Data type	Description
Sign	Word	Identifier passed to triggering call of SRT_DINT

5.4.5.4 Cyclic interrupt OB

Cyclic interrupt OBs execute at a specified interval. You can configure up to a total of 20 cyclic interrupt events, with one OB corresponding to each cyclic interrupt event.

Cyclic interrupt events

The cyclic interrupt events allow you to configure the execution of an interrupt OB at a configured cycle time. You configure the initial cycle time when you create the cyclic interrupt OB. A cyclic event interrupts the program cycle and executes the corresponding cyclic interrupt OB. Note that the cyclic interrupt event is at a higher priority class than the program cycle event.

You can attach only one cyclic interrupt OB to a cyclic event.

You can assign a phase shift to each cyclic interrupt so that the execution of cyclic interrupts can be offset from one another by the phase offset amount. For example, if you have a 5 ms cyclic event and a 10 ms cyclic event, every ten milliseconds both events occur at the same moment. If you phase shift the 5 ms event by 1 to 4 ms and the 10 ms event by 0 ms, then the two events do not occur at the same moment.

The default phase offset is 0. To change the initial phase shift, or to change the cyclic time for a cyclic event, follow these steps:

1. Right-click the cyclic interrupt OB in the project tree.
2. Select "Properties" from the context menu.
3. Click "Cyclic interrupt" from the "Cyclic interrupt [OB 30]" dialog, and enter the new initial values.

The maximum phase offset is 6000000 microseconds (6 seconds) or the maximum Cyclic time, whichever is smaller.

You can also query and change the cycle time and the phase shift from your program using the Query cyclic interrupt (QRY_CINT) and Set cyclic interrupt (SET_CINT) instructions. Cycle time and phase shift values set by the SET_CINT instruction do not persist through a power cycle or a transition to STOP mode; cycle time and phase shift values return to the initial values following a power cycle or a transition to STOP. The CPU supports a total of 20 cyclic interrupt events.

Table 1-147 Start information for cyclic interrupt OB

Name	Data type	Meaning
Initial_Call	BOOL	=TRUE in the first call of this OB • At the transition from STOP or HOLD to RUN • After reloading
Event_Count	INT	Number of discarded cyclic interrupt events since the last start of this OB

5.4.5.5 Hardware interrupt OB

Hardware interrupt OBs execute when the relevant hardware event occurs. A hardware interrupt OB interrupts normal cyclic program execution in reaction to a signal from a hardware event.

Hardware interrupt events

Changes in the hardware, such as a rising or falling edge on an input point, or an HSC (High Speed Counter) event trigger hardware interrupt events. The S7-1200 G2 supports hardware interrupt OBs to respond to hardware interrupt events.

You enable the hardware events in the device configuration, and assign an OB for an event in the device configuration or with an ATTACH instruction in the STEP 7 program. The CPU supports several hardware interrupt events. The CPU model and the number of input points determine the exact events that are available.

Limits on hardware interrupt events are as follows:

Edges:

- One for each CPU and SB digital input
- Additional hardware interrupt events are possible from distributed I/O depending on the device and submodules that you use.

HSC events:

- CV=PV: maximum of 8
- Direction changed: maximum of 8
- External reset: maximum of 8

Table 1-148 Start information for a hardware interrupt OB

Input	Data type	Description
LADDR	HW_IO	Hardware identifier of the module that triggered the hardware interrupt
USI	WORD	User structure identifier (16#0001 to 16#FFFF), reserved for future use
IChannel	USINT	Number of the channel that triggered the interrupt
EventType	BYTE	Identifier for the module-specific event type associated with the event triggering the interrupt, for example falling edge or rising edge.

Table 1-149 Bits in EventType based on module and process event

Module / Sub-module	Value	Process event
Onboard I/O from CPU, SB, or distributed I/O	16#0	Rising edge
	16#1	Falling edge
HSC	16#0	HSC CV=RV1
	16#1	HSC direction changed
	16#2	HSC reset

5.4.5.6 Time error interrupt OB

If configured, the time error interrupt OB (OB 80) executes when either the scan cycle exceeds the maximum cycle time or a time error event occurs. If triggered, it executes, interrupting normal cyclic program execution or any event OB at priority 21 or lower.

The occurrence of either of these events generates a diagnostics buffer entry describing the event. The diagnostics buffer entry is generated regardless of the existence of the time error interrupt OB.

Time error interrupt events

The occurrence of any of several different time error conditions results in a time error event:

- Scan cycle exceeds maximum cycle time

  The "maximum cycle time exceeded" condition results if the program cycle does not complete within the specified maximum scan cycle time. See the topic Monitoring and configuring the cycle time (Page 120) for more information.
- CPU cannot start requested OB because a second time interrupt (cyclic or time-delay) starts before the CPU finishes execution of the first interrupt OB
- Queue overflow occurred

  The "queue overflow occurred" condition results if the interrupts are occurring faster than the CPU can process them. The CPU limits the number of pending (queued) events by using a different queue for each event type. If an event occurs when the corresponding queue is full, the CPU generates a time error event.

All time error events trigger the execution of the time error interrupt OB if it exists. If the time error interrupt OB does not exist, then the following conditions determine the CPU behavior:

- If a time error interrupt OB has never been downloaded to the CPU, the CPU ignores the first scan timeout condition and remains in RUN mode. If a second scan timeout condition occurs in the same program scan (two times the maximum cycle time value), the CPU generates a diagnostic buffer entry and transitions to STOP mode.
- If the time error interrupt OB has previously been downloaded, but has since been deleted, the CPU transitions to STOP mode if a time error event occurs, because the CPU cannot find the time error OB.

The user program can extend the program cycle execution time up to ten times the configured maximum cycle time by executing the RE_TRIGR instruction to restart the cycle time monitor. However, if two "maximum cycle time exceeded" conditions occur within the same program cycle without resetting the cycle timer, then the CPU transitions to STOP, regardless of whether the time error interrupt OB exists. See the topic Monitoring and configuring the cycle time (Page 120).

Time error interrupt OB includes start information that helps you determine which event and OB generated the time error. You can program instructions inside the OB to examine these start values and to take appropriate action.

Table 1-150 Start information for the time error OB (OB 80)

Input	Data type	Description
Fault_ID	BYTE	16#01: Cycle time exceeded 16#02: The requested OB is still being processed. 16#05: Expired time interrupt due to time jump 16#06: Expired time interrupt upon re-entry into RUN after HOLD 16#07: Overflow of the OB request buffer for the current priority class 16#08: Isochronous mode interrupt - time error 16#09: Interrupt loss due to high interrupt load 16#0B: Technology synchronization interrupt - time error 16#0C: (only for S7-1500 R/H CPUs) cycle time exceeded for the second time
Csg_OBnr	OB_ANY	Number of the OB which was being executed when the error occurred
Csg_Prio	UINT	Priority of the OB causing the error

See topic Organization blocks (OBs) (Page 101) for instructions on adding OBs to your project.

5.4.5.7 Diagnostic error interrupt OB

The diagnostic error interrupt OB executes when the CPU detects a diagnostic error, or if a diagnostics-capable module recognizes an error and you have enabled the diagnostic error interrupt for the module. The diagnostic error interrupt OB interrupts the normal cyclic program execution. You can include an STP instruction in the diagnostic error interrupt OB to put the CPU in STOP mode if you desire your CPU to enter STOP mode upon receiving this type of error.

If you do not include a diagnostic error interrupt OB in your program, the CPU ignores the error and stays in RUN mode.

Diagnostic error events

PROFINET, local analog, and some local digital devices are capable of detecting and reporting diagnostic errors. The occurrence or removal of any of several different diagnostic error conditions results in a diagnostic error event. Standard CPUs and modules can generate the following diagnostic errors:

- No user power
- High limit exceeded
- Low limit exceeded
- Wire break
- Short circuit

Distributed devices can generate additional diagnostic errors.

Diagnostic error events trigger the execution of the diagnostic error interrupt OB (OB 82) if it exists. If it does not exist, then the CPU ignores the error.

See topic Organization blocks (OBs) (Page 101) for instructions on adding an OB to your project.

NOTE

Diagnostic errors for multi-channel local analog devices

The diagnostic error interrupt OB can process only one channel's diagnostic error at a time. If two channels of a multi-channel device have an error, then the second error only triggers the diagnostic error interrupt OB under the following conditions: the first channel error clears, the execution of the diagnostic error interrupt OB that the first error triggered is complete, and the second error still exists.

The diagnostic error interrupt OB includes startup information that helps you determine whether the event is due to the occurrence or removal of an error, and the device and channel which reported the error. You can program instructions inside the diagnostic error interrupt OB to examine these startup values and to take appropriate action.

NOTE

If the outgoing event leaves the submodule with no pending diagnostics, the Diagnostic error OB start information references the submodule as a whole (16#8000), even if the source of the event was a specific channel.

Table 1-151 Startup information for the diagnostic error interrupt OB

Input	Data type	Description
IOstate	WORD	IO state of the device: • Bit 0 = 1 if the configuration is correct, and = 0 if the configuration is no longer correct. • Bit 4 = 1 if an error is present (such as a wire break). (Bit 4 = 0 if there is no error.) • Bit 5 = 1 if the configuration is **not** correct, and = 0 if the configuration is correct again. • Bit 7 = 1 if an I/O access error has occurred. Refer to LADDR for the hardware identifier of the I/O with the access error. (Bit 6 = 0 if there is no error.) Status of the hardware object: • Bit 0: Good • Bit 1: Deactivated • Bit 2: Maintenance required • Bit 3: Maintenance demanded • Bit 4: Error • Bit 5: Not available • Bit 6: Qualified • Bit 7: Not available • Bits 8 to 14: Reserved (always "0") • Bit 15: Network / hardware fault If bit 4 = 1 or bit 5 = 1: – Bit 15 = 0: Network error – Bit 15 = 1: Hardware error

[1] The LADDR input contains the hardware identifier of the device or functional unit which returned the error. The hardware identifier is assigned automatically when components are inserted in the device or network view and appears in the System constants tab of PLC tags. A name is also assigned automatically for the hardware identifier. These entries in the System constants tab of the PLC tags cannot be changed.

Input	Data type	Description
LADDR	HW_ANY	Hardware identifier of the device or functional unit that reported the error[1]
Channel	UINT	Channel number
MultiError	BOOL	TRUE if more than one error is present

[1] The LADDR input contains the hardware identifier of the device or functional unit which returned the error. The hardware identifier is assigned automatically when components are inserted in the device or network view and appears in the System constants tab of PLC tags. A name is also assigned automatically for the hardware identifier. These entries in the System constants tab of the PLC tags cannot be changed.

5.4.5.8 Pull or plug of modules OB

The "Pull or plug of modules" OB executes when a configured and non-disabled distributed I/O module or submodule generates an event related to inserting or removing a module.

Pull or plug of modules event

The following conditions generate a pull or plug of modules event:

- Someone removes or inserts a configured module
- A configured module is not physically present in an expansion rack
- An incompatible module is in an expansion rack that does not correspond to the configured module
- A compatible module for a configured module is in an expansion rack, but the configuration does not allow substitutes
- A module or submodule has parameterization errors

If you have not programmed this OB, the CPU remains in RUN mode when any of these conditions occur with a configured and non-disabled distributed I/O module.

Regardless of whether you have programmed this OB, the CPU changes to STOP mode when any of these conditions occur with a module in the local rack.

Table 1-152 Start information for pull or plug of modules OB

Input	Data type	Description
LADDR	HW_IO	Hardware identifier
Event_Class	Byte	16#38: module inserted 16#39: module removed
Fault_ID	Byte	Fault identifier For event class 16#38: • 54: Submodule inserted, which conforms to the parameterized submodule • 55: Submodule inserted, which does not conform to the submodule parameter assignment • 56: Submodule inserted, but error in module parameter assignment • 57: Submodule inserted, but with a fault or maintenance issue • 58: Submodule access error remedied For event class 16#39 • 51: Module removed • 54: Submodule removed

5.4.5.9 Rack or station failure OB

The "Rack or station failure" OB executes when the CPU detects the failure or communication loss of a distributed rack or station.

Rack or station failure event

The CPU generates a rack or station failure event when it detects one of the following:

- The failure of a DP master system or of a PROFINET IO system (in the case of either an incoming or an outgoing event).
- The failure of a DP slave or of an IO device (in the case of either an incoming or an outgoing event)
- Failure of some of the submodules of a PROFINET I-device

If you have not programmed this OB, the CPU remains in RUN mode when any of these conditions occur.

Table 1-153 Start information for rack or station failure OB

Input	Data type	Description
LADDR	HW_Device	Hardware identifier
Event_Class	Byte	16#38: outgoing event 16#39: incoming event
Fault_ID	Byte	Fault identifier (possible values: 16#C3, 16#C4, 16#C9, 16#CA, 16#CB, 16#CC, 16#CD, 16#CE, 16#CF, 16#F8, 16#F9)

The following table shows which event caused the start of OB 86.

ev_class 16# ...	fault_id 16# ...	Meaning
39	C3	Failure of a DP master system
39/38	C4	Failure/return of a DP slave
39	CA	Failure of a PROFINET IO system
39/38	CB	Failure/return of a PROFINET IO device
38	CC	Return of a PROFINET IO device with fault or maintenance
38	CD	Return of a PROFINET IO device, deviation between preset/actual configuration
38	CE	Return of a PROFINET IO device, error in module configuration
39/38	F8	Failure/return of some of the submodules of a PROFINET I-device
38	F9	Return of some of the submodules of a PROFINET I-device with a device configuration difference

5.4.5.10 Time of day OB

Time of day OBs execute based on configured clock time conditions. The CPU supports up to 20 time of day OBs.

Time of day events

You can configure a time of day interrupt event to occur once on a specified date or time or cyclically with one of the following cycles:

- Every minute: The interrupt occurs every minute.
- Hourly: The interrupt occurs every hour.
- Daily: The interrupt occurs every day at a specified time (hour and minute).
- Weekly: The interrupt occurs every week at a specified time on a specified day of the week (for example, every Tuesday at 4:30 in the afternoon).
- Monthly: The interrupt occurs every month at a specified time on a specified day of the month. The day number must be between 1 and 28, inclusive.
- Every end of month: The interrupt occurs on the last day of every month at a specified time.
- Yearly: The interrupt occurs every year on the specified date (month and day). You cannot specify a date of February 29.

Table 1-154 Start information for a time of day event OB

Input	Data type	Description
CaughtUp	Bool	OB call is caught up because time was set forward
SecondTime	Bool	OB call is started a second time because time was set backward

5.4.5.11 Synchronous cycle OB

IRT (Isochronous Realtime) is a transmission method that can synchronize PROFINET devices with very high accuracy. You can operate I/O modules in distributed PROFINET I/O systems isochronously, for example, ET 200SP and ET 200MP distributed I/O systems. Both the I/O modules and the interface modules of the I/O systems must support isochronous mode.

The Synchronous cycle interrupt OB uses an isochronous mode interrupt to trigger the start of subprograms isochronously to the PROFINET send clock.

Refer to Cycle time and communication load (Page 122) for considerations of how higher priority OBs affect the main scan cycle.

Table 1-155 Start information for Synchronous cycle OB

Input	Data type	Meaning
Initial_Call	BOOL	TRUE = the first call of this OB during transition from STOP to RUN
PIP_Input	BOOL	Always FALSE. The program must call the SYNC_PI instruction to update the corresponding process image partition of the inputs.
PIP_Output	BOOL	Always FALSE. The program must call the SYNC_PO instruction to update the corresponding process image partition.

Input	Data type	Meaning
IO_System	USINT	Number of the distributed I/O system triggering the interrupt
Event_Count	INT	• = n: Number of lost cycles • = -1: An unknown number of cycles has been lost (for example, because cycle has changed)
SyncCycleTime	LTIME	Configured cycle time of the Synchronous cycle OB

5.4.5.12 Status OB

Status OBs execute if a PNIO slave triggers a status interrupt. This might be the case if a component (module or rack) of a PNIO slave changes its operating mode, for example from RUN to STOP.

Status events

For detailed information on events that trigger a status interrupt, refer to the manufacturer's documentation for the PNIO device.

Table 1-156 Start information for status OB

Input	Data type	Description
LADDR	HW_IO	Hardware identifier
Slot	UInt	Slot number
Specifier	Word	Alarm specifier

5.4.5.13 Update OB

Update OBs execute if a PNIO slave triggers an update interrupt.

Update events

For detailed information on events that trigger an update interrupt, refer to the manufacturer's documentation for the PNIO slave.

Table 1-157 Start information for update OB

Input	Data type	Description
LADDR	HW_IO	Hardware identifier
Slot	UInt	Slot number
Specifier	Word	Alarm specifier

5.4.5.14 Profile OB

Profile OBs execute if a DPV1 or PNIO slave triggers a profile-specific interrupt.

Profile events

For detailed information on events that trigger a profile interrupt, refer to the manufacturer's documentation for the DPV1 or PNIO slave.

Table 1-158 Start information for profile OB

Input	Data type	Description
LADDR	HW_IO	Hardware identifier
Slot	UInt	Slot number
Specifier	Word	Alarm specifier

5.4.5.15 MC-Servo and MC-Interpolator OB

STEP 7 creates the read-only MC-Servo and MC-Interpolator OBs automatically when you create a motion technology object and set the drive interface to be "Analog drive connection" or "PROFIDrive". You do not need to edit any OB properties or create this OB directly. The CPU uses these OBs for closed loop control. Refer to the STEP 7 Information System for further details.

The MC Servo OB uses a system-defined PIP with the name "PIP OB Servo".

Table 1-159 Start information for MC-Servo OB

Input	Data type	Description
Initial_Call	BOOL	TRUE indicates first call of this OB on transition from STOP to RUN
PIP_Input	BOOL	TRUE indicates the associated process image input is up to date.
PIP_Output	BOOL	TRUE indicates that the CPU transferred the associated process image output to the outputs in good time after the last cycle.
IO_System	USINT	Number of the distributed I/O system triggering the interrupt
Event_Count	INT	n: number of lost cycles -1: unknown number of cycles lost (for example, because cycle has changed)
Synchronous	BOOL	TRUE: The MC-Servo [OB91] is called synchronously with a bus system

Table 1-160 Start information for MC-Interpolator OB

Input	Data type	Description
Initial_Call	BOOL	TRUE indicates first call of this OB on transition from STOP to RUN
PIP_Input	BOOL	TRUE indicates the associated process image input is up to date.
PIP_Output	BOOL	TRUE indicates that the CPU transferred the associated process image output to the outputs in good time after the last cycle.
IO_System	USINT	Number of the distributed I/O system triggering the interrupt
Event_Count	INT	n: number of lost cycles -1: unknown number of cycles lost (for example, because cycle has changed)
Reduction	UInt	Reduction ratio of MC-Interpolator [OB92] to MC-Servo [OB91]

5.4.5.16 MC-PreInterpolator

The organization block MC_PreInterpolator [OB68] can be programmed and is called in the application cycle configured at the MC_Servo (Page 112). The MC_PreInterpolator is called directly before the MC_Interpolator .

Via the organization block, you can read out the configured application cycle.

Structure of the start information

Optimized start information:

Name	Data type	Meaning	
Initial_Call	BOOL	TRUE	In the first call of this OB after the CPU is switched on
PIP_Input	BOOL	TRUE	The associated process image input is up-to-date.
PIP_Output	BOOL	TRUE	The associated process image output was transferred to the outputs in time after the last cycle.
IO_System	USINT	Number of the distributed I/O system triggering the interrupt	
Event_Count	INT	n	Number of lost cycles
		-1	An unknown number of cycles has been lost, e.g. because the cycle has changed.
Reduction	UINT	Reduction ratio of MC_Interpolator to MC_Servo	
CycleTime	UDINT	Display of the application cycle configured for the MC_Interpolator in ns	

5.4.5.17 MC-PreServo

You can program the MC-PreServo OB to contain program logic for the STEP 7 program to execute directly before the MC-Servo OB executes.

MC-PreServo events

The MC-PreServo OB allows you to read out the configured application cycle information in microseconds.

Table 1-161 Start information for MC-PreServo OB

Input	Data type	Description
Initial_Call	BOOL	TRUE indicates first call of this OB on transition from STOP to RUN
PIP_Input	BOOL	TRUE indicates the associated process image input is up to date.
PIP_Output	BOOL	TRUE indicates that the CPU transferred the associated process image output to the outputs in good time after the last cycle.
IO_System	USINT	Number of the distributed I/O system triggering the interrupt
Event_Count	INT	n: number of lost cycles -1: unknown number of cycles lost (for example, because cycle has changed)
Synchronous	BOOL	Reserved
CycleTime	UDINT	Display of the application cycle configured for the MC-Servo OB in microseconds

5.4.5.18 MC-PostServo

You can program the MC-PostServo OB to contain program logic for the STEP 7 program to execute directly after the MC-Servo OB executes.

MC-PostServo events

The MC-PostServo OB allows you to read out the configured application cycle information in microseconds.

Table 1-162 Start information for MC-PostServo OB

Input	Data type	Description
Initial_Call	BOOL	TRUE indicates first call of this OB on transition from STOP to RUN
PIP_Input	BOOL	TRUE indicates the associated process image input is up to date.
PIP_Output	BOOL	TRUE indicates that the CPU transferred the associated process image output to the outputs in good time after the last cycle.
IO_System	USINT	Number of the distributed I/O system triggering the interrupt
Event_Count	INT	n: number of lost cycles -1: unknown number of cycles lost (for example, because cycle has changed)
Synchronous	BOOL	Reserved
CycleTime	UDINT	Display of the application cycle configured for the MC-Servo OB in microseconds

5.4.5.19 MC-LookAhead

STEP 7 creates the read-only MC_LookAhead OB automatically when you create a kinematics technology object. MC_LookAhead calculates the motion preparation of the kinematics technology object.

STEP 7 creates only one MC_LookAhead OB for all kinematics.

MC_LookAhead prepares the jobs of the job sequence in advance. In this way, less time is required for motion preparation in the MC_Interpolator organization block (Page 112) and you can set a shorter application cycle of the MC_Servo organization block (Page 112).

Downloading in RUN mode (Page 323) increases the CPU time required to prepare the motion jobs in the job sequence.

Block call and priority

MC_LookAhead is triggered by MC_Interpolator.

You configure the priority of the MC_LookAhead in the properties of the organization block under "General > Attributes > Priority". You can set values from 15 to 16 (default setting 15) for the priority. The priority of MC_LookAhead must be lower than the priority of MC_Interpolator.

Process response

Overflows can occur in the program scan cycle. Note the following response to overflows:

- The CPU tolerates a maximum of three consecutive MC_Interpolator overflows.
- The execution of an MC_Interpolator can only be interrupted by an MC_Servo call.

If more overflows or interruptions occur, the CPU transitions to STOP mode.

5.4.5.20 Programming error OB

The programming error OB executes if a programming error occurs during the processing of an instruction of the STEP 7 program. The programming error OB is processed according to its priority (Page 117).

You can handle programming errors locally using the GET_ERROR or GET_ERR_ID instructions within a program block. Otherwise, the CPU performs global error handling.

With global error handling, a programming error event triggers the execution of the programming error OB, if it exists, and the CPU stays in RUN mode. If the STEP 7 program does not include the programming error OB, the CPU goes to STOP mode when a programming error occurs.

Table 1-163 Start information for the programming error OB

Name	Data type	Meaning
BlockNr	UINT	Number of the block in which the programming error occurred
Reaction	USINT	• 0: Ignore errors • 1: Replace incorrect value • 2: Skip command • 3: Programmed error handling, triggered by an array access with invalid index, for example, or by an error during parameter supply of an FC or FB
Fault_ID	BYTE	Error code (possible values: B#16#00, B#16#03, B#16#04, B#16#05, B#16#20, B#16#21, B#16#22, B#16#23, B#16#24, B#16#25, B#16#26, B#16#27, B#16#28, B#16#29, B#16#2C, B#16#30, B#16#31, B#16#32, B#16#33, B#16#34, B#16#35, B#16#38, B#16#39, B#16#3A, B#16#3B, B#16#3C, B#16#3D, B#16#3E, B#16#3F, B#16#50, B#16#51, B#16#75, B#16#76, B#16#A1, B#16#A2)
BlockType	USINT	Type of block in which the error occurred: • OB: 1 • FC: 2 • FB: 3 • SFC: 4 • SFB: 5 • DB: 6
Area	USINT	Area in which the incorrect access occurred: • Local data: B#16#40 to 4E, 86, 87, 8E, 8F, C0 to CE • Process image input: B#16#01 • Process image output: B#16#02 • Technology DB: B#16#04 • I: B#16#81 • Q: B#16#82 • M: B#16#83 • DB: B#16#84, 85, 8A, 8B
DBNr	DB_ANY	DB no. if AREA = DB or DI
Csg_OBNr	OB_ANY	OB number
Csg_Prio	USINT	OB priority

Name	Data type	Meaning
Width	USINT	Type of access during which the error occurred: • Bit: – B#16#00 for access to the standard memory area – B#16#01 for access to the optimized memory area • Byte: B#16#01 • Word: B#16#02 • DWord: B#16#03 • LWord: B#16#04

5.4.5.21 I/O access error OB

I/O access error OBs execute when the CPU executes an instruction that references I/O that does not exist.

You can handle I/O access errors locally using the GET_ERROR or GET_ERR_ID instructions within a program block. Otherwise, the CPU performs global error handling. With global error handling, an I/O access error event triggers the execution of the I/O access error OB, if it exists.

Table 1-164 Start information for the I/O access error OB

Name	Data type	Meaning
BlockNr	UINT	Number of the block in which the I/O access error occurred
Reaction	USINT	0: Ignore error, 1: Replace incorrect value, 2: Skip command
Fault_ID	BYTE	Error code: • B#16#42: I/O access error, reading • B#16#43: I/O access error, writing
BlockType	USINT	Type of block in which the error has occurred: • OB: 1 • FC: 2 • FB: 3 • SFC: 4 • SFB: 5 • DB: 6
Area	USINT	Identifier for the range in which the incorrect access occurred: • B#16#01: Direct access to input • B#16#02: Direct access to output • B#16#81: Access to process image input • B#16#82: Access to process image output
DBNr	DB_ANY	not user-relevant
Csg_OBNr	OB_ANY	OB number causing the I/O access error
Csg_Prio	USINT	OB priority that causes the I/O access error
Width	USINT	Type of access during which the error occurred: • Bit: B#16#00 • Byte: B#16#01 • Word: B#16#02 • DWord: B#16#03 • LWord: B#16#04

5.4.5.22 Event execution priorities and queuing

Events control CPU processing. An event triggers an interrupt OB to be executed. You can specify the interrupt OB for an event during the creation of the block, during the device configuration, or with an ATTACH or DETACH instruction. Some events happen on a regular basis like the program cycle or cyclic events. Other events happen only a single time, like the startup event and time delay events. Some events happen when the hardware triggers an event, such as an edge event on an input point or a high speed counter event. Events like the diagnostic error and time error event only happen when an error occurs. The event priorities and queues are used to determine the processing order for the event interrupt OBs.

The CPU processes events in order of priority where 1 is the lowest priority and 26 is the highest priority. You can assign a priority class to an OB in the attributes of the OB properties.

Interruptible OBs

OBs (Page 101) execute in priority order of the events that trigger them.

If an OB is executing and a higher priority event occurs before the OB completes its execution, the running OB is interrupted to allow the higher-priority event OB to run. The higher-priority event runs, and at its completion, the OB that was interrupted continues. When multiple events occur while an interruptible OB is executing, the CPU processes those events in priority order.

Consider the case where interrupt events trigger a cyclic OB and a time delay OB. In this example, the time delay OB (OB 201) has no process image partition assignment (Page 97) and executes at priority 4. The cyclic OB (OB 200) has a process image partition assignment of PIP1 and executes at priority 2. The following illustration shows interruptible OB execution mode:

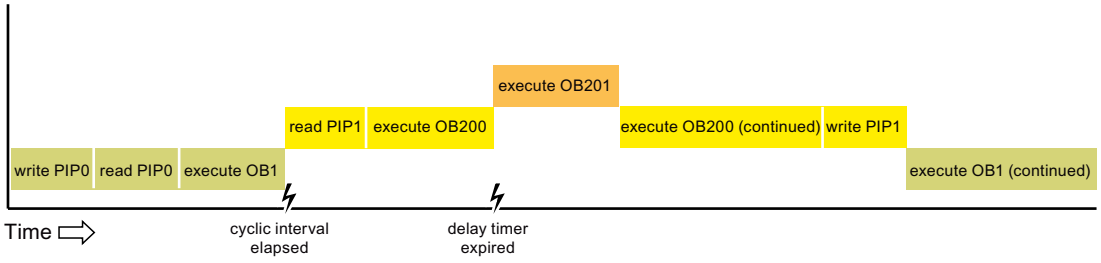
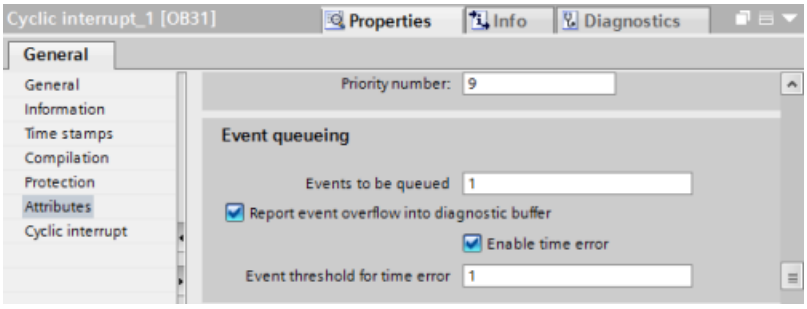


Figure 1-43 Interruptible OB execution

Understanding event execution priorities and queuing

The CPU limits the number of pending (queued) events from a single source, using a different queue for each event type. Upon reaching the limit of pending events for a given event type, the next event is lost. You can use a time error interrupt OB (Page 105) to respond to queue overflows.

Note that STEP 7 allows you to configure some specific event queueing parameters for the Cyclic interrupt OB and the Time of day OB.



For further information on CPU overload behavior and event queueing, refer to the "CPU overload behavior (https://docs.tia.siemens.cloud/access?ft:originId=./39470090251/39481356555_enUS.htm&ft:clusterId./39470090251/39481356555.htm)" topic. The TIA Portal Information System does not have a specific S7-1200 G2 topic on overload behavior and event queueing.

Each CPU event has an associated priority. In general, the CPU services events in order of priority (highest priority first). The CPU services events of the same priority on a "first-come, first-served" basis.

Table 1-165 OB events

Event	Quantity allowed	Default OB priority
Program cycle	1 program cycle event[1] Multiple OBs allowed	1
Startup	1 startup event [1] Multiple OBs allowed	1
Time delay	Up to 20 time events 1 OB per event	OB 20: 3 OB 21: 4 OB 22: 5 OB 23: 6 OB 123 to OB 32767: 3
Cyclic interrupt	Up to 20 events 1 OB per event	8 to 17
Hardware interrupt	Up to 50 hardware interrupt events[2] 1 OB per event, but you can use the same OB for multiple events	16
Time error	1 event (only if configured)[3]	22

1 The startup event and the program cycle event never occur at the same time because the startup event runs to completion before the program cycle event starts.

2 You can have more than 50 hardware interrupt event OBs if you use the DETACH and ATTACH instructions.

3 You can configure the CPU to stay in RUN if the scan cycle exceeds the maximum scan cycle time or you can use the RE_TRIGR instruction to reset the cycle time. However, the CPU goes to STOP mode the second time that one scan cycle exceeds the maximum scan cycle time.

4 Programming errors enable the program block to handle errors with GET_ERROR and GET_ERROR_ID within a program block. In the absence of these instructions, the CPU uses global error handling.

5 The CPU logs the first direct I/O read/write error in the diagnostics buffer and stays in RUN mode. You can access the error cause using the GET_ERROR_ID instruction.

Event	Quantity allowed	Default OB priority
Diagnostic error	1 event (only if configured)	5
Pull or plug of modules	1 event	6
Rack or station failure	1 event	6
Synchronous cycle	1 event	21
Time of day	Up to 20 events	2
Status	1 event	4
Update	1 event	4
Profile	1 event	4
MC-Servo	1 event	25
MC-Interpolator	1 event	24
MC-PreServo	1 event	Same priority as MC-Servo
MC-PostServo	1 event	Same priority as MC-Servo
MC-PreInterpolator	1 event	Same priority as MC-Interpolator
MC-Lookahead	1 event	15
Programming error[4]	1 event	7
I/O access error[5]	1 event	7

1 The startup event and the program cycle event never occur at the same time because the startup event runs to completion before the program cycle event starts.

2 You can have more than 50 hardware interrupt event OBs if you use the DETACH and ATTACH instructions.

3 You can configure the CPU to stay in RUN if the scan cycle exceeds the maximum scan cycle time or you can use the RE_TRIGR instruction to reset the cycle time. However, the CPU goes to STOP mode the second time that one scan cycle exceeds the maximum scan cycle time.

4 Programming errors enable the program block to handle errors with GET_ERROR and GET_ERROR_ID within a program block. In the absence of these instructions, the CPU uses global error handling.

5 The CPU logs the first direct I/O read/write error in the diagnostics buffer and stays in RUN mode. You can access the error cause using the GET_ERROR_ID instruction.

In addition, the CPU recognizes other events that do not have associated OBs. The following table describes these events and the corresponding CPU actions:

Table 1-166 Additional events

Event	Description	CPU action
Max cycle time error	CPU exceeds the configured cycle time twice	The CPU logs the error in the diagnostics buffer and transitions to STOP mode.
Peripheral access error	I/O error during process image update	The CPU logs the first occurrence in the diagnostics buffer and stays in RUN mode.

Interrupt latency

The interrupt event latency (the time from notification of the CPU that an event has occurred until the CPU begins execution of the first instruction in the OB that services the event) is approximately 200 µsec, provided that a program cycle OB is the only event service routine active at the time of the interrupt event.

5.4.6 Monitoring and configuring the cycle time

The cycle time is the time that the CPU operating system requires to execute the cyclic phase of the RUN mode. The CPU provides two methods of monitoring the cycle time:

- Maximum scan cycle time
- Minimum scan cycle time

Scan cycle monitoring begins after the startup event is complete. Configuration for this feature appears under the "Device Configuration" for the CPU under "Cycle".

The CPU monitors the scan cycle. If the scan cycle time exceeds the configured maximum scan cycle time, the CPU generates an error and responds as follows:

- If the user program includes a time error interrupt OB (Page 105), then the CPU executes it.
- If the user program does not include a time error interrupt OB, then the time error event generates a diagnostic buffer entry. The CPU behavior is determined by the following:
  - If a time error interrupt OB has never been downloaded to the CPU, the CPU ignores the first scan timeout condition and remains in RUN mode. If a second scan timeout condition occurs in the same program scan (two times the maximum cycle time value), the CPU generates a diagnostic buffer entry and transitions to STOP mode.
  - If the time error interrupt OB has previously been downloaded, but has since been deleted, the CPU transitions to STOP mode if a time error event occurs, because the CPU cannot find the time error OB.

The RE_TRIGR instruction (re-trigger cycle time monitoring) allows you to reset the timer that measures the cycle time. If the elapsed time for the current program cycle execution is less than ten times the configured maximum scan cycle time, the RE_TRIGR instruction retriggers the cycle time monitoring and returns with ENO = TRUE. If not, the RE_TRIGR instruction does not retrigger the cycle time monitoring. It returns ENO = FALSE.

Typically, the scan cycle executes as fast as it can and the next scan cycle begins as soon as it completes. Depending upon the user program and communication tasks, the time period for a scan cycle can vary from scan to scan. To eliminate this variation, the CPU supports an optional minimum scan cycle time. By default, the minimum scan cycle time is enabled and is 1ms. When enabled, the CPU delays after the execution of the program cycle OBs until the minimum scan cycle time elapses before repeating the program cycle.

In the event that the CPU completes the normal scan cycle in less time than the specified minimum cycle time, the CPU spends the additional time of the scan cycle performing runtime diagnostics and/or processing communication requests (Page 122).

In the event that the CPU does not complete the scan cycle in the specified minimum cycle time, the CPU completes the scan normally (including communication processing) and does not create any system reaction as a result of exceeding the minimum scan time. The following table defines the ranges and defaults for the cycle time monitoring functions:

Table 1-167 Range for the cycle time

Cycle time	Range (ms)	Default
Maximum scan cycle time[1]	1 to 6000	150 ms
Minimum scan cycle time[2]	1 to maximum scan cycle time	1 ms

1 The maximum scan cycle time is always enabled. Configure a cycle time between 1 ms to 6000 ms. The default is 150 ms.

2 The minimum scan cycle time is 1 ms by default. If required, configure a cycle time between 1 ms and the maximum scan cycle time.

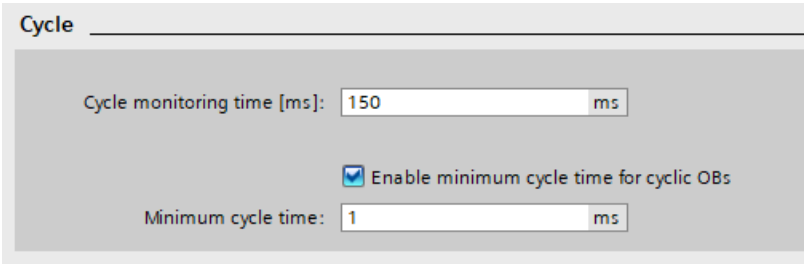
NOTE

To run as fast as possible, deselect "Enable minimum cycle time for cyclic OBs" under "Cycle > Cycle monitoring time [ms]" in Device configuration.

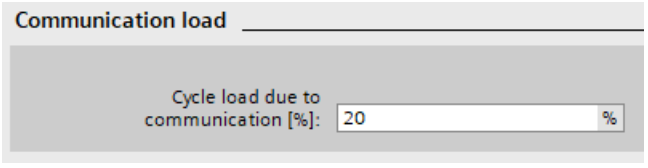
5.4.7 Cycle time and communication load

You use the CPU properties in the Device configuration to configure the following parameters:

- Cycle: You can enter a maximum scan cycle monitoring time. You can also enable and enter a minimum scan cycle time.



- Communication load: You can configure a percentage of the time to be dedicated for communication tasks.



NOTE

Communication impact on scan cycle

Using OBs with a higher priority than the main scan cycle can cause a performance strain on the execution cycle of the CPU. To mitigate this issue, reduce the Communication load setting. more information about cycle and response times, see SIMATIC S7-1500, S7-1500R/H, ET 200SP, ET 200pro Cycle and response times (https://support.industry.siemens.com/cs/us/en/view/59193558/158758826123).

NOTE

Communication priority

Communication tasks have a priority of 15. CPU events with a priority of 16 or higher can interrupt communication processing. Interrupts from other events can negatively affect communication processing during the scan cycle. You can adjust the "Cycle load due to communication" percentage to increase the portion of the scan cycle dedicated to communication processing.

For more information about the scan cycle, see Execution of the user program (Page 97)

5.4.8 CPU memory

5.4.8.1 Memory management

The CPU provides the following memory areas to store the user program, data, and configuration:

- Load memory is non-volatile storage for the user program, data and configuration. When you download a project to the CPU, the CPU first stores the program in the Load memory area. This area is located either in a SIMATIC memory card (if present) or in the CPU. The CPU maintains this non-volatile memory area through a power loss. The memory card supports a larger storage space than that built-in to the CPU.
- Work memory is volatile storage for some elements of the user project while executing the user program. The CPU copies some elements of the project from load memory into work memory. This volatile area is lost when power is removed and is restored by the CPU when power is restored. Work memory consists of two types:
  - Code work memory
  - Data work memory
- Retentive memory is non-volatile storage for a limited quantity of work memory values. The CPU uses the retentive memory area to store the values of selected user memory locations during power loss. When a power down or power loss occurs, the CPU restores these retentive values upon power up.

The size of the user program, data, and configuration is limited by the available load memory and work memory in the CPU.

To display the memory usage for a compiled program block, right-click the block in the "Program blocks" folder in the STEP 7 project tree and select "Properties" from the context menu. The Compilation properties display the load memory and work memory for the compiled block.

To display the memory usage for the online CPU, double-click "Online & diagnostics" in STEP 7, expand "Diagnostics", and select "Memory".

Representation of load memory

Load memory as represented in the Project info window includes the program blocks, technology objects, data types, and PLC tags.

Load memory as represented in Online & diagnostics includes additional objects that correspond to the project, such as project languages, certificates, and other configuration data.

Retentive memory

You can avoid data loss after power failure by marking certain data as retentive. The CPU allows you to configure the following data as retentive:

- Bit memory (M): You can define the size of retentive memory for bit memory in the PLC tag table or in the assignment list. Retentive bit memory always starts at MB0 and runs consecutively up through a specified number of bytes. Specify this value from the PLC tag table or in the assignment list by clicking the "Retain" toolbar icon. Enter the number of M bytes to retain starting at MB0.

Note: You can display an assignment list for bit memory (M) by selecting the CPU in the project tree and selecting the **Tools > Assignment list** menu command.

- Tags of a function block (FB): If an FB is of type "Optimized block access", then the interface editor for this FB includes a "Retain" column. In this column, you can select either "Retain", "Non-retain", or "Set in IDB" individually for each tag. When you place such an FB in the program, the instance DB that corresponds to the FB includes this "Retain" column as well. You can only change the retentive state of a tag from within the instance DB interface editor if you selected "Set in IDB" (Set in instance data block) in the Retain selection for the tag in the optimized FB.

  If an FB is **not** of type "Optimized block access", then the interface editor for this FB does not include a "Retain" column. When you place such an FB in the program, the instance DB that corresponds to the FB does, however, include a "Retain" column that is available for edit. In this case, selecting the "Retain" option for any tag results in the selection of **all** tags. Similarly, deselecting the option for any tag results in the deselection of **all** tags.

  To view or modify whether an FB is optimized, open the properties of the FB and select the attributes.
- Tags of a global data block: If you select "Optimized block access" for the attributes in the properties of the data block, you can set each tag to be retentive or not. If you do not select "Optimized block access", then all of the data block tags have the same state. The tags are either all retentive or all non-retentive.

The technical specifications for the CPUs state the retentive data allocation. The STEP 7 project version can alter the amount of retentive memory. From the PLC tag table in STEP 7 or the assignment list, click the "Retain" toolbar icon to see how much memory is available.

5.4.8.2 Notes about retentive memory

NOTE

Downloading a program does not clear or make any changes to existing values in retentive memory. If you want to clear retentive memory before a download, then reset your CPU to factory settings prior to downloading the program.

NOTE

When power failure occurs, the CPU switches off power to all expansion modules and expansion boards. This ensures that the CPU has sufficient power to save retentive data to non-volatile memory.

5.4.8.3 System and clock memory

Use the CPU properties to enable bytes for "system memory" and "clock memory". Your program logic can reference the individual bits of these functions by their tag names.

The CPU initializes these bytes on the transition from STOP mode to STARTUP mode. The bits of the clock memory change synchronously to the CPU clock throughout the STARTUP and RUN modes.

⚠ WARNING

Risks with overwriting the system memory or clock memory bits

Overwriting the system memory or clock memory bits can corrupt the data in these functions and cause your user program to operate incorrectly. Because both the clock memory and system memory are unreserved in M memory, instructions or communications can write to these locations and corrupt the data.

Avoid writing data to these locations to ensure the proper operation of these functions, and always implement an emergency stop circuit for your process or machine.

Incorrect program operation can cause damage to equipment, severe injury, or death.

System memory

You can assign one byte in M memory for system memory. The byte of system memory provides the following four bits that can be referenced by your user program by the following tag names:

- First cycle: (Tag name "FirstScan") bit is set to1 for the duration of the first scan after the startup OB finishes. (After the execution of the first scan, the "first scan" bit is set to 0.)
- Diagnostics status changed: (Tag name: "DiagStatusUpdate") is set to 1 for one scan after the CPU logs a diagnostic event. Because the CPU does not set the "DiagStatusUpdate" bit until the end of the first execution of the program cycle OBs, your user program cannot detect if there has been a diagnostic change either during the execution of the startup OBs or the first execution of the program cycle OBs.
- Always 1 (high): (Tag name "AlwaysTRUE") bit is always set to 1.
- Always 0 (low): (Tag name "AlwaysFALSE") bit is always set to 0.

System memory bits have specific meanings, as shown in the table below:

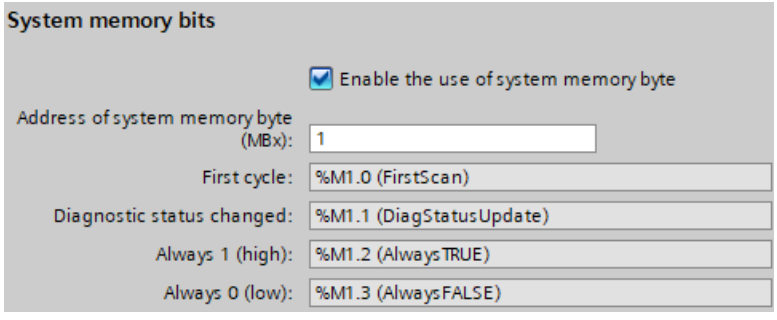


Table 1-168 System memory

7	6	5	4	3	2	1	0
Reserved Value 0				Always off Value 0	Always on Value 1	Diagnostic status indicator • 1: Change • 0: No change	First scan indicator • 1: First scan after startup • 0: Not first scan

Clock memory

You can assign one byte in M memory for clock memory. Each bit of the byte configured as clock memory generates a square wave pulse on the corresponding M memory bit. The byte of clock memory provides 8 different frequencies, from 0.5 Hz (slow) to 10 Hz (fast). You can use these bits as control bits, especially when combined with edge instructions, to trigger actions in the user program on a cyclic basis.

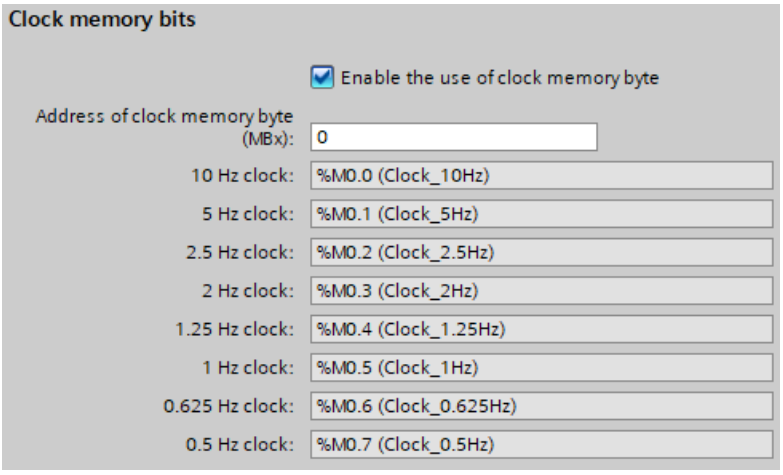


Table 1-169 Clock memory

Bit number	7	6	5	4	3	2	1	0
Period (s)	2.0	1.6	1.0	0.8	0.5	0.4	0.2	0.1
Frequency (Hz)	0.5	0.625	1	1.25	2	2.5	5	10

Because clock memory runs asynchronously to the CPU cycle, the status of the clock memory can change several times during a long cycle.

5.4.9 Diagnostics buffer

The CPU supports a diagnostics buffer that contains an entry for each diagnostic event. Each entry includes a date and time the event occurred, an event category, and an event description. The entries are displayed in chronological order, with the most recent event at the top. When the log is full (500 events), a new event replaces the oldest event in the log. If the CPU loses power, the diagnostics buffer retains the 100 most recent diagnostic events.

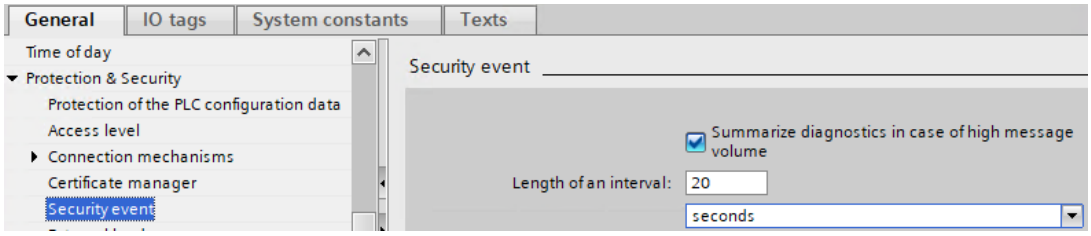
The following types of events are recorded in the diagnostics buffer:

- Each system diagnostic event; for example, CPU errors and module errors
- Each state change of the CPU (each power up, each transition to STOP, each transition to RUN)
- Each user diagnostic alarm generated by the Gen_UsrMsg instruction.

To access the diagnostics buffer, you must be online. From the "Online & diagnostics (Page 313)" view, locate the diagnostics buffer under "Diagnostics > Diagnostics buffer".

Reducing the number of security diagnostic events

Some security events generate repeated entries in the diagnostics buffer. These messages can fill up the diagnostics buffer and potentially obscure other event messages. You can configure the PLC to limit the number of diagnostic messages from security events. You make selections in the device configuration of the CPU based on the time interval in which you want to suppress recurring messages:



If you choose to summarize security events within a time interval, you have the choice of setting a time interval in seconds, minutes, or hours, and a numerical value in the range 1 .. 255.

If you choose to restrict security events, you will be restricting these types of events:

- Going online with the correct or incorrect password
- Manipulated communications data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (by instruction or CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging in to the Web server with the correct or incorrect password

5.4.10 Program alarms

The S7-1200 G2 allows you to create, edit, and monitor Program alarms in your STEP 7 project. These alarms deliver error messages or notifications about the PLC program running on your CPU.

From your STEP 7 project's Device configuration, select the "Diagnostics" tab and then select the "Alarm display" tab to view a log of Program alarms and their associated information. You can also configure Program alarms to display and be acknowledgeable in an HMI.

You can edit existing Program alarms in the Project tree under "PLC supervisions and alarms".

NOTE

The S7-1200 G2 CPU does not support supervisions.

See the following TIA Portal Information System topics for more detailed information on creating and editing Program alarms:

- Creating and editing alarms (https://docs.tia.siemens.cloud/access?ft:originId=./4511680523/41028912907_enUS.htm&ft:clusterId./4511680523/41028912907.htm)
- Program_Alarm: Generate program alarm with associated values (https://docs.tia.siemens.cloud/access?ft:originId=./15889165323/41068416779_enUS.htm&ft:clusterId./15889165323/41068416779.htm)
- Program example for Get_Alarm & Ack_Alarms (https://docs.tia.siemens.cloud/access?ft:originId=./15889165323/90334347915_enUS.htm&ft:clusterId./15889165323/90334347915.htm)

5.4.11 Time of day clock

The CPU supports a time-of-day clock. A super-capacitor supplies the energy required to keep the clock running during times when the CPU is powered down. The super-capacitor charges while the CPU has power. After the CPU has been powered up at least 24 hours, then the super-capacitor has sufficient charge to keep the clock running for typically 20 days.

STEP 7 sets the time-of-day clock to system time, which has a default value out of the box or following a factory reset. To utilize the time-of-day clock, you must set it. Timestamps such as those for diagnostics buffer entries, data log files, and data log entries, are based on the system time. You set the time of day from the "Set time of day" function (Page 313) in the "Online & diagnostics" view of the online CPU. STEP 7 then calculates the system time from the time you set plus or minus the Windows operating system offset from UTC (Coordinated Universal Time). Setting the time of day to the current local time produces a system time of UTC if your Windows operating system settings for time zone and daylight savings time correspond to your locale.

⚠ WARNING

Risk of attacker accessing your networks through open interfaces

If an attacker can access your networks through open interfaces, such as software like STEP 7, the SIMATIC Automation Tool, or through an HMI, the attacker can possibly disrupt control of your process by shifting the CPU system time.

The CPU supports "time of day" interrupts and clock instructions that depend upon accurate CPU system time. You must restrict access to the CPU by enabling access control and disabling the "Anonymous" user. Failure to do so can cause a security breach that allows an unknown user to disrupt control of your process by shifting the CPU system time.

Disruptions to process control can possibly cause death, severe injury, or property damage.

For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Website.

STEP 7 includes instructions (Page 172) to read and write the system time (RD_SYS_T and WR_SYS_T), to read the local time (RD_LOC_T), and to set the time zone (SET_TIMEZONE). The RD_LOC_T instruction calculates local time using the time zone and daylight saving time offsets that you set in the "Time of day" configuration in the general properties of the CPU (Page 158). These settings enable you to set your time zone for local time, optionally enable daylight saving time, and specify the start and end dates and times for daylight saving time. You can also use the SET_TIMEZONE instructions to configure these settings.

NOTE

Time zone differences

If you set the time of day clock and the time zone of your programming device is different from the time zone you configured in the device configuration for your CPU (Page 158), then you might see unexpected timestamps for items such as the following:

- Diagnostic buffer entries
- Data log files
- Entries in data logs

5.4.12 Data storage, memory areas, I/O and addressing

5.4.12.1 Accessing the data of the CPU

STEP 7 facilitates symbolic programming. You can create symbolic names or "tags" for I/O and memory. To use these tags in your user program, enter the tag name for the instruction parameter.

The CPU provides several options for storing data:

- Global memory: The CPU provides a variety of specialized memory areas, including inputs (I), outputs (Q) and memory (M). This memory is accessible by all code blocks without restriction.
- PLC tag table: You can enter symbolic names in the STEP 7 PLC tag table for specific memory locations. These tags are global to the STEP 7 program and allow programming with names that are meaningful for your application.
- Data block (DB): You can include DBs in your user program to store data for the code blocks. The data stored persists when the execution of the associated code block comes to an end. A "global" DB stores data that can be used by all code blocks, while an instance DB stores data for a specific FB and is structured by the parameters for the FB.
- Temp memory: Whenever the program calls a code block, the CPU allocates temporary, or local, memory (L) to be used during the execution of the block. When the execution of the code block finishes, the CPU reallocates the local memory for the execution of other code blocks.

Each memory location has a unique address. Your user program uses these addresses to access the information in the memory location. References to the input (I) or output (Q) memory areas, such as I0.3 or Q1.7, access the process image. To immediately access the physical input or output, append the reference with ":P" (such as I0.3:P, Q1.7:P, or "Stop:P").

You can force values (Page 322) for some memory areas. Some memory areas are retentive (Page 123) or optionally retentive.

Table 1-170 Memory areas

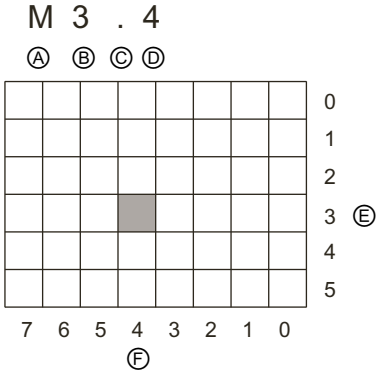
Memory area	Description	Force	Retentive
I Process image input I_:P [1] (Physical input)	Copied from physical inputs at the beginning of the scan cycle	No	No
	Immediate read of the physical input points on the CPU, SB, and SM	Yes	No
Q Process image output Q_:P [1] (Physical output)	Copied to physical outputs at the beginning of the scan cycle	No	No
	Immediate write to the physical output points on the CPU, SB, and SM	Yes	No
M Bit memory	Control and data memory	No	Yes (optional)
DB Data block	Data memory and also parameter memory for FBs	No	Yes (optional)
Temp memory	Temporary data for a block local to that block	No	No

[1] To immediately access (read or write) the physical inputs and physical outputs, append a ":P" to the address or tag (such as I0.3:P, Q1.7:P, or "Stop:P").

Each memory location has a unique address. Your user program uses these addresses to access the information in the memory location. The absolute address consists of the following elements:

- Memory area identifier (such as I, Q, or M)
- Size of the data to be accessed ("B' for Byte, "W" for Word, or "D" for DWord)
- Starting address of the data (such as byte 3 or word 3)

When accessing a bit in the address for a Boolean value, enter the memory area, the byte location, and the bit location for the data (such as I0.0, Q0.1, or M3.4).



A	Memory area identifier	E	Bytes of the memory area
B	Byte address: byte 3	F	Bits of the selected byte
C	Separator ("byte.bit")		
D	Bit location of the byte (bit 4 of 8)		

In the example, the memory area and byte address (M = bit memory area, and 3 = Byte 3) are followed by a period (".") to separate the bit address (bit 4).

5.4.12.2 Using absolute addressing to access CPU data

When using symbolic names for data (Page 129), you typically create tags either in the PLC tag table, a data block, or in the interface of an OB, FC, or FB. These tags include a name, data type, offset, and comment. Additionally, in a data block, you can specify a start value. You can use these tags when programming by entering the tag name at the instruction parameter.

Optionally, you can enter the absolute operand (memory area, size and offset) at the instruction parameter for most data types. The examples in the following sections show how to enter absolute operands. The % character is inserted automatically in front of the absolute operand by the program editor. You can toggle the view in the program editor to one of these: symbolic, symbolic and absolute, or absolute.

You cannot use absolute addressing for the long data types (64-bit) such as LWORD, LINT, ULINT, LREAL, LTIME, LTOD, and LDT. You must use symbolic addressing for the long data types.

I (process image input): The CPU samples the peripheral (physical) input points just prior to the cyclic OB execution of each scan cycle (Page 97) and writes these values to the input process image. You can access the input process image as bits, bytes, words, or double words. Both read and write access is permitted, but typically, process image inputs are only read.

Table 1-171 Absolute addressing for I memory

Bit	I[byte address].[bit address]	I0.1
Byte, Word, or Double Word	I[size][starting byte address]	IB4, IW5, or ID12

By appending a ":P" to the address, you can immediately read the digital and analog inputs of the CPU, SB, SM or distributed module. The difference between an access using I_:P instead of I is that the data comes directly from the points being accessed rather than from the input process image. This I_:P access is referred to as an "immediate read" access because the data is retrieved immediately from the source instead of from a copy that was made the last time the input process image was updated.

Because the physical input points receive their values directly from the field devices connected to these points, you cannot write to these points. I_:P accesses are read-only, as opposed to I accesses which can be read or written to.

I_:P accesses are also restricted to the size of inputs supported by a single CPU, SB, or SM, rounded up to the nearest byte.

For example, if the inputs of a 4 DI / 4 DQ SB are configured to start at I4.0, then the input points can be accessed as I4.0:P, I4.1:P, I4.2:P, and I4.3:P or as IB4:P. Accesses to I4.4:P through I4.7:P are not rejected, but make no sense since these points are not used. Accesses to IW4:P and ID4:P are prohibited since they exceed the byte offset associated with the SB.

Accesses using I_:P do not affect the corresponding value stored in the input process image.

Table 1-172 Absolute addressing for I memory (immediate)

Bit	I[byte address].[bit address]:P	I0.1:P
Byte, Word, or Double word	I[size][starting byte address]:P	IB4:P, IW5:P, or ID12:P

Q (process image output): The CPU copies the values stored in the output process image to the physical output points. You can access the output process image in bits, bytes, words, or double words. Both read and write access is permitted for process image outputs.

Table 1-173 Absolute addressing for Q memory

Bit	Q[byte address].[bit address]	Q1.1
Byte, Word, or Double word	Q[size][starting byte address]	QB5, QW10, QD40

By appending a ":P" to the address, you can immediately write to the physical digital and analog outputs of the CPU, SB, SM or distributed module. The difference between an access using Q_:P instead of Q is that the data goes directly to the points being accessed in addition to the output process image (writes to both places). This Q_:P access is sometimes referred to as an "immediate write" access because the data is sent immediately to the target point; the target point does not have to wait for the next update from the output process image.

Because the physical output points directly control field devices that are connected to these points, reading from these points is prohibited. That is, Q_:P accesses are write-only, as opposed to Q accesses which can be read or write.

Q_:P accesses are also restricted to the size of outputs supported by a single CPU, SB, or SM, rounded up to the nearest byte.

For example, if the outputs of a 4 DI / 4 DQ SB are configured to start at Q4.0, then the output points can be accessed as Q4.0:P, Q4.1:P, Q4.2:P, and Q4.3:P or as QB4:P. Accesses to Q4.4:P through Q4.7:P are not rejected, but make no sense since these points are not used. Accesses to QW4:P and QD4:P are prohibited since they exceed the byte offset associated with the SB.

Accesses using Q_:P affect both the physical output as well as the corresponding value stored in the output process image.

Table 1-174 Absolute addressing for Q memory (immediate)

Bit	Q[byte address].[bit address]:P	Q1.1:P
Byte, Word, or Double word	Q[size][starting byte address]:P	QB5:P, QW10:P or QD40:P

M (bit memory area): Use the bit memory area (M memory) for both control relays and data to store the intermediate status of an operation or other control information. You can access the bit memory area in bits, bytes, words, or double words. Both read and write access is permitted for M memory.

Table 1-175 Absolute addressing for M memory

Bit	M[byte address].[bit address]	M26.7
Byte, Word, or Double Word	M[size][starting byte address]	MB20, MW30, MD50

Temp (temporary memory): The CPU allocates the temp memory on an as-needed basis. The CPU allocates the temp memory for the code block and initializes the memory locations to 0 at the time when it starts the code block (for an OB) or calls the code block (for an FC or FB).

Temp memory is similar to M memory with one major exception: M memory has a "global" scope, and temp memory has a "local" scope:

- M memory: Any OB, FC, or FB can access the data in M memory, meaning that the data is available globally for all of the elements of the user program.
- Temp memory: The CPU restricts access to the data in temp memory to the OB, FC, or FB that created or declared the temp memory location. Temp memory locations remain local and different code blocks do not share temp memory, even when the code block calls another code block. For example: When an OB calls an FC, the FC cannot access the temp memory of the OB that called it.

The CPU limits memory as follows:

- 16 Kbytes temp (local) memory per block (OB/FB/FC)
- 64 Kbytes total temp (local) memory per event priority class.

You must consider each block's memory allocation and the nesting depth from the calling OB in planning memory usage.

You access temp memory by symbolic addressing only.

You can find out the amount of temp (local) memory that the blocks in your program use through the call structure in STEP 7. From the project tree select Program info and then select the Call structure tab. You will see all of the OBs in your program and you can drill down to see the blocks that they call. For each block, you can see the local data allocation. You can also access the Call structure display from the STEP 7 **Tools > Call structure** menu command.

DB (data block): Use the DB memory for storing various types of data, including intermediate status of an operation or other control information parameters for FBs, and data structures required for many instructions such as timers and counters. You can access data block memory in bits, bytes, words, or double words. Both read and write access is permitted for read/write data blocks. Only read access is permitted for read-only data blocks.

Table 1-176 Absolute addressing for DB memory

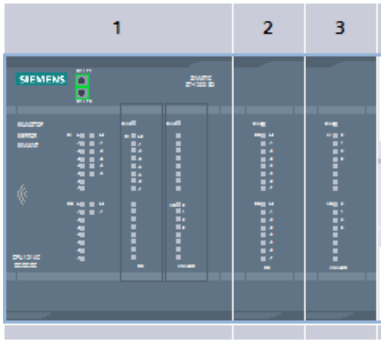
Bit	DB[data block number].DBX[byte address].[bit address]	DB1.DBX2.3
Byte, Word, or Double Word	DB[data block number].DB [size][starting byte address]	DB1.DBB4, DB10.DBW2, DB20.DBD8

NOTE

When you specify an absolute address in LAD or FBD, STEP 7 precedes this address with a "%" character to indicate that it is an absolute address. While programming, you can enter an absolute address either with or without the "%" character (for example %I0.0 or I.0). If omitted, STEP 7 supplies the "%" character.

In SCL, you must enter the "%" before the address to indicate that it is an absolute address. Without the "%", STEP 7 generates an undefined tag error at compile time

5.4.12.3 Addressing the local and expansion I/O



When you add a CPU and I/O boards or modules to your device configuration, STEP 7 automatically assigns input and output addresses. You can change the default addressing by selecting the address field in the device overview and entering new numbers.

- STEP 7 assigns digital inputs and outputs in groups of 8 points (1 byte), whether the module uses all the points or not.
- STEP 7 allocates analog inputs and outputs in groups of 4, where each analog point occupies 2 bytes.

The Device overview shows the I/O address assignments.

Device overview

...	Module	Slot	I address	Q address	Type
		0			
	G2_PLC_1	1			CPU 1214C DC/DC/DC
	DI 14/DQ 10_1	1 8	0...1	0...1	DI 14/DQ 10
	DI8 signal board (100 kHz)_1	1 9	4		DI8 signal board (100 kHz)
	AQ4 Signal board_1	1 10		80...87	AQ4 Signal board
	SM 1222 DQ16 x 24VDC_1	2		8...9	SM 1222 DQ16 x 24VDC
	SM 1233 AI4/AQ4_1	3	112...119	112...119	SM 1233 AI4/AQ4

This example represents the following configuration:

- CPU
- Signal board with 8 digital inputs
- Signal board with 4 analog outputs
- Signal module with 16 digital outputs
- Signal module with 4 analog inputs and 4 analog outputs

You can change I and Q addresses. STEP 7 assists you by preventing changes that are the wrong size or conflict with other addresses.

5.4.13 Processing of analog values

General purpose analog signal modules provide input signals or expect output values that represent either a voltage range or a current range. These ranges are as follows:

- Analog inputs: ±10 V, ±5 V, ±2.5 V, 0 to 20 mA, or 4 to 20 mA
- Analog outputs: ±10 V, 0 to 20 mA, or 4 to 20 mA

The values returned by the modules are integer values where 0 to 27648 represents the rated range for current, and -27648 to 27648 for voltage. Anything outside the range represents either an overflow or underflow. See the tables for analog input representation (Page 415) and analog output representation (Page 416) for details about the types of out-of-range values.

In your control program, you probably need to use these values in engineering units, for example to represent a volume, temperature, weight or other quantitative value. To do this

for an analog input, you must first normalize the analog value to a real (floating point) value from 0.0 to 1.0. Then you must scale it to the minimum and maximum values of the engineering units that it represents. For values that are in engineering units that you need to convert to an analog output value, you first normalize the value in engineering units to a value between 0.0 and 1.0, and then scale it between 0 and 27648 or -27648 to 27648, depending on the range of the analog module. STEP 7 provides the NORM_X and SCALE_X instructions for this purpose. You can also use the CALCULATE instruction to scale the analog values.

Example: analog value processing

Consider, for example, an analog input that has a current range of 0 - 20 mA. The analog input module returns values in the range 0 to 27648 for measured values. For this example, consider that you are using this analog input value to measure a temperature range from 50 °C to 100 °C. A few sample values would have the following meanings:

Analog input value	Engineering units
0	50 °C
6192	62.5 °C
12384	75 °C
18576	87.5 °C
27648	100 °C

The calculation for determining engineering units from the analog input value in this example is as follows:

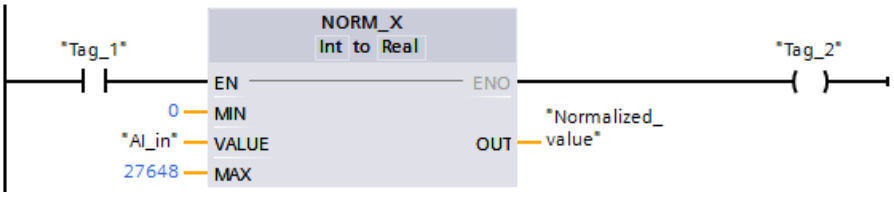
Engineering units value = 50 + (Analog input value) * (100 - 50) / (27648 - 0)

For the general case, the equation would be:

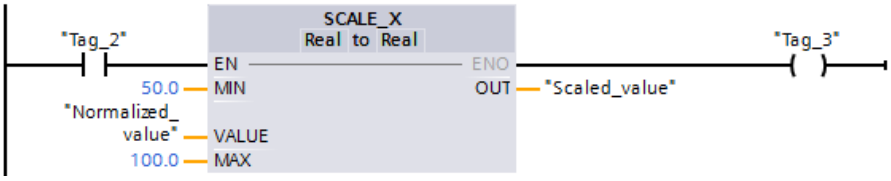
Engineering units value = (Low range of engineering units) +
(Analog input value) *
(High range of engineering units - Low range of engineering units) /
(Maximum analog input range - Minimum analog input range)

In PLC applications, the typical method is to normalize the analog input value to a floating point value between 0.0 and 1.0. Then, you would scale the resulting value to a floating point value in the range of your engineering units. For simplicity, the following LAD instructions use constant values for the ranges; you might actually choose to use tags:

Network 1



Network 2



5.4.14 Using a memory card

5.4.14.1 Memory cards

NOTE

The CPU supports SIMATIC memory cards (Page 468) for the following purposes:

- Empty memory card (Page 139)
- Transfer card (Page 139)
- Program card (Page 141)
- Firmware update card (Page 144)
- Card for protection of confidential PLC configuration data (Page 146)

You can use supported non-SIMATIC memory cards (Page 468) only for transferring the license conditions and copyrights OSS information (Page 149) to a memory card.

Transfer cards and program cards contain the following elements if they exist in the project:

- Device configuration
- Code blocks
- Data blocks
- Technology objects
- Data logs
- Recipes
- User files

Transfer cards and program cards do not contain the following:

- Force tables
- Watch tables
- PLC tag tables

Use a transfer card to copy a program to the internal load memory (ILM) of the CPU without using STEP 7.

Use an empty transfer card to recover a password-protected CPU when you have lost or forgotten the password (Page 148).

Use a program card as external load memory for the CPU.

NOTE
Do not use the Windows formatter utility or any other formatting utility to reformat the memory card.
If a Siemens memory card is reformatted using the Microsoft Windows formatter utility, then the memory card will no longer be usable by any Siemens CPU.

Inability to use memory cards created with S7-1200 G2 V1.0

If you formatted a SIMATIC memory card for an S7-1200 G2 V1.0 CPU in the TIA Portal, the card is incorrectly formatted for use with firmware V4.1.

The invalid memory card prevents the CPU from starting. The Diagnostic buffer reports the error and the Status LEDs (Page 315) indicate the missing program memory card pattern.

To correct the card formatting problem, follow these steps:

1. Copy the memory card contents to your computer.*
2. Using the CPU that you upgraded to firmware V4.1, format the memory card from the TIA Portal.
3. Restore the memory card contents from your computer to the memory card.

*Do not include the system files crdinfo.bin and __LOG__.

5.4.14.2 Inserting a memory card in the CPU

NOTICE

Risks associated with electrostatic discharge
Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable.
To protect the memory card and receptacle from electrostatic discharge, do the following:

- Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card.
- Store the memory card in a conductive container.

Receptacle or memory card malfunction can result in property damage.



Check that the memory card is not write-protected. Slide the protection switch away from the "Lock" position.

The memory card is keyed for proper installation. Insert the memory card with the correct orientation.

If you insert a write-protected memory card into the CPU, STEP 7 displays a diagnostic message on the next power up, alerting you to that fact. The CPU powers up without failure as long as the memory card you inserted is not blank. Instructions involving recipes or data logs, for example, return errors if the card is write-protected.

⚠ WARNING

Verify that the CPU is not running a process before inserting the memory card.
If you insert or remove a memory card of any type into a running CPU, the CPU restarts, resulting in diagnostic events, temporary loss of communication, and process disruption. Before inserting or removing a memory card, always ensure that the CPU is not actively controlling a machine or process. Always install an emergency stop circuit for your application or process. Power off the CPU before inserting or removing a memory card. Disruption of a running process can result in death, severe personal injury, and/or property damage.

NOTE

Do not insert program cards (Page 141) or transfer cards (Page 139) with S7-1200 projects into S7-1200 G2 CPUs.
S7-1200 projects are not compatible with version S7-1200 G2 CPUs. Inserting a memory card that is incompatible causes a CPU error.
If you do insert an invalid program card or transfer card, remove the card.

CPU behavior when you insert a memory card

When you insert a memory card in the CPU, the CPU restarts and performs the following steps:

1. Evaluates the card, and flashes the LEDs while evaluating
2. Performs actions based on the type of card:
   - Empty memory card (Page 139)
   - Transfer card (Page 139)
   - Program card (Page 141)
   - Firmware update card (Page 144)
   - Memory card for protecting confidential PLC configuration data (Page 146)
   - Memory card for copying license conditions and copyrights from the CPU (Page 149)

Procedure after card evaluation and processing

If the card is not an empty memory card (Page 139) or a program card (Page 141), power off the CPU and remove it.

After you remove the card, the CPU restarts and remains in STOP mode.

5.4.14.3 Empty memory card

An empty memory card does not have a job file (S7_JOB.S7S). The CPU behavior when you insert an empty memory card (Page 137) depends on the selection for "Disable copy from internal load memory to external load memory" in the "Protection & Security > External load memory" CPU properties (Page 158):

- If the check box is not selected, the CPU adds a job file. The CPU then copies internal load memory to external load memory (memory card) and erases internal load memory.
- If the check box is selected, the CPU does not create a program job file and it does not copy internal load memory to external load memory (memory card). It does not erase internal load memory.

If you insert a memory card that is not an empty memory card into the CPU, the configuration setting for "Disable copying from internal load memory to external load memory" has no effect on how the CPU evaluates the memory card.

5.4.14.4 Configuring the startup parameter of the CPU before copying the project to the memory card

When you copy a program to a transfer card or a program card, the program includes the startup parameter for the CPU (Page 158). Before copying the program to the memory card, always ensure that you have configured the operating mode for the CPU following a power-cycle. Select whether the CPU starts in STOP mode, RUN mode, or in the previous mode (prior to the power cycle).

5.4.14.5 Transfer card

NOTICE
Risks associated with electrostatic discharge Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable. To protect the memory card and receptacle from electrostatic discharge, do the following: • Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card. • Store the memory card in a conductive container. Receptacle or memory card malfunction can result in property damage.

Creating a transfer card

Configure the startup parameter of the CPU (Page 139) before copying a program to the transfer card.

To create a transfer card, follow these steps:

1. Insert an empty SIMATIC memory card that is not write-protected into an SD card reader/writer attached to your computer. (If the card is write-protected, slide the protection switch away from the "Lock" position.)

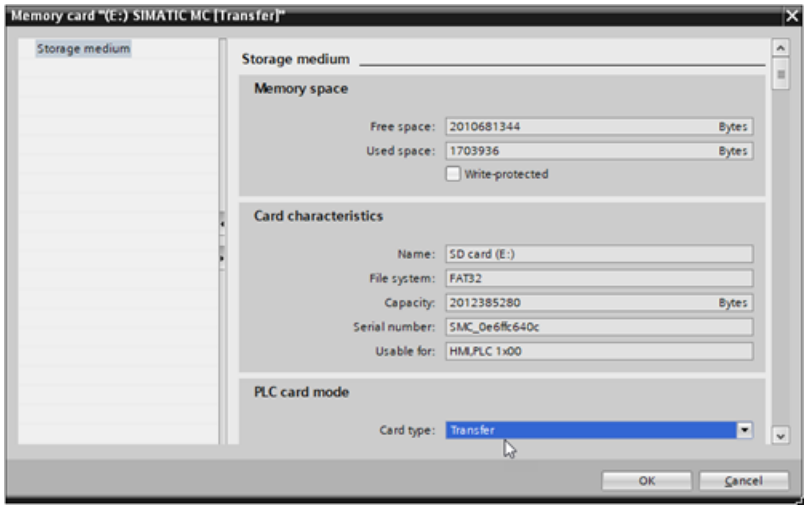
   If you are reusing a SIMATIC memory card that contains a user program, data logs, recipes, or a firmware update, you **must** delete the files before reusing the card. Use Windows File

Explorer to display the contents of the memory card and delete the following files and folders if they exist:

- S7_JOB.S7S
- SIMATIC.S7S
- FWUPDATE.S7S
- DataLogs
- Recipes
- UserFiles

NOTICE
Do NOT delete the hidden files "__LOG__" and "crdinfo.bin" from the memory card. The "__LOG__" and "crdinfo.bin" files are required for the memory card. If you delete these files, you cannot use the memory card with the CPU.

2. In the Project tree (Project view), expand the "Card Reader/USB memory" folder and select your card reader. If you are creating an empty transfer card, you can go to Step 6.
3. Add the program by selecting the CPU in the Project tree and dragging the CPU to the memory card. Another method is to copy the CPU and paste it to the memory card. Copying the CPU to the memory card opens the "Load preview" dialog.
4. In the "Load preview" dialog, click the "Load" button to copy the CPU to the memory card.
5. When the dialog displays a message that the CPU (program) has been loaded without errors, click the "Finish" button.
6. Right-click the drive letter corresponding to the memory card and select "Properties" from the shortcut menu.
7. In the "Memory card" dialog, select "Transfer" from the "Card type" drop-down menu and click OK.



8. Remove the transfer card from the card reader.

Using a transfer card

⚠ WARNING

Risks when inserting a transfer card
Inserting a memory card causes the CPU to restart and evaluate the card, which can affect the operation of an online process or machine.
Before inserting a transfer card, ensure that the CPU is in STOP mode and your process is in a safe state.
Unexpected operation of a process or machine can result in death or injury to personnel and/or property damage.

To transfer the program to a CPU, insert the transfer card into the CPU (Page 137). At this point, the existing program is still in the CPU.

The CPU evaluates the memory card and attempts to copy the program and all files on it to the internal load memory of the CPU. The CPU then responds as follows:

- If the copy process completes successfully, the MAINT LED flashes (yellow). Remove the transfer card.
- If the copy process fails for any reason, including exceeding the size of internal load memory (ILM), the copy aborts. The Diagnostic buffer shows an error. The ERROR LED blinks red and the STOP LED is solid yellow.

  If the program transferred successfully, but data logs and recipes did not transfer, you can set the CPU to RUN mode after you remove the transfer card and the CPU restarts.

  Instructions that require the missing data logs and recipes will report errors. You can retry the transfer if the failure occurred due to a disruption in the transfer process. If the failure was a result of ILM not having enough space for all the transfer card contents, you can delete some files from the transfer card and try again.

The CPU is in STOP mode after a transfer. The transfer card is unchanged.

See also

Recovery from a lost password (Page 148)

5.4.14.6 Program card

NOTICE

Risks associated with electrostatic discharge
Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable.
To protect the memory card and receptacle from electrostatic discharge, do the following:

- Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card.
- Store the memory card in a conductive container.

Receptacle or memory card malfunction can result in property damage.



Check that the memory card is not write-protected. Slide the protection switch away from the "Lock" position.

The memory card is keyed for proper installation. Insert the memory card with the correct orientation.

If you insert a write-protected memory card into the CPU, STEP 7 displays a diagnostic message on the next power up, alerting you to that fact. The CPU powers up without failure, but instructions involving recipes or data logs, for example, return errors if the card is write-protected.

Before you copy any program elements to the program card, delete any previously saved programs from the memory card.

Creating a program card

When used as a program card, the memory card is the external load memory of the CPU. If you remove the program card, the internal load memory of the CPU is empty. A program card includes the STEP 7 program and any data logs, recipes, or user files that belong to the program.

NOTE

If you insert an empty memory card into the CPU, the CPU copies the program and force values from internal memory to the memory card. After the copy has completed, the program in internal load memory is erased.

If you powered off the CPU before inserting the memory card, the CPU then goes to the configured startup mode (Page 139).

If you inserted the memory card without powering off, the CPU remains in STOP mode.

Always remember to configure the startup parameter of the CPU (Page 139) before copying a project to the program card. To create a program card, follow these steps:

1. Insert an empty SIMATIC memory card that is not write-protected into an SD card reader/writer attached to your computer.

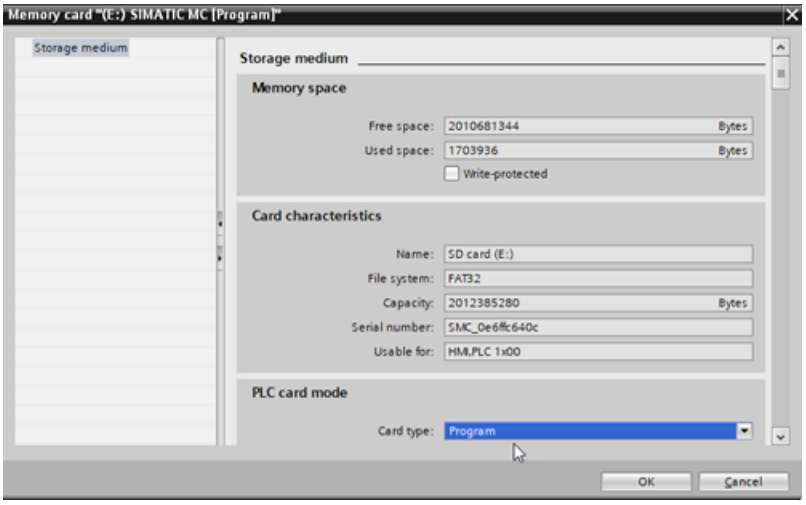
   If you are reusing a SIMATIC memory card that contains a user program, data logs, recipes, or a firmware update, delete the files before reusing the card. Use Windows File Explorer to display the contents of the memory card and delete the following files and folders if they exist:

   – S7_JOB.S7S
   – SIMATIC.S7S
   – FWUPDATE.S7S
   – DataLogs
   – Recipes
   – UserFiles

NOTICE
Do NOT delete the hidden files "__LOG__" and "crdinfo.bin" from the memory card. The "__LOG__" and "crdinfo.bin" files are required for the memory card. If you delete these files, you cannot use the memory card with the CPU.

2. In the Project tree (Project view), expand the "Card Reader/USB memory" folder and select the card reader.

3. Display the "Memory card" dialog by right-clicking the drive letter corresponding to the memory card in the card reader and selecting "Properties" from the context menu.
4. In the "Memory card" dialog, select "Program" from the Card type dropdown menu.



5. Add the program by selecting the CPU device (such as G2_PLC_1 [CPU 1214C DC/DC/DC]) in the Project tree and dragging the CPU device to the memory card. (Another method is to copy the CPU device and paste it to the memory card.) Copying the CPU device to the memory card opens the "Load preview" dialog.
6. In the "Load preview" dialog, click the "Load" button to copy the CPU device to the memory card.
7. When the dialog displays a message that the download completed without errors, click the "Finish" button.

Using a program card as the load memory for a CPU

⚠ WARNING

Risks associated with inserting a program card
Use caution when inserting a program card while the CPU is in RUN mode. If you insert a program card into a CPU, the CPU restarts. Unexpected equipment operation can occur.
Ensure that the CPU is in STOP mode before inserting a program card.
Unexpected equipment operation can result in death, injury, and equipment damage.

To use a program card with a CPU, insert the program card (Page 137) into the CPU. The CPU evaluates the program card and erases the internal load memory of the CPU.

The program card must then remain in the CPU.

WARNING

Risks associated with removing a program card
If a program card is removed while the CPU is in RUN mode, the CPU restarts.
Use caution when removing a program card while the CPU is in RUN mode. Removing the program card removes the program from the CPU.
Unexpected equipment operation can occur resulting in death, injury, and equipment damage.

Service life of a SIMATIC memory card

The service life of a SIMATIC memory card depends on factors such as the following:

- Number of delete and write operations per memory block
- Number of bytes written
- External influences, such as ambient temperature

NOTE

Effect of write and delete operations on SIMATIC memory card service life
Write or delete operations, particularly repeated (cyclic) write/delete operations, reduce the service life of the SIMATIC memory card.
Cyclic execution of the following actions reduces the service life of the memory card depending on the number of write operations and data:

- Data Log handling (for example, DataLogWrite)
- Recipe handling (for example, RecipeExport)
- System Function Calls (SFCs) that write/delete to the file system (for example, WRIT_DBL, CREATE)
- System Function Blocks (SFBs) that write/delete to file system (for example, FileWriteC, FileDelete)
- Any other cyclic action that changes data on the persistent store (for example, Tracing, SET-TimeZone)

5.4.14.7 Firmware update card

You can use a SIMATIC memory card for performing a firmware update.

NOTE

You cannot update an S7-1200 CPU to S7-1200 G2 by firmware update.

Firmware updates are available on the Siemens Industry Online Support (https://sieportal.siemens.com/en-ww/support) Web site. From this Web site, navigate to "Downloads". From there, search for the specific type of module that you need to update.

Alternatively, you can access the downloads Web page (https://support.industry.siemens.com/cs/ww/en/ps/13639/dl) directly. Filter the downloads for S7-1200 G2 or a specific article number.

NOTICE
Risks associated with electrostatic discharge Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable. To protect the memory card and receptacle from electrostatic discharge, do the following: • Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card. • Store the memory card in a conductive container. Receptacle or memory card malfunction can result in property damage.

You can also use one of these methods to perform a firmware update:

- Online and diagnostic tools of STEP 7 (Page 313)
- SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300)

Downloading and installing a firmware update

To download the firmware update to your memory card, follow these steps:

1. Insert an empty SIMATIC memory card that is not write-protected into an SD card reader/writer attached to your computer. If the card is write-protected, slide the protection switch away from the "Lock" position.

   You can reuse a SIMATIC memory card that contains a user program or another firmware update. To avoid any confusion, you should also delete files S7_JOB.S7S, SIMATIC.S7S, and FWUPDATE.S7S if they exist.

   NOTE

   Do NOT delete the hidden files "__LOG__" and "crdinfo.bin" from the memory card. The "__LOG__" and "crdinfo.bin" files are required for the memory card. If you delete these files, you cannot use the memory card with the CPU.

2. Select the zip file for the firmware update that corresponds to your module, and download it to your computer. Double-click the file, set the file destination path to be the root directory of the SIMATIC memory card, and start the extraction process. After the extraction is complete, the root directory (folder) of the memory card will contain a "FWUPDATE.S7S" directory and the "S7_JOB.S7S" file.

   NOTE

   Do not put multiple firmware updates for the same article number (MLFB) on your memory card. Putting multiple updates for the same article number on the memory card causes the firmware update to fail.

   You can put multiple firmware updates for different article (MLFB) numbers on a single memory card. This allows you to use a single memory card to update the firmware of multiple station hardware modules.

3. Safely eject the card from the card reader/writer.

Installing a firmware update

⚠ WARNING

Risks when installing firmware updates
Installing the firmware update causes the CPU to restart, which can affect the operation of an online process or machine.
Verify that the CPU is not actively running a process before installing the firmware update. Before inserting the memory card, always ensure that the CPU is offline and in a safe state.
Unexpected operation of a process or machine can result in death or injury to personnel and/or property damage.

To install the firmware update, insert the firmware update card into the CPU (Page 137).

After you insert the card, the firmware update starts. When the MAINT LED flashes (yellow), the firmware update has finished. Remove the firmware update card. A firmware update does not affect the STEP 7 program and device configuration.

During update, the firmware update procedure ignores UPD files that do not correspond to any station hardware modules. If you have multiple station hardware modules with the same article number (MLFB), the firmware update is installed on all of those modules. This allows you to create a master firmware update memory card to update all stations in your facility.

If you powered off the CPU before removing the memory card, the CPU then goes to the configured startup mode (Page 139).

If you removed the memory card without powering off, the CPU remains in STOP mode.

The Diagnostics buffer includes entries when firmware update attempts are made, whether successful or not. In the case of a failure, the Diagnostics buffer message provides an explanation for the failure. You can then easily scan the Diagnostics buffer for any unexpected anomalies.

5.4.14.8 Memory card for protecting confidential PLC configuration data

You can use a SIMATIC memory card to set or remove the password for Protection of confidential PLC configuration data. To change an existing password for Protection of confidential PLC configuration data, you must first clear the existing password and then set the new password.

NOTICE

Risks associated with electrostatic discharge
Electrostatic discharge can damage the memory card or the receptacle on the CPU. If damaged, the receptacle or memory card can malfunction or become inoperable.
To protect the memory card and receptacle from electrostatic discharge, do the following:

- Make contact with a grounded conductive pad or wear a grounded wrist strap when handling the memory card.
- Store the memory card in a conductive container.

Receptacle or memory card malfunction can result in property damage.

Risks associated with the decommissioning process

S7-1200 G2 CPUs do not support secure erasure of the memory card and internal flash. Therefore, during the decommissioning process, you must securely dispose of the CPU and memory card to prevent the loss of proprietary or confidential information.

How to create a memory card with a Protection of confidential PLC configuration data password

To create the memory card with this password, follow these steps:

1. Insert an empty SIMATIC memory card that is not write-protected into an SD card reader/writer attached to your computer. If the card is write-protected, slide the protection switch away from the "Lock" position.
   You can reuse a SIMATIC memory card that contains a user program or firmware update, but you must delete some of the files on the memory card. To reuse a memory card, you must delete the "S7_JOB.S7S" file before creating the Protection of confidential PLC configuration data file. Use Windows Explorer to display the contents of the memory card and to delete the "S7_JOB.S7S" file.

NOTICE
Do NOT delete the hidden files "__LOG__" and "crdinfo.bin" from the memory card. The "__LOG__" and "crdinfo.bin" files are required for the memory card. If you delete these files, you cannot use the memory card with the CPU.

2. Create a file on the root of the memory card called "S7_JOB.S7S". Open the file with a text editor and type the following: SET_PWD.
3. Create a folder on the root of the memory card called: SET_PWD.S7S.
4. Under the "SET_PWD.S7S" folder, create a text file called "PWD.TXT". The file must be named "PWD.TXT".
5. Enter your Protection of confidential PLC configuration data password as the text contents of the file. The file must contain a single line of text representing the Protection of confidential PLC configuration data password. Follow the STEP 7 rules for passwords when creating the password, using these characters:
   - 0123456789
   - A...Z a...z
   - !#$%&()*+,-./:;<=>?@ [\]_{|}~^
6. Safely eject the card from the card reader/writer.

How to use a memory card to clear the Protection of confidential PLC configuration data password

To clear the Protection of confidential PLC configuration data password, follow these steps to create a memory card with an empty password, and then use that card to clear the password in the CPU:

1. Follow steps 1 - 4 above to create a memory card with the required structure.
2. Leave the PWD.TXT file empty.
3. Insert the memory card (Page 137)with no password into the CPU. The CPU evaluates the card and clears the Protection of confidential PLC configuration data password.
4. Remove the memory card. After the CPU restarts, it has no Protection of confidential PLC configuration data password.

How to set the Protection of confidential PLC configuration data password

To set the Protection of confidential PLC configuration data password, follow these steps:

1. Verify that the CPU is not actively running a process before setting the Protection of confidential PLC configuration data password.
2. Insert the memory card (Page 137) you created with your password into the CPU. The CPU evaluates the card and sets the Protection of confidential PLC configuration data password.
3. Remove the memory card. After the CPU restarts, it uses the new Protection of confidential PLC configuration data password.

If the existing program requires the Protection of confidential PLC configuration data password you set with the memory card, the PLC can go to RUN based on the project configuration.

If the existing user program requires a different Protection of confidential PLC configuration data password than what you set with the memory card, the program will not load after restarting. You must clear the existing program and download a program that uses the Protection of confidential PLC configuration data password that you set in the previous steps.

5.4.14.9 Recovery from a lost password

If you have lost the password for a password-protected CPU, use an empty transfer card (Page 139) to delete the password-protected program. The empty transfer card erases the internal load memory of the CPU. You can then download a new user program from STEP 7 to the CPU.

⚠ WARNING

Risks when inserting transfer cards
If you insert a transfer card in a running CPU, the CPU goes to STOP. Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment.
Verify that the CPU is not actively running a process before inserting the memory card.
Before inserting a transfer card, always ensure that the CPU is in STOP mode and your process is in a safe state.
Such unexpected operations can result in death or serious injury to personnel, and/or damage to equipment

You must remove the transfer card before setting the CPU to RUN mode.

5.4.14.10 Memory card for copying license conditions and copyrights from the CPU

License conditions and copyright files for open-source and third-party software (OSS files) are embedded in the CPU firmware. You can copy them to a supported non-SIMATIC standard memory card (Page 468).

Copying license conditions and copyrights to a non-SIMATIC memory card

To copy the license conditions and copyright files to a supported non-SIMATIC standard memory card, insert a supported non-SIMATIC standard memory card (Page 137) into the CPU. The format of the memory card must be "FAT32" file system.

The CPU restarts and copies the license conditions and copyrights to the memory card. They are in a zip file in a folder named OSS at the root level of the memory card file system. You can remove the memory card.

5.4.14.11 Using a memory card with the S7-1200 G2 fail-safe CPU

The S7-1200 G2 fail-safe CPU behavior when using a memory card has some differences from the standard CPU:

- When the S7-1200 G2 fail-safe CPU starts with no memory card and the Internal Load Memory (ILM) is empty, the fail-safe CPU's STOP and MAINT LEDs flash for three seconds. Power cycle the CPU. This provides a temporary visual indication that the ILM is empty. You must use the TIA Portal, the SIMATIC Automation Tool, or a memory card to load a user program.
- When the fail-safe CPU starts with a program memory card installed and the ILM is not empty, the fail-safe CPU erases the ILM, flashes the STOP and MAINT LEDs, and waits for user action. This is a visual indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. After the power cycle or memory reset, subsequent power cycles load the program from the memory card.
- When the fail-safe CPU starts with an empty memory card installed and the ILM is not empty, the fail-safe CPU copies the program from the ILM to the memory card. The fail-safe CPU then erases the ILM, flashing the STOP and MAINT LEDs, and waits for user action. This is an indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. After the power cycle or memory reset, subsequent power cycles load the program from the memory card.
- When the fail-safe CPU starts with a transfer memory card installed and the ILM is not empty, the fail-safe CPU erases the ILM, flashing the STOP and MAINT LEDs. This is a visual indication that the ILM is erased and that the fail-safe CPU is waiting for a power cycle or a memory reset command in order to continue. After the power cycle or memory reset, the fail-safe CPU copies the user program from the memory card to the ILM, and the fail-safe CPU stops, with the STOP LED on and the MAINT LED flashing. At this point, you must remove the transfer memory card. After the fail-safe CPU restarts, subsequent power cycles load the program from the ILM.

Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual", "Function test of safety program and protection through program identification" for instructions on transferring programs.

⚠ WARNING

Loading an incorrect user program into a fail-safe CPU results in incorrect execution and total or partial loss of the safety function.
Loss of the safety function can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.
Follow the instructions as provided in the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* for properly identifying safety programs and controlling how you load programs into a fail-safe CPU.

See also

SIMATIC Safety - Configuring and Programming manual (https://support.industry.siemens.com/cs/us/en/view/54110126)

5.5 Managing users and roles

With the TIA Portal you can perform user management and access control (UMAC). This allows you to create and manage users and roles in your project who are allowed to perform specific functions. You can assign roles with specific rights to each user. You can then assign runtime rights to your S7-1200 G2 PLC.

You can also create and manage central users outside the TIA Portal in UMC (User Management Component). UMC provides the capability to define users and roles in a central location that can then be used across multiple projects.

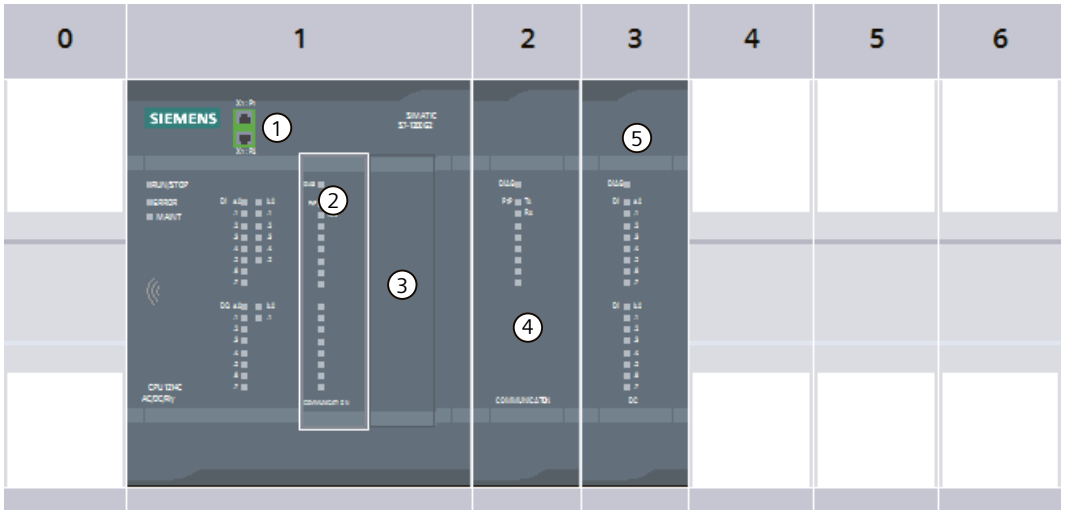
After adding users and making role assignments, you must load the project to the CPU(s) to activate UMAC. After you load the project to your S7-1200 G2 PLC, only authorized users can access various CPU functions (Page 313).

For more information, refer to "Managing users and roles" in the TIA Portal Information System.

5.6 Device configuration

5.6.1 Overview

You create the device configuration for your PLC by adding a CPU and additional boards and modules to your project as needed.



① PROFINET port(s) of CPU (under door)
② Signal board (SB) or Communication board (CB)
③ CPU
④ Communication module (CM) or Communication processor (CP)
⑤ Signal module (SM) for digital or analog I/O

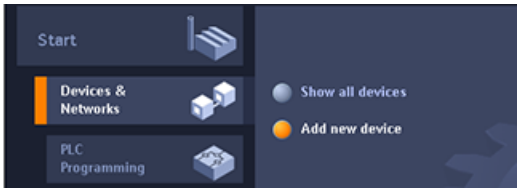
To learn more about the number of modules you can configure in your project, see Installing and removing expansion modules (Page 72).

Refer to Ordering Information (Page 467) for expansion boards and modules that are available.

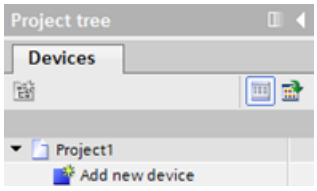
5.6.2 Inserting a CPU

You can insert a CPU into your project from either the Portal view or the Project view of STEP 7:

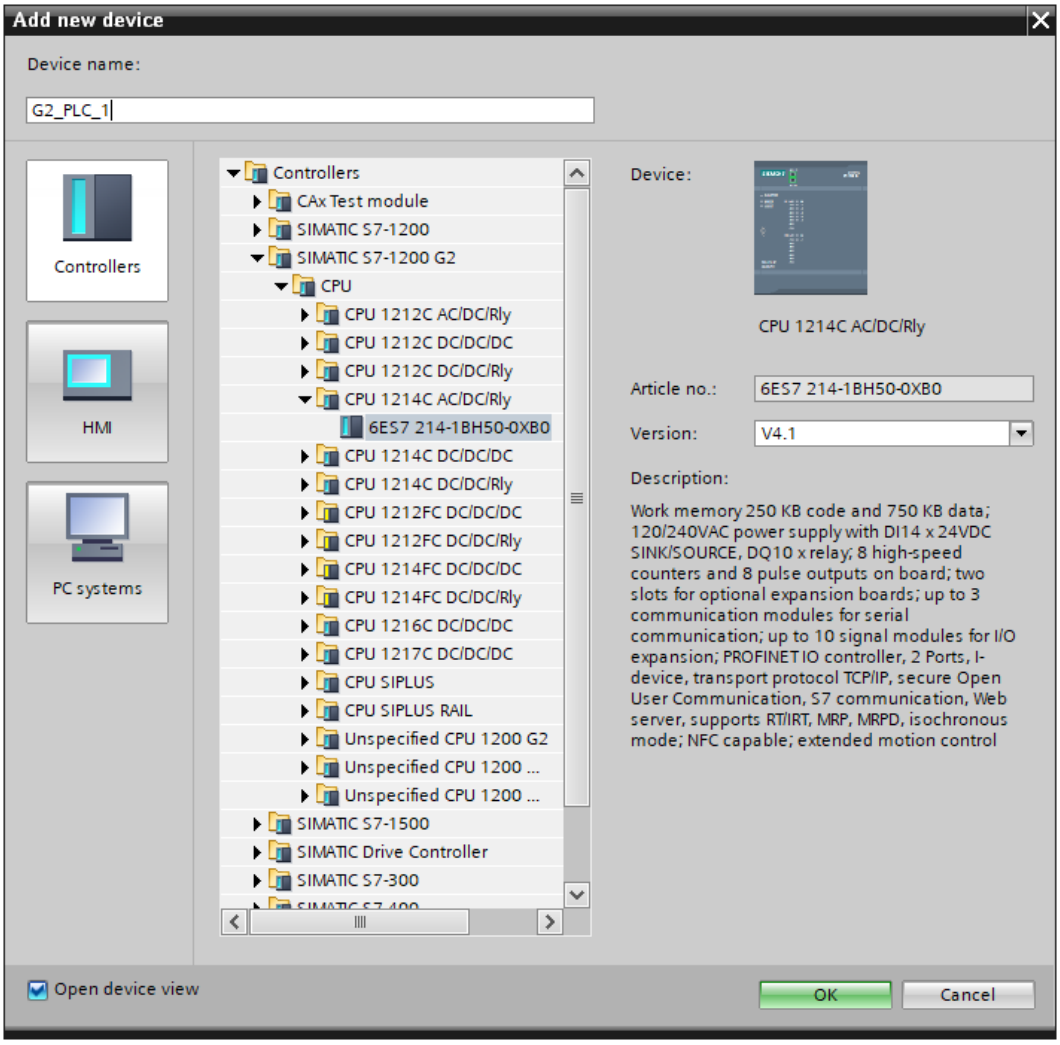
- In the Portal view, select "Devices & Networks" and click "Add new device".



- In the Project view, under the project name, double-click "Add new device".



From the "Add new device" dialog, select the correct Article Number and firmware version from the list.



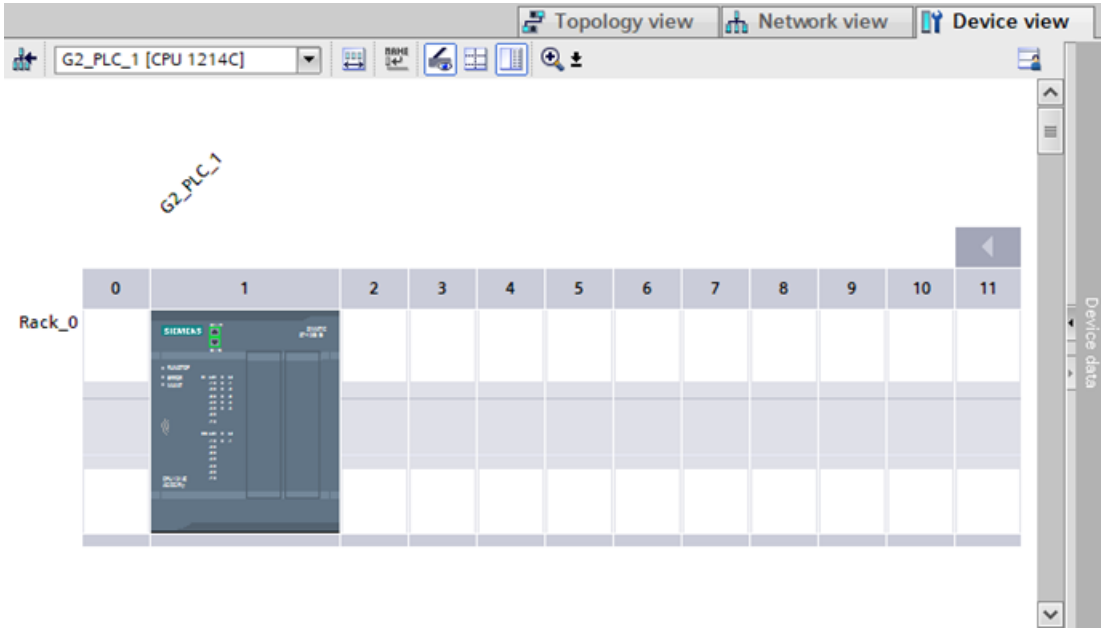
Configuring PLC security settings for your inserted CPU

When you insert an S7-1200 G2 CPU, STEP 7 launches the security wizard to help you set up your PLC security settings. Follow the steps in the wizard to set up your PLC security settings.

Refer to Protection & Security topics in the TIA Portal Information System to learn more about each configuration task and related security concepts.

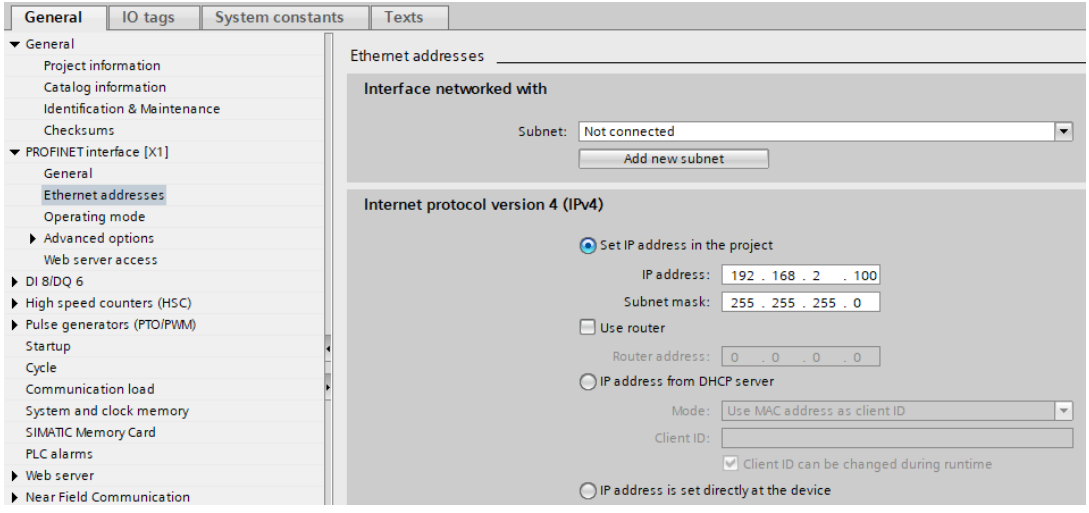
Device configuration for the inserted CPU

After you add a CPU, STEP 7 creates the rack and displays the CPU in the Device view:



Clicking the CPU in the Device view displays the CPU properties in the inspector window.

You can assign an IP address for the CPU during the device configuration. If your CPU is connected to a router on the network, select the checkbox next to "Use router" and enter the router's IP address.



5.6.3 Uploading the configuration of a connected CPU

STEP 7 provides two methods for uploading the hardware configuration of a connected CPU:

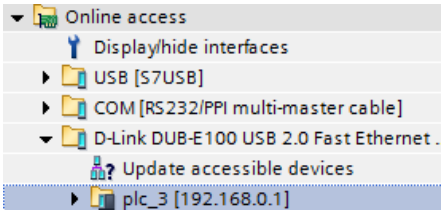
- Uploading the connected device as a new station
- Configuring an unspecified CPU and detecting the hardware configuration of the connected CPU

Note that the first method uploads both the hardware configuration and the software of the connected CPU.

Uploading a device as a new station

To upload a connected device as a new station, follow these steps:

1. Expand your communications interface from the "Online access" node of the project tree.



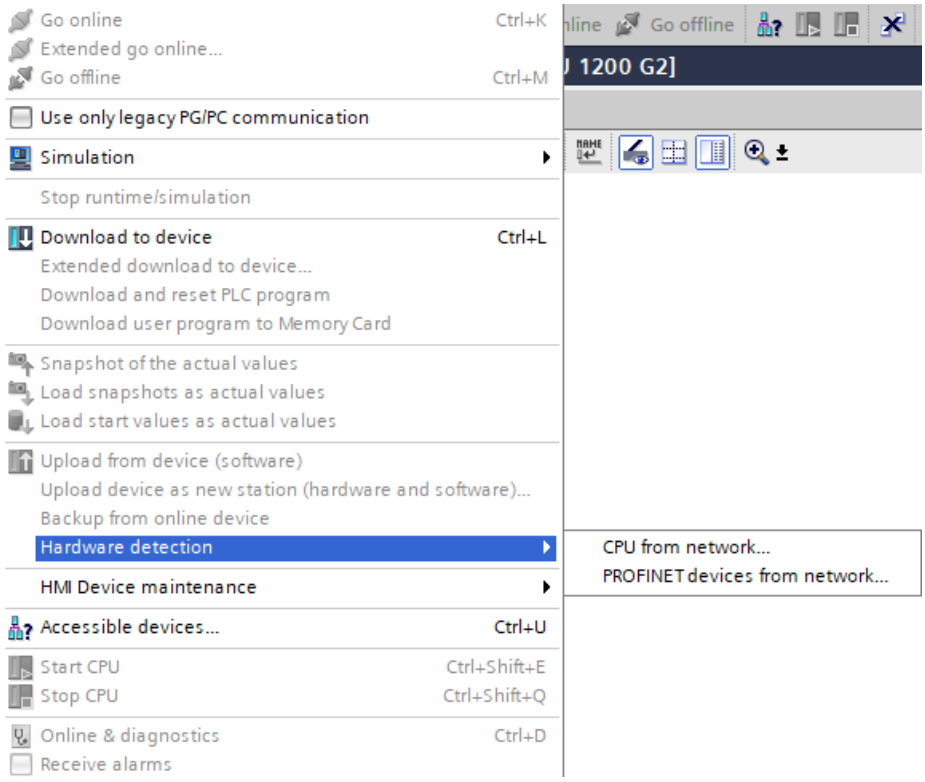
2. Double-click "Update accessible devices".
3. Select the PLC from the detected devices.
4. From the Online menu of STEP 7, select the "Upload device as new station (hardware and software)" menu command.

STEP 7 uploads both the hardware configuration and the program blocks.

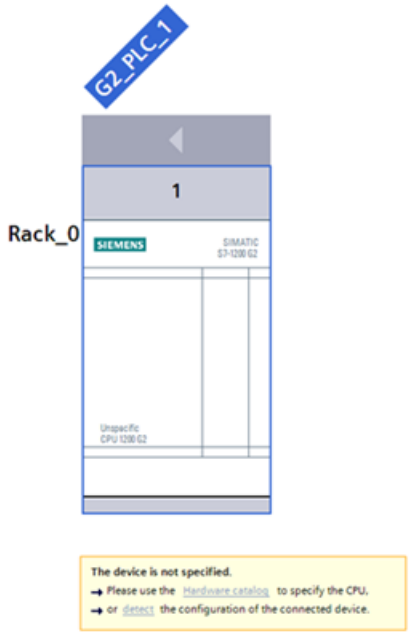
Detecting the hardware configuration of an unspecified CPU

If you are connected to a CPU, you can upload the configuration of that CPU, including any modules, to your project. Create a new project and use "Add new device (Page 157)" to add an "Unspecific S7-1200 G2 CPU".

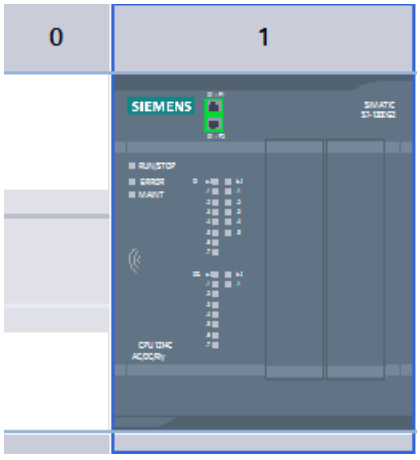
From the program editor, select the "Hardware detection" command from the "Online" menu.



From the device configuration, select "detect" in the box below the CPU. STEP 7 then detects the configuration of the PLC.



After you select the CPU from the online dialog and click Load, STEP 7 uploads the hardware configuration from the CPU, including any devices. You can then configure the parameters for the CPU and the modules (Page 158).



NOTE

Increased CPU Power-on time with missing/unplugged modules

Powering the CPU while it has missing or unplugged modules relative to your downloaded configuration causes an increased power-on time. During this period, the CPU and NFC functionality (Page 299) are unresponsive due to a longer CPU startup time. The length of the timeout for SBs is shorter than for CMs or SMs.

5.6.4 Adding modules to the configuration

Use the STEP 7 hardware catalog to add any of the following expansion modules or expansion boards to the CPU device configuration:

- Signal modules (SM) provide additional digital or analog I/O points. These modules are connected to the right side of a CPU, CM, CP, or SM.
- Signal boards (SB) provide additional I/O points for the CPU. The SB is installed on the front of the CPU.
- A Communication board (CB) provides an additional communication port (such as RS485). The CB is installed on the front of the CPU.
- A Communication module (CM) or Communication processor (CP) provides an additional communication port (such as RS232/RS485/RS422). Either module is connected to the right side of a CPU, CM, or CP.
- A Battery board (BB) provides long-term backup for the CPU's Real-Time Clock (RTC). The BB is installed in an SB slot on the front of the CPU. You can only add one BB to the device configuration.

To learn more about possible configurations of expansion modules, see S7-1200 G2 Modules (Page 57).

To insert a module into the device configuration, select the device in the hardware catalog and either double-click or drag the device to the appropriate slot. If you have one or more CMs or CPs in your project, add them to the right of the CPU before adding any SMs. An invalid module order causes a compile error. You must download your device configuration to the CPU for the devices to be functional.

5.6.5 Configuring the operation of the CPU

STEP 7 enables you to configure your S7-1200 G2 CPU by editing the CPU properties listed below. You can change Startup behavior, modify the behavior of digital I/O, or enable security settings, in addition to other valuable functions.

To configure the operational parameters for the CPU, select the CPU in the Device view and use the "Properties" tab of the inspector window.

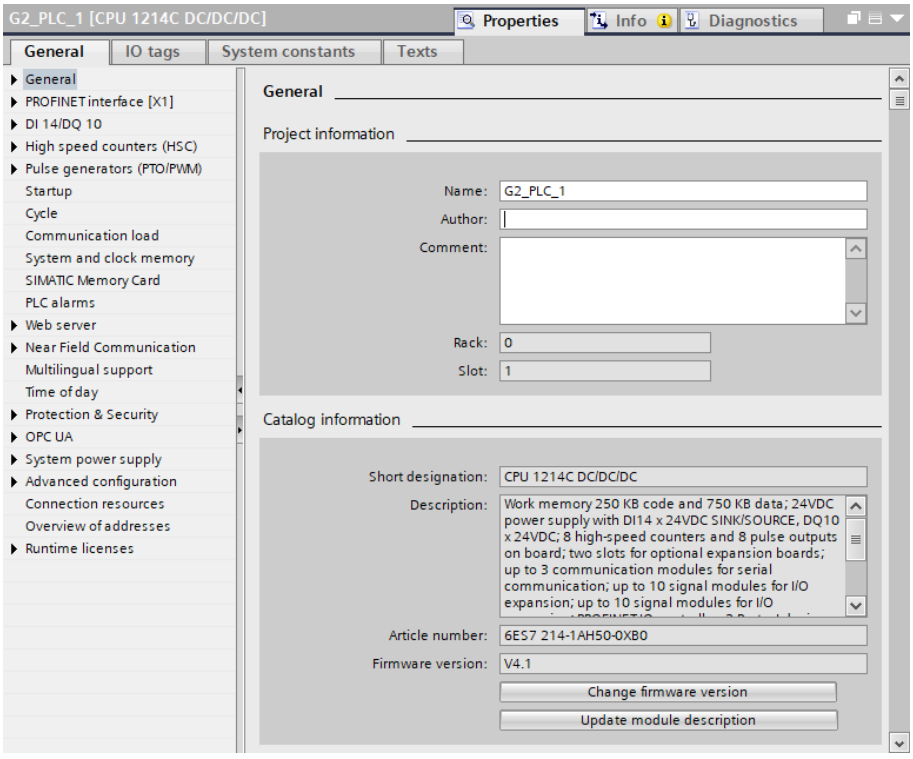


Table 1-177 CPU properties

Property	Description
General	Contains Project information, Catalog information, Identification & Maintenance, and Checksums.
PROFINET interface	Sets the IP address and Advanced PROFINET features.
DI and DQ	Configures the behavior of the local (onboard) digital I/O (for example, digital input filter times and digital output reaction to a CPU stop).
High-speed counters (Page 174) and pulse generators (Page 172)	Enables and configures the high-speed counters (HSC) and the pulse generators used for pulse train output (PTO) and pulse-width modulation (PWM). When you configure a digital output of the CPU or signal board (SB) as an HSC Compare output, or as a pulse output for use with PWM, PTO, or motion control instructions, that physical output is now controlled by the HSC or pulse-generator function. The corresponding process-image value is no longer written to that physical output; changes to the process image will be ignored by a physical output assigned to an HSC or pulse generator.

[1] If you disable access control, every user has full access to the CPU without a password. You are essentially granting users "Full access (no protection)" (if using a standard CPU) or "Full access incl. fail-safe (no protection)" (if using an F-CPU). Users can access most CPU functions. Because of this, Siemens recommends disabling access control only during commissioning and that only authorized persons have access to the CPU during this phase.

Property	Description
Startup (Page 99)	**Startup after POWER ON:** Selects the behavior of the CPU following an off-to-on transition, such as to start in STOP mode or to go to RUN mode after a warm restart.
	Comparison preset to actual configuration: Specifies the startup characteristics of the CPU for situations in which the actual configuration of the S7-1200 G2 station does not correspond to the preset configuration: • Startup of the CPU only if compatible • Startup of the CPU even if mismatch A module in the configured slot must be compatible with the configured module. Compatible means that the module that is present matches the number of inputs and outputs and must match with respect to its electrical and functional properties. It may be more capable, but not less capable. Beginning with S7-1200 G2 firmware version V4.1, this setting applies to configurations with missing SMs, SBs, CMs, CPs, or CBs.
	Configuration time: Specifies a maximum amount of time (default: 60000 ms) in which the local I/O and distributed I/O must start up. (The CMs receive power and communication parameters from the CPU during startup. This assignment time allows time for the I/O connected to the CM to be brought online.) The CPU goes to RUN as soon as the local I/O and distributed I/O have started and are ready for operation, regardless of the assignment time. If the local I/O and distributed I/O have not been brought online within this time, the CPU still goes to RUN--without the local I/O and distributed I/O.
Cycle (Page 120)	Defines a maximum cycle time or a fixed minimum cycle time.
Communication load	Allocates a percentage of the CPU time to be dedicated to communication tasks.
System and clock memory (Page 125)	Enables a byte for "system memory" functions and enables a byte for "clock memory" functions (where each bit toggles on and off at a predefined frequency).
SIMATIC Memory Card	Allows you to configure the CPU to determine when the SD card has aged to a configured percentage value. You can select the "Aging of the SIMATIC Memory card" checkbox to configure the threshold value percentage. You can use the GetSMCInfo instruction to check the SIMATIC memory card against this configured value.
PLC alarms	Enables central alarm management, allowing the CPU to transfer alarm text to the HMI device.
Web server (Page 300)	Enables and configures the Web server feature.
Near Field Communication (Page 299)	Enables reading data from a supported CPU with the S7-1200 G2 NFC app.
Multilingual support	Assigns a project language for the device and the Web server to use for displaying diagnostics buffer entry texts for each of the possible Web server user interface display languages.
Time of day	Selects the time zone and configures daylight saving time. Allows for Time Synchronization across plant components.
Protection & Security	**Protection of the PLC configuration data** (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/141646478219_enUS.htm&ft:clusterId./10866368523/141646478219.htm): Allows for password protection of confidential PLC configuration data.

[1] If you disable access control, every user has full access to the CPU without a password. You are essentially granting users "Full access (no protection)" (if using a standard CPU) or "Full access incl. fail-safe (no protection)" (if using an F-CPU). Users can access most CPU functions. Because of this, Siemens recommends disabling access control only during commissioning and that only authorized persons have access to the CPU during this phase.

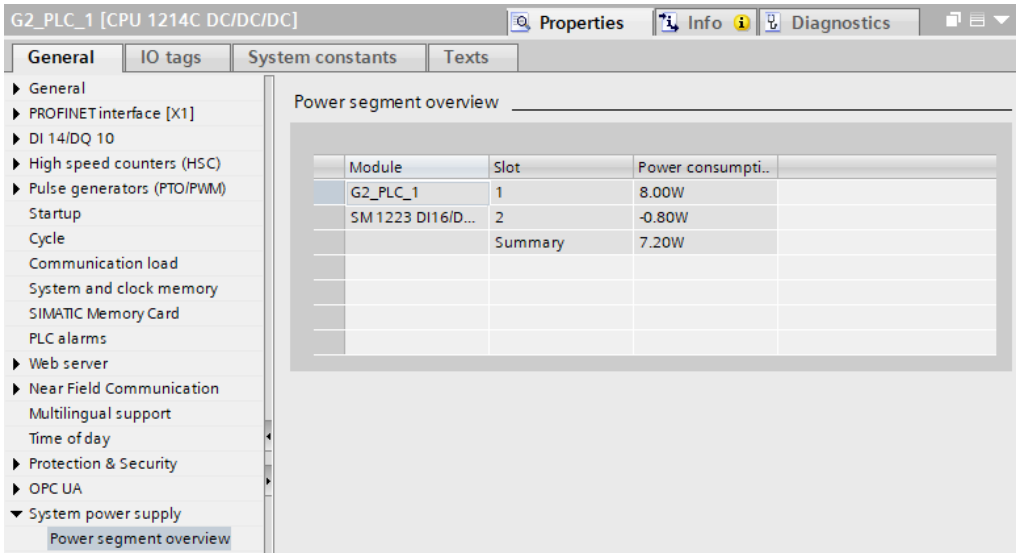
Property	Description
Protection & Security	**Access control**: Allows for disabling or enabling access control and, optionally, access levels.[1]
	Lockout of user account at runtime: Allows for the configuration of settings for the lockout of user accounts following a failed login attempt.
	Connection mechanisms (Page 209): Permits access with PUT/GET communication from a remote partner when the Anonymous user is enabled. Allows for configuration of secure PG/HMI certificate-based communication.
	Certificate manager (Page 209): Enables certificate-based security settings for global or partner devices.
	Syslog: Allows for the logging and non-retentive storage of critical operations event messages.
	Security event: Details important actions and events in the diagnostics buffer which can trigger group alarms.
	External load memory: Allows for the disabling of copying from internal to external load memory.
OPC UA	Enables access to the PLC as an OPC UA server and allows for the configuration of security settings through security policies and certificates on the server.
System power supply (Page 161)	Enables automatic calculation of power consumption by providing an overview of power segments representing each configured module.
Advanced configuration	Contains: • Hostname and domain - Assign the name or IP address of the host computer and activate the domain configuration in STEP 7. • DNS configuration (Page 203) - Configure the DNS server address. • SNMP (Page 203) - Activate SNMP (Simple Network Management Protocol).
Connection resources (Page 207)	Provides a summary of the communication connection resources that are available for the CPU and the number of connection resources that have been configured.
Overview of addresses	Provides a summary of the I/O addresses that have been configured for the CPU.
Runtime licenses	Allows for the selection of runtime licenses that enable the CPU to act as an OPC UA server.

[1] If you disable access control, every user has full access to the CPU without a password. You are essentially granting users "Full access (no protection)" (if using a standard CPU) or "Full access incl. fail-safe (no protection)" (if using an F-CPU). Users can access most CPU functions. Because of this, Siemens recommends disabling access control only during commissioning and that only authorized persons have access to the CPU during this phase.

You can learn more about the above CPU properties by referring to the related device configuration topics in the TIA Portal Information System.

5.6.5.1 Configuring the system power supply

As you add modules to your configuration of the S7-1200 G2, TIA Portal automatically calculates your overall power consumption (Page 66). This enables you to anticipate the energy needs of a given physical device configuration.



You can configure the Sensor Supply wired interface to suit your application.

5.6.5.2 Pulse catch

The S7-1200 G2 CPU provides a pulse catch feature for digital input points. The pulse catch feature allows you to capture high-going pulses or low-going pulses that are of such a short duration that they would not always be seen when the CPU reads the digital inputs at the beginning of the scan cycle (Page 97).

Enabling pulse catch

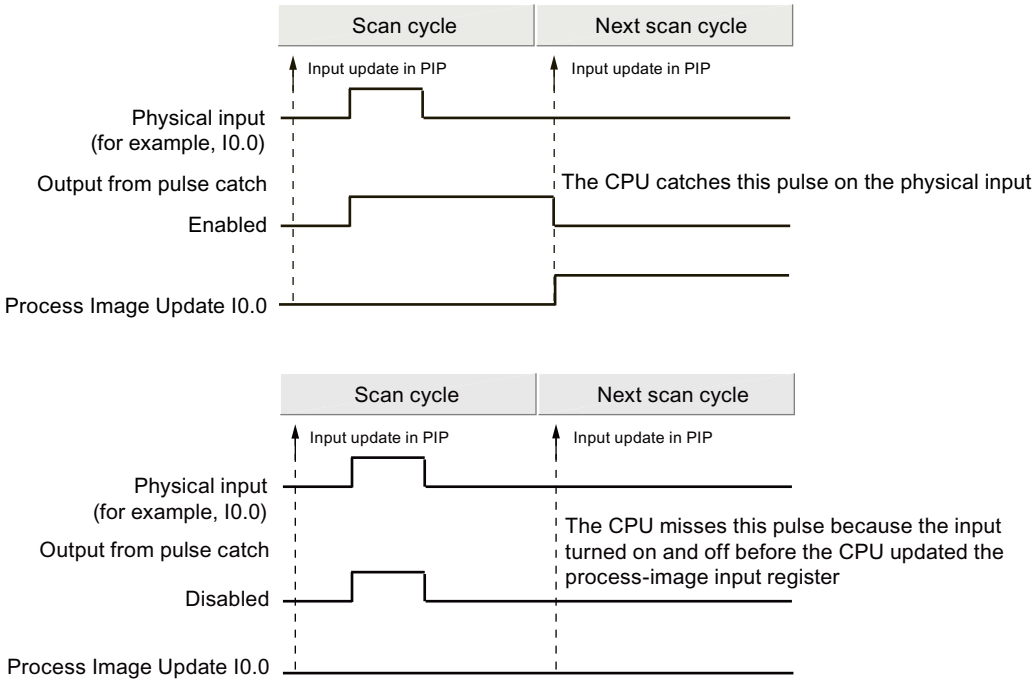
To enable pulse catch for a digital input, follow these steps:

1. Select "Digital inputs" in the Inspector window.
2. Select the desired channel.
3. Select "Enable pulse catch."

Basic operation of pulse catch

When you enable pulse catch for an input, a change in state of the input is latched and held until the next input cycle update. This ensures that a pulse that lasts for a short period of time will be caught and held until the CPU reads the inputs.

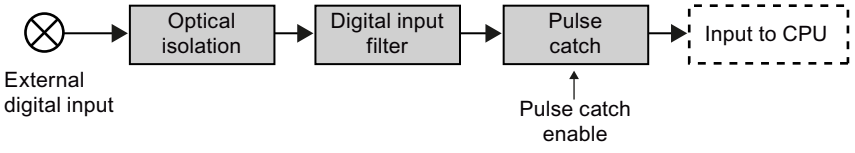
The figures below show the basic operation of the S7-1200 G2 CPU with and without pulse catch enabled:



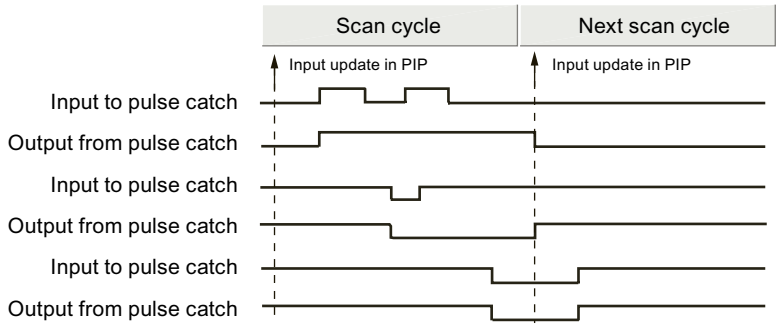
NOTE

Because the pulse catch function operates on the input after it passes through the input filter, you must adjust the input filter time so that the filter does not remove the pulse.

The figure below shows a block diagram of the digital input circuit:



The figure below shows the response of an enabled pulse catch function to various input conditions. If you have more than one pulse in a given scan, only the first pulse is read. If you have multiple pulses in a given scan, you should use the rising/falling edge interrupt events:



5.6.6 Configuring the parameters of the modules

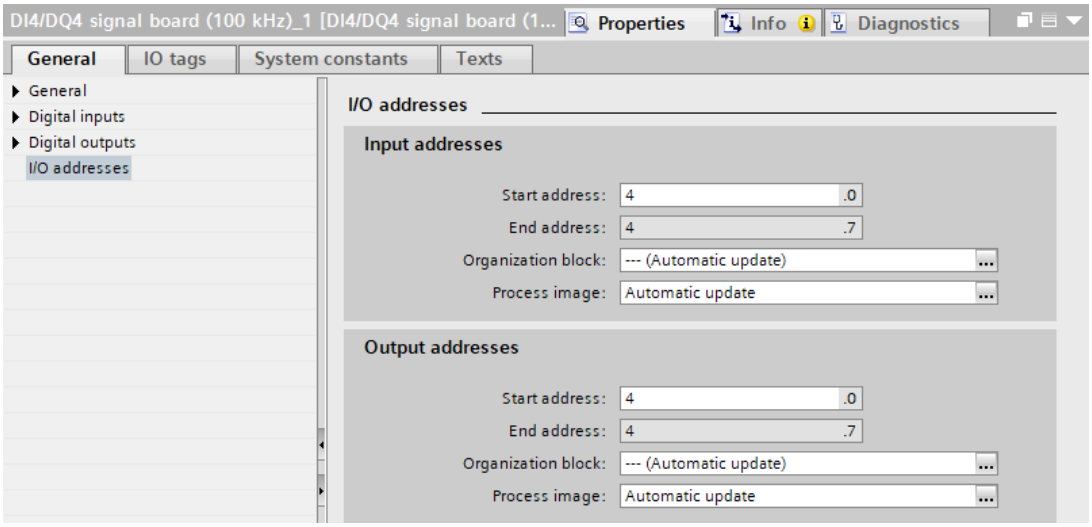
STEP 7 enables you to configure the inputs and outputs of devices connected to your S7-1200 G2 CPU on the network. You can assign values to both analog and digital I/O to accomplish tasks such as "pulse catch", to update process image partitions, or to monitor diagnostic functions.

To configure the operational parameters for the modules, select the module in the Device view and use the "Properties" tab of the inspector window.

Configuring a signal module (SM) or a signal board (SB)

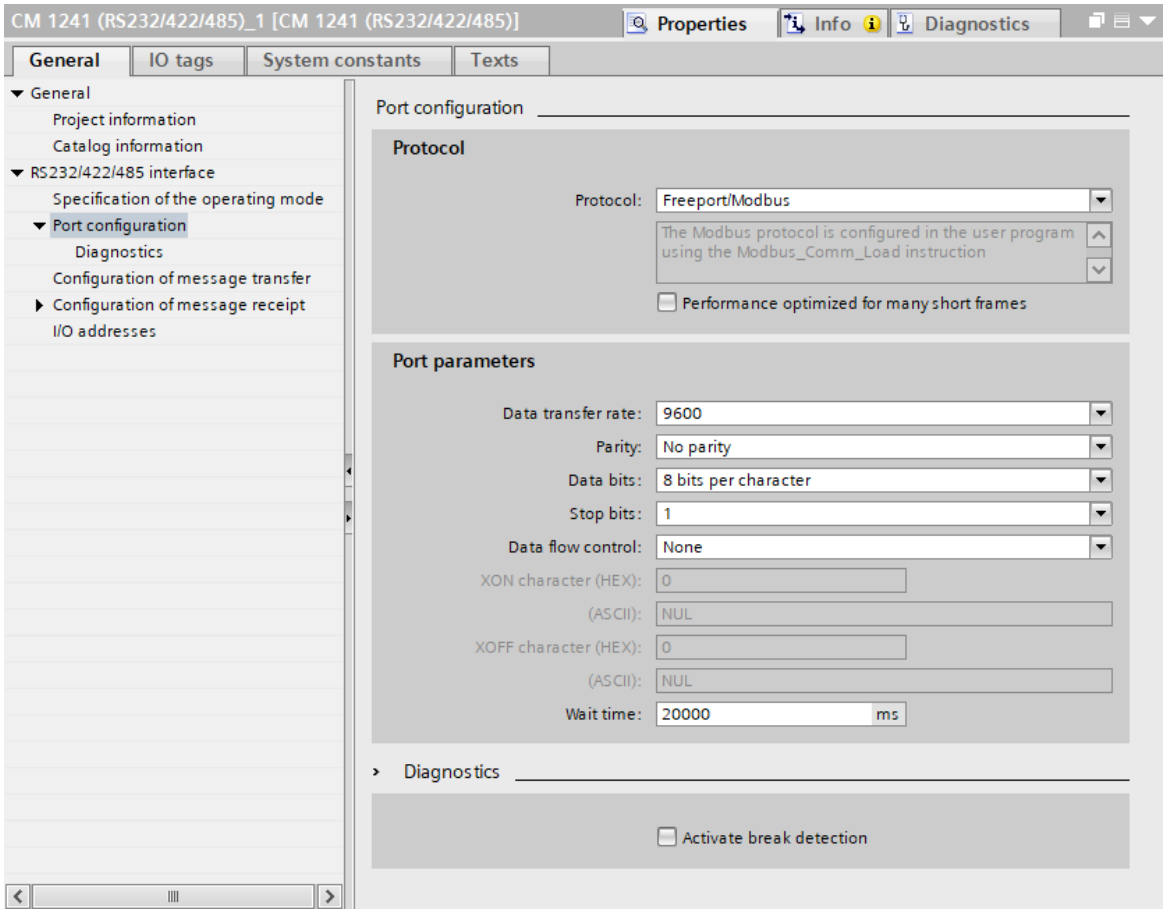
The device configuration for signal modules and signal boards provides the means to configure the following:

- Digital I/O: You can configure inputs for rising-edge detection or falling-edge detection (associating each with an event and hardware interrupt) or for "pulse catch" (to stay on after a momentary pulse) through the next update of the input process image. Outputs can use a freeze or substitute value.
- Analog I/O: For individual inputs, you can configure parameters such as measurement type (voltage or current), range, and smoothing, as well as enable underflow or overflow diagnostics. Analog outputs provide parameters such as output type (voltage or current) and for diagnostics, such as short circuit (for voltage outputs) or upper/lower limit diagnostics. You can configure the ranges of analog inputs and outputs in engineering units in your program logic.
- I/O addresses: You can configure the start address for the set of inputs and outputs of the module. You can also assign the inputs and outputs to a process image partition (PIP) or to automatically update, or to use no process image partition. See "Execution of the user program" (Page 97) for an explanation of the process image and process image partitions.



Configuring a communication module (CM)

You can configure the parameters for point-to-point communication modules (CMs) on the network.

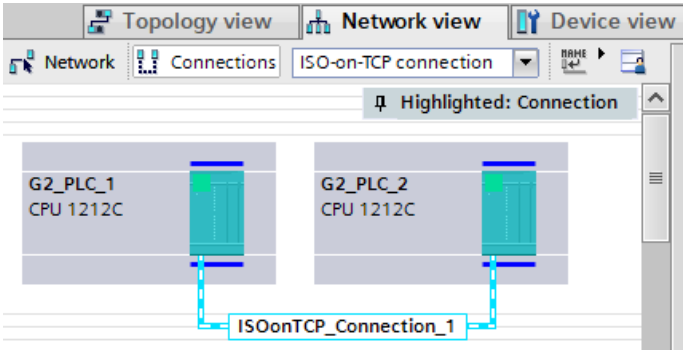


5.6.7 Configuring the CPU for communication

The S7-1200 G2 is designed to solve your communications and networking needs by supporting both simple and complex networks. The S7-1200 G2 also provides tools that allow you to communicate with other devices, which might use their own communications protocols.

Creating a network connection

Use the "Network view" of Device configuration to create the network connections (Page 212) between the devices in your project. After creating the network connection, use the "Properties" tab of the inspector window to configure the parameters of the network.



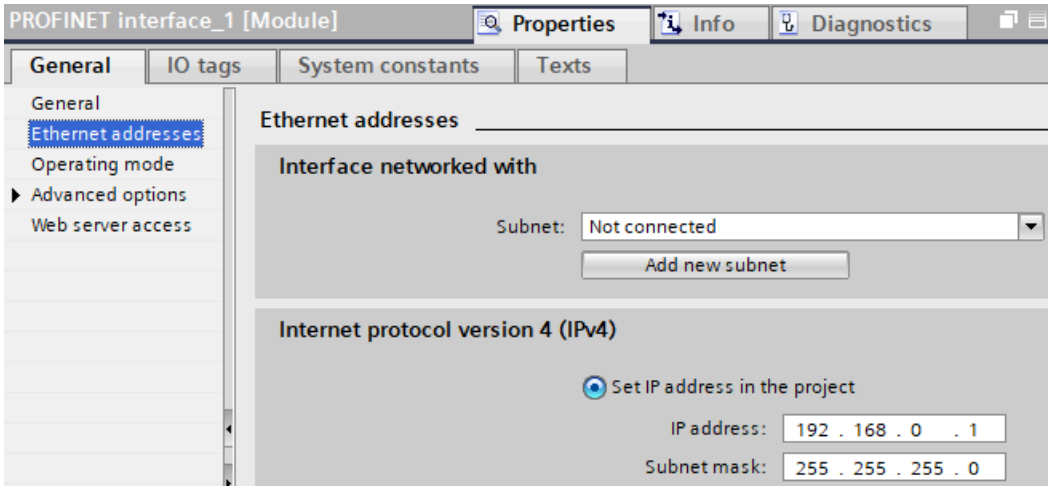
The S7-1200 G2 CPU supports the following connections:

- S7 connection (Page 252)
- ISO-on-TCP connection (Page 225)
- TCP connection (Page 224)
- UDP connection (Page 225)
- HMI connection (PLC to an HMI) (Page 209)

Assigning the IP address and Subnet

The S7-1200 G2 CPU does not have a pre-configured IP address. You must manually assign an IP address (Page 217) for the CPU in the Properties Tab under "General > Ethernet addresses".

To make a connection to your CPU, your chosen network interface and the CPU must be on the same class of network and on the same subnet. You can either set up your network interface to match the default IP address of the CPU, or you can change the IP address of the CPU to match the network class and subnet of your network interface.

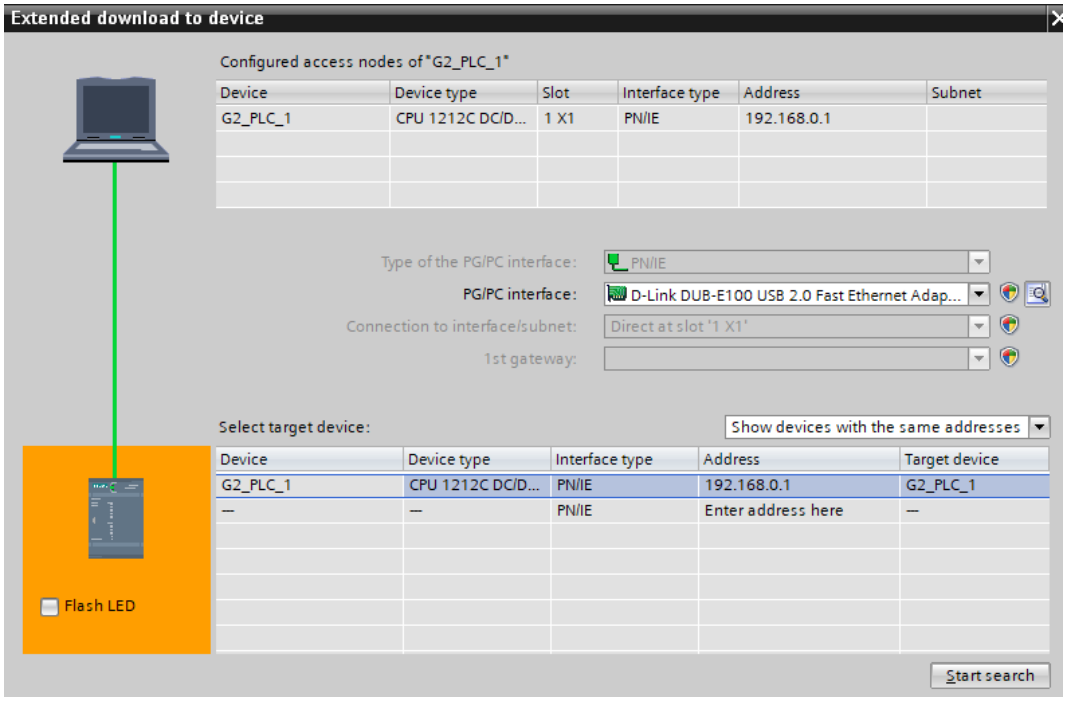


Configuring the Local/Partner connections

For the TCP, ISO-on-TCP, and UDP Ethernet protocols, use the "Properties" of the instruction (TSEND_C, TRCV_C, or TCON) to configure the "Local/Partner" connections (Page 213).

Downloading to the CPU

After configuration, download your STEP 7 project to the CPU to test the PROFINET network (Page 221). The download operation sets all IP addresses for devices configured as "Set IP address in the project".



5.6.8 Time synchronization

The objective of time synchronization of the time-of-day clocks is to have one master clock that synchronizes all other local clocks. The master clock synchronizes the local clocks initially and also periodically re-synchronizes the clocks to avoid the effects of drift over time.

In the case of the S7-1200 G2 and its local base components, only the CPU has time-of-day clocks that might need to be synchronized. You can configure the CPU's time-of-day clock to be synchronized to an external master clock. The external master clock might supply the time of day using an NTP server.

Setting the time-of-day clock

There are multiple ways to set the time-of-day clock in the S7-1200 G2 CPU:

- Using the NTP server (Page 223)
- Using STEP 7
- From the user program
- Using an HMI panel
- From the SIMATIC Automation Tool
- From the Web server

By default, time synchronization using the NTP server to change the CPU's clock is disabled.

You can select the update interval using the NTP server. The update interval of the NTP server is set to 10 seconds by default.

When you activate time synchronization in a module, STEP 7 prompts you to select the "CPU synchronizes the modules of the device", if you have not already selected the check box in the CPU's "Time synchronization" dialog. STEP 7 also warns you if you configured more than one master clock source for time synchronization.

⚠ WARNING

Risk of attacker accessing your networks through open interfaces
If an attacker can access your networks through open interfaces, such as software like STEP 7 or SAT, or through an HMI, the attacker can possibly disrupt control of your process by shifting the CPU system time.
The S7-1200 G2 CPU supports "time of day" interrupts and clock instructions that depend upon accurate CPU system time. You must restrict access to the CPU by enabling access control and disabling the "Anonymous" user. Failure to do so can cause a security breach that allows an unknown user to disrupt control of your process by shifting the CPU system time. Disruptions to process control can possibly cause death, severe injury, or property damage.
For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Website.

NOTE

Receiving time synchronizations for the CPU from more than one source could cause conflicting time updates. Time synchronizations from multiple sources could adversely affect instructions and events based on time of day.

5.7 Compatibility between STEP 7 versions and the S7-1200 G2 CPU

TIA Portal versions V20 and later support configuration and programming of the S7-1200 G2 CPU. Older versions of the TIA Portal do not support the S7-1200 G2 family.

Working with an older project and adding S7-1200 G2 CPUs

You might want to add S7-1200 G2 CPUs to an existing application that uses other CPUs and that was created in an older version of the TIA Portal. To do this, you will need a TIA Portal V21 project.

You can open a V14 or later project in the latest version of the TIA Portal and upgrade the project to the latest TIA Portal version. The TIA Portal dialogs guide you in upgrading the project if it is possible. You can then add the S7-1200 G2 CPUs for your application and perform these tasks in the TIA Portal:

1. Configure the S7-1200 G2 devices.
2. Program the logic for the S7-1200 G2 CPUs.
3. Download the hardware configuration and software to the S7-1200 CPUs.

⚠ WARNING

Risks with editing and executing program logic from versions older than TIA Portal V13
Do not attempt to upgrade a project that is older than V14 to the current version by copying program logic from one CPU to an S7-1200 G2 CPU.
You must first open the older project in TIA Portal V14 and upgrade the project to V14. Then you can open the latest version of the TIA Portal and upgrade the project from V14 to the current TIA Portal version.
Executing STEP 7 program logic that you copied from an older version to a newer version can cause unpredictable program behavior and can result in death or severe personal injury.

Migrating program logic from an S7-1200 CPU to an S7-1200 G2 CPU

If you want to migrate existing program logic from an S7-1200 CPU to an S7-1200 G2 CPU, note that there is no device exchange from any type of CPU to an S7-1200 G2 CPU. Note also that the instruction set and library support in S7-1200 G2 has differences from other CPU families. To migrate program logic from an S7-1200 CPU to an S7-1200 G2 CPU, follow these steps:

1. Add an S7-1200 G2 CPU to the upgraded project that has S7-1200 CPUs and configure the device. Be sure to observe the Warning above when upgrading a project.
2. Copy the program blocks (Page 95) from the S7-1200 CPU to the program blocks of the S7-1200 G2 CPU.
3. Create and edit any PLC tag tables that you need.
4. Attempt to compile the program, choosing "rebuild all" for both hardware and software.
5. Resolve any memory and I/O addressing differences between the two CPUs. Resolve any instruction differences between the two CPUs. Continue resolving compiler errors until the program compiles.

TIA Portal Add-ins (https://support.industry.siemens.com/cs/us/en/view/109773999) might also be useful in program migration.

5.8 Instruction set

5.8.1 Supported programming languages

STEP 7 provides the following standard programming languages for the S7-1200 G2:

- LAD (ladder logic) is a graphical programming language. The representation is based on circuit diagrams.
- FBD (Function Block Diagram) is a programming language that is based on the graphical logic symbols used in Boolean algebra.
- SCL (structured control language) is a text-based, high-level programming language.
- CEM (Cause-Effect-Matrix) for programming Function Blocks (FBs)

When you create a code block (Page 95), you select the programming language for that block.

The STEP 7 program can utilize code blocks created in any or all of the programming languages.

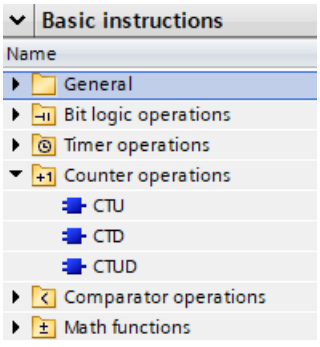
See the STEP 7 Information System for information on any of the programming languages.

5.8.2 Instructions for programming the PLC

STEP 7 provides instructions to program your S7-1200 G2 PLC. Categories and folders differ based on your programming language. The LAD Programming language presents instructions in the following main categories:

- Basic
- Extended
- Technology
- Communication
- Optional Packages

Folders under each main category list the instruction group as shown in the example below:



To find more information about each instruction and its use, follow these steps:

1. Open a program block to display the Instruction task card.
2. Expand an instruction group.
3. Do one of the following:
   - Select the individual instruction and press F1.
   - Hover over an individual instruction to reveal a TIA Portal tooltip. If you click the tooltip, or continue to hover over the instruction, a cascading tooltip provides a link to the corresponding instruction topic in the TIA Portal Information System.

You can access the TIA Portal Information System in one of the following ways:

- Select “Help” in the Portal view.
- Select the “Help > Show help” menu command in the Project view.

There you can find information on programming and instructions (https://docs.tia.siemens.cloud/access?ft:originId=./16544462091/16544462091_enUS.htm&ft:clusterId./16544462091/16544462091.htm).

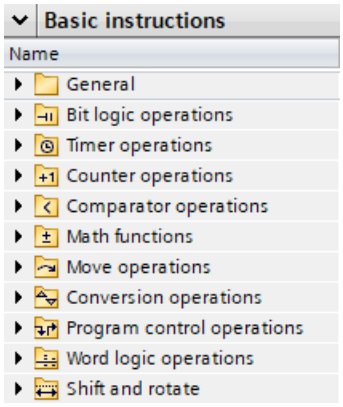
NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently within the tooltips or table of contents based on PLC family, follow the S7-1500 option for the instruction topic.

5.8.3 Basic instructions

Basic Instructions are instructions that you use often and include the following folder groups:

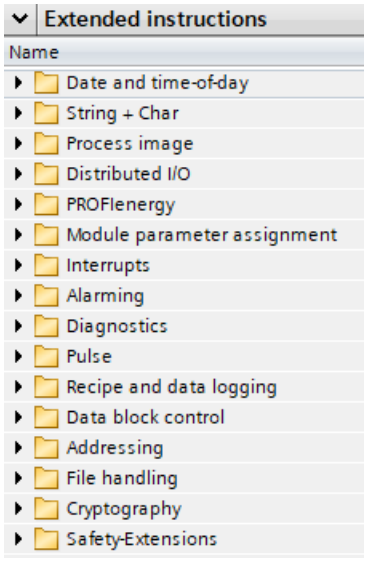


Instructions in these folders allow you to do the following:

- General - Add a network and connect network elements.
- Bit logic operations - Perform Boolean logic.
- Timer operations - Delay actions and measure elapsed time.
- Counter operations - Count internal program or external process events.
- Comparator operations - Compare two values or compare a value with a range and use the compare result in Boolean logic.
- Math functions - Perform calculations including integer and floating-point math.
- Move operations - Copy data elements to a new memory address and convert from one data type to another.
- Conversion operations - Convert from one data type to another, perform scaling, and round a floating-point number to the nearest integer.
- Program control operations - Control program sequence including jumps, retrigger cycle monitoring timer, and STOP the PLC.
- Word logic operations - Compare two values, bit by bit, using Boolean logic.
- Shift and rotate - Shift or rotate a value right or left by a specified number of bits.

5.8.4 Extended instructions

Extended instructions allow for more possibilities and include the following folder groups:



Instructions in these folders allow you to do the following:

- Date and time-of-day - Manipulate and compare time values. Set and read local time and system time.
- String + Char - Create, convert, and manipulate strings and characters. Search for, replace, insert, or append substrings.
- Process image - Update or synchronize the process image inputs or outputs.
- Distributed I/O - Exchange information with distributed I/O using read and write records.
- PROFIenergy - Activate or deactivate energy-saving states in lower-level PROFIenergy devices.
- Module parameter assignment - Read and write parameter records to modules.
- Interrupts - Control runtime aspects of interrupt events. Attach and detach OBs to interrupt events.
- Alarming - Generate program alarms and user diagnostic alarms.
- Diagnostics - Read status and diagnostic information. Generate diagnostic information for third-party components.
- Pulse - Control pulse width modulation (PWM) and pulse train output (PTO) functions.
- Recipe and data logging
  - Import and export recipes
  - Create, open, write, clear, close, and delete data logs (See "Working with data logs" below.)
- Data block control - Create a new data block in load or work memory. Transfer data between data blocks.
- Addressing - Convert module addresses among these options:
  - IO address
  - Hardware identifier
  - Slot
- File handling - Create a file on a memory card; write to and read from this file.

- Cryptography - Generate a random number. Perform encoding and decoding.
- Safety-Extensions - Acknowledge warning message about exceeding the F-cycle time.

Working with data logs

The TIA Portal Information System documents data logging at this path: Information System > Programming a PLC > Instructions > Instructions (S7-1200, S7-1500) > Extended instructions > Recipes and data logging > Data logging

In addition, be aware of this information when working with data logs:

NOTICE
Recommended frequency for write operations when using data logs When using data logs in internal or external load memory, a high frequency of write operations can affect the S7-1200 system negatively. To ensure the overall performance and robustness of your system, limit write operations to every 200 ms or longer. Exceeding this limit can shorten the lifespan of the memory card or internal flash.

NOTE

Data log management

Keep no more than 1000 data logs in a file system. Exceeding this number can prevent the Web server from having enough CPU resources to display the data logs.

Manage your data logs to ensure that you only keep the number that you need to maintain, and do not exceed 1000 data logs.

NOTE

Editing data logs on the memory card

You can copy data logs from a memory card using a PC card reader. Do not change them or delete them using a PC card reader.

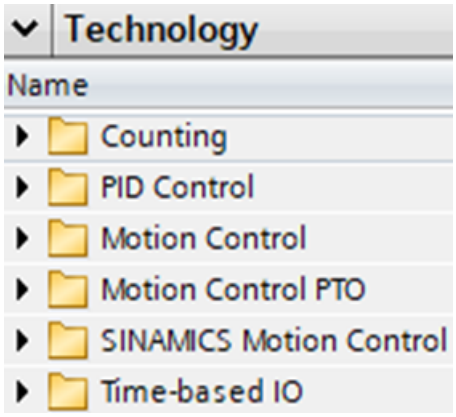
To delete, download, or display data logs use one of the following methods:

- SIMATIC Automation Tool
- DataLogDelete instruction
- Web API (Page 300) methods "DataLogs.DownloadAndClear", "Files.Browse", "Files.Download" and supporting code as documented for displaying data logs.

If you open the file system of the memory card in the File explorer, you run the risk of accidentally deleting or changing a data log or other system files, potentially damaging files or making the memory card unusable.

5.8.5 Technology instructions

Technology Instructions allow you to perform technological functions and include the following folder groups:

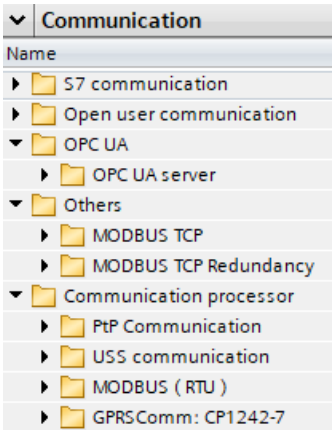


Instructions in these folders allow you to do the following:

- Counting - Control high-speed counter (HSC) functions such as counting and frequency measurement.
- PID Control - Control proportional-integral-derivative (PID) functions.
- Motion Control - Initiate absolute or relative moves. Perform homing and jog operations.
- Motion Control PTO - Power, reset, move, halt, home, and manage parameters for motion axes controlled via Pulse Train Output (PTO).
- SINAMICS Motion Control - Control stepper motors and servo motors. Coordinate motion axes.
- Time-based IO - Precisely monitor digital input state changes. Precisely control digital output state changes.

5.8.6 Communication instructions

Communication Instructions provide for communication using various network protocols and include the following folder groups:

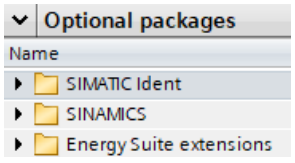


Instructions in these folders allow you to do the following:

- S7 Communication – Read data from or write data to a remote CPU using S7 protocol.
- Open user communication - Establish and terminate communication connections, send and receive data, send emails.
- OPC UA (server) - Define custom logic and actions that execute before and after a client calls an OPC UA server method.
- Others -
  - MODBUS TCP - Exchange data using Modbus TCP protocol (client or server) over the PROFINET interface.
  - MODBUS TCP Redundancy - Establish and manage redundant TCP communication connections between clients and servers.
- Communication Processor - Control serial communications such as point-to-point (PtP), Universal Serial Interface Protocol (USS), and Modbus Remote Terminal Unit (Modbus RTU).

5.8.7 Optional instructions

Optional Instructions provide additional functionality and include the following folder groups:



Instructions in these folders allow you to do the following:

- SIMATIC Ident - Interface with Siemens radio-frequency (RF) and optical identification systems.
- SINAMICS - Control Siemens variable-frequency drives (VFD).
- Energy Suite extensions - Calculate energy data. Create an energy report as a data log.

Protection

6

6.1 Overview of the protection functions

Advantages and customer benefits of protection functions

The protection functions listed protect your investments from unauthorized access and manipulation, helping to secure plant availability.

Protection functions

To set up secure networks, the SIMATIC S7-1200 G2 automation system offers an integrated security concept:

Table 1-178 Overview of protection functions

Protection function	Description
Integrity protection	The CPUs come with integrity protection functions as standard. These help detect any manipulations in the following: • Engineering data on the SIMATIC Memory Card • Engineering data during data transfer between TIA Portal and CPU • Engineering data during data transfer between HMI system and CPU • Encrypted firmware
Protection of confidential configuration data	Protection of confidential CPU configuration data (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/141646478219_enUS.htm&ft:clusterId./10866368523/141646478219.htm)
Central user management	Connection of a central server (UMC server) that is responsible for the administration and authentication of users. The central user management UMC (User Management Component) allows management of user groups and users independently of TIA Portal for extensive automation solutions.
Local user management	Management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can use the local user management in the editor to manage all project users along with their rights, including access rights for project users and roles in the TIA Portal.
Access protection	Protection against unauthorized configuration changes using authorization levels
Know-how protection	Protection against unauthorized access and modifications to algorithms with password protection

You can find more information about security mechanisms of the SIMATIC automation systems in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

Integrity protection of the SIMATIC Memory Card

Integrity protection of the SIMATIC Memory Card depends on the password for protecting confidential configuration data that you assigned during the configuration of the CPU. This results in the following changes when using SIMATIC Memory Cards:

- To transfer a CPU to a card reader/USB memory device with drag and drop:

  You must enter the password of the CPU you want to use with the SIMATIC Memory Card. If you enter an incorrect password, the CPU does not start booting after power on and reports the content of the SIMATIC Memory Card as faulty.
- To insert a CPU from a card reader/USB memory device:

  You must enter the password of the CPU from which the project was loaded. In this case, STEP 7 checks the data on the SIMATIC Memory Card and reports potential damage.

  Entering the password is optional. If you do not want to use the integrity check, you do not need to enter the password to restore the project.

You can select whether you also want to protect the entire configuration of the CPU in addition to protecting the configuration data. The data is encrypted and stored in the SIMATIC.S7S folder on the SIMATIC Memory Card and can only be decrypted with the password for the protection of confidential configuration data.

If you remove or add the setting for the protection of all data, the SIMATIC.S7S folder on the SIMATIC Memory Card remains formatted the next time it is loaded onto the CPU. Other files, for example, recipes or backup files on the SIMATIC Memory Card, are not formatted. After formatting, the CPU performs a restart.

You can find more information about the folder structure on the SIMATIC Memory Card in the "Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101)" Function Manual.

Secure communication

There is an increasing need to transfer data to external computers in encrypted form via Intranet or public networks.

SIMATIC S7-1200 G2 CPUs support the Internet PKI (RFC 5280) with STEP 7. This makes the configuration and the operation of secure communication possible, for example:

- Hypertext Transfer Protocol Secure (HTTPS)
- Secure Open User Communication
- Secure communication with OPC UA

A public key infrastructure (PKI) can issue, distribute, and check digital certificates. For S7-1200 G2 CPUs, you create certificates for various applications in the CPU properties in STEP 7, for example, TLS certificates for Secure Open User Communication, Web server certificates, or OPC UA certificates.

SIMATIC S7-1200 G2 CPUs, together with STEP 7 and WinCC, support innovative and standardized secure PG/PC and HMI communication.

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the S7-1200 G2 CPU from external sources and through the network:

- Deactivation of the Web server
- Disabling the OPC UA server

You can find more information on the security mechanisms for OPC UA server in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication
- Deactivation of SNMP

When you use the Web server, protect your S7-1200 G2 automation system against unauthorized access by doing the following:

- Set password-protected access rights for specific users in the user administration.
- Use the pre-set option "Permit access only via HTTPS".

The option allows access to the Web server only with the secure hypertext transmission protocol HTTPS.

When you use the OPC UA server, protect your S7-1200 G2 automation system against unauthorized access by doing the following:

- Do not set up OPC UA server access for the "Anonymous" user.
- Disable the "Automatically accept client certificates during runtime" option

Security functions in communications processors

Communication processors support security functions, such as access protection using a firewall, protection against data manipulation using VPN, FTPS, HTTPS, SNMPv3, and secure NTP.

More information

You can find more information on the protection functions described in the TIA Portal Information System.

Siemens products and solutions are only one element of a comprehensive industrial security concept. Observe the additional information on Industrial Security (http://www.siemens.com/industrialsecurity).

6.2 Protection of confidential configuration data

You can assign a password for protecting confidential configuration data of a CPU, such as private keys that are required for the proper functioning of certificate-based protocols.

You can find detailed information on protecting confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

6.3 Local user management

6.3.1 Useful information on the local user administration and access control

The S7-1200 G2 CPUs and TIA Portal provide management of users, roles, and CPU function rights (User Management & Access Control, UMAC).

You can manage all project users along with their rights, including access rights for all CPUs in the projects. In the TIA Portal, navigate to Security settings > Users and roles to manage users, role, and rights.

TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs.

After loading the configuration, the user management becomes effective in the respective CPUs. After loading, every CPU "knows" who may access which service and execute certain functions.

This new feature is also called "local user management and access control" below.

NOTE

Support of central users and groups for CPU function rights
UMC (User Management Component) can also be used to manage users (Page 150) centrally in TIA Portal. With this component, you can manage central users and groups on connected UMC servers, for example, by connecting an MS Active Directory. The authentication is then implemented via UMC.

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution, but only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example regarding the "Defense in Depth" security concept, in particular the remarks on plant security and hardening measures.

You can find detailed information in the Industrial cybersecurity (Page 21) section.

Users, roles and function rights

Users and roles are managed in the TIA Portal under "Security settings > Users and roles".

CPU function rights are valid during runtime. These rights are located in the "Runtime rights" tab in the Users and roles editor. For each CPU in the project, there is a section for assigning CPU function rights, which are listed according to CPU services such as PG/HMI communication, Web server, and OPC UA.

In addition to user management for projects, user management possibilities are available for the following:

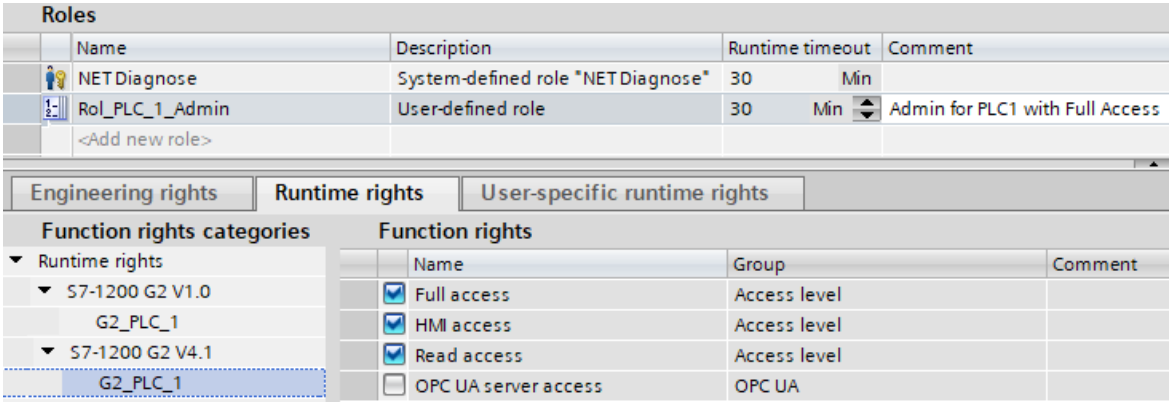
- OPC UA server users (authentication)
- Web server users (authentication and access control)

Local user management and access control

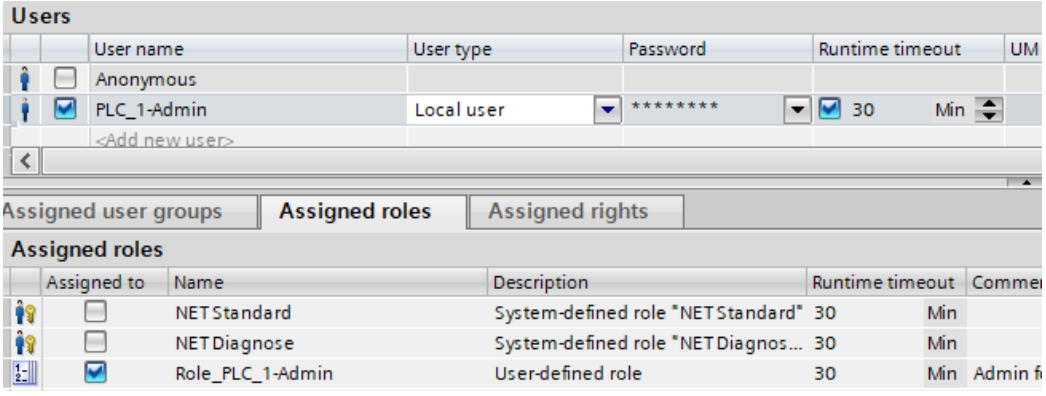
Use "Security settings > Users and roles" in the TIA Portal project tree to manage all users, roles, and CPU function rights. User management also enables you to set access protection (Page 182) for engineering/HMI access.

As with engineering rights, you use role assignments for combining individual function rights. You can assign these roles to individual users. You can see the function rights that are assigned to user from user roles for a specific CPU in the "Assigned rights" tab.

The following example shows the available and activated function rights of a CPU. At least one user must have full access to the CPU. Otherwise, the configuration cannot be compiled. A role with full access to the CPU must be created for this.



In this example, the "PLC_1-Admin" user has a role ("Role_PLC_1-Admin") that provides full access to PLC "G2_PLC_1".



Requirement

To make use of users, roles and function rights for a CPU, the "Enable access control" option must be selected in the "Protection & Security > Access control" area.

In the "Configuration of user management" area, the "Local user management" option is preset, whereby the users are loaded to the CPU.

If you select the "Central user management" option, you must add additional parameters such as the UMC server address and server ID.

No project protection is required for user management (Page 150).

Default characteristics

The "Activate access control" option is preset for access control. Users can be configured with their assigned passwords and their roles and function rights.

Downloading to device

If you want to download changes to the user configuration in RUN mode, the hardware configuration in the CPU and in the STEP 7 project must be unchanged. Otherwise, a transition to STOP is required to download the user configuration together with the changed hardware configuration.

To download in RUN mode, save your STEP 7 project and then configure only the desired changes in the user configuration prior to loading the project into the CPU.

You can only download changes to access rights for the "Anonymous" user in STOP mode.

For an F-CPU, only a user with the runtime right "Full access incl. fail-safe (no protection)" can download a STEP 7 project. Otherwise, STEP 7 displays an error message when loading the configuration.

Explanations of the options for the user management download (Load preview):

- If you select the option "Keep online user management data", the local user management is not downloaded to the CPU.
- If you select the option "Download all user management data (reset to project)", all passwords changed online via WebAPI are deleted. After the download, the configured local user data is valid.
- If you select the option "Update user management data, but keep online passwords" and have not changed existing user names, the passwords changed online via WebAPI are retained. Only changes to function rights and/or roles take effect. Newly configured users are downloaded with their settings and deleted users are no longer available after the download to the CPU.

If you have changed a user name in the project and assigned a password to this user in the project, this setting becomes valid after the download. The previously valid user name in the online CPU is deleted during the download.

Runtime timeout

You can set a runtime timeout for both the role and the user in "Security Settings > Users and Roles".

For a S7-1200 G2 CPU, these settings are taken into account by the various services as follows:

- From the Web API you can, for example, create a Web page or application that takes the settings for the runtime timeout into account. Standard web pages do not take the settings for runtime timeout into account and use the default value.
- The other services (PG/HMI communication and OPC UA server) do not use the runtime timeout. The logged-in user is not logged out after the set time.

6.3.2 Advantages of the local user administration and access control

Quick activation/deactivation of local user management

The options for user administration are located in the "Protection & Security > Access control" tab:

- Access control deactivated: Every user has full access to all functions.

  ⚠ WARNING

  Disabling access control
  Disabling access control carries the risk of unauthorized access to the CPU.
  Only disable access control in a protected environment, such as during commissioning.
  Unauthorized access can cause death, personal injury, or property damage.

- Access control enabled: The configured users with their assigned roles and associated function rights become effective after loading.

Access protection and user authentication for PG/HMI access

In addition to assigning passwords for access levels for S7-1200 G2 CPUs, you can configure users with corresponding function rights for the CPUs.

In the TIA Portal project tree, you can configure protection for the project and password settings for runtime and engineering. From Security settings > Users and roles (Page 150), you can configure users for each CPU with designated roles and rights.

Powerful password functions

TIA Portal together with the CPU provide powerful password functions:

- Support for compliance with complexity rules for password creation:

  At the password creation stage, you can have the TIA Portal check for compliance with complexity rules, such as rules on password length, uppercase/lowercase letters (project tree, "Security settings > Settings" area).

  The complexity rules are also saved in the CPU when the user management is loaded. When the password is changed online, the CPU determines and considers these rules. This prevents a user from overriding the complexity rules set by the configuration engineer and assigning a non-secure password.

- The period of validity of passwords is adjustable:

  To ensure that a user does not have access to the CPU with a compromised password for an unlimited time, you can parameterize a period of validity. Before the period of validity expires, the remaining time is then displayed on login so that each user has the possibility to change their password in time.

Loading the user management during operation

You can load certain security-relevant configuration data in both STOP and RUN modes. This means that loading the hardware configuration does not necessarily lead to a CPU STOP.

You can download the following hardware configuration changes in STOP or RUN mode:

- Local user management extensions/changes
- TIA Portal-configured certificate modifications
- Syslog configuration changes

If you made additional changes to the hardware configuration (for example, modules added, parameters reassigned, or others), then the CPU automatically requests STOP mode before loading the configuration.

For example, if you load just one user with modified roles/function rights to the CPU, this process does not require the CPU to be in STOP mode.

The preview dialog for loading contains a security area so that you can determine how the CPU should deal with user data that has changed. (This is not applicable for loading for the first time). This allows changes to user data, for example, password changes during runtime, to be retained.

Loading the device as a new station - with user data

If you load a previously configured CPU into a new project, the user data is also loaded into the project and is available for further editing of the CPU settings.

Changing of passwords during operation

You can use the Web server API to write an application with which each user can change their password at runtime, provided that the original password was entered correctly and the new password corresponds to the password guidelines.

Requirement: You have enabled access control for the CPU.

Users can change their own password at any time, even if the password has expired. If the password has expired, the user must change the password. Login is not possible with an expired password.

API methods used:

- Api.ChangePassword
- Api.GetPasswordPolicy

You can find more information about the API methods in the Web server Function Manual (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/comprehensive-information/cpu-function-manuals/web-server).

NOTE

Passwords changed at runtime take priority over loaded passwords
If you have changed your password during running operation and subsequently load your project, the password assigned during runtime takes precedence over the password set in the project (default setting).
If you want to overwrite the passwords changed during runtime by loading the project, you have to select the option "Load all user management data (reset to project data)". In this case, **all** passwords changed during runtime will be lost.

6.3.3 Access levels and function rights

Access levels as function rights

From the TIA Portal project, you can add users and roles (Page 150) with the necessary function rights for access control. The assignment between access level and the associated function right is as follows:

- Users who are to have full access must have a role with the function right "Full access", or "Full access incl. failsafe" for F-CPUs.

  You can only compile and load a CPU configuration if at least one user has the function right "Full access" or "Full access incl. failsafe".
- Users who are to have read access must have a role with the function right "Read access".
- Users who are to have HMI access must have a role with the function right "HMI access".

If a user does not have any of these specified function rights, that user has no access to the CPU.

Access levels also follow a hierarchical organization for the corresponding function rights:

- A user with "Full access incl. failsafe" also has "Full access".
- A user with "Full access" also has the function rights "Read access" and "HMI access".
- A user with "Read access" also has the function right "HMI access".

NOTE

Compatibility of the ENDIS_PW instruction
The ENDIS_PW instruction (https://docs.tia.siemens.cloud/access?ft:originId=./10867183243/52385784203_enUS.htm&ft:clusterId./10867183243/52385784203.htm) can only be used to disable or enable passwords for access levels. The ENDIS_PW instruction has no effect on assigned rights for users or roles. When using ENDIS_PW, take care to prevent users from being locked out of access to the CPU (Page 186). (Page 186)

Continuing to use access levels

You can use access level protection only. This is required, for example, for HMI devices that only support access levels and do not yet support assignment of users and roles.

If, for example, you require the configuration of an access level to ensure HMI device access, you must activate the "Use legacy access control via access levels" option in the CPU properties.

NOTE

Users for OPC UA and for the web server

Independent of the access protection, you always have to configure the users (Page 150) for the Web server and OPC UA server.

Restrictions on continued use of the access levels

When using the "Legacy access control" option, you cannot select the access level directly in the table for setting the access levels. You can only set access protection via the function rights of the "Anonymous" user.

The local user "Anonymous" is created in a project by the system by default. With the "Anonymous" user, you determine the behavior of the CPUs in the project for someone who logs in without a user name and password. For security reasons, the Anonymous user is deactivated. You must activate it to use it.

In the CPU properties in the device configuration or in the security wizard when you add a CPU, you can access the editor to provide settings for the "Anonymous" user.

Examples:

- If the "Anonymous" user is deactivated or if the "Anonymous" user is activated and no function rights have been assigned to that user, then nobody can log in without a user name and password. This corresponds to the access level "No access (complete protection").
- If the "Anonymous" user is activated and the "Full access" function right for a CPU is assigned to that user via a corresponding role, the result of this setting is "No protection". You can achieve the same effect with regard to access protection by setting "No access protection" in the "Protection & Security" area of the CPU properties.

Procedure

To activate the "Legacy access control" and set the required access level, follow these steps:

1. In the CPU properties, go to "Protection & Security > Access control".
2. Select the option "Activate access control" and, in addition, select the check box "Use legacy access control via access levels" check box.

   The access level selection cannot be used in this setting. You have to set the access level via the "Anonymous" user of the CPU.

   The "Anonymous" user is deactivated by default. This means that the resulting access level for users without a password is "No access (complete protection)" (default setting).
3. Go to "Security Settings > Users and roles" in the project tree.

4. Activate the "Anonymous" user if you want to set a different access level than "No access (complete protection)". You can assign a role with function rights that grants access to the CPU without password input, only to the activated "Anonymous" user.
5. You cannot assign function rights for a CPU directly to a user. You must first assign a role.

To assign a role, switch to the "Roles" tab and add a new role. Assign a meaningful name, for example, "PLC1-Read-Access-Role". If you assign this role to a user, this user should have read access to PLC1 during operation.

1. Assign the required function right for the access to the CPU with the name "PLC1" to the role "PLC1-Read-Access-Role", in this case "Read access".
2. Switch to the "User" tab and assign the "PLC1-Read-Access-Role" role to the activated "Anonymous" user.

   Result: The "Anonymous" user has read access for PLC1. This means that the access level tables of the CPU "PLC1" in the project are preset to "Read access" (cannot be changed) and users who are not logged in only have read access.

   For full access, or full access including fail-safe, you must configure a password for the full access in the table for the access protection. Users who need full access to the CPU during runtime via an action, for example, because a project is to be loaded onto the CPU, must legitimize themselves for this action with this password.

6.3.4 Important information when using the ENDIS_PW instruction

Using the ENDIS_PW instruction (https://docs.tia.siemens.cloud/access?ft:originId=./10867183243/52385784203_enUS.htm&ft:clusterId./10867183243/52385784203.htm) to disable password access on the S7-1200 G2 CPU requires planning to prevent being locked out from CPU access. Because the S7-1200 G2 CPU does not have a display or keyswitch, like the S7-1500 CPU, if a reset of the CPU occurs where the startup state transitions to STOP mode, the ENDIS_PW instruction cannot run to re-enable passwords. This could cause users to be locked out of access to the CPU.

In versions 4.1 and later of the S7-1200 G2 CPU, existing password locks are removed during the transition from POWER OFF to POWER ON. This was not the case for V1.0.x versions where the passwords remained locked after POWER ON..

The S7-1200 G2 CPU applies configured passwords on power-up of the CPU. To have the passwords disabled after power-up, you must re-run the ENDIS_PW instruction to disable the passwords again.

Preventing unintentional lockout of an S7-1200 G2 CPU

Existing password locks are removed during the transition from POWER OFF to POWER ON of an S7-1200 G2 CPU. This means that it is possible and advisable to prevent unintentional lockout with the help of specific program sequences within your program.

To avoid unintentional lockout, program a time control with either a Cyclic interrupt OB or a timer in
OB 1. This gives you the option of calling the ENDIS_PW instruction in OB1 or the Cyclic interrupt OB relatively quickly after a transition from POWER OFF to POWER ON.

Call ENDIS_PW in the Startup OB to keep as short as possible the time window in which the application is not active and thus ensure that no restrictions exist in the password legitimization. This procedure offers you the greatest possible protection against unauthorized access.

If there has been an accidental lockout, you can omit the call in the Startup OB, by querying an input parameter, for example, and setting a time, for example, ten seconds up to one minute to establish a connection to the CPU before the lock becomes active once again.

If there is no timer in your program code and a lockout has occurred, follow the procedure below to recover from lost passwords.

Procedure for lost passwords with an S7-1200 G2 CPU

If you have lost the password for a password-protected S7-1200 G2 CPU, delete the password-protected program with an empty transfer card or program card. The empty transfer card or program card deletes the internal load memory of the CPU. You can then load a new user program from STEP 7 to in the CPU.

6.4 Central user management

6.4.1 Useful information on central user management and access control

S7-1200 G2 CPUs have a feature whereby authentication of users can be left to a central UMC server.

You manage users centrally and combine multiple users with the same roles/function rights into one group.

The central authentication service is performed by the UMC (User Management Component) (https://support.industry.siemens.com/cs/us/en/view/109780337).

You set up linking between user/group and assigned roles and function rights in the editor "Users and roles (Page 150)" in TIA Portal - as with the local user management.

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution, but only if you ensure the confidentiality of the user-relevant information.

In addition, you must observer the rules for industrial cybersecurity (Page 21), for example regarding the "Defense in Depth" security concept, and in particular the remarks on plant security and hardening measures.

Advantages of central user management

Central user management allows management of users and user groups independently of TIA Portal. This enables the user management to be scaled from a few users and CPUs in a single project (local user management) up to extensive automation solutions with multiple projects, users and user groups (central user management) without increased workload.

If you use the central user management (UMC), you can, for example, configure user groups on the UMC server set up for this purpose. The users of a group then have the same roles and function rights on the CPU.

During operation, users can be added to or removed from a group or passwords can be changed on the UMC server. The CPU configurations do not need to be changed and reloaded.

NOTE

Decoupling the user management from the CPU involves risks

When central user management is used, the CPU or TIA project has no way of checking the central user administration. UMC administrators must carefully check the effect of their changes with regard to modified roles and function rights.

Changes to central users at the time of the change do not affect the existing connection to the CPU. These include, for example, the following changes:

- Deletion of a user on the UMC server
- Moving users to other groups on the UMC server, which causes changes to roles and rights.

The changed user configuration only takes effect when you log in again.

Requirements

The Users and roles editor in the TIA Portal provides you with a wide scope of usage scenarios in connection with UMC:

- Programming device with TIA Portal that is connected to a UMC domain: In this case, the users and groups can be synchronized in the editor for users and roles.
- Programming device with TIA Portal that is not connected to a UMC domain but the names of the user groups/central users used in operation are known and can be added without contact to the UMC server:
  - The names of the user groups/central users can also be entered without connection to the UMC domain and synchronized with the UMC domain later.
  - Synchronization is not necessary for authentication of CPU users via a UMC server. The group names or user names only have to match to make use of the authentication service.

A CPU that needs to authenticate the querying users (for example, via web, PG/HMI communication, or OPC UA) for diverse online functions requires the following information for accessing the authentication service:

- The UMC server address

  Example: https://central.umc.testnet:443/ra

  (443 = Port for https, ra = remote authentication)
- A server ID (fingerprint of the server certificate).

  You can determine the fingerprint of a certificate through Windows: (Open the certificate, "Details" tab, "Fingerprint" field).

As an alternative to the server ID, you can configure a list of CA certificates. These certificates are used by the CPU to verify the certificate returned by the UMC server when a connection is established. In order for the verification to be successful, the entire certificate chain down to the root certificate must have been loaded. The verification does not work for end-entity certificates or for intermediate certificates without a certificate chain to the root certificate.

Further requirements for operation during runtime are as follows:

- User groups and users have been set up on the UMC server.
- A connection can be established between the CPU and UMC server via the configured UMC server address.
- CPU time is current. As with local user management, central users are informed about the remaining validity of their password. CPU and UMC server must have the same date and time settings.

NOTE

No logon possible if the UMC server is not available or the CPU time is reset

– If you use only UMC users and UMC user groups to access the CPU during operation and the UMC server becomes unreachable, for example, due to connection abort, then no one can log on anymore.
  – To enable access to the CPU in this case, configure at least one local user with the required roles/function rights.
– If you use UMC user groups or UMC users to access the CPU during operation, the CPU time must be up-to-ate.
  If the CPU time has been reset, for example, by restoring the factory settings, and no NTP time synchronization has been configured, it is also not possible to log on via the central user management. Authentication of the UMC server using certificates requires an up-to-date CPU time.
  – To enable access to the CPU in this case, configure at least one local user with the required roles/function rights to set the time (for example, from the "Web server – Maintenance" group).
  – Alternatively, you can synchronize the CPU time using NTP servers (Page 167)

Basic procedure for using the User Management Component (UMC)

The following tasks are required to use the User Management Component (UMC):

1. Installation of UMC on one or more computers in the system
2. Assigning a corresponding UMC version as a UMC ring server or UMC server to create a UMC system consisting of one or multiple UMC computers.
3. Creating users and user groups in UMC: These can exist only in UMC or can be imported from a Microsoft Active Directory.
4. Connection of the UMC agent that is installed on the computer with the TIA Portal installation: The connection can be established with the TIA Administrator or with the Windows command line.
5. Use of UMC users and UMC user groups, for example, in the context of the TIA Portal project creation
6. Authentication of UMC users after logging on via UMC

NOTE

Enabled "Anonymous" user is always loaded

An enabled "Anonymous" user with its configured roles/function rights is loaded even if you only enabled the central user management. Local user management does not have to be additionally enabled for the "Anonymous" user to take effect.

6.4.2 Configuring central user management in the editor for users and roles

The following procedures describe central user management in TIA Portal with an S7-1200 G2 CPU for the following use cases:

- The project is configured in the environment that has access to the UMC server.
- The project is created in an environment that has no access to the UMC server.

  This is, for example, the case for a machine that is configured independently of the later place of installation and environment. The parameters for the user management must still be modified at the installation location.

Requirements - TIA Portal has access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is an online connection to the UMC server.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (Project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click the "Add new UMC user group" button.



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the user groups, select the user groups to be imported into the editor.
6. Assign the desired roles to the groups.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User" tab.
3. Click "Add user".



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the central users, select the users to be imported into the editor.
6. Assign the desired roles to the users.

Requirements - TIA Portal has no access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is no online connection to the UMC server at the time in which user management is configured.

NOTE

Case sensitivity of user name

Although the UMC server does not differentiate between upper and lower case of the user name/group name when logging on, deviations in case prevent the user from logging on for users/groups configured offline or unsynchronized in the TIA Portal.

Recommendation:

- Before login, synchronize users and user groups in the TIA Portal and download this configuration to the CPU. In this practice, the case of the user name is not relevant during logon.
- If possible, import users/groups as described above.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click in the <Add new user group> field in the "Name" column.
   The TIA Portal enters a default name.
4. Modify the default name. This name will be used in the target environment of UMC.
   The name can also be modified in the target environment during commissioning.

Result: The groups are set up but not synchronized, that is, no UM domain ID is assigned.

When a connection to the UMC server exists in the target environment, the following process takes place when a central user logs on:

- The CPU forwards the authentication request to the UMC server.
- After a successful check, the UMC server returns a list of groups to which the logged-on user belongs.
- The CPU determines the assigned roles and function rights for the user based on the group names.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Click in the <Add new user> field in the "User name" column.
   The user type "Local user" is preset.
3. Modify the default user name - this name will be used in the target environment of UMC.
4. In the column "User type" change the entry to "Central user".

Result: The central user has been set up but not yet synchronized, meaning that no UM domain ID is assigned.

In the target environment with a connection to a UMC server, you can still adjust the provisional group and central user names using the TIA Portal.

Effects of changing the user type

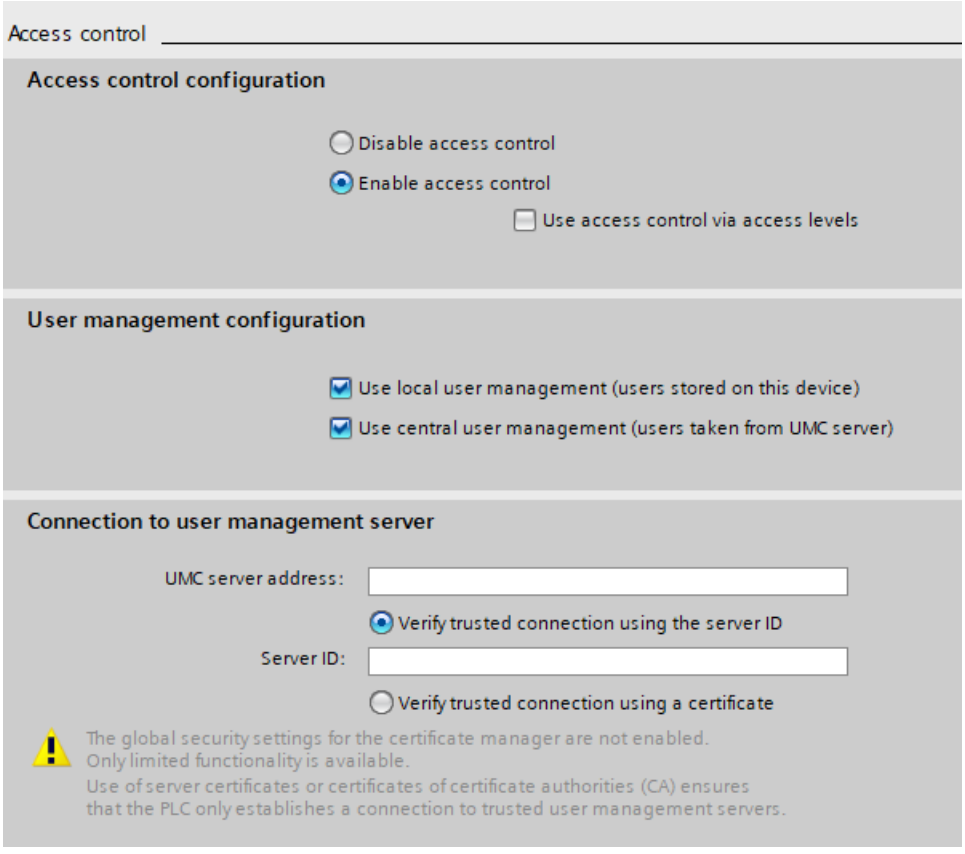
- When you change the user type from central user > to local user, the data for the connection to the UMC server is lost.
- When the user type is changed from local user to a central user, the configured password and the comment are lost.

6.4.3 Configuring central user management for an S7-1200 G2 CPU

Procedure - CPU configuration for central user management

To configure the central user management for an S7-1200 G2 CPU, follow these steps:

1. From the properties of the CPU in Device configuration, navigate to "Protection & Security > Access control".
2. Ensure that access control has been enabled.
3. Activate the option "Use central user management (users taken from UMC server)".
   In addition, you can also activate local user management to be able to access the CPU if, for example, the connection to the UMC server fails.
4. Add the specifications to the UMC server address and server ID for authentication of the UMC server.
   As an alternative to the server ID, you can also add the CA certificate or intermediate certificate for authentication. The CPU must have the entire certificate chain for verification of the server certificate including root certificate.



Changing the connection data for the UMC server

A user with a role that grants full access to the CPU can download modified connection data (UMC server address and server ID) in both STOP and RUN modes of the CPU.

6.4.4 Logon of central users

The processes for the logon of central users are described below from the perspective of different applications.

Requirements

Requirements for logging on as a central user are as follows:

- A UMC server is connected to the CPU and is accessible.
- The required central users and groups have been set up for the UMC server.
- The CPUs are configured accordingly for the central user management (roles and function rights) and the configuration is loaded.

Logging onto a protected CPU

If you access a CPU online and the operation requires function rights, a dialog appears where you enter the user type. You can log on as a central user.

Causes of a failed logon of a central user

Common logon failures include the following:

- Entering an unconfigured or wrong user name
- Entering a wrong password
- A network problem such as the UMC server is not reachable or an oversized response frame

Tip: Set up a local user who can read the diagnostic buffer in the event of a failed logon and determine the exact cause. In the diagnostic buffer, the causes are represented by an error code that you can interpret using the following table. Each entry in the diagnostic buffer also leads to a corresponding syslog message so that connected evaluation systems can record the processes.

Table 1-179 Error codes for failed login

Error code	Meaning
#8000 0001	Missing configuration. The UMC server endpoint is not specified.
#8000 1000	Unspecified UMC system error.
#8000 1001	No DNS address configured.
#8000 1002	The DNS server is not reachable, for example, because it was shut down as the remote port is not reachable due to firewall settings.
#8000 1003	During data exchange with the UMC server: The interface is currently receiving new parameters.
#8000 1004	The UMC server is not reachable. The UMC server does not respond to the ARP frame or there are problems with the TCP handshake to establish a connection.
#8000 1005	The IP address of the UMC server is not reachable due to missing routing information.

Error code	Meaning
#8000 1006	The UMC server refuses to establish the connection. Connection was closed unexpectedly.
#8000 2xxx	Internal, unrecoverable TLS error.
#8000 3001	Validation of the UMC server certificate failed. Possible causes: Verification against the chain of trust not possible. Certificate not valid or expired. Verification of Identity failed (subject alternative name, FQDN, IPv4 check). Server ID verification failed (fingerprint).
#8000 4001	UMC server does not respond (timeout).
#8000 4002	HTTP response frame too long (system limit exceeded).
#8000 4003	Invalid HTTP response.
#8000 5xxx	Encoded HTTP status code of the HTTP request. Example of an encoding of Status Code 500 (#1F4) = Internal Server Error: Coding: #8000 5000 + #1F4 (=500) = #8000 51F4
#8000 6001	Syntax error in JSON response frame from UMC server.
#8000 6002	JSON response frame from the UMC server too long (system limit exceeded).
#8000 6003	Unexpected JSON format. The message has a valid JSON format, but it is not a valid UMC authentication response from the UMC server.
#8000 7xxx	Login failed (unknown error).

Logging on as an OPC UA client or as a Web client

When an OPC UA client logs on to the OPC UA server of the S7-1200 G2 CPU, the user name and password are transferred via the UserNameIdentityToken.

The user name and password are also queried for Web clients if you want to use the full functionality of the Web server (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/comprehensive-information/cpu-function-manuals/web-server). The following process applies to OPC UA clients and Web clients:

- For central users, the CPU forwards the authentication query to the UMC server.
- If the authentication is successful, the UMC server returns the assigned groups to which the user belongs.
- The CPU generates the corresponding session context and grants the authorizations (function rights from the determined roles).
- The client can then execute the access in the context of the session in accordance with the granted function rights.

How does the CPU (OPC UA server or the Web site of the Web server) detect whether the user is a local or central user?

You have the freedom to configure a user both as a local user and as a central user. This results in an ambiguity about which service is responsible for the authentication and which user ultimately gains access. Since access permission for the user depends solely on the

password in this case, you should use strong passwords, for example, created by a password generator.

The following rules apply to ensure unambiguousness for the responsible authentication service (local or central user management):

- For logon of a local user, add the prefix "L:" (uppercase or lowercase) in front of the user name.

  Example: L:username
- If you do not use a prefix for the user names, central user management is automatically responsible (when central and local user management are used at the same time). If you use only one type of user management, access is unambiguous even without a prefix.
- A user name must not begin with the string "L:" (uppercase or lowercase).

6.5 Configuring access protection for the CPU

Introduction

You can use the local user management (Page 179) in the editor for users and roles in the project tree. The access levels are represented there by function rights of the same name which you assign to individual users through their roles.

The CPU provides you with various access levels to limit access to specific functions.

By setting up access levels and passwords, you limit the functions and memory areas that are accessible without a password. The individual access levels and their associated passwords are specified in the object properties of the CPU.

Rules for passwords

Ensure that passwords are sufficiently secure by applying the following rules:

- Assign a password that is at least ten characters long.
- Use different cases and characters: uppercase/lowercase, numbers and special characters.

Passwords must not follow a machine-recognizable pattern.

Access levels of the CPU

Access levels	Access restrictions
Full access including fail-safe (no protection)	Users of STEP 7 and HMI applications have access to all standard and fail-safe functions. A password is not required.
Complete access (no protection)	Users of STEP 7 have access to standard functions. HMI applications can access all functions (fail-safe and standard). Additionally, to access the fail-safe functions, the user must enter the password for "Full access incl. fail-safe" in STEP 7.
Read access	In this access level, only read access to the hardware configuration and the blocks is possible without a password. HMI access and access to diagnostics data is also possible. You can download neither blocks nor the hardware configuration to the CPUs without the password. Additionally, you cannot write test functions or perform an online firmware update without the password.

Access levels	Access restrictions
HMI access	The access restrictions that apply to read access also apply to HMI access. Additionally, you cannot perform test functions, change the operating mode (RUN/STOP), perform a firmware update, or display an online/offline comparison status.
No access (complete protection)	When the CPU has complete protection, no read or write access to the hardware configuration and the blocks is possible (without access authorization in the form of a password). HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level and cannot be changed. Authentication with the password provides you full access to the CPU.

An enumeration of which functions are available in the different access levels is available in "Setting options for the protection" in the TIA Portal Information System.

Properties of the access levels

Each access level allows unrestricted access to certain functions without entering a password, for example, identification using the "Accessible devices" function.

The default of the CPUs is "No access (complete protection)". In the default access level, the user can neither read nor change the hardware configuration or the blocks. To obtain access to the CPUs, use one of the following alternative parameter assignments in the properties of the CPU:

- A password for the protection level "No access (complete protection)"
- A different protection level, for example, "Full access (no protection)"

Communication between the CPUs, such as through the communication functions in the blocks, is not restricted by the access level of the CPU, unless PUT/GET communication is deactivated in the "No access (complete protection)" access level.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

NOTE

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes on the CPU through network access. Access levels are used to restrict the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC Memory Card are not write-protected or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC Memory Card.

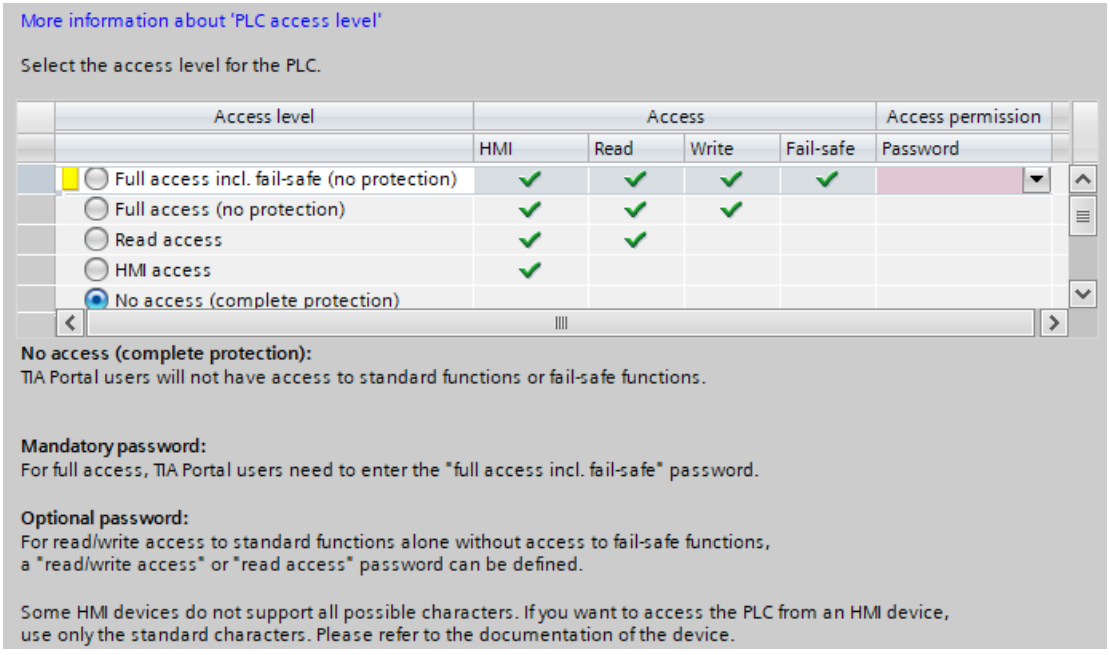
Behavior of functions with different access levels

The TIA Portal Information System contains a tabular list of the online functions that are possible in the various access levels.

Configuring access levels

To configure the access levels for an S7-1200 G2 CPU, follow these steps:

1. Open the properties of the S7-1200 G2 CPU in the Inspector window.
2. Open the "Protection & Security" entry in the area navigation.
   A table with the possible access levels appears in the Inspector window.



3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the respective access level show you which operations are still available without entering the password. In this example, access is not possible without a password.
4. In the "Access permission" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to prevent incorrect entries.
5. Assign additional passwords as required for other access levels.
6. Download the hardware configuration for the access level to take effect.

The CPU logs the following actions with an entry in the diagnostic buffer:

- Input of the correct or incorrect password
- Changes to access level configuration

Behavior of a password-protected CPU during operation

Protection of an S7-1200 G2 CPU takes effect for an online connection after you have downloaded the settings to the CPU. If you set a higher access level and download it to the CPU, all other online connections are interrupted. You must then establish a new online connection.

Before an online function is executed, STEP 7 checks the necessary permission and, if necessary, prompts the user to enter a password. The functions protected by a password can

only be executed by one programming device/PC at any one time. Another programming device/PC cannot log on.

Logon authorization to the protected data applies for the duration of the online connection or for as long as you have STEP 7 open. The menu command "Online > Delete access rights" cancels the access authorization.

Access level for F-CPUs

For fail-safe CPUs, there is an additional access level in addition to the four described access levels. For more information on this access level, refer to the description of the fail-safe system in SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/us/en/view/54110126).

6.6 Know-how protection

Application

You can use know-how protection to protect one or more OB, FB or FC blocks as well as global data blocks in your program from unauthorized access. Enter a password to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block. Know-how protection does not involve the CPU (offline access in STEP 7).

Password provider

As an alternative to manual password input, you can assign a password provider to STEP 7. When using a password provider, you select a password from a list of available passwords. When a protected block is opened, STEP 7 connects to the password provider and retrieves the corresponding password.

To connect a password provider you have to install and activate it. A settings file in which you define the use of a password provider is also required.

A password provider offers you the following advantages:

- The password provider defines and manages the passwords. When know-how protected blocks are opened, you work with symbolic names for passwords. For example, a password is marked with the symbolic name "Machine_1" n the password provider. The actual password behind "Machine1" remains hidden from you.
  A password provider therefore offers optimum block protection as the users do not know the password themselves.
- STEP 7 automatically opens know-how protected blocks without the direct entry of a password. This saves you time.

You can find more information on connecting a password provider in the STEP 7 online help.

Readable data

If a block is know-how protected, only the following data is readable without the correct password:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling within a program
- Online/offline comparison
- Load

Global data blocks and array data blocks

You protect global data blocks (global DBs) from unauthorized access with know-how protection. If you do not have the valid password, you can read the global data block but not change it.

Know-how protection is not available for array data blocks (array DBs).

Setting up block know-how protection

To set up block know-how protection, follow these steps:

1. Open the properties of the respective block.
2. Select the "Protection" option under "General".

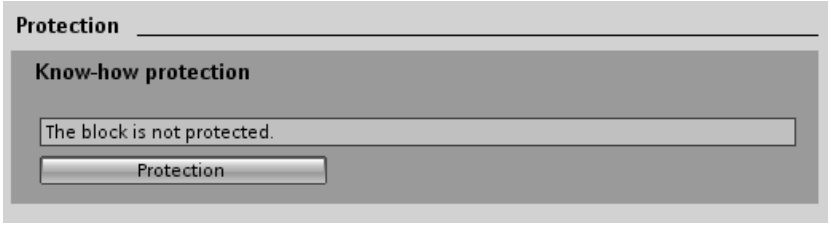


Figure 1-44 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Define protection" dialog.

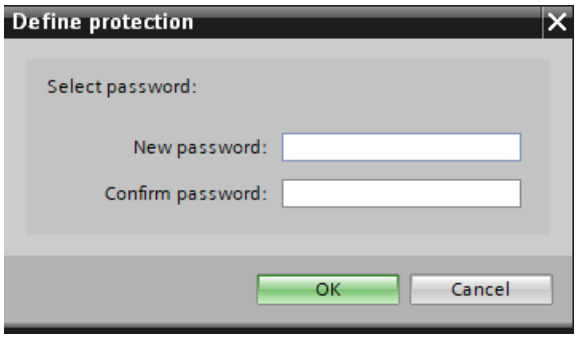


Figure 1-45 Setting up block know-how protection (2)

4. Enter the new password in the "New password" field. Enter the same password in the "Confirm password" field.
5. Click "OK" to confirm your entry.
6. Close the "Know-how protection" dialog by clicking "OK".

Result: The blocks selected will be know-how-protected. Know-how protected blocks are marked with a lock symbol in the project tree. The password entered applies to all blocks selected.

NOTE

Password provider

Alternatively, you can set up know-how protection for blocks with a password provider.

Opening know-how protected blocks

To open a know-how protected block, follow these steps:

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected blockopens.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. You need to enter the password again the next time you open the block. If you close the "Access protection" dialog with "Cancel", the block will open but the block code will not be displayed. You will not be able to edit the block.

If you copy the block or add it to a library, for example, this does not cancel the know-how protection of the block. The copies will also be know-how-protected.

Changing know-how protection for blocks

To change the know-how protection for blocks, follow these steps:

1. Select the block for which you want to change the know-how protection. The protected block must not be open in the program editor.
2. To open the "Change protection" dialog, select the "Know-how protection" command in the "Edit" menu.
3. To change the password for the know-how protection, enter the current password under "Old password".
4. Then enter a new password under "New password" and confirm the password under "Confirm password".
5. Click "OK" to confirm your entry.

Result: The password for the know-how protection of the selected block has been changed.

Removing know-how protection for blocks

To remove block know-how protection, follow these steps:

1. Select the block from which you want to remove know-how protection. The protected block must not be open in the program editor.
2. Select the "Know-how protection" command in the "Edit" menu.

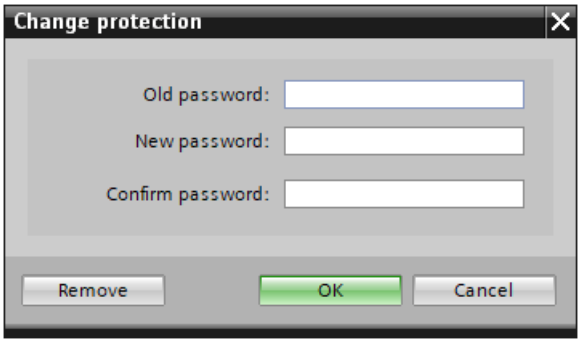


Figure 1-46 Removing know-how protection for blocks

3. To remove the block protection, enter the current password under "Old password". Leave the fields for the new password empty.
4. Click "Remove" to confirm your entry.

Result: Know-how protection for the selected block has been canceled.

6.7 Using the user program to set additional access protection

Access protection by means of the user program

In addition to access protection, you can also restrict access to a password-protected CPU using the ENDIS_PW instruction (https://docs.tia.siemens.cloud/access?ft:originId=./10867183243/52385784203_enUS.htm&ft:clusterId./10867183243/52385784203.htm) in STEP 7. When using ENDIS_PW, take care to prevent users from being locked out of access to the CPU (Page 186).

Communication 7

7.1 Overview

The S7-1200 G2 offers several types of communication between CPUs and programming devices, HMIs, and other CPUs.

PROFINET

PROFINET (https://us.profinet.com/) (PN) is used for exchanging data through the STEP 7 program with other communications partners through Ethernet.

For the S7-1200 G2, PROFINET supports 31 IO devices with a maximum of 512 submodules as well as the following:

- S7 communication (Page 252)
- Open User Communication with the following protocols:
  - User Datagram Protocol (Page 225) (UDP)
  - ISO on TCP (Page 225) (RFC 1006)
  - Transport Control Protocol (Page 224) (TCP)
- PROFINET Security Class 1 (https://support.industry.siemens.com/cs/ww/en/view/49948856/184125926283)

PROFINET IO controller

As an IO controller using PROFINET IO, the CPU communicates with up to 31 PN devices on the local PN network.

CPU-to-CPU S7 communication

You can create a communication connection (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/34492344715_enUS.htm&ft:clusterId./10866368523/34492344715.htm) to a partner station and use the PUT and GET instructions (Page 252) to communicate with S7 CPUs.

Network security

⚠ WARNING

Avoiding security risks from network attacks
If an attacker can access your networks, the attacker can possibly read and write data.
For example, I/O exchange through PROFINET, PUT/GET (Page 252), T-Block, and communication modules (CMs) have no security features. You must protect these forms of communication.
If you fail to protect these forms of communication, death or severe personal injury can result.
For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Web site.

OPC UA server

S7-1200 G2 CPUs support configuration as an OPC UA server (Page 257) for data access. OPC UA clients can securely connect to the S7-1200 G2's OPC UA serverto read or write the PLC data.

7.2 Secure communication

S7-1200 G2 CPUs implement secure communication between PLCs and the TIA Portal, SIMATIC Automation Tool, and HMIs. This implementation uses the industry standard TLS 1.3 (Transport Layer Security) protocol. The S7-1200 G2 CPU does not support legacy PG/PC communication.

Advantages of secure communication

Secure communication offers the following advantages:

- Confidentiality: Ensures that data remains confidential and cannot be accessed by unauthorized individuals.
- Integrity: Guarantees that the received message has not been modified during transmission.
- End point authentication: Verifies the identity of the communication partner.

Today, networked industrial machinery and control systems with sensitive data are at high risk and consequently pose high security requirements for data exchange.

Protection through firewall, VPN connection, or a security module, was common in the past and remains common. In addition to physical security, secure communication supports the transfer of data to external communication partners in encrypted form.

The CPU uses X.509 certificates (Page 209) to provide secure communication between the CPU and clients. Clients such as STEP 7 and the SIMATIC Automation Tool might require that you trust the certificate that is in the CPU. Be aware of the certificate you download to a CPU so that you can trust it when prompted.

Considerations when using secure communication

Communication speeds can be slower with secure communication.

- Actual firmware version of the physical CPU
- Configured firmware version (Page 169) of the CPU in the STEP 7 project

Additional information

You can find additional details about the implementation of secure communication in the TIA Portal Information System. In particular, additional information about certificates is in the following TIA Portal Information System topics:

- Confidentiality through encryption
- Managing certificates with STEP 7
- Examples for the management of certificates
- Authenticity and integrity through signatures

7.3 Communication protocols and ports used by Ethernet communication

The specified ports are the standard port numbers that the S7-1200 G2 CPU uses. Many communication protocols and implementations enable you to use other port numbers. The following tables show different layers, protocols, and ports used in the S7-1200 G2 CPU.

Table 1-180 Transport layer ports and protocols by S7-1200 G2

Port(s)	Direction	Protocol	Application	Description	Default setting/notes
25	Outbound	TCP	SMTP	SMTP is used for sending e-mails.	Default: Deactivated. Can be enabled via TMAIL_C instruction in the STEP 7 program.
68	Outbound	UDP	DHCP	The IP address suite is obtained from a DHCP server during the startup of the PROFINET interface.	Default: Deactivated. Can be changed in the CPU properties
102	Inbound/ Outbound	TCP	ISO-on-TCP	ISO-on-TCP (according to RFC 1006). The S7 protocol uses ISO-on-TCP according to RFC 1006 for PG/HMI communication with TIA Portal.	Default: Activated. This function cannot be deactivated.
123	Outbound	UDP	NTP	NTP is used for synchronization of the CPU system time with the time of an NTP server.	Default: Deactivated. Can be enabled in the CPU properties.
161	Inbound	UDP	SNMP	SNMP is used for reading and setting network management data (SNMP managed Objects) by the SNMP Manager.	Default: Deactivated. Can be enabled via data record in the STEP 7 project or in CPU Properties. Provides customizable community strings to limit access.
443	Inbound	TCP	HTTPS	HTTPS is used for secure communication with the CPU-internal web server over TLS.	Default: Deactivated. Can be enabled by enabling the Web server in the CPU properties.
465, 587	Outbound	TCP	SMTPS	SMTPS is used for sending e-mails over secure connections.	Default: Deactivated. Can be enabled via TMAIL_C instruction in the STEP 7 program.

Port(s)	Direction	Protocol	Application	Description	Default setting/notes
502	Inbound/ Outbound	TCP	Modbus	Modbus/TCP is used by MB_CLIENT/MB_SERVER instructions in the STEP 7 program.	Default: Deactivated. Can be activated via Modbus instructions in the STEP 7 project. Port 502 is the default port for Modbus, but can be configured to other values via the Modbus instructions in the STEP 7 program.
4840	Inbound	TCP	OPC UA	Open Platform Communications Unified Architecture (based on TCP/IP protocol). A communication standard ranging from the enterprise level to the field level.	Default: Deactivated. Can be enabled in the CPU properties.
6514, 514	Outbound	TCP (6514) UDP (514)	Syslog Client	The Syslog client of the CPU is used for transferring syslog messages to a server.	Default: Deactivated. Can be enabled in the CPU properties. You can configure the forwarding of syslog messages to a syslog server in the CPU properties. The collection of system logging events within a CPU cannot be disabled. Port 6514 is the default value for Syslog servers in STEP 7. Port 514 is the standard port for UDP Syslog servers, but it is not the default value even if you select UDP in the STEP 7 project configuration.
34964	Inbound/ Outbound	UDP	PROFINET Context Manager	The PROFINET Context Manager provides an endpoint mapper in order to establish an application relation (PROFINET AR).	Default: Enabled (UDP port open). This function cannot be deactivated.

Table 1-181 Port ranges that could be used by Open User Communication (OUC) and other protocols.

Port Range	Direction	Protocol	Application	Description
1-1999	Varies	TCP/UDP	OUC	This port range can be used to limited extent, excluding already used ports.
2000-5000	Varies	TCP/UDP	OUC	This is the recommended port range for OUC.
5001-49151	Varies	TCP/UDP	OUC	This port range can be used to limited extent, excluding already used ports.
49152-65535	Outbound	TCP/UDP	Varies	This is the Dynamic port area used for active connection end point if the application does not determine the local port number.

You define these communication parameters in the STEP 7 program.

Table 1-182 Protocols used by S7-1200 G2 in the Data Link and Network Layer (Layer 2, 3) of the OSI model.

Protocol	Direction	Ethertype	Description
PROFINET DCP	Inbound/Outbound	0x8892	DCP is used by PROFINET to discover PROFINET devices and provide basic settings. DCP uses the special multicast MAC addresses: 01-0E-CF-00-00-00 and 01-0E-CF-00-00-01.
LLDP	Outbound	0x88CC	LLDP is used by PROFINET to discover and manage neighbor relationships between PROFINET devices. LLDP uses the special multicast MAC address: 01-80-C2-00-00-0E.

Protocol	Direction	Ethertype	Description
PROFINET IO	Inbound/Outbound	0x8892	The PROFINET IO frames are used to transmit IO data cyclically between PROFINET IO controller and IO devices via Ethernet.
ICMP	Inbound	0x0800	Internet Control Message Protocol is used for diagnostic or control purposes.
MRP	Inbound/Outbound	0x88E3	Media Redundancy Protocol enables control of redundant transmission paths in a ring topology. MRP uses the special multicast MAC addresses: 01:15:4E:00:00:01 and 01:15:4E:00:00:02

7.4 Asynchronous communication connections

Overview of communication services

The CPU supports the following communication services:

Communication service	Functionality	Ethernet
PG communication	Commissioning, testing, diagnostics	Yes
HMI communication	Operator control and monitoring	Yes
S7 communication	Data exchange using configured connections	Yes
PROFINET IO	Data exchange between I/O controllers and I/O devices	Yes
Web server	Diagnostics, maintenance, and process data	Yes
SNMP (Page 250) [1] (Simple Network Management Protocol)	Standard protocol for network diagnostics and parameterization	Yes
Open communication over TCP/IP	Data exchange over Industrial Ethernet with TCP/IP protocol (with Open user communication instructions)	Yes
Open communication over ISO on TCP	Data exchange over Industrial Ethernet with ISO on TCP protocol (with Open user communication instructions)	Yes
Open communication over UDP	Data exchange over Industrial Ethernet with UDP protocol (with Open user communication instructions)	Yes
Near Field Communication (NFC) (Page 299)	Data exchange between the PLC and a mobile phone	No

[1] The CPU supports SNMP V1 without TRAPs (alarm frames).

Available connections

The CPU supports a fixed number of maximum simultaneous asynchronous communication connections for PROFINET; you cannot change these values. You can configure the "Free available connections" to increase the number of any category as required by your application.

Some connection types have a fixed number of reserved resources (sometimes called guaranteed). This means that the CPU is guaranteed to support up to the number of reserved resources for the connection type. Additional connections beyond the number of reserved

resources can be made for a connection type, but those connection resources must come from the "dynamic" resources pool.

The dynamic resources (sometimes called Free) are a collection of resources that can be used for any connection type. These resources are used by connections that do not have any reserved resources or by connections that have used up all of their reserved resources.

S7-1200 G2 CPUs have 10 reserved connection resources and 78 dynamic resources for a total of 88 connection resources.

Based upon the allocated connection resources, the following number of connections per CPU are available:

Type	Maximum guaranteed connections	Maximum dynamic connections	Total connections possible[2]
Programming device (PG) communication	4	78[1]	82
Human Machine Interface (HMI) communication	4	78[1]	82
S7 communication	0	78[1]	78
Open User communication	0	78[1]	78
Web communication	2	78	80

[1] Adding CMs/CPs allows for 40 additional dynamic connections.

[2] Since the dynamic connections are shared, it is not possible to max out all connections simultaneously.

For an example, the CPU has four available PG connection resources. Depending on the current PG functions in use, the PG might actually use one, two, three, or four of its available connection resources. You can always use one PG.

NOTE

Web server connections: The CPU provides connections for multiple Web browsers. The number of browsers that the CPU can simultaneously support depends upon how many connections a given Web browser requests/utilizes and the number of dynamic connection resources available in the CPU.

NOTE

The Open user communication, S7 connection, HMI, programming device, and Web server communication connections can utilize multiple connection resources based upon the features currently being used.

7.5 Supported certificates

Secure communication services require certificates with certain security parameters.

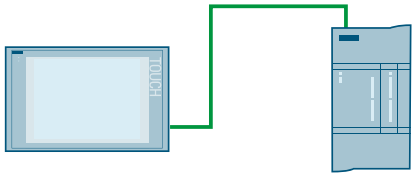
You can create or select these certificates from the following areas in the TIA Portal "General" tab of the CPU "Properties" window:

- "Web server > Security": Use for the generation and assignment of Web server certificates.
- "Protection & Security > Connection mechanisms": Use for the generation or assignment of PLC communication or Secure PG/PC and HMI communication certificates.
- "Protection & Security > Certificate manager": Use for the generation or assignment of all types of certificates. The default setting for the creation of certificates is TLS certificates for Secure Open User Communication (Secure OUC), Syslog, and OPC UA.

For more information on generating and assigning certificates or certificate parameters, refer to the TIA Portal Information System.

7.6 PROFINET

The S7-1200 G2 CPU supports PROFINET communications connections to HMIs.



Consider the following requirements when setting up communications between CPUs and HMIs:

Configuration/Setup:

- The PROFINET port of the CPU must be configured to connect with the HMI.
- The HMI must be setup and configured.
- The HMI configuration information is part of the CPU project and can be configured and downloaded from within the project.
- The HMI driver must be selected from the Device wizard. The S7-1200 G2 CPU uses the "SIMATIC S7-1500" driver to communicate with Basic or Comfort HMIs, and the "SIMATIC S7-1200/1500" driver to communicate with Unified panels.

NOTE

All S7-1200 G2 CPUs feature one PROFINET interface equipped with two ports that operate as an Ethernet switch.

Configuring communication between the HMI and a CPU

To configure communication between the HMI and a CPU, do the following:

1. Establish the hardware communications connection (Page 231). A PROFINET interface establishes the physical connection between an HMI and a CPU. Since Auto-Cross-Over functionality is built into the CPU, you can use either a standard or crossover Ethernet cable for the interface. An Ethernet switch is not required to connect an HMI and a CPU.
2. Configure the device (Page 232).

3. Configure the logical network connections between an HMI and a CPU (Page 212).
4. Configure an IP address in your project (Page 217). You must configure IP addresses for the HMI and the CPU.
5. Test the PROFINET network (Page 233). You must download the configuration for each CPU and HMI device.

Supported HMI connection mechanisms

You can configure your HMI communication preferences in the "Device configuration" for your CPU under "Protection & Security > Connection mechanisms". The S7-1200 G2 supports the following HMI connection mechanisms based on panel type:

Panel type	S7-1200 G2 supported HMI connection mechanisms
Basic Panel	GET/PUT (Page 252)
	Secure PG/PC and HMI Communication
Comfort Panel	GET/PUT
	Secure PG/PC and HMI Communication
Unified Panel	GET/PUT
	Secure PG/PC and HMI Communication
	Standard Modbus TCP/IP (Page 293)

NOTE

Secure PG/PC and HMI Communication requires an HMI device image of V17 or later.

Supported HMI tags and subscriptions

The CPU supports 2000 tags for up to 250 HMI subscriptions. For further details on HMI connection resources and connection optimization, see the "Connection resources and connection optimization for HMI operator panels with S7-Controllers (https://support.industry.siemens.com/cs/pl/en/view/109479986)" FAQ.

See also

Supported certificates (Page 209)

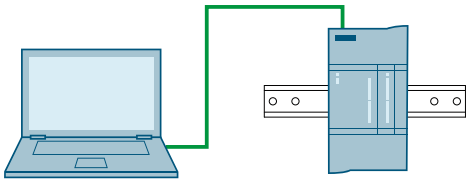
7.6.1 CPU communication

The S7-1200 G2 CPU can communicate with the following devices:

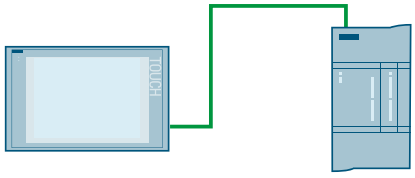
- Other CPUs
- Programming devices
- HMI devices
- Non-Siemens devices using standard TCP communications protocols

Example connections are as follows:

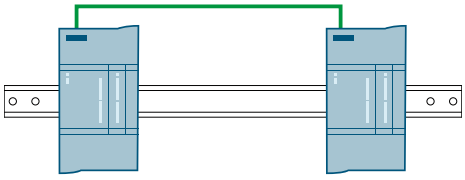
Programming device connected to the CPU (Page 230)



HMI connected to the CPU (Page 209)



A CPU connected to another CPU (Page 234)



NOTE

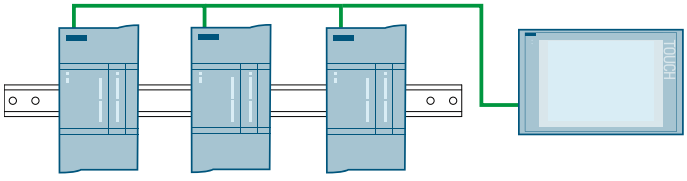
S7-1200 G2 CPUs do not support the IE/PB Link module.

Ethernet switching

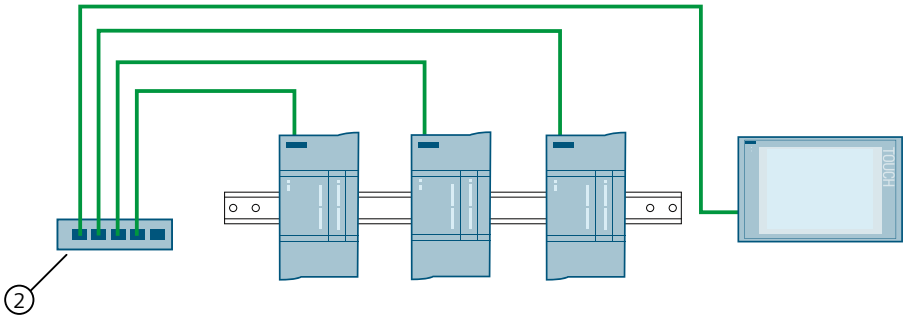
The S7-1200 G2 CPUs have a built-in 2-port Ethernet switch. You can use these built-in switches to create a network.

Example connections are as follows:

Multiple CPUs connected to an HMI device using the built-in 2-port Ethernet switch



Multiple CPUs connected to an HMI device using an external ethernet switch

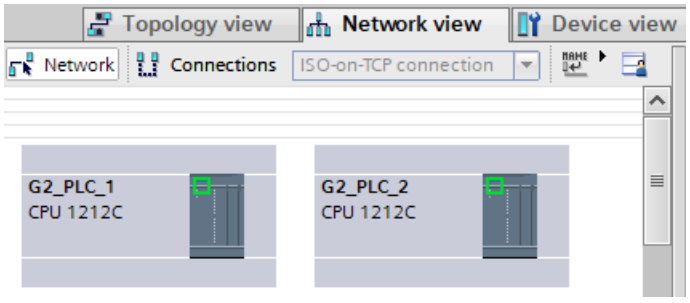


② External Ethernet switch

7.6.2 Creating a network connection

Use the "Network view" of Device configuration to create the network connections between the devices in your project.

1. Select "Network view" to display the devices to be connected.

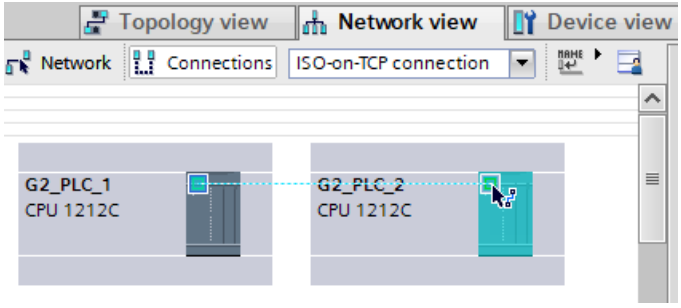


2. Select the "Connections" tab in the toolbar of Network view and choose your connection type from the dropdown menu.

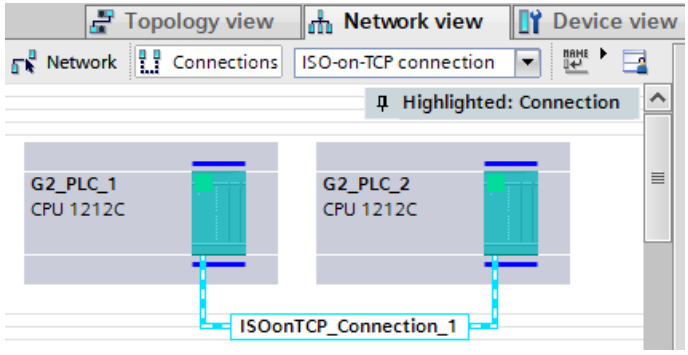
   Note: the S7-1200 G2 supports the following connections:

   – S7 connection (Page 252)
   – ISO-on-TCP connection (Page 225)
   – TCP connection (Page 224)
   – UDP connection (Page 225)
   – HMI connection (Page 209) (PLC to an HMI)

3. Select the port on one device and drag the connection to the port on the second device.



4. Release the mouse button to create the network connection.



After creating the network connection, use the "Properties" tab of the inspector window to configure the parameters of the network.

7.6.3 Configuring the Local/Partner connection path

A Local/Partner (remote) connection defines a logical assignment of two communication partners to establish communication services. A connection defines the following:

- Communication partners involved (one active, one passive)
- Type of connection (for example, a PLC, HMI, or device connection)
- Connection path

Communication partners execute the instructions to set up and establish the communication connection. You use instruction parameters to specify the active and passive communication end point partners. After the STEP 7 program sets up and establishes the connection, the CPU automatically maintains and monitors the connection.

If the connection is terminated (for example, due to a line break), the active partner attempts to re-establish the configured connection. You do not have to execute the communication instruction again.

For more information, see the following:

- "Connection configuration (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/42307475211_enUS.htm&ft:clusterId./10866368523/42307475211.htm)"
- "Connection parameters (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13452671883_enUS.htm&ft:clusterId./10866368523/13452671883.htm)"

7.6.4 Locating the Ethernet (MAC) address on the CPU

In PROFINET networking, a Media Access Control address (MAC address) is an identifier assigned to the network interface by the manufacturer for identification. A MAC address usually encodes the manufacturer's registered identification number.

The standard (IEEE 802.3) format for printing MAC addresses in human-friendly form is six groups of two hexadecimal digits, separated by hyphens (-) or colons (:), in transmission order, (for example, 01-23-45-67-89-ab or 01:23:45:67:89:ab).

Each CPU is loaded at the factory with a permanent, unique MAC address. You cannot change the MAC address of a CPU.

The MAC address is printed on the front, upper-left corner of the CPU. Note that you have to lower the upper door to see the MAC address information.

The CPU interface is designated as X1, and initially has no IP address, only a factory-installed MAC address. PROFINET communication requires that all devices be assigned a unique IP address.

NOTE

Three sequential MAC addresses are assigned to the CPU:

- The lowest number, the number printed on the CPU, is for the X1 interface.
- The next higher number is for port P1R.
- The highest number is for port P2R.

The low-level protocols (Page 243) require the MAC addresses for P1R and P2R.

7.6.5 Assigning Internet Protocol (IP) addresses

7.6.5.1 Assigning IP addresses to programming and network devices

If the network interface of your programming device connects to a local area network (LAN) with multiple subnets, both the programming device and the CPU must be on the same subnet. You assign the subnet as a combination of the IP address and subnet mask for the device. See your local network administrator for help.

The Network ID of a Class C IP address is the first three octets of the IP address. The network ID of 211.154.184.16, for example, is 211.154.184. This network ID uniquely identifies your IP network. The subnet mask normally has a value of 255.255.255.0. Because your computer is on a plant LAN, however, the subnet mask might have various values, for example, 255.255.254.0, to set up unique subnets. The subnet mask, when combined with the device IP address in a logical AND operation, defines the boundaries of an IP subnet.

NOTE

You must assign unique IP addresses to all devices on your subnet.

⚠ WARNING

Unauthorized access to a CPU

Users with CPU full access or full access (incl. fail-safe) privileges have privileges to read and write PLC variables. Regardless of the access level for the CPU, Web server users can have privileges to modify PLC data and execute functions. Unauthorized access to the CPU can disrupt process operation.

Siemens recommends that you observe the following security practices:

- Enable Access control under "Protection & Security > Access control".
- Do not enable the "Anonymous" user.
- Use strong passwords, as defined in STEP 7.
- Use a secure Virtual Private Network (VPN) to connect to the S7-1200 G2 PLC from a location outside your protected network.
- Perform error-checking and range-checking on your variables in your program logic because Web server or users can change PLC variables to invalid values.

Disruption of process operations can result in death, severe personal injury, and/or property damage.

NOTE

A secondary network adapter card is useful when you do not want your CPU on your company LAN. During initial testing or commissioning tests, this arrangement is particularly useful.

Assigning or checking the IP address of your programming device

To assign or check your programming device's IP address, follow these steps:

1. Open the Control Panel.
2. Navigate to the "Network and Sharing Center".
3. Click "Change adapter settings" in the left column.

4. Right-click the network interface connected to your CPU.
5. Select "Properties" to open the properties dialog.
6. In the properties dialog, select the checkbox for "Internet Protocol Version 4 (TCP/IPv4)".
7. Click the "Properties" button.
8. Select "Obtain an IP address automatically" or to enter a static IP address select "Use the following IP address".

   If you selected "Use the following IP address", set the IP address and subnet mask:

   – Set the IP address to use the same Network ID and same subnet as the CPU. For example, if the CPU IP address is **192.168.0**.1, you could set the IP address to **192.168.0**.200.
   – Select a subnet mask of 255.255.255.0.
   – Leave the default gateway blank.

Consult your network administrator to help you set up a network configuration to allow you to connect to the S7-1200 G2 CPU.

7.6.5.2 Checking the IP address and MAC address of your network interface

To check the MAC and IP addresses of your network interface in STEP 7, follow these steps:

1. In the "Project tree", expand "Online access".
2. Right-click the required network interface, and select "Properties".
3. In the dialog, expand "Configurations", and select "Industrial Ethernet".

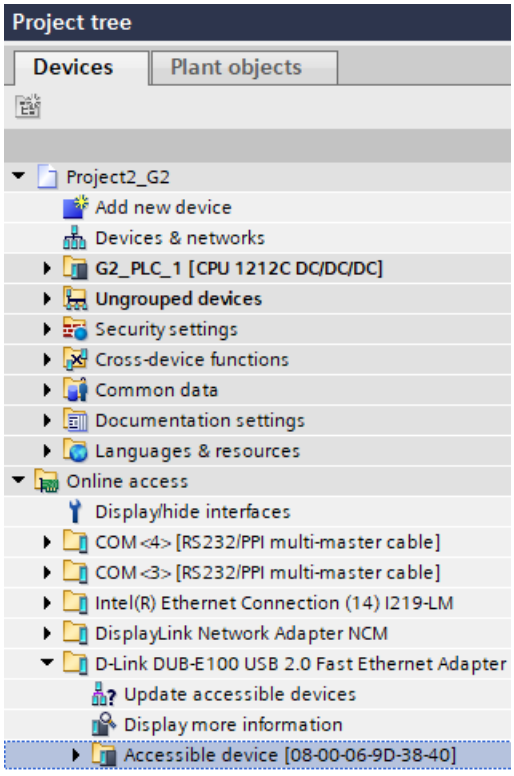
The window displays the MAC and IP addresses of the network interface.

7.6.5.3 Assigning an IP address to an online CPU

You can assign an IP address to a network device online. This is particularly useful in an initial device configuration.

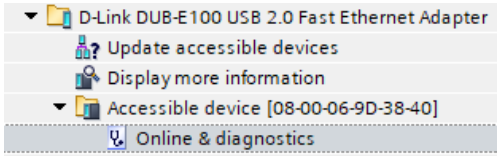
To verify that the CPU does not have a configured IP address, do the following:

1. In the "Project tree", expand "Online access".
2. Expand the network in which the device is located.
3. Double-click "Update accessible devices".
   If STEP 7 displays a MAC address instead of an IP address, then no IP address has been assigned.



To assign an IP address, follow these steps:

1. Expand the PLC for which you want to assign an IP address.
2. Double-click "Online & diagnostics".

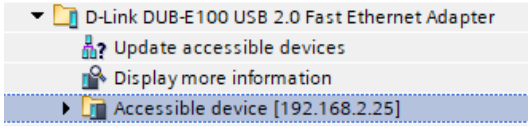


3. In the "Online & diagnostics" dialog, select "Functions > Assign IP address".

4. In the "IP address" field, enter your new IP address, and click "Assign IP address".



To verify that STEP 7 has assigned your new IP address to the CPU, double-click "Update accessible devices". It should now display the IP address that you configured.



7.6.5.4 Configuring an IP address for a CPU in your project

Configuring the PROFINET interface

In the Device configuration (Page 151) of the CPU, you can configure parameters for the PROFINET interface. Click the green PROFINET interface on the CPU and then select the "Properties" tab in the inspector window to display the PROFINET port.

Subnet and Subnet mask

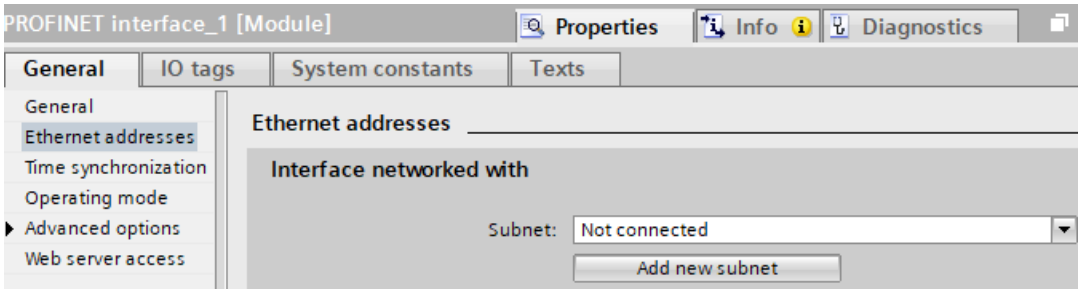
A subnet is a logical grouping of connected network devices. Nodes on a subnet tend to be located in close physical proximity to each other on a Local Area Network (LAN). A mask, known as the subnet mask or network mask, defines the boundaries of an IP subnet.

A subnet mask of 255.255.255.0 is suitable for a small local network. This means that all IP addresses on this network should have the same first three octets, and the various devices on this network are identified by the last octet (8-bit field). An example of this is to assign a subnet mask of 255.255.255.0 and an IP address of 192.168.2.0 through 192.168.2.255 to the devices on a small local network.

The only connection between different subnets is through a router. You must use an IP router if you use more than one subnet.

To set your subnet in your STEP 7 project, follow these steps:

1. In Device configuration, select the "Properties" Tab.
2. Under the "General" tab, select "Ethernet addresses".
3. In the "Interface networked with" section, click "Add new subnet" to create a new subnet. The default "Not connected" provides a local connection. You can choose a previously added subnet from the dropdown menu.



Internet Protocol (IP) address

Each device must also have an Internet Protocol (IP) address. This address allows the device to deliver data on a more complex, routed network. Each IP address is divided into four 8-bit octets and is expressed in a dotted, decimal format (for example, 211.154.184.16). The first part of the IP address is used for the Network ID, and the second part of the address is for the Host ID which is unique for each device on the network. An IP address of 192.168.x.y is a standard designation recognized as part of a private network that is not routed on the Internet.

In your STEP 7 project, you can configure how the IP address is set. In Device configuration, click the "Properties" Tab and select "Ethernet addresses". Choose one of the following options:

- Set IP address in the project
- IP address from DHCP (Dynamic HostConfiguration Protocol) server
- IP address is set directly at the device

Optionally, select "Use router" and enter the router's IP address if your network uses a router.

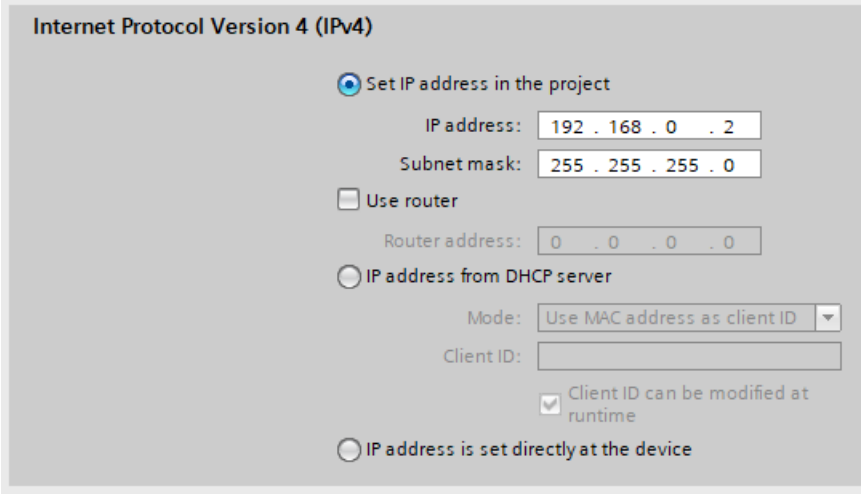


Table 1-183 Parameters for the IP address

Protocol	Parameter	Description
Set IP address in the project	IP address	Assigned IP address for the CPU
	Subnet mask	Assigned subnet mask
Use router		Click the checkbox to indicate the use of an IP router. Routers are the link between LANs. Using a router, a computer in a LAN can send messages to any other networks, which might have other LANs behind them. If the destination of the data is not within the LAN, the router forwards the data to another network or group of networks where it can be delivered to its destination. Routers rely on IP addresses to deliver and receive data packets.
	Router address	Assigned IP address for the router, if applicable
IP address from DHCP server	Mode	An external DHCP server provides the IP address (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/139974759307_enUS.htm&ft:clusterId./10866368523/139974759307.htm) based on either the MAC address of your network interface or an optional client ID. However, if the client ID is not configured, the server will not provide the MAC address as the identification.
	Client ID	
IP address is set directly at the device		Click the radio button set the IP address set directly at the device.

NOTE

The download operation sets all IP addresses for devices configured as "Set IP address in the project". If the CPU does not have a pre-configured IP address, download to the accessible device with the MAC address of your target device. If your CPU is connected to a router on a network, you must also enter the IP address of the router.

The "IP address is set directly at the device" radio button allows you to change the IP address through a tool such as the SIMATIC Automation Tool, Online & Diagnostics in the TIA Portal (Page 216), or by using the T_CONFIG instruction (Page 226) after the program is downloaded.

⚠ WARNING

Downloading a hardware configuration with "IP address is set directly at the device"

After downloading a hardware configuration with the "IP address is set directly at the device" option enabled, you cannot use communication functions to transition the CPU from RUN to STOP or from STOP to RUN until you set an IP address. User equipment continues to run under these conditions and can result in unexpected equipment and process operations.

Ensure that your CPU IP address(es) are set before using the CPU in an actual automation environment. This can be done by using STEP 7, the SIMATIC Automation Tool, or an attached HMI device in conjunction with the T_CONFIG instruction.

Unexpected equipment and process operations can cause death, severe personal injury, or property damage if proper precautions are not taken.

⚠ WARNING

Condition in which PROFINET network might stop
Changing the IP address of a CPU online or from the STEP 7 program can create a condition where the PROFINET network might stop. If the CPU's IP address is changed to one outside the subnet, the PROFINET network loses communication, and all data exchange stops. User equipment might be configured to keep running under these conditions. Loss of PROFINET communication can result in unexpected machine or process operations.
If an IP address must be changed, ensure that the new IP address lies within the subnet.
Unexpected machine or process operations can cause death, severe personal injury, or property damage if proper precautions are not taken.

Configuring the PROFINET port

By default, the CPU configures port(s) of the PROFINET interface for autonegotiation, a feature that allows connected devices to automatically determine and configure the best possible parameters for communication. For autonegotiation to function properly, you must configure both stations to autonegotiate. If one station has a fixed configuration (for example, full-duplex at 100 Mbps) and the other station is set to autonegotiate, then autonegotiation fails, resulting in half-duplex operation.

To overcome this limitation of autonegotiation, the S7-1200 G2 provides an option to disable autonegotiation. When you disable autonegotiation, the S7-1200 G2 is automatically configured for full-duplex operation at 100 Mbps.

To set the transmission rate and duplex to a fixed value for each port, follow these steps:

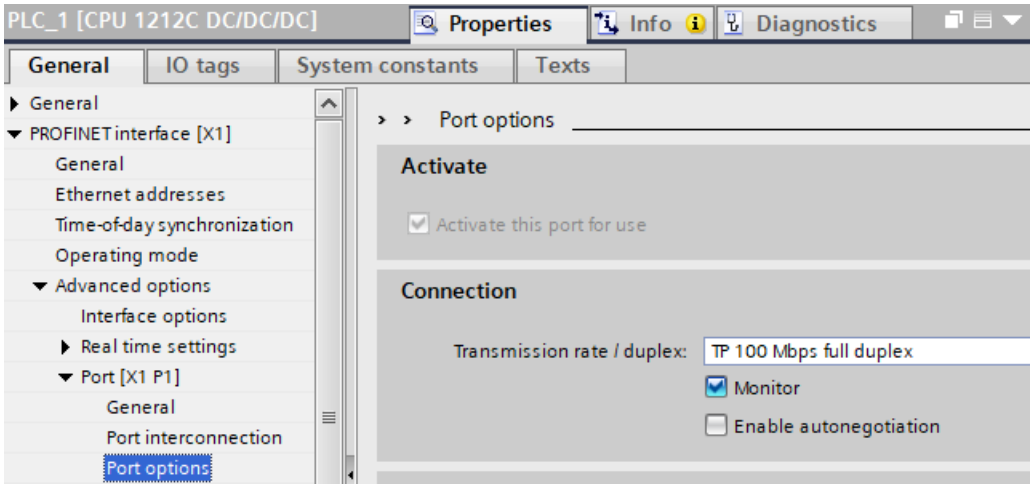
1. Select Advanced options and the port you need to configure. Then, select Port options.
2. In the Connection, Transmission rate / duplex field, select one of the following:
   - Automatic: The CPU and the peer device determine the port's transmission rate and duplex by autonegotiation.
   - TP 100 Mbps full-duplex: If you disable autonegotiation, the port operates at 100 Mbps full-duplex. If you enable autonegotiation, the port can operate at 100 Mbps full-duplex or another transmission rate / duplex that is autonegotiated between the CPU and the peer device. This places a message in the diagnostics buffer if "Monitor" is selected (see below).

You have the option to select the following parameters:

- Monitor: When you select this checkbox, the CPU places a message in the diagnostics buffer if any of the following occur at the port:
  - A link cannot be established
  - An established link fails
  - You select "TP 100 Mbps full-duplex" as the Transmission rate / duplex, and the CPU establishes a link using autonegotiation with the negotiated transmission rate not equal to 100 Mbps or the negotiated duplex equal to half-duplex.
- Enable autonegotiation: Once you set the Transmission rate / duplex field to full-duplex at 100 Mbps, you can then disable autonegotiation. Deselect the "Enable autonegotiation" checkbox to disable autonegotiation.

NOTE

If you disable autonegotiation, the CPU and the peer device do not negotiate the port's transmission rate and duplex.

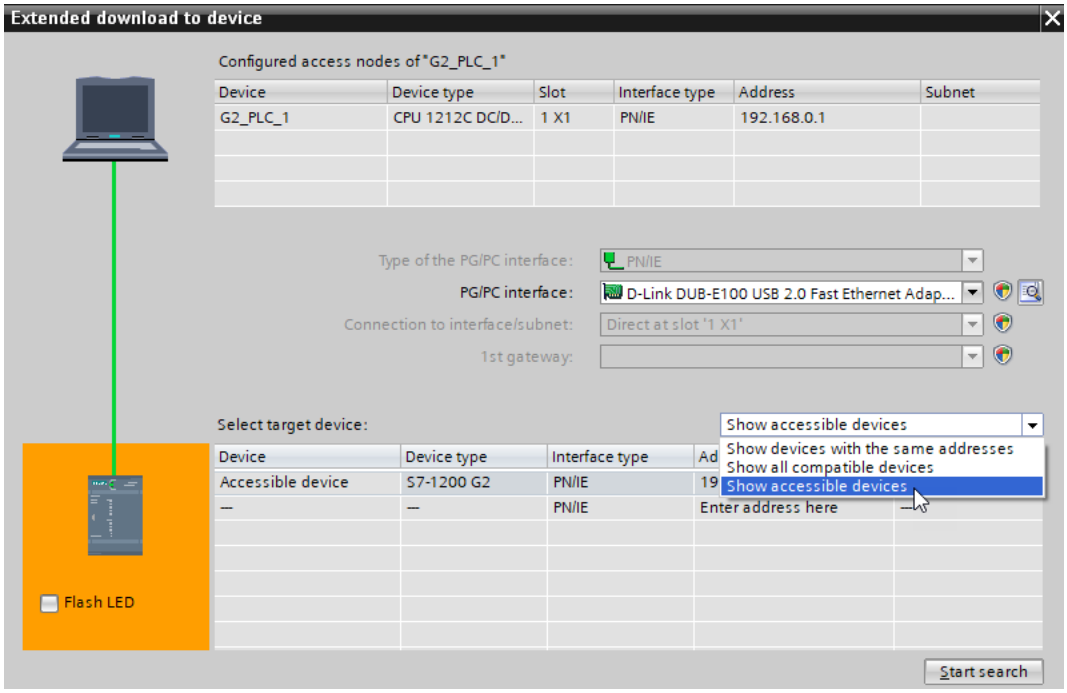


7.6.6 Testing the PROFINET network

After completing the configuration, download the project (Page 165) to the CPU.

Using the "Extended download to device" dialog to test for connected network devices

The S7-1200 G2 CPU "Download to device" function and its "Extended download to device" dialog show all accessible network devices and whether unique IP addresses have been assigned to all devices. To display all accessible and available devices with their assigned MAC or IP addresses, select "Show accessible devices" from the "Select target device" dropdown menu.



If the required network device is not in this list, communications to that device have been interrupted. The device and network must be investigated for hardware and/or configuration errors.

7.6.7 PROFINET device startup time, naming, and address assignment

PROFINET IO can extend the startup time for your system (Configuration time). More devices and slow devices impact the amount of time it takes to switch to RUN.

On your PROFINET network, you can have a maximum of 31 PROFINET IO devices, reducing to 30 devices if the CPU is an I-Device and 29 if the CPU is a shared I-Device.

All PROFINET devices must have a Device name and an IP Address.

Each station (or IO Device) starts up independently on startup, and this affects the overall CPU startup time. If you set the "Configuration time" too low, there might not be a sufficient overall CPU startup time for all stations to complete startup. If this situation occurs, false station errors will result.

The default Configuration time is 60,000 ms (1 minute). You can configure this in CPU Properties > Startup > Configuration time.

PROFINET address assignment at system startup

The controller broadcasts the names of the devices to the network, and the devices respond with their MAC addresses. The controller then assigns an IP address to the device using the PROFINET DCP protocol:

- If the MAC address has a configured IP address, then the station performs startup.
- If the MAC address does not have a configured IP address, STEP 7 assigns the address that is configured in the project, and the station then performs startup.

If there is a problem with this process, a station error occurs and no startup takes place. This situation causes the configurable time-out value to be exceeded.

7.6.8 Configuring Network Time Protocol (NTP) synchronization

The Network Time Protocol (NTP) is widely used to synchronize the clocks of computer systems to Internet time servers. In NTP mode, the CPU sends time-of-day queries at regular intervals (in the client mode) to the NTP server in the subnet (LAN). Based on the replies from the server, the NTP determines the most reliable and most accurate time and synchronizes the time of day on the querying module.

⚠ WARNING

Risk of network attacks through Network Time Protocol (NTP) synchronization
If an attacker can access your networks through Network Time Protocol (NTP) synchronization, the attacker can possibly disrupt control of your process by shifting the CPU system time.
The S7-1200 G2 CPU disables the NTP client feature by default. When you enable the NTP feature, then only the IP addresses that you configure can act as NTP servers. You must configure the NTP feature to allow CPU system time corrections from remote servers.
The S7-1200 G2 CPU supports "time of day" interrupts and clock instructions that depend upon accurate CPU system time. If you configure NTP and accept time synchronization from a server, you must ensure that the server is a trusted source. Failure to do so can cause a security breach that allows an unknown user to disrupt control of your process by shifting the CPU system time.
For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Web site.
Disruptions to process control can cause death, severe injury, or property damage.

The advantage of NTP mode is that it allows the time to be synchronized (https://docs.tia.siemens.cloud/access?ft:originId=./52541677963/31476189579_enUS.htm&ft:clusterId./52541677963/31476189579_enUS.htm) across subnets.

7.6.9 Open user communication

7.6.9.1 Protocols

The integrated PROFINET interface of the CPU supports multiple communications standards over an Ethernet network:

- Transport Control Protocol (TCP) (Page 224)
- ISO on TCP (Page 225)
- User Datagram Protocol (UDP) (Page 225)

Table 1-184 Protocols and communication instructions for each

Protocol	Usage examples	Entering data in the receive area	Communication instructions	Addressing type
TCP (Page 224)	CPU-to-CPU communication Transport of frames	Ad hoc mode (Page 226)	Only TRCV_C and TRCV	Assigns port numbers to the Local (active) and Partner (passive) devices
		Data reception with specified length	TSEND_C, TRCV_C, TCON, TCONSettings, TDISCON, TSEND, TRCV, T_RESET, and T_DIAG	
ISO on TCP (Page 225)	CPU-to-CPU communication Message fragmentation and reassembly	Ad hoc mode	Only TRCV_C and TRCV	Assigns TSAPs to the Local (active) and Partner (passive) devices
		Protocol-controlled	TSEND_C, TRCV_C, TCON, TCONSettings, TDISCON, TSEND, TRCV, T_RESET, and T_DIAG	
UDP (Page 225)	CPU-to-CPU communication STEP 7 program communications	User Datagram Protocol	TUSEND and TURCV	Assigns port numbers to the Local (active) and Partner (passive) devices, but is not a dedicated connection

7.6.9.2 TCP, ISO on TCP, and UDP

TCP

Transport Control Protocol (TCP) is a standard protocol described by RFC 793: Transmission Control Protocol (https://www.rfc-editor.org/info/rfc793). The primary purpose of TCP is to provide reliable connection service between pairs of processes. Most of the user application protocols, such as TELNET and FTP, commonly use TCP. This protocol offers the following features and capabilities:

- Offers an efficient communications protocol that is closely tied to the hardware
- Allows for the handling of data amounts up to 64 KB.
- Provides extensive facilities for applications, notably error recovery, flow control, and reliability
- Operates as a connection-oriented protocol
- Offers flexibly for integration with third-party systems that exclusively support TCP
- Provides routing capabilities
- Supports only static data lengths
- Acknowledges messages
- Addresses applications using port numbers
- Requires programming effort for data management due to the SEND / RECEIVE programming interface

ISO on TCP

International Organization for Standardization on Transport Control Protocol, commonly known as "ISO on TCP", is described by RFC 1006 (https://www.rfc-editor.org/info/rfc1006) as a mechanism that enables ISO applications to be ported to the TCP/IP network. This protocol has the following features and capabilities:

- Offers an efficient communications protocol that is closely tied to the hardware
- Allows for the handling of medium-sized to large data amounts (up to 64 KB)
- Provides routing capabilities; can be used in WAN
- Supports dynamic data lengths
- Requires programming effort for data management due to the SEND / RECEIVE programming interface

In contrast to TCP, the messages feature an end-of-data identification and are message-oriented.

Using Transport Service Access Points (TSAPs), TCP protocol allows multiple connections to a single IP address (up to 64K connections). With RFC 1006, TSAPs uniquely identify these communication end point connections to an IP address.

UDP

UDP (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/25643073419_enUS.htm&ft:clusterId./10866368523/25643073419.htm) is a standard protocol described by RFC 768: User Datagram Protocol (https://www.rfc-editor.org/info/rfc768). UDP is a simpler transport control protocol than TCP that provides a mechanism for one application to send a datagram to another; however, delivery of data is not guaranteed. UDP has the following features and capabilities:

- Offers a quick communications protocol
- Allows for the handling of small-sized to medium data amounts (up to 2048 bytes)
- Provides a thin layer that yields low overheads
- Offers flexibly for integration with many third-party systems
- Provides routing capabilities
- Uses port numbers to direct the datagrams
- Requires the application to take responsibility for error recovery and security as messages are unacknowledged
- Requires programming effort for data management due to the SEND / RECEIVE programming interface

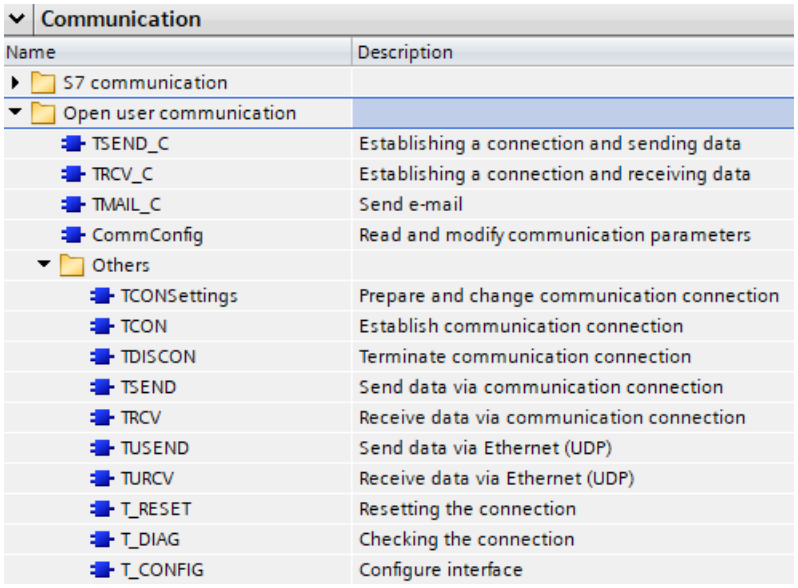
UDP supports broadcast communication. To use broadcast, you must configure the IP address portion of the ADDR configuration. For example: A CPU with an IP address of 192.168.2.10 and subnet mask of 255.255.255.0 would use a broadcast address of 192.168.2.255.

7.6.9.3 Ad hoc mode

Typically, TCP and ISO on TCP receive data packets of a specified length, ranging from 1 to 8192 bytes. However, the TRCV_C (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/19135463947_enUS.htm&ft:clusterId./18560165643/19135463947.htm) and TRCV (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/19142302219_enUS.htm&ft:clusterId./18560165643/19142302219.htm) communication instructions also provide an "ad hoc" communications mode that can receive data packets of a variable length from 1 to 1460 bytes.

7.6.9.4 Instructions

Open user communication instructions (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13367222283_enUS.htm&ft:clusterId./10866368523/13367222283.htm) provide for communication using various network protocols and include the following folder groups:



NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently within the tooltips or table of contents based on PLC family, follow the S7-1500 option for the instruction topic.

7.6.9.5 Connection IDs for the Open user communication instructions

Create an instance DB to configure the communications channel (or connection) between the devices by inserting the TSEND_C, TRCV_C or TCON instructions into STEP 7. To configure the parameters for the connection, utilize the Properties of the instruction. One of these parameters is the connection ID, which must be unique for the CPU. Ensure that each connection you create has a different DB and connection ID. Also, note the following:

- Both the local CPU and the partner CPU can use the same connection ID number for the same connection, but the connection ID numbers are not required to match. The connection ID number is relevant only for the Open user communication instructions within the user program of the individual CPU.
- You can use any number in the range of 1 to 4095 for the connection ID of the CPU. However, configuring the connection IDs sequentially from "1" provides an easy method for tracking the number of connections in use for a specific CPU. Alternatively, you can use the TCONSettings instruction to request a connection ID from the CPU.

NOTE

Each TSEND_C, TRCV_C, or TCON instruction in STEP 7 creates a new connection. It is important to use the correct connection ID for each connection.

For more information, see the following topics in the Open User Communication chapter of the TIA Portal Information System:

- TCON: Establish communication connection (S7-1200, S7-1500) (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/46790960779_enUS.htm&ft:clusterId./18560165643/46790960779.htm)
- TSEND_C: Establishing a connection and sending data (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/41150802699_enUS.htm&ft:clusterId./18560165643/41150802699.htm)
- TRCV_C: Establishing a connection and receiving data (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/41150876811_enUS.htm&ft:clusterId./18560165643/41150876811.htm)

7.6.9.6 Parameters for the OUC connection

The TSEND_C, TRCV_C, and TCON instructions require connection-related parameters (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13452671883_enUS.htm&ft:clusterId./10866368523/13452671883.htm) to connect to the partner device. The TCON_Param structure assigns these parameters for the TCP, ISO-on-TCP, and UDP protocols. Use the "Configuration" tab of the "Properties" of the instruction to specify these parameters. If the "Configuration" tab is not accessible, provide the TCON_Param structure in the instruction parameters.

NOTE

If you specify the address of a device as an FQDN via the connection types of TCON_QDN or TCON_QDN_SEC, you need to configure a DNS server (Page 228).

NOTE

Connection types of TCON_QDN_SEC and TCON_IP_V4_SEC use TLS for security (Page 228).

7.6.9.7 Transport Layer Security (TLS)

TLS is Transport Layer Security in the application layer of data communications. TLS increases security and privacy in communication between the S7-1200 G2 CPU and other devices.

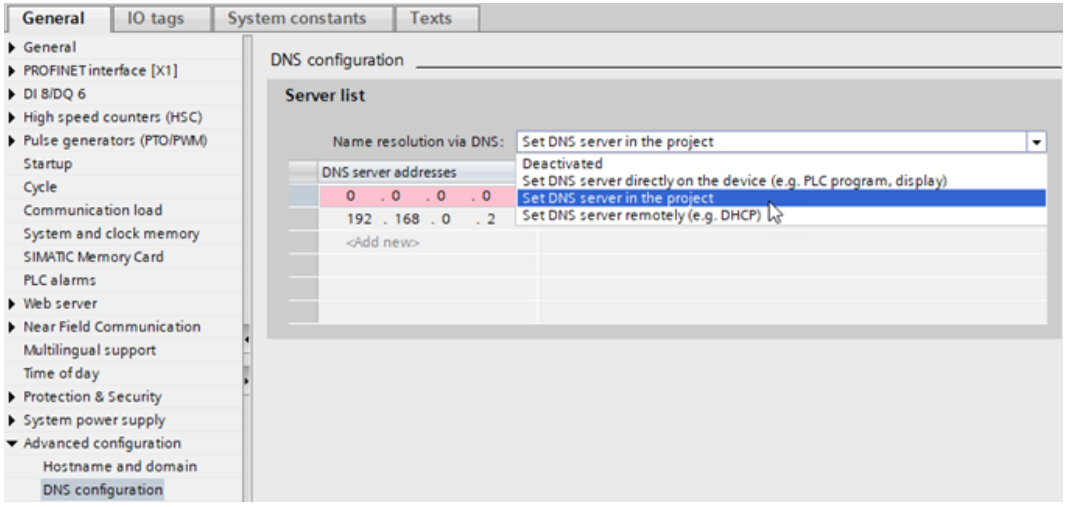
7.6.9.8 Configuring DNS

A DNS server might be required when the module itself, a communications partner, or for example an FTP server should be reachable via the host name (FQDN). If you specify the address of a connection partner as FQDN, configure a DNS server. In this case, the IP address of the connection partner is obtained via the configured DNS server.

To use DNS, you must have at least one DNS server in your network, and you must configure at least one DNS server for the S7-1200 G2 CPU.

To configure a DNS server, follow these steps:

1. From the Device view for your S7-1200 G2 CPU, navigate to "Properties > General".
2. Navigate to "Advanced configuration > DNS configuration" to display the configuration pane.
3. Select "Set DNS servers in the project" in the dropdown menu.



4. In the Server list table, click "<Add new>" and enter the IP address of your DNS server.

7.6.9.9 Configuring an OUC connection in the TIA Portal

For complete information on configuring an Open User Communication connection in STEP 7, see the following topics and chapters under "Using Open User Communication" in the TIA Portal Information System:

- Basics of Open User Communication (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13367222283_enUS.htm&ft:clusterId./10866368523/13367222283.htm)
- Connection configuration (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/42307475211_enUS.htm&ft:clusterId./10866368523/42307475211.htm)
- Connection parameters (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13452671883_enUS.htm&ft:clusterId./10866368523/13452671883.htm)

7.6.9.10 Common parameters for instructions

REQ input parameter

Many of the OUC instructions use the REQ input to initiate the operation on a low to high transition. The REQ input must be high (TRUE) for one execution of an instruction, but the REQ input can remain TRUE for as long as you choose. The instruction does not initiate another operation until it has been executed with the REQ input FALSE so that the instruction can reset the history state of the REQ input. This is required so that the instruction can detect the low to high transition to initiate the next operation.

When you place one of these instructions in your program, STEP 7 prompts you to identify the instance DB. Use a unique DB for each instruction call. This ensures that each instruction properly handles inputs such as REQ.

ID input parameter

The ID parameter is a reference to the "Local ID (hex)" on the "Network view" of "Devices and networks" in STEP 7 and is the ID of the network that you want to use for this communication block. The ID must be identical to the associated parameter ID in the local connection description.

DONE, NDR, BUSY, ERROR, and STATUS output parameters

The following parameters are common to the OUC instructions and provide outputs describing the completion status:

Table 1-185 Open User Communication instruction output parameters

Parameter	Data type	Default	Description
DONE	Bool	FALSE	Is set TRUE for one execution to indicate that the last request completed without errors; otherwise, FALSE.
NDR	Bool	FALSE	Is set TRUE for one execution to indicate that the requested action has completed without error and new data has been received; otherwise, FALSE.

Parameter	Data type	Default	Description
BUSY	Bool	FALSE	Is set TRUE when active to indicate that: • The job is not yet complete. • A new job cannot be triggered. Is set FALSE when job is complete.
ERROR	Bool	FALSE	Is set TRUE for one execution to indicate that the last request completed with errors, with the applicable error code in STATUS; otherwise, FALSE.
STATUS	Word	0	Is set to a status value as follows: • If the DONE or NDR bit is set, then STATUS is set to 0 or to an informational code. • If the ERROR bit is set, then STATUS is set to an error code. • If none of the above bits are set, then the instruction returns status results that describe the current state of the function. STATUS retains its value for the duration of the execution of the function.

NOTE
Note that DONE, NDR, and ERROR are set for one execution only.

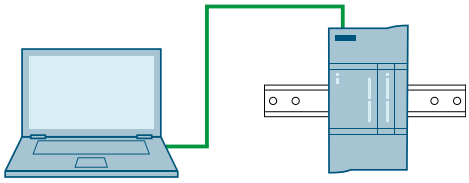
7.6.9.11 Restricted TSAPs or port numbers for passive ISO and TCP communication

If you use the TCON instruction to set up and establish a passive communications connection, do not use the following restricted port addresses:

- ISO TSAP (passive):
  - 01.00, 01.01, 02.00, 02.01, 03.00, 03.01
  - 10.00, 10.01, 11.00, 11.01, ... BF.00, BF.01
- TCP port (passive) and UDP port (passive):
  - 20, 21, 25, 80, 102, 443, 5001, 34962, 34963, 34964, 49152 to 65535

7.6.10 Communication with a programming device

A CPU can communicate with a STEP 7 programming device on a network.

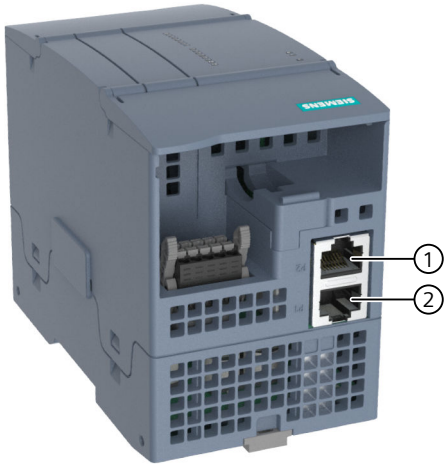


7.6.10.1 Establishing the hardware communications connection

PROFINET interfaces establish the physical connections between a programming device and a CPU. Since Auto-Cross-Over functionality is built into the CPU, either a standard or crossover Ethernet cable can be used for the interface. An Ethernet switch is not required to connect a programming device directly to a CPU.

Follow the steps below to create the hardware connection between a programming device and a CPU:

1. Install the CPU (Page 69).
2. Plug the Ethernet cable into one of the two PROFINET ports located on the top left of the CPU.
3. Connect the Ethernet cable to the programming device.



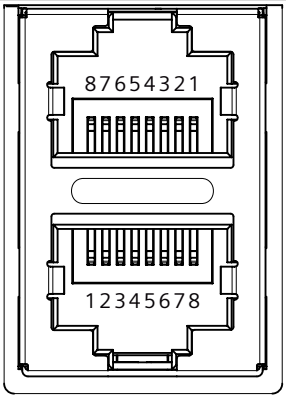
① X1P2
② X1P1

PROFINET interface X1 port pinouts

S7-1200 G2 CPUs connect to the PROFINET network using standard female RJ45 jacks. All S7-1200 G2 CPUs have dual-ports, but one interface. The connector pinout is the same for all CPUs.

The dual-ports of S7-1200 G2 CPUs have a standard Ethernet MDI-X pin configuration as follows:

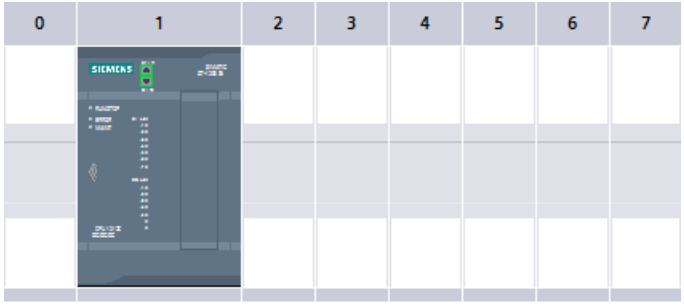
Pin	Signal name	Description	RJ45 female jack pinout
1	TD+	Transmit data	
2	TD-		
3	RD+	Receive data	
4	GND	Ground	
5	GND		

Pin	Signal name	Description	RJ45 female jack pinout
6	RD-	Receive data	
7	GND	Ground	
8	GND		

NOTE
All S7-1200 G2 CPUs are dual-port CPUs with no crossover between pins. There is an internal Ethernet switch in the units: The TD+/- and RD+/- pairs are not crossed over internally.

7.6.10.2 Configuring the devices

If you have already created a project with a CPU, open your project in STEP 7.
If not, create a project and insert a CPU (Page 152) into the rack.



Autonegotiation

If the port's configuration enables autonegotiation, the S7-1200 G2 CPU automatically detects the cable type and swaps the transmit/receive lines, if needed. If the port's configuration disables autonegotiation, the CPU also disables this automatic swap. You configure a port's autonegotiation setting (Page 217) in the TIA Portal's port options dialog. This is a port-specific advanced option for the PROFINET interface (X1) of the CPU's properties.

7.6.10.3 Testing the PROFINET network

After completing the configuration, download the project to the CPU. The download operation sets all IP addresses for devices configured as "Set IP address in the project".

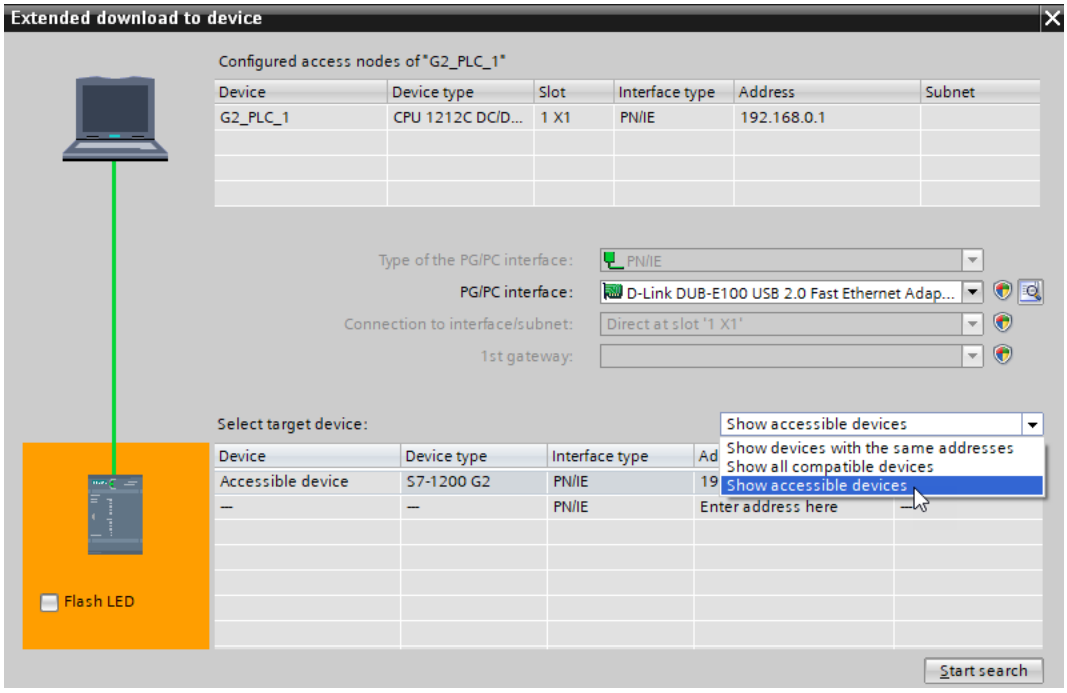
Assigning an IP address to an online CPU

The CPU does not have a pre-configured IP address. You must manually assign an IP address for the CPU in one of the following ways:

- Assign an IP address to an online CPU (Page 216).
- Assign IP address for a CPU in your project (Page 217). You must configure the IP address, save the configuration, and download it to the CPU.

Using the "Extended download to device" dialog to test for connected network devices

The CPU "Download to device" function and its "Extended download to device" dialog can show all accessible network devices and whether or not unique IP addresses have been assigned to all devices. To display all accessible and available devices with their assigned MAC or IP addresses, select "Show all accessible devices" from the dropdown menu.



If the required network device is not in this list, communications to that device have been interrupted for some reason. Check the device and network for hardware or configuration errors.

7.6.10.4 Assigning Internet Protocol (IP) addresses

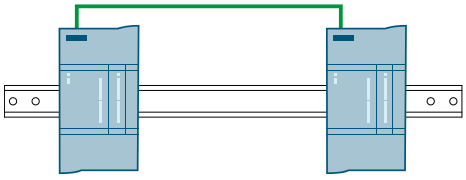
In a PROFINET network, each device must have an Internet Protocol (IP) address. This address allows the device to deliver data on a more complex, routed network:

- If you have programming or other network devices that use a network interface connected to your plant LAN or an Ethernet-to-USB adapter connected to an isolated network, you must assign IP addresses to them. Refer to "Assigning IP addresses to programming and network devices" (Page 214) for more information.
- You can also assign an IP address to a CPU or network device online (Page 216). This is particularly useful in an initial device configuration.
- After you have configured your CPU or network device in your project, you can configure parameters for the PROFINET interface to include its IP address. Refer to "Configuring an IP address for a CPU in your project" (Page 217) for more information.

7.6.11 PLC-to-PLC communication

A CPU can communicate with another CPU on a network.

One way to configure two CPUs to communicate with each other is by using the TSEND_C and TRCV_C instructions.



Consider the following when setting up communications between two CPUs:

- Configuration/Setup
- Supported functions: Reading/Writing data to a peer CPU
- No Ethernet switch is required for one-to-one communications; an Ethernet switch is required for more than two devices in a network unless the devices have a built in switch.

Configuring communication between two CPUs

To configure communication between two CPUs, follow these steps:

1. Establish the hardware communications connection (Page 231). A PROFINET interface establishes the physical connection between two CPUs. Since Auto-Cross-Over functionality is built into the CPU, you can use either a standard or crossover Ethernet cable for the interface. An Ethernet switch is not required to connect the two CPUs.
2. Configure the devices (Page 232). You must configure two CPUs in your project.
3. Configure the logical network connections between two CPUs (Page 212).
4. Configure an IP address in your project (Page 217). You must configure IP addresses for two CPUs (for example, PLC_1 and PLC_2).
5. Configure transmit (send) and receive parameters (Page 235). You must configure TSEND_C and TRCV_C instructions in both CPUs to enable communications between them.
6. Test the PROFINET network (Page 233). You must download the configuration for each CPU.

7.6.11.1 Configuring connection parameters

Configuring connection parameters

To specify the connection parameters, select any part of the instruction and do the following:

1. In the inspector window of STEP 7, select the "Properties" tab
2. Select the "Configuration" tab at right.
3. Select "Connection parameter".

Refer to "Configuring the Local/Partner connection path (Page 213)" for more information on each parameter.

Defining TSAPs (Transport Service Access Points) or Ports

If you configure a communication connection in your STEP 7 program, STEP 7 automatically assigns the TSAP (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/13575570443_enUS.htm&ft:clusterId./10866368523/13575570443.htm).

If you are using TBlocks, you can edit the TSAP fields in the "Address Details" section of the Connection parameters dialog or directly in the connection parameter Data block .

7.6.11.2 Configuring transmit (send) and receive parameters

Communication blocks (for example, TSEND_C and TRCV_C) are used to establish a connection between two CPUs. Before the CPUs can engage in PROFINET communications, you must configure parameters for transmitting (or sending) messages and receiving messages.

For more information on Configuring the TSEND_C and TRCV_C instructions, see the following topics:

- TSEND_C: Establishing a connection and sending data (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/41150802699_enUS.htm&ft:clusterId./18560165643/41150802699.htm)
- TRCV_C: Establishing a connection and receiving data (https://docs.tia.siemens.cloud/access?ft:originId=./18560165643/41150876811_enUS.htm&ft:clusterId./18560165643/41150876811.htm)

7.6.12 Configuring a CPU and PROFINET IO device

7.6.12.1 Adding a PROFINET IO device

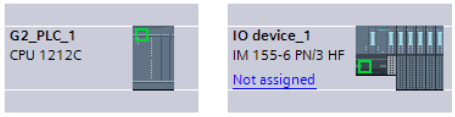
CPU-to-PROFINET IO device communication allows for data transmission and reception with specified length.

To add PROFINET IO devices in your STEP 7 program, follow these steps:

1. From the "Project tree", double click to select "Device configuration" for your CPU.
2. In the center window, select the "Network view" tab.
3. From the "Hardware catalog" pane at right, select the PROFINET IO device (sorted by part number).
4. Drag and drop the selected IO device into the "Network view" inspector window.

For example, expand the following containers in the hardware catalog to add an ET 200SP IO device: Distributed I/O, ET 200SP, Interface modules, and PROFINET. You can then select the interface module from the list of ET 200SP devices and add the ET 200SP IO device.

Table 1-186 Adding an ET 200SP IO device to the device configuration

Insert the IO device	Result
	

You can now connect the PROFINET IO device to the CPU:

1. Right-click the "Not assigned" link on the device and select "Assign new IO controller" from the context menu to display the "Select IO controller" dialog.
2. Select your CPU (in this example, "S7-1200 G2") from the list of IO controllers in the project.
3. Click "OK" to create the network connection.

You can also go to the "Devices and networks" window and use the "Network view" to create the network connections between the devices in your project:

1. To create a PROFINET connection, click the green (PROFINET) box on the first device, and drag a line to the PROFINET box on the second device.
2. Release the mouse button to configure the PROFINET connection.

Refer to "Device Configuration: Configuring the CPU for communication (Page 165)" for more information.

7.6.12.2 Assigning CPUs and device name

Network connections between the devices also assign the PROFINET IO device to the CPU, which is required for that CPU to control the device. To change this assignment, click the PLC name shown on the PROFINET IO device. Use the dialog box to disconnect the PROFINET IO device from the current CPU and reassign it to another CPU. Alternatively, you can leave the PROFINET IO device unassigned.

To connect with the CPU, you must assign a name to the devices on your PROFINET network (https://docs.tia.siemens.cloud/access?ft:originId=./19260980235/20299041291_enUS.htm&ft:clusterId./19260980235/20299041291.htm). If you have not assigned a name to the

devices, or if you need to change a device's name, use the "Network view" option. Select the PROFINET IO device and right-click to choose "Assign device name".

NOTE
You must assign the same name to each PROFINET IO device in both the STEP 7 project and the PROFINET network.

You can use one of the following tools to assign the device name in the PROFINET network:

- STEP 7 "Online & diagnostics" tool
- PRONETA commissioning, configuration, and diagnostics tool
- SIMATIC Automation Tool

If a name is missing or does not match in either location, the PROFINET IO data exchange mode will not run.

7.6.12.3 Assigning Internet Protocol (IP) addresses

In a PROFINET network, each device must have an Internet Protocol (IP) address. Note the following:

- If you have programming or other network devices that use an onboard adapter interface connected to your plant LAN or an Ethernet-to-USB adapter card connected to an isolated network, you must assign IP addresses to them. Refer to "Assigning IP addresses to programming and network devices" (Page 214) for more information.
- You can also assign an IP address to a CPU or network device online. This is particularly useful in an initial device configuration. Refer to "Assigning an IP address to a CPU online" (Page 216) for more information.
- After you have configured your CPU or network device in your project, you can configure parameters for the PROFINET interface to include its IP address. Refer to "Configuring an IP address for a CPU in your project" (Page 217) for more information.

7.6.12.4 Configuring the IO cycle time

The CPU supplies a PROFINET IO device with new data within an IO cycle time period. The update time can be separately configured for each device and determines the time interval in which data is transmitted from the CPU to and from the device.

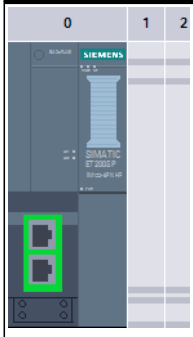
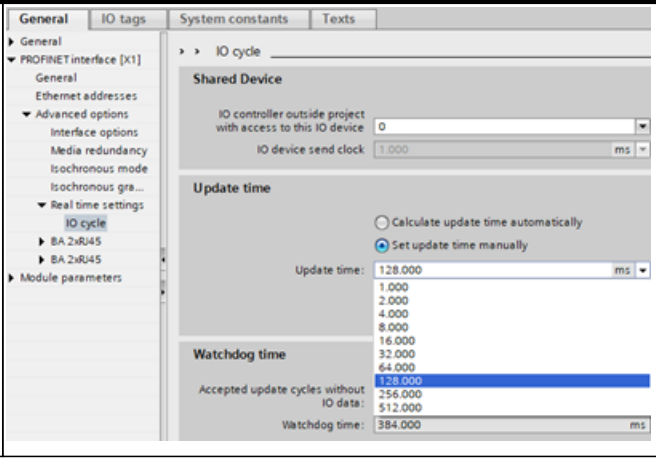
STEP 7 calculates the IO cycle update time automatically in the default setting for each device of the PROFINET network, taking into account the volume of data to be exchanged and the number of devices assigned to this controller. If you do not want to have the update time calculated automatically, you can change this setting.

To access the IO cycle parameters, click a PROFINET port on the ET 200SP IO device. From Properties dialog, select "Advanced options > Realtime settings > IO cycle".

Define the IO cycle "Update time" with the following selections:

- To have a suitable update time calculated automatically, select "Calculate update time automatically".
- To set the update time yourself, select "Set update time manually" and choose the required update time in ms from the dropdown menu.

Table 1-187 Configuring the ET 200SP PROFINET IO cycle time

ET 200SP PROFINET IO device	ET 200SP PROFINET IO cycle dialog
	

7.6.12.5 Prioritized startup of an IO device

IO devices can use "Prioritized Startup (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/22911324171_enUS.htm&ft:clusterId./10866368523/22911324171.htm)" to reduce CPU connection time during power-up. With an S7-1200 G2 CPU, selecting this option implements Accelerated Startup instead of Fast Startup. Accelerated Startup provides faster device initialization than standard startup, but does not utilize DCP Hello messages to establish communication.

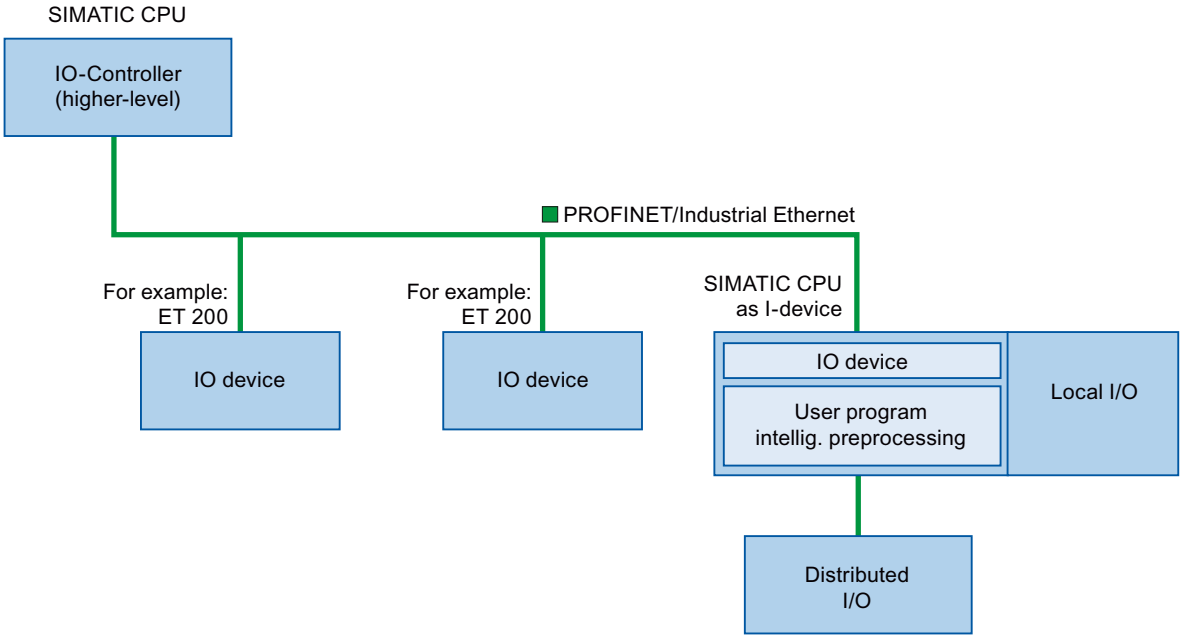
7.6.13 Configuring a CPU and PROFINET I-device

7.6.13.1 I-device functionality

A CPU with I-device functionality is called an "I-device".

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller and operation of the CPU as an intelligent preprocessing unit of subprocesses, for example. The I-device is linked as an IO device to a "higher-level" IO controller.

STEP 7 handles the preprocessing on the CPU. The process values acquired in the local or distributed (PROFINET IO) I/O are preprocessed by STEP 7 and made available through a PROFINET IO interface to the CPU of a higher-level station.



The S7-1200 G2 CPU can act as an I-device with PROFI-Energy functionality.

7.6.13.2 Properties and advantages of the I-device

The I-device allows you to separate STEP 7 automation projects between creators and users, with the GSD file serving as the interface between these projects. This establishes a connection to standard IO controllers through a standardized interface. Additionally, the I-device has a deterministic PROFINET IO system for real-time communication through the PROFINET IO interface.

Advantages

The I-device offers the following advantages:

- Simple linking of IO controllers
- Real-time communication between IO controllers
- Relieving the IO controller by distributing the computing capacity to I-devices
- Lower communications load by processing process data locally

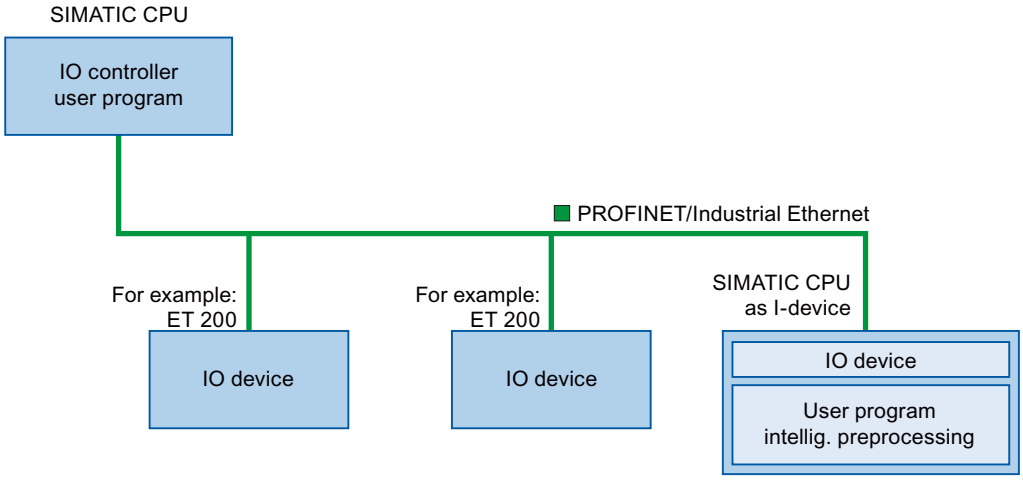
- Manageable solution design that includes the following:
  - Distributed processing: Divide complex automation tasks into smaller subprocesses for increased manageability and simplified subtasks.
  - Separating subprocesses: You can subdivide complicated, widely distributed and extensive processes into subprocesses with manageable interfaces by using I-devices. Store these subprocesses in separate STEP 7 projects and later merge them into a single master project.
  - Know-how protection: Deliver components with a GSD file for the I-device interface description instead of a STEP 7 project. This approach protects your program and eliminates the need for program publication.

7.6.13.3 Characteristics of an I-device

An I-device is included in an IO system like a standard IO device.

I-device without lower-level PROFINET IO system

The I-device does not have its own distributed I/O. The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example, ET 200).

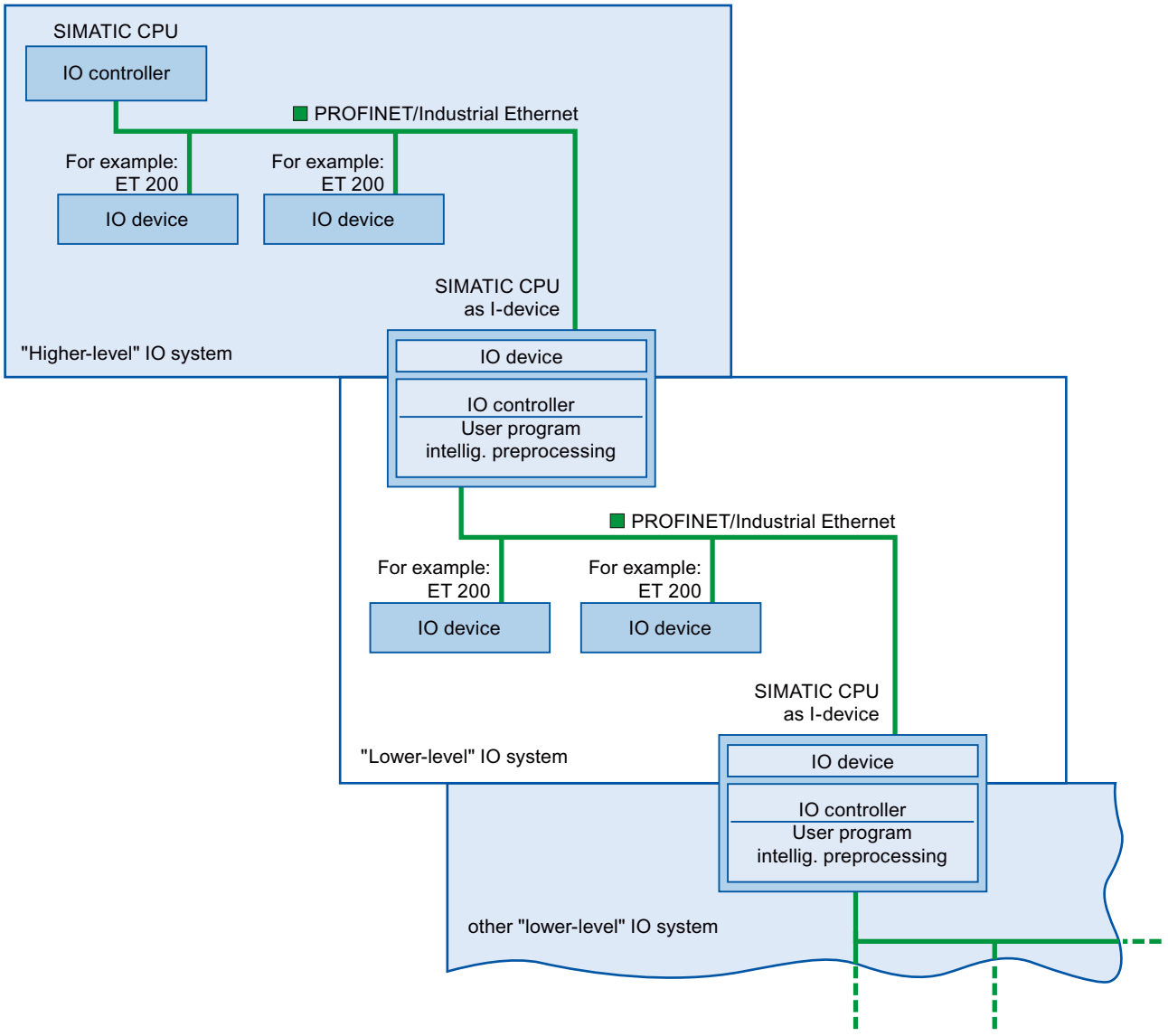


I-device with lower-level PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of an IO device.

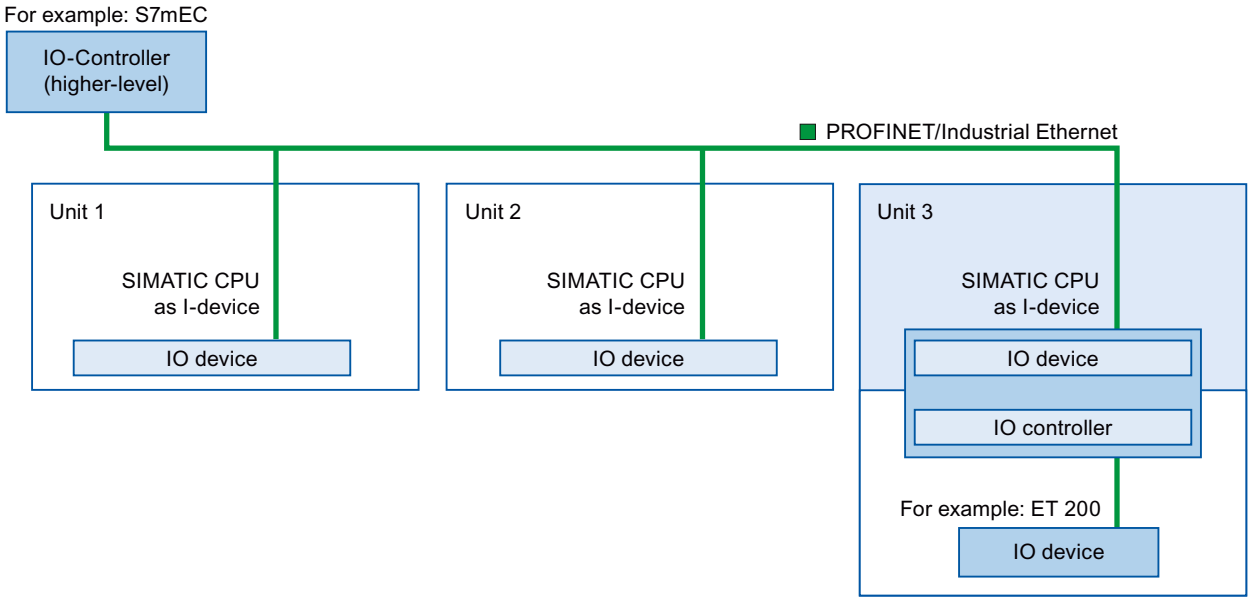
This means that the I-device can be part of a higher-level IO system through its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices. This makes hierarchically structured IO systems possible.



Example: I-device as IO device and IO controller

This example explains the use of an I-device as IO device and IO controller in a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.



Unit 1 and unit 2 each consist of an I-device with local I/O. The I-device along with the distributed I/O system (for example, ET 200) forms unit 3.

The STEP 7 program on the I-device is responsible for preprocessing the process data. For this task, the STEP 7 program of the I-device requires default settings (for example, control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example, status of its subtask).

7.6.13.4 Data exchange between higher- and lower-level IO system

Transfer areas are an interface to the STEP 7 program of the I-device CPU. The CPU processes the inputs and sets the outputs.

The data for communication between IO controller and I-device is available in the transfer areas. A transfer area contains an information unit that is exchanged consistently between IO controller and I-device (Page 245).

Input transfer areas behave differently upon network loss between controller and I-device

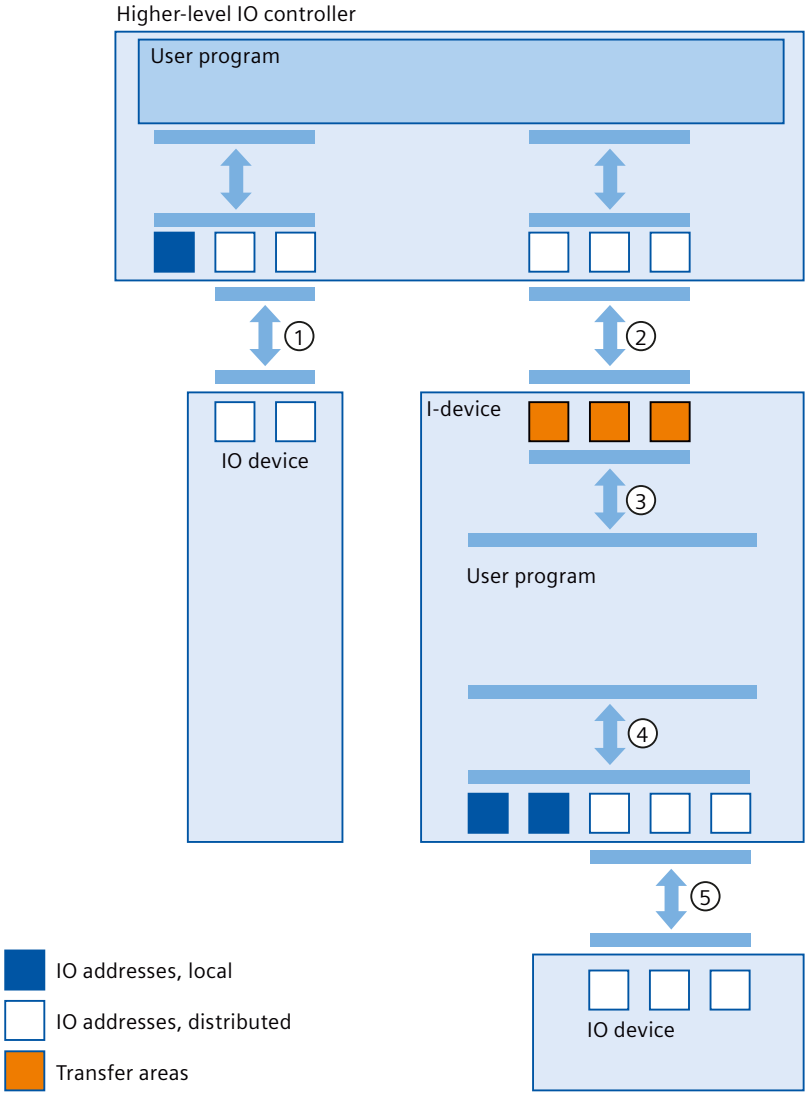
On the controller, the CPU writes zero to the input transfer areas upon network loss. On the I-device, the input transfer areas retain their last values.

You can configure your system to avoid this condition for the general I-device case (non-shared I-device). To do this, clear the input transfer areas for the I-device in a "Rack or Station Failure OB" for a coming event. Follow these steps:

1. Add a "Rack or Station Failure OB (Page 109)" to your project.
2. Add logic to the OB to write the values of the inputs for the I-device to zero when the startup variable of LADDR indicates the value of the I-device hardware ID and the startup variable of Event_Class indicates a "coming" event:
   - You can find the I-device hardware ID in the Default tag table in the "System constants" tab. The hardware ID is a type of "HW_Device", and the name of the tag indicates that it is an I-device (for example, "Local~PROFINET_interface_1~IODevice").
   - A value of "16#39" in the Event_Class indicates a "coming" event. If the "Event_Class" input variable contains the value of "16#39", this indicates that the "Rack or Station Failure OB" is now active (as opposed to being cleared).

Data exchange flow

The data exchange between the higher- and lower-level IO system is as follows:



① **Data exchange between higher-level IO controller and IO-device** through PROFINET.

② **Data exchange between higher-level IO controller and I-device** through PROFINET.
The data exchange between a higher-level IO controller and an I-device is based upon the conventional IO controller / IO device relationship.
For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.
The output data of the IO controller is the input data of the I-device. Similarly, the input data of the IO controller is the output data of the I-device.

③ **Transfer relationship between the STEP 7 program and the transfer area**
STEP 7 and the transfer area exchange input and output data.

④ **Data exchange between the STEP 7 program and the I/O of the I-device**
STEP 7 and the local / distributed I/O exchange input and output data.

⑤ **Data exchange between the I-device and a lower-level IO device** through PROFINET.

7.6.13.5 Configuring the I-device

You have two possibilities for configuration:

- Configuration of an I-device within a project
- Configuration of an I-device that is used in another project or in another engineering system

STEP 7 allows you to configure an I-device for another project or for another engineering system by exporting a configured I-device to a GSD file. You import the GSD file in other projects or engineering systems as with other GSD files. The transfer areas for the data exchange, among other data, are stored in this GSD file.

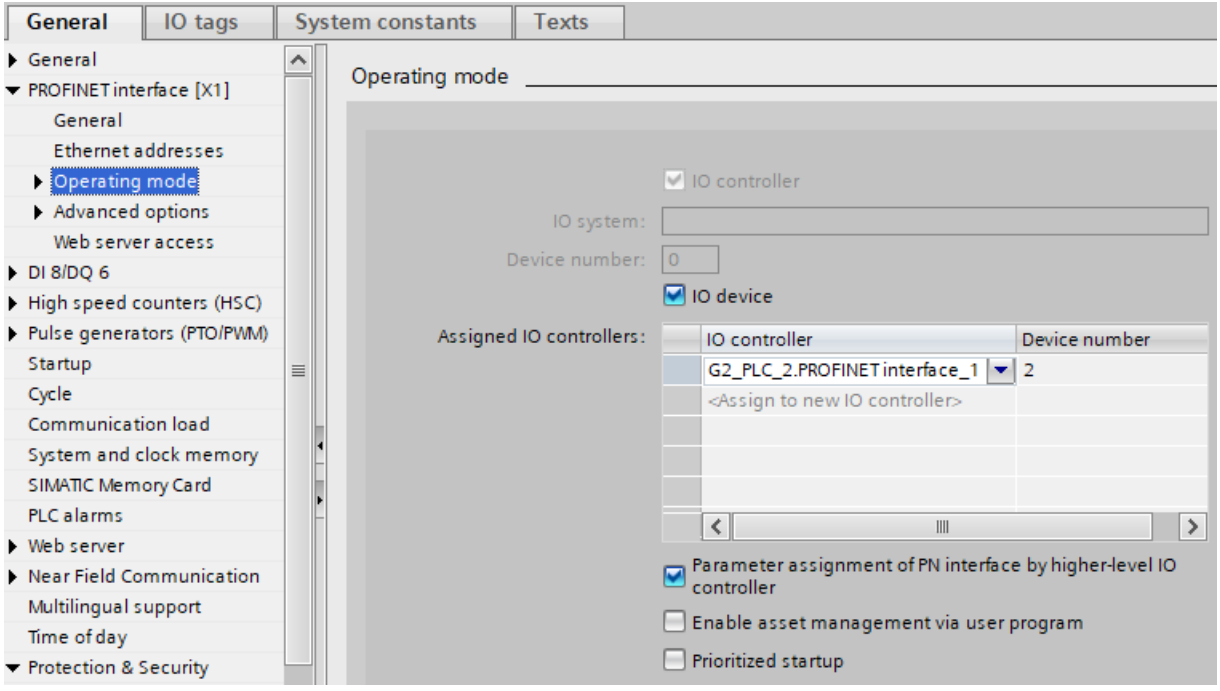
NOTE

When you use the S7-1200 G2 as a shared I-device and as a controller, ensure that you increase the PROFINET I-device and PROFINET IO update times to alleviate the communications performance impact. The system is very stable and works well when you select 2 ms for the update time of a single PROFINET device time and you select 2 ms for the update time of a single PROFINET IO time.

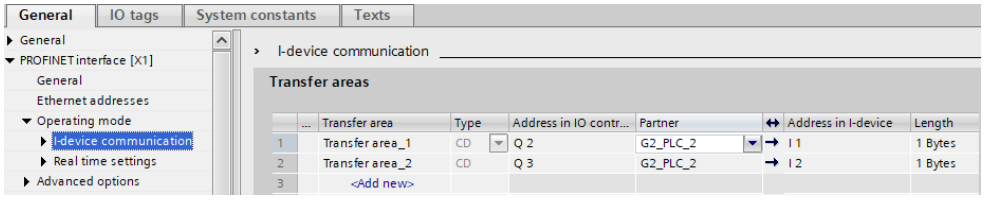
Configuration of an I-device within a project

1. Drag-and-drop a PROFINET CPU from the hardware catalog into the network view.
2. Drag-and-drop the second PROFINET CPU, which can also be configured as an IO device, from the hardware catalog into the network view. This device is configured as an I-device (for example, CPU 1212C).
3. Click the device in the Device view to display the "Properties" tab view.
4. In the left column, select and expand the PROFINET interface for the I-device and select the "Operating Mode" category.
5. In the inspector window, select the checkbox for "IO device".

6. Choose the IO controller in the "Assigned IO controller" drop-down list.
   After you have chosen the IO controller, the network view displays the networking and the IO system between both devices.



7. With the "Parameter assignment of PN interface by higher-level IO controller" checkbox, you specify whether the interface parameters will be assigned by the Idevice or by a higher-level IO controller.
   If you operate the I-device with a lower-level IO system, then the parameters of the I-device PROFINET interface (for example, the port parameter) cannot be assigned with the higher-level IO controller.
8. Configure the transfer areas. The transfer areas are found in the area navigation section "I-device communication":
   – Click in the first field of the "Transfer area" column. STEP 7 assigns a default name, which you can change.
   – Type of communication relation is set to CD (Communication Direction) by default.
   – Addresses are automatically preset; you can correct addresses if necessary, and determine the length of the transfer area which is to be consistently transferred.



9. A separate entry is created under "I-device communication" for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

NOTE
If you configure an S7-1200 G2 as an I-device, the maximum size of a transfer area is 1024 input or output bytes. There are possible constraining factors depending on local I/O as well as address space limitations on the controlling device.

Configuring an I-device with a GSD file

If you use an I-device in another project, or if the I-device is used in another engineering system, you must configure the higher-level IO controller and the I-device as follows:

1. Configure the transfer areas so the I-device creates a new GSD file (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/26415319307_enUS.htm&ft:clusterId./10866368523/26415319307.htm). This GSD file represents the configured I-device in other projects.
2. Assign a name for the I-device proxy as well as a description in the fields provided.
3. Click the "Export" button in the "I-device communication" section of the Inspector window.

To test, import the GSD file, for example, in another project.

7.6.14 Shared device functionality

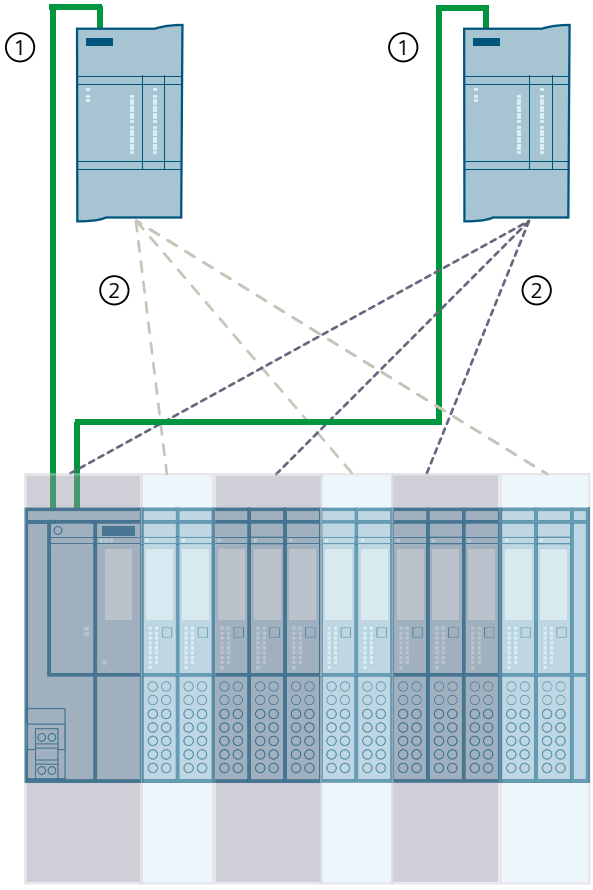
Large or widely distributed systems might use multiple IO controllers.

By default, one IO controller manages each IO module of an IO device. The "Shared Device" function allows you to divide the modules or submodules of an IO device among different IO controllers.

Configuration

When you configure an S7-1200 G2 CPU as an I-device, it enables the support of shared I-device functionality (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/159334733835_enUS.htm&ft:clusterId=./10866368523/159334733835.htm) for up to two IO controllers. If both the IO controllers and the I-device are SIMATIC CPUs, configure them within a single STEP 7 project.

If one or both IO controllers are non-SIMATIC CPUs, use a GSD file for the configuration process (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/59728529419_enUS.htm&ft:clusterId=./10866368523/59728529419.htm).



① PROFINET
② Logical assignment

7.6.15 Media Redundancy Protocol (MRP)

The S7-1200 G2 CPUs support Media Redundancy Protocol (MRP) functionality and MRP ring setup as either a "Manager" or a "Client":

Media Redundancy Protocol	CPU as a Client	CPU as a Manager or Manager (Auto)
Functionality	Must operate in an MRP ring by forwarding MRP packets over its interface and reporting connection breaks to a manager in the network.	Must send MRP packets around the network, detect open ports in the ring, and manage blocked ports. Manager (Auto) only: Negotiate manager status with other potential managers.
Ring setup	Forwards test frames instead of making the check itself.	Uses test frames to check and make sure the ring is not interrupted.

Use the MRP protocol and configuration parameters (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/20055466635_enUS.

htm&ft:clusterId./10866368523/20055466635.htm) to initialize MRP client and manager operation.

7.6.16 Media Redundancy with Planned Duplication of frames (MRPD)

The MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD) (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/89155688459_enUS.htm&ft:clusterId./10866368523/89155688459.htm) provides the advantage that, in the case of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times.
MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

Requirements for media redundancy with MRPD

- All the devices of the ring must support MRPD. Terminal devices at the switch that cyclically exchange IRT data with a ring component must also support MRPD.
  MRPD support is listed in the device information in the STEP 7 hardware catalog (Devices & networks).
- You have configured MRP for all the devices of the ring.
- You have assigned the MRP role "Not device in the ring" to devices that are not located in the ring.
- You have configured IRT for all the involved components.

Configuring MRPD

You do not have to activate MRPD in STEP 7. The function is available automatically as soon as all the requirements for MRPD are fulfilled.

7.6.17 S7 routing

The S7-1200 G2 CPU supports S7 routing (https://docs.tia.siemens.cloud/access?ft:originId=./20713735819/26747797643_enUS.htm&ft:clusterId./20713735819/26747797643.htm) for up to 16 connections. When you have at least two PROFINET interfaces and up to three CP devices installed, the S7-1200 G2 CPUs offer two routing options within the station:

- Between the CPU and a CP
- From one CP to another CP

NOTE
You must add at least one CP.

7.6.18 Isochronous Real-Time PROFINET (IRT)

The S7-1200 G2 CPUs support Isochronous Real-Time PROFINET (IRT).

IRT is a transmission method by which PROFINET devices are synchronized with very high accuracy. A sync master specifies the clock to which sync slaves are synchronized. An IO controller or an IO device can have the role of sync master.

Sync master and sync slaves are always devices in a sync domain. Bandwidth is reserved within the sync domain for IRT communication. Real-time and non-real-time communication (TCP/IP communication) is possible outside of the reserved bandwidth.

PROFINET with IRT (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/39589711499_enUS.htm&ft:clusterId./10866368523/39589711499.htm) is especially suited for the following:

- High performance and deterministics for large quantity structures with regard to user data communications (productive data).
- High performance even with many devices in the line topology with regard to user data communications (productive data).
- Parallel transmission of production and TCP/IP data over wire, and securing the forwarding of production data when data volume is high by reserving transmission bandwidth.

7.6.19 SNMP

Simple Network Management Protocol (SNMP) is an Internet standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behavior. Devices that typically support SNMP include routers, switches, servers, workstations, printers, modem racks, and more.

Network management systems use SNMP to monitor network-attached devices for conditions that warrant administrative attention. SNMP uses various services and tools for detection and diagnostics of the network topology. You can find information about the properties of devices capable of SNMP in the Management Information Base (MIB) files. You must have the required rights to access the MIB files.

SNMP exposes management data in the form of variables on the managed systems, which describe the system configuration. Managing applications can query (and sometimes set) these variables.

SNMP uses the UDP transport protocol and has two network components:

- SNMP manager: Monitors the network nodes
- SNMP client: Collects the various network-specific information in the individual network nodes and stores it in a structured form in the Management Information Base (MIB). You can use this data to perform detailed network diagnostics.

For security reasons, SNMP is disabled by default on S7-1200 G2 CPUs, preventing read and write access of SNMP variables. You must enable SNMP to remotely view and edit SNMP variables.

After enabling SNMP, certain conditions might require you to disable it. Examples of these conditions include the following:

- The security settings in your network do not allow the use of SNMP.
- You use your own SNMP solution (for example, with your own communications instructions).

If SNMP is disabled on the device, some functions and tools that rely on access to SNMP variables are unavailable or inoperable. For example, topology detection in TIA Portal is

inoperable, and some functions of the SIMATIC Automation Tool V4.x and prior, are inoperable.

NOTE
Restoring the CPU to factory defaults disables SNMP.

Enabling and disabling SNMP from the device configuration

To enable or disable SNMP follow these steps:

1. From the Project Tree, under the CPU, double-click Device configuration.
2. From the General tab of the device properties, expand Advanced configuration and select SNMP.
3. To enable SNMP, select the "Activate SNMP" checkbox or to disable SNMP, deselect it.
4. Enter a Read-only community string or use the default (public) and enter a Read-write community string or use the default (private).

   NOTE
   To share SNMP data between the STEP 7 project and the PLC, the community name entered in the STEP 7 project must match the community name entered for the host when creating the SNMP database connection.

5. Download the configuration to the CPU.

Enabling and disabling SNMP from the STEP 7 program

For detailed information on enabling and disabling SNMP from your STEP 7 program, see the following areas in the TIA Portal Information System:

- Configuring SNMP (https://docs.tia.siemens.cloud/access?ft:originId=./52499730827/59148451211_enUS.htm&ft:clusterId./52499730827/59148451211.htm)
- Activating and deactivating SNMP (https://docs.tia.siemens.cloud/access?ft:originId=./11627607179/90872859787_enUS.htm&ft:clusterId./11627607179/90872859787.htm)
- Disabling SNMP: Full program example (https://docs.tia.siemens.cloud/access?ft:originId=./11627607179/96590122635_enUS.htm&ft:clusterId./11627607179/96590122635.htm)

7.7 S7 communication

7.7.1 PUT and GET (Write and read from a remote CPU)

You can use the PUT and GET instructions to communicate with S7 CPUs through PROFINET connections. This is only possible if the "Permit access with PUT/GET communication from remote partner" function is activated for the partner CPU in the "Protection & Security" property of the local CPU properties:

- Accessing data in a remote CPU: An S7-1200 G2 CPU can only use absolute addresses in the ADDR_x input field to address variables of remote CPUs (S7-200/300/400/1200).
- Accessing data in a standard DB: An S7-1200 G2 CPU can only use absolute addresses in the ADDR_x input field to address DB variables in a standard DB of a remote S7 CPU.
- Accessing data in an optimized DB: An S7-1200 G2 CPU cannot access DB variables in an optimized DB of a remote S7-1200 G2 CPU.
- Accessing data in a local CPU: An S7-1200 G2 CPU can use either absolute or symbolic addresses as inputs to the RD_x or SD_x input fields of the PUT or GET instruction, respectively.

Enabling PUT/GET access

PUT/GET operation is not automatically enabled.

To enable PUT/GET access, follow these steps:

1. In the Project tree under "Security settings" > "Users and roles", click the checkbox to enable the Anonymous user.
2. In the "Roles" tab, click "Add new role" and give it a name.
3. From the "Roles" tab, click the "Runtime rights" tab and select your PLC from the dropdown menu at left.
4. Assign at least one of the following function rights for your PLC:
   - HMI access
   - Read Access
   - Full access
5. Select the "Users" tab in the top right and click the checkbox beside the new role to assign it to the Anonymous user.
6. In the CPU's "Device configuration" inspector window, select the "Properties" tab > "Protection & Security > Connection mechanisms" and click the checkbox to "Permit access with PUT/GET communication from remote partner".

⚠ WARNING

Avoiding security risks from network attacks

If an attacker can access your networks, the attacker can possibly read and write data.

For example, I/O exchange through PROFINET, PUT/GET, T-Block, and communication modules (CMs) have no security features. You must protect these forms of communication.

If you fail to protect these forms of communication, death or severe personal injury can result.

For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Web site.

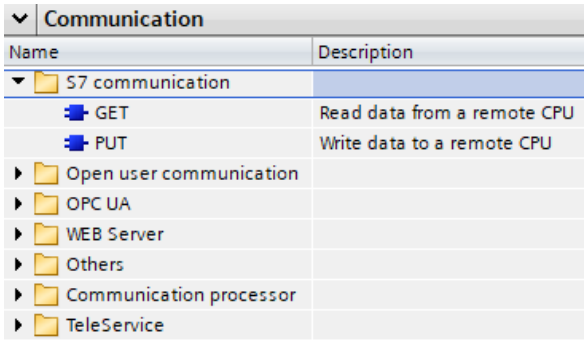
Protocol

The protocol for S7 communication and communication instructions are as follows:

Protocol	Usage examples	Entering data in the receive area	Communication instructions	Addressing type
S7 communication	CPU-to-CPU communication Read/write data from/to a CPU	Data transmission and reception with specified length	PUT and GET	Assigns TSAPs to the Local (active) and Partner (passive) devices

Instructions

The S7 communication (https://docs.tia.siemens.cloud/access?ft:originId=./15891429899/15891429899_enUS.htm&ft:clusterId./15891429899/15891429899.htm) PUT and GET instructions allow you to read and write data from a remote CPU:



7.7.2 Creating an S7 connection

You must have permission to access remote connection partners with PUT/GET instructions.

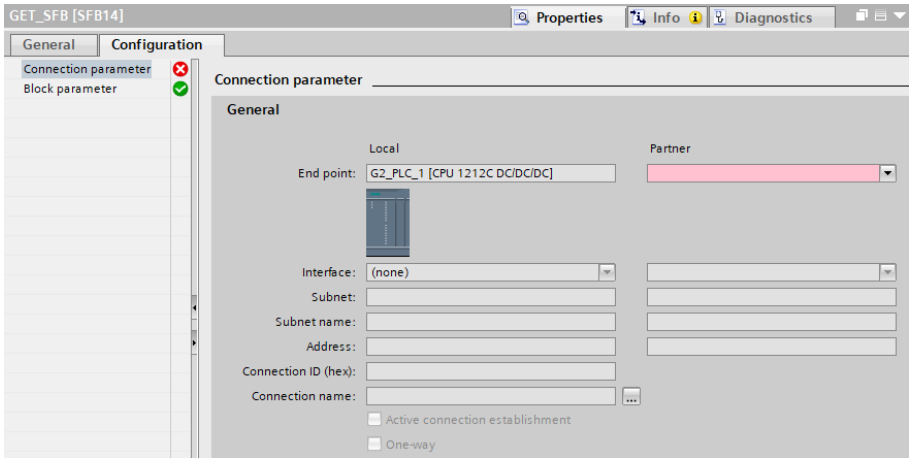
By default, the "Permit access with PUT/GET communication from remote partner" option is disabled. In this case, read and write access to CPU data is only possible for communication connections that require configuration (https://docs.tia.siemens.cloud/access?ft:originId=./10866368523/25480655883_enUS.htm&ft:clusterId./10866368523/25480655883.htm) or programming both for the local CPU and for the communication partner.

7.7.3 PUT/GET connection parameter assignment

The PUT/GET instructions connection parameter assignment is a user aid for configuring CPU-to-CPU S7 communication connections.

After inserting a PUT or GET instruction, the Properties tab for the instruction displays the connection parameter assignment dialog for the GET/PUT instructions.

The "Connection parameters" dialog allows you to configure the necessary S7 connection and to configure the parameter "Connection ID" that is referenced by the GET/PUT block parameter "ID". The dialog has information about the local endpoint and allows you to define the local interface. You can also define the partner end point.



The "Block parameters" dialog allows you to configure the additional block parameters.

Table 1-188 Connection parameter: General definitions

Parameter		Definition
Connection parameter: General	End point	"Local End point": Name assigned to the Local CPU "Partner End point": Name assigned to the Partner (remote) CPU Note: In the "Partner End point" dropdown list, the system displays all potential S7 connection partners of the current project as well as the option "unspecified". An unspecified partner represents a communication partner which is not currently in the STEP 7 project (for example, a third party device communication partner).
	Interface	Name assigned to the interfaces Note: You can change the connection by changing the Local and Partner interfaces
	Subnet	Type of subnet
	Subnet name	Name assigned to the subnets
	Address	Assigned IP addresses Note: You can specify the remote address of a third party device for an "unspecified" communication partner.
	Connection ID (hex)	ID number: Automatically generated by the GET/PUT connection parameter assignment

Parameter		Definition
Connection parameter: General	Connection name	Local and Partner CPU data storage location: Automatically generated by the GET/PUT connection parameter assignment
	Active connection establishment	Checkbox to select Local CPU as the active connection
	One-way	Checkbox to specify a one-way or two-way connection; read-only Note: In a PROFINET GET/PUT connection, both the local and partner devices can act as a server or a client. This allows a two-way connection, and the "One-way" checkbox is unchecked.

7.7.3.1 Connection ID parameter

You can change the system-defined connection IDs in one of the following ways:

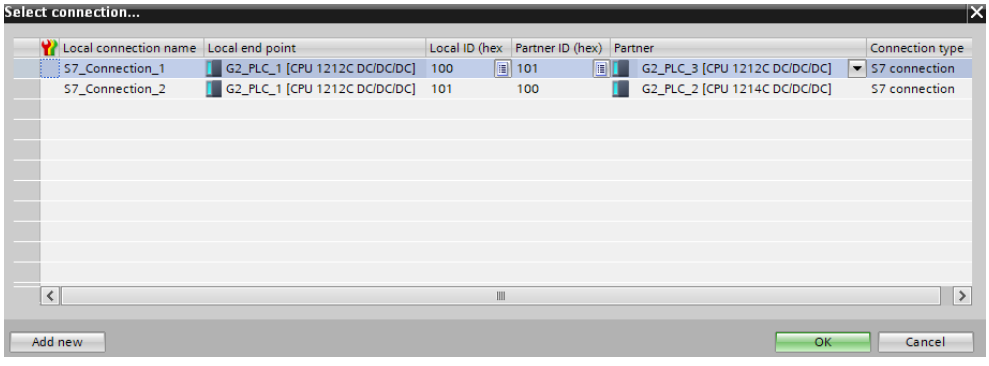
- Change the current ID directly on the GET/PUT instruction. If the new ID belongs to an already existing connection, the connection is changed.
- Change the current ID directly on the GET/PUT instruction, but the new ID does not already exist. A new S7 connection is created by the system.
- Change the current ID through the "Connection overview" dialog: Your input is synchronized with the ID-parameter on the corresponding GET/PUT instruction.

NOTE

The parameter "ID" of the GET/PUT instruction is not a connection name, but a numerical expression, which is written like the following example: W#16#1

7.7.3.2 Connection name parameter

The connection name is editable through the "Select connection" dialog. This dialog offers all the available S7 connections that could be selected as an alternative for the current GET/PUT communication. You can create a new connection in this table. Click the button to the right of the "Connection name" field to start the "Select connection" dialog.



7.8 Diagnostic events for distributed I/O

As shown in the following table, the CPU supports diagnostics that can be configured for the components of the distributed I/O system. Each of these errors generates a log entry in the diagnostics buffer.

Table 1-189 Handling of diagnostic events for PROFINET

Type of error	Diagnostic information for the station?	Entry in the diagnostics buffer?	CPU operating mode
Diagnostic error	Yes	Yes	Stays in RUN mode
Rack or station failure	Yes	Yes	Stays in RUN mode
I/O access error [1]	No	Yes	Stays in RUN mode
Peripheral access error [2]	No	Yes	Stays in RUN mode
Pull / plug event	Yes	Yes	Stays in RUN mode

[1] I/O access error example cause: Reading inputs or writing outputs for a module that has been removed or not communicating.

[2] Peripheral access error example cause: Reading peripheral inputs or writing peripheral outputs for a module that has been removed or not communicating.

Use the GET_DIAG instruction for each station to obtain the diagnostic information. This will allow you to programmatically handle the errors encountered on the device and if desired take the CPU to STOP mode. This method requires you to specify the hardware device from which to read the status information.

The GET_DIAG instruction uses the "L address" (LADDR) of the station to obtain the health of the entire station. This L Address can be found within the Network Configuration view and by selecting the entire station rack, the L Address is shown in the Properties Tab of the station. The LADDR for each individual module is either in the properties for the module in the device configuration or in the default tag table for the CPU.

7.9 What to do when you cannot access the CPU by the IP address

In case you cannot reach a CPU by the IP address, you can set an emergency (temporary) IP address for the CPU. The emergency IP address enables you to re-establish communication with the CPU in order to download a device configuration with a valid IP address.

Reasons why you might need an emergency IP address

Your CPU might be inaccessible if someone downloaded a project with one of the following problems:

- The IP address of the PROFINET interface of the CPU is a duplicate of another device on the network.
- The subnet is incorrect for the CPU.
- The subnet mask makes the CPU unreachable.

In these cases, the CPU is no longer accessible from STEP 7.

Assigning an emergency IP address

You can assign an emergency IP address under the following conditions:

- The device configuration in STEP 7 has "Set IP address in the project" for the IP protocol.
- The CPU is in STOP mode.

Under these conditions, you can use a DCP tool to set the IP address of the device to an emergency IP address. The SIMATIC Automation Tool, for example, has a DCP Set IP address command. You can set an emergency IP address regardless of the protection level of the CPU. After you set a temporary IP address with a DCP tool, the Maintenance LED on the CPU turns on. The Diagnostics Buffer also includes an entry indicating that you enabled an emergency address of an Ethernet interface.

Restoring an IP address after assigning an emergency IP address

The diagnostics buffer informs you when you have enabled or disabled an emergency IP address. You can reset the emergency IP address by powering the CPU off and on.

After you have assigned an emergency IP address, you can then download a STEP 7 project with a valid IP address for the CPU. After you download the project, power cycle the CPU.

7.10 OPC UA server

S7-1200 G2 CPUs support configuration as an OPC UA server (https://docs.tia.siemens.cloud/access?ft:originId=./19342675723/111512317451_enUS.htm&ft:clusterId./19342675723/111512317451.htm) for data access. For additional information on OPC UA servers, visit the OPC Foundation Web site (https://opcfoundation.org/).

S7-1200 G2 OPC UA server features

The S7-1200 G2 CPUs provide OPC UA server capabilities, including the following:

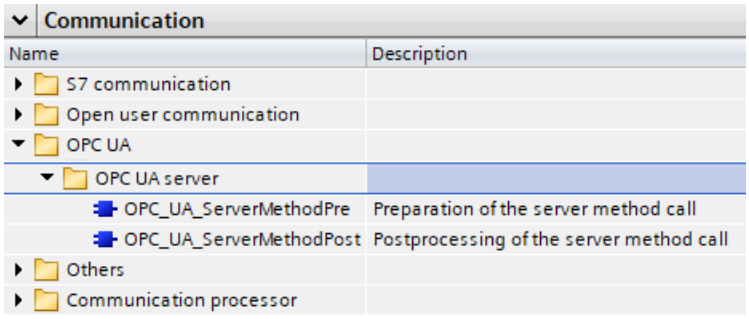
- Data access
- Diagnostics
- Server method support

OPC UA server configuration

The OPC UA server is deactivated by default. To use the OPC UA server, you must configure the OPC UA settings in STEP 7.

7.10.1 OPC UA Server method instructions

The OPC UA Server method instructions provide the capability to inject custom logic and checks before an OPC UA method (https://docs.tia.siemens.cloud/access?ft:originId=./19342675723/111512403723_enUS.htm&ft:clusterId./19342675723/111512403723.htm) is executed and to process its outcome or perform follow-up actions after it completes. These can be found in the following folders:{"OPC UA Server method instructions"}{"Instructions";"OPC UA Server method"}



7.10.2 Limitations of the OPC UA server

When using OPC UA server interfaces, you must comply with the following limitations:

- Number of server interfaces
- Number of companion specifications
- Reference namespaces
- Number of OPC UA nodes
- Number of namespaces

NOTE

The S7-1200 G2 OPC UA server does not support the S7-1500 feature of “standard SIMATIC” server interface. You must define and download an OPC UA server interface in STEP 7.

Interface, method, and subscription limitations

The following tables apply to S7-1200 G2 CPUs and S7-1200 G2 Fail-safe CPUs. Consider these limitations when compiling and loading a configuration. Exceeding these limitations results in an error message.

Interface limitations	Description	Maximum
Number of server interfaces	The number of concurrent OPC UA server connections that can be established. A server interface can be a "Companion specification" type or a "Server interface" type.	2
Number of companion specifications	The number of extra templates or add-ons that your OPC UA server can use to share data.	2

Interface limitations	Description	Maximum
Reference namespaces	Unique identifiers that organize related data items into separate groups.	10
Number of OPC UA nodes	The maximum number includes nodes internally defined by the server interface.	2000
Total number of namespaces	The total number of defined namespaces for all server interface types: " server interface", "companion specification", and "reference namespace"	18

Method limitations	Maximum
Server methods	20[1]
Server method instance DBs for all server interfaces and associated server methods	20
Server method input arguments	20
Server method output arguments	20

[1] If you download a program with more than the maximum allowed OPC UA methods, the program cannot call any of the OPC UA methods.

Subscription limitations	Maximum
Concurrent subscriptions[1]	50
Subscriptions per session	5

[1] Concurrent subscriptions is equal to the configured number of concurrent sessions multiplied by the maximum number of subscriptions per session.

7.10.3 OPC UA server security

The OPC UA server requires a certificate for activation. When you activate the server, TIA Portal generates a certificate. You can change this certificate in the PLC properties.

Supported security policies

Selecting a supported security policy at runtime determines the security of communications (https://docs.tia.siemens.cloud/access?ft:originId=./19342675723/111512278283_enUS.htm&ft:clusterId./19342675723/111512278283.htm) between the client and server. The S7-1200 G2 supports the following security policies:

Security Policy	Enabled by default?
No security	No
Basic128Rsa15 - Sign	No
Basic128Rsa15 - Sign & Encrypt	No
Basic256 - Sign	No
Basic256 - Sign & Encrypt	No
Basic256Sha256 – Sign	No
Basic256Sha256 – Sign & Encrypt	Yes
Aes128-Sha256-RsaOaep - Sign	No

Security Policy	Enabled by default?
Aes128Sha256RsaOaep - Sign & Encrypt	No
Aes256Sha256RsaPss - Sign	No
Aes256Sha256RsaPss - Sign & Encrypt	No

Trusted Clients

You can accept client certificates using one of the following two methods from the "Trusted clients" window in your STEP 7 project:

- You can define a list of trusted clients by adding their certificates to the list. At runtime, only clients with a trusted certificate can connect.
- You can select the checkbox at the bottom of the window to "Automatically accept client certificates during runtime". At runtime, all client certificates are accepted automatically.

7.11 Communication Processor (CP)

7.11.1 CP 1243-1

The S7-1200 G2 Ethernet Communications Processor (CP) equips the S7-1200 G2 with an extra Ethernet interface. Through this interface, the CP establishes a reliable, secure link for data exchange and remote command execution, facilitating Industrial Remote Control (TeleControl) of S7-1200 G2 processes. The CP further supports web server access.

Ethernet CP for the S7-1200 G2

For TeleControl applications, the CP 1243-1 is available with details as follows:

- Article number: 6GK7243-1BX50-0XE0
- Communications processor for connecting the SIMATIC S7-1200 G2 to Industrial Ethernet or via the Internet to the DNP3 master station.
- You can use the CP as an interface extension of the CPU. In this role, it serves the purpose of network separation.
- You communicate between the CP and CPU using configurable data points that access PLC tags.

Secure communication

The well-proven SINAUT ST7 protocol or the standardized DNP3 or IEC 60870-5 protocol adds security to Industrial Remote Communication. The TeleControl solution provides comprehensive measures to prevent data falsification and loss. Each transmission module has a large memory for several thousand data frames, which offers the ability to bridge downtimes in the transmission link.

The TeleControl solution via DNP3 provides comprehensive measures to prevent data falsification and loss. Each transmission module has a large memory for several thousand data frames, which offers the ability to bridge downtimes in the transmission link. The DNP3 implementation also provides security via TLS.

Updating CP 1243-1 firmware

If you update the CP firmware, you must power cycle your PLC to activate the new firmware.

7.11.2 Further information

The SIMATIC CP 1243-1 (https://sieportal.siemens.com/su/blZek) manual provides detailed information on connection, requirements, applications, block instructions, accessories, and configuration examples.

For further information and documentation, visit the following:

- CP 1243-1 (https://sieportal.siemens.com/su/blYx6)
- Firmware updates as available (https://sieportal.siemens.com/su/blYzU)

7.12 Point-to-point (PtP) communication

7.12.1 Overview

The following table outlines the point-to-point (PtP) character-based serial protocols supported by the CPU, along with the available instruction sets and communication hardware options for each protocol.

Protocol	Instruction Folder	Local CM 1241 RS232/422/485	Local CB 1241 RS485	Distributed CM PtP (example: ET 200MP CM or ET 200SP CM)
Freeport (Page 265)	Communication > Communication processor > PtP communication	Yes	Yes	Yes
3964(R) (Page 279)	Communication > Communication processor > PtP communicaton	Yes (RS232 or RS422)	No	Yes (RS232 or RS422)
USS (Page 287)	Communication > Communication processor > USS communication	Yes (RS485)	Yes	Yes (RS485)

7.12.2 Using the serial communication interfaces

The CM 1241 RS232/422/485 (Page 460) and the CB 1241 RS485 (Page 462) provide the interface for Point-to-point (PtP) communications.

You can connect up to three CMs and the following number of CBs as serial communication interfaces:

- One CB for the 1212C or 1212FC CPUs
- Up to two CBs for the 1214C or 1214FC CPUs

Install the CM to the right of the CPU or another CM or CP. Install the CB(s) on the front of the CPU. Refer to the installation guidelines (Page 72) for information on module installation and removal.

The serial communication interfaces feature the following:

- Isolated port
- Support for Point-to-Point protocols
- Configuration and programming through the PtP communication processor instructions
- Display of transmit and receive activity, as well as diagnostics, by means of LEDs
- No external power connection is needed as they are powered by the CPU

Refer to the technical specifications for communication interfaces (Page 458).

LED indicators

The CM and CB each have three LED indicators:

- Diagnostic LED (DIAG): This LED flashes red until it is addressed by the CPU. After the CPU powers up, it checks for CM/CB and addresses them. The diagnostic LED begins to flash green. This means that the CPU has addressed the CM/CB, but has not yet provided the configuration to it. The CPU downloads the configuration to the configured CM/CB when the program is downloaded to the CPU. After a download to the CPU, if no errors are detected, the diagnostic LED on the communication module shows a steady green. If an error is detected, the diagnostic LED flashes red.
- Transmit LED (Tx): The transmit LED illuminates when data is being transmitted out the communication port.
- Receive LED (Rx): This LED illuminates when data is being received by the communication port.

7.12.3 Biasing and terminating an RS422 or RS485 network connector

Biasing

The S7-1200 G2 CM/CB includes built-in biasing functionality. This allows the CM/CB to automatically select and apply the appropriate biasing based on the mode or configuration you have selected and downloaded to the CPU from your STEP 7 project.

Terminating a network connector

To ensure optimal signal transmission and prevent signal reflections or interference, you must properly connect and terminate the ends of an RS422 or RS485 network connector.

To ensure interference-free data traffic for RS422 or RS485, add a terminating resistor of approximately 330Ω at the receiving end of the cable.

NOTE

When the parallel terminating resistor is wired in the circuit, you must enable the bias resistors in your STEP 7 project. Otherwise, data reads are incorrect because the receive buffer incorrectly detects the wrong start bit and bit-shifts the data being received.

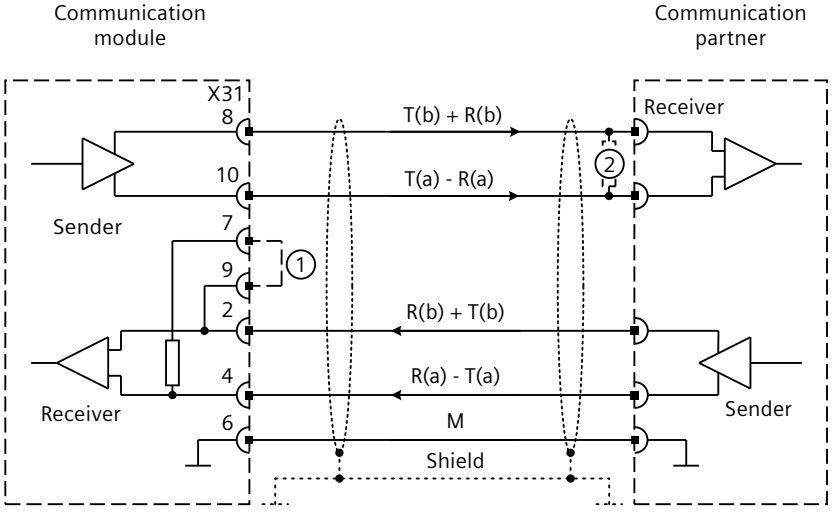
You can use the following cable types with both RS422 and RS485 network connectors. The cable supports various lengths based on the baud rate as follows:

- Max. 1200 m at 19200 baud
- Max. 500 m at 38400 baud
- Max. 350 m at 76800 baud
- Max. 250 m at 115200 baud
- Max. 200 m at 250000 baud (RS485 only)

NOTICE
Risks of connecting a cable shield directly to the ground (GND) Connecting a cable shield directly to the GND can cause electrical current induction, which could damage the expansion modules. To mitigate this risks, connect the GND wire on both ends of the cable. This helps maintain a consistent ground potential and minimizes the chances of electrical current induction or other related issues that can affect the performance and reliability of the network connection.

Terminating the RS422 network connector

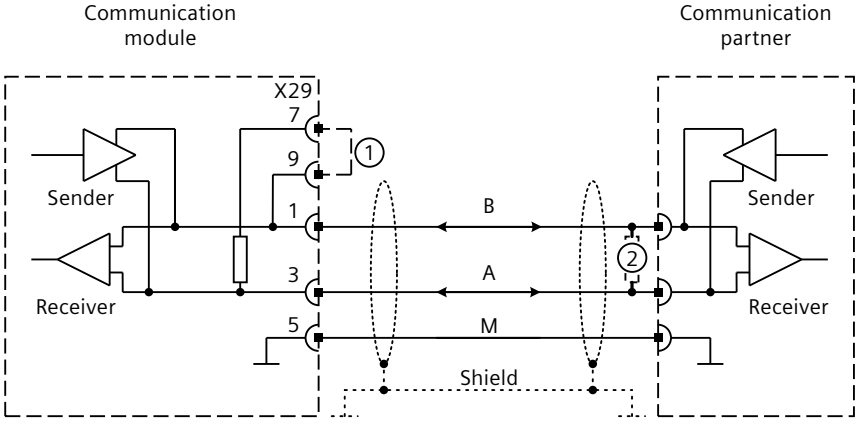
You can confiure the RS422 point-to-point connection cable as shown in the following example:



① Jumper (adds internal terminating resistor)
② Terminating resistor

Terminating the RS485 network connector

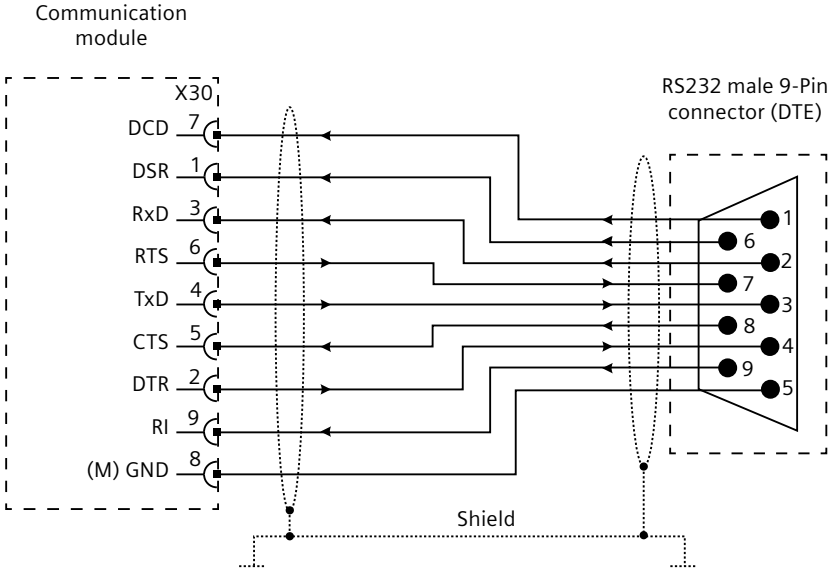
You can configure the RS485 point-to-point connection cable as shown in the following example:



① Jumper (adds internal terminating resistor)
② Terminating resistor

Connecting an S7-1200 G2 CPU to a 9-pin D connector

You can connect the S7-1200 G2 CPU to a standard RS232 DTE 9-pin D connector as shown in the following example:



Your application might not require all of these signal connections.

NOTE

The maximum cable length for this connection should not exceed 10 meters.

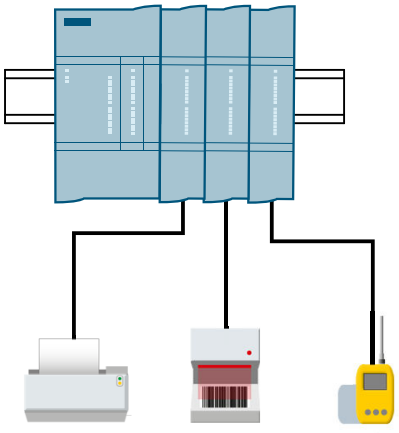
7.12.4 PtP, Freeport communication

PtP with a Freeport, or freely constructed, protocol provides maximum freedom and flexibility, but requires extensive implementation in the STEP 7 program.

PtP enables a wide variety of possibilities:

- The ability to send information directly to an external device such as a printer
- The ability to receive information from other devices such as barcode readers, RFID readers, third-party camera or vision systems, and many other types of devices
- The ability to exchange information, sending and receiving data, with other devices such as GPS devices, third-party camera or vision systems, radio modems, and many more

This type of PtP communication is serial communication that uses standard UARTs to support a variety of baud rates and parity options.The RS232/422/485 communication module (CM 1241) and the RS485 communication board (CB 1241) provide the electrical interfaces for performing the PtP communications.



PtP Freeport over PROFINET

PtP enables you to use a PROFINET distributed I/O rack to communicate to various devices (RFID readers, GPS device, and others). You connect the Ethernet interface of the S7-1200 G2 CPU to a PROFINET interface module. PtP communication modules in the rack with the interface module can then provide serial communications to the PtP devices.

Communications over distributed I/O use the following modules:

Station	Module	Article number	Interface
ET 200MP	CM PtP RS232 BA	6ES7540-1AD00-0AA0	RS232
	CM PtP RS232 HF	6ES7541-1AD00-0AB0	RS232
	CM PtP RS422/485 BA	6ES7540-1AB00-0AA0	RS422/RS485
	CM PtP RS422/485 HF	6ES7541-1AB00-0AB0	RS422/RS485
ET 200SP	CM PtP	6ES7137-6AA01-0BA0	RS232 and RS422/RS485

NOTE

You can use the same point-to-point instructions to access a communication board, local serial modules, and serial modules over PROFINET.

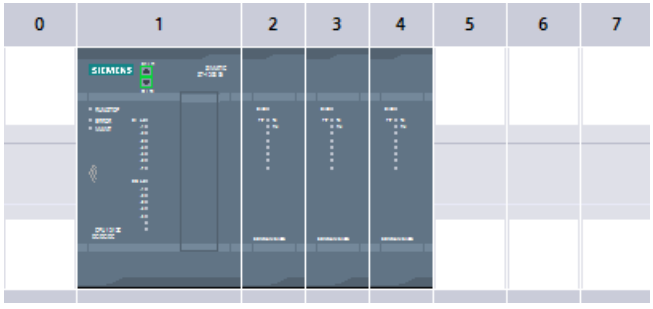
7.12.5 Configuring the PtP Freeport communication

7.12.5.1 Configuring the communication ports

You can use either of the following methods to configure the communication interfaces for PtP Freeport communication:

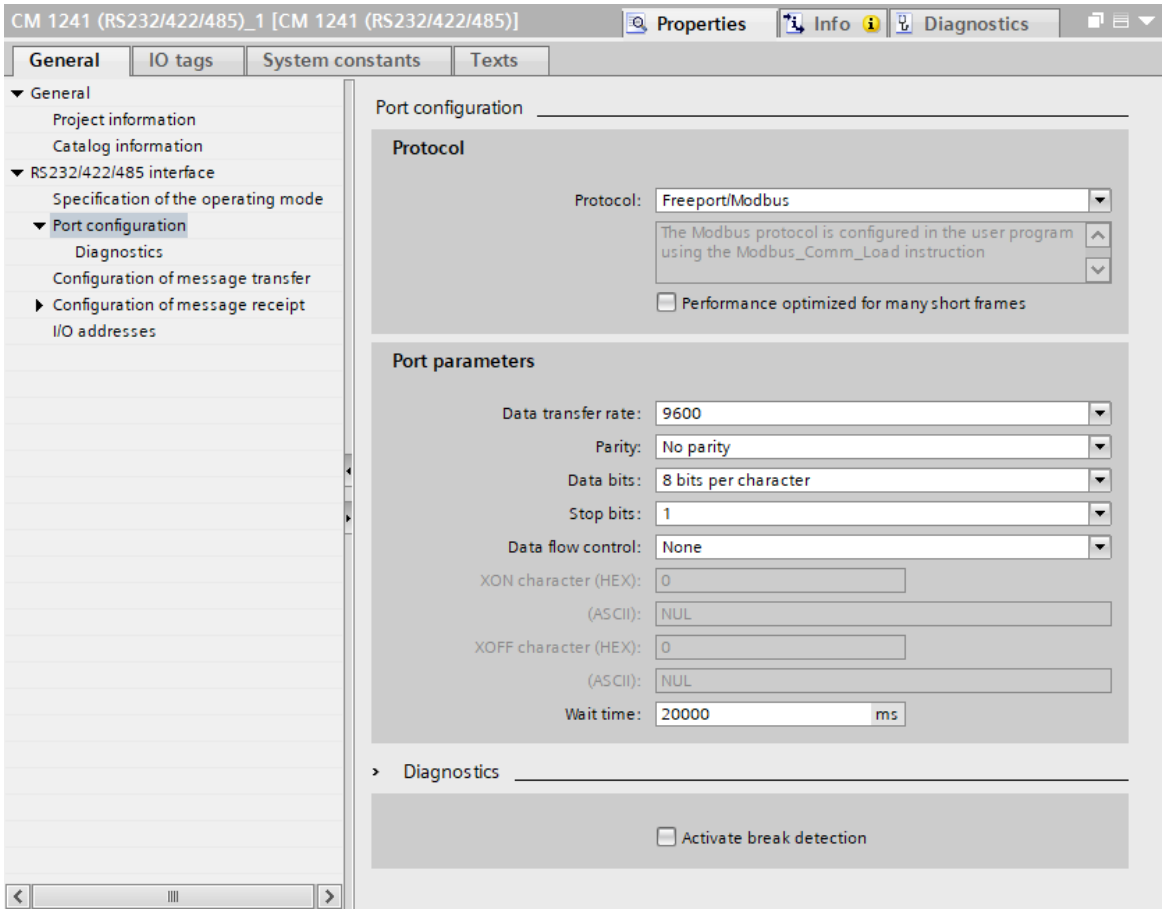
- Use the device configuration in STEP 7 to configure the port parameters (baud and parity), the send parameters, and the receive parameters. The CPU stores the device configuration settings and applies the settings after a power cycle and a RUN to STOP transition.
- Use the Port_Config, Send_Config, and Receive_Config instructions (Page 284) to set the parameters. The port settings set by the instructions are valid while the CPU is in RUN mode. The port settings revert to the device configuration settings after a STOP transition or power cycle.

After configuring the hardware devices (Page 151), select one of the configured CMs or CBs to configure parameters for the communication interfaces.



The "Properties" tab of the inspector window displays the parameters of the selected CM. Select "Port configuration" to edit the following parameters:

- Protocol - "Performance optimized for many short frames"[1]
- Operating mode
- Data transmission rate
- Parity
- Data bits
- Stop bits
- Flow control - RS232 or RS422 only
- Wait time



The CB 1241 supports standard performance only; The CM 1241 supports both standard performance and "Performance optimized for many short frames". Optimized performance is faster but requires more process image space.

- Standard performance
  - Handshaking is done via the process image.
  - Data are sent via records.
- Optimized performance
  - Handshaking is done via the process image.
  - Data are sent via the process image.

For more information regarding the sending and receiving of data for both standard and optimized performance, see the the following chapters in the SIMATIC S7-1500, ET 200MP, ET 200SP CM PtP - Configurations for point-to-point connections Function manual (https://support.industry.siemens.com/cs/us/en/view/59057093):

- "Configuring/parameter assignment"
- "Programming - communication using instructions"

The STEP 7 program can also configure the port or change the existing configuration (https://docs.tia.siemens.cloud/access?ft:originId=./39512235019/CM1500_Prog_Port_Config_enUS.htm&ft:clusterId=./39512235019/CM1500_Prog_Port_Config.htm) with the Port_Config instruction.

Parameter	Definition
Protocol	This selects the Protocol Freeport/Modbus or 3964(R) (CM only).
Performance optimized for many short frames	Click the checkbox to optimize performance (CM only).
Operating mode	This selects the type of communication (RS232, RS422, or RS485) and the network configuration. The default mode for Operating mode is RS232 mode. Other valid choices are: • Full duplex (RS422) 4-wire operation point to point • Full duplex (RS422) 4-wire operation multipoint master • Full duplex (RS422) 4-wire operation multipoint slave • Half duplex (RS485) 2-wire operation
Data transfer rate	The default value for the data transmission rate is 9600 bits/s. Valid choices in bits/s are: • 300 • 600 • 1200 • 2400 • 4800 • 9600 • 19200 • 38400 • 57600 • 76800 • 115200 • 250000 (RS422 and RS485 only)
Parity	The default value for parity is no parity. Valid choices are: • No parity • Even • Odd • Mark (parity bit always set to 1) • Space (parity bit always set to 0)
Data bits per character	The number of data bits in a character. Valid choices are 7 or 8.
Number of stop bits	The number of stop bits can be either 1 or 2. The default is 1.
Data flow control	The RS485 communication interfaces do not support flow control. The RS232 mode of the CM 1241 RS232/422/485 module allows you to select either hardware or software flow control (Page 269). If you select hardware flow control, you can select whether the RTS signal is always on, or RTS is switched. If you select software flow control, you can define the XON and XOFF characters. The RS422 mode of the CM 1241 RS232/422/485 module supports software flow control.
Wait time	Wait time specifies the time that the CM or CB waits to receive CTS after asserting RTS, or for receiving an XON after receiving an XOFF, depending on the type of data flow control. If the wait time expires before the communication interface receives an expected CTS or XON, the CM or CB aborts the transmit operation and returns an error to the STEP 7 program. You specify the wait time in milliseconds. The range is 1 to 65535 milliseconds.

7.12.5.2 Managing flow control

Flow control refers to a mechanism for balancing the sending and receiving of data transmissions to avoid the loss of data. Flow control ensures that a transmitting device is not sending more information than a receiving device can handle. Flow control can be accomplished through either hardware or software. The RS232 mode of the CM 1241 RS232/422/485 module supports both hardware and software flow control. The RS422 mode of the CM 1241 RS232/422/485 module supports software flow control. You specify the type of flow control either when you configure the port or with the Port_Config instruction. The RS485 mode of the CM (1241 RS232/422/485) and the CB 1241 RS485 do not support flow control.

Hardware flow control works through the Request-to-send (RTS) and Clear-to-send (CTS) communication signals. For the RS232 mode of the CM 1241 RS232/422/485 module (Page 460), the RTS signal is output from pin 6 and the CTS signal is received through pin 5 of the X30 wiring terminal. The RS232 mode of the CM 1241 RS232/422/485 module is a DTE (Data Terminal Equipment) device which asserts RTS as an output and monitors CTS as an input.

Hardware flow control: RTS switched

If you enable RTS switched hardware flow control for the RS232 mode of the CM 1241 RS232/422/485, the module sets the RTS signal active to send data. The CM module monitors the CTS signal to determine whether the receiving device can accept data. When the CTS signal is active, the module can transmit data as long as the CTS signal remains active. If the CTS signal goes inactive, then the transmission must stop.

Transmission resumes when the CTS signal becomes active. If the CTS signal does not become active within the configured wait time, the module aborts the transmission and returns an error to the STEP 7 program. You specify the wait time in the port configuration (Page 266).

The RTS switched flow control is useful for devices that require a signal that the transmit is active. An example would be a radio modem that uses RTS as a "Key" signal to energize the radio transmitter. The RTS switched flow control will not function with standard telephone modems. Use the RTS always on selection for telephone modems.

Hardware flow control: RTS always on

In "RTS always ON" mode, the CM 1241 RS232/422/485 sets RTS active by default. A device acting as a communication partner monitors the RTS signal from the CM and utilizes this signal as a clear-to-send. The device only transmits to the CM when RTS is active, that is, when the device sees an active CTS. If RTS is inactive, the device does not transmit to the CM.

To allow the device to send data to the CM at any time, configure "RTS always ON" hardware flow control. The CM thus sets the RTS signal active all the time. The CM will not set RTS inactive even if the device cannot accept characters. The transmitting device must ensure that it does not overrun the receive buffer of the CM.

Data Terminal Ready (DTR) and Data Set Ready (DSR) signal utilization

The CM sets DTR active for either type of hardware flow control. The module transmits only when the DSR signal becomes active. The state of DSR is only evaluated at the start of the send operation. If DSR becomes inactive after transmission has started, the transmission will not be paused.

Software flow control

Software flow control uses special characters in the messages to provide flow control. You configure Hex characters that represent XON and XOFF.

XOFF indicates that a transmission must stop. XON indicates that a transmission can resume. XOFF and XON must not be the same character.

When the transmitting device receives an XOFF character from the receiving device, it stops transmitting. Transmitting resumes when the transmitting device receives an XON character. If it does not receive an XON character within the wait time that is specified in the port configuration (Page 266), the CM aborts the transmission and returns an error to the STEP 7 program.

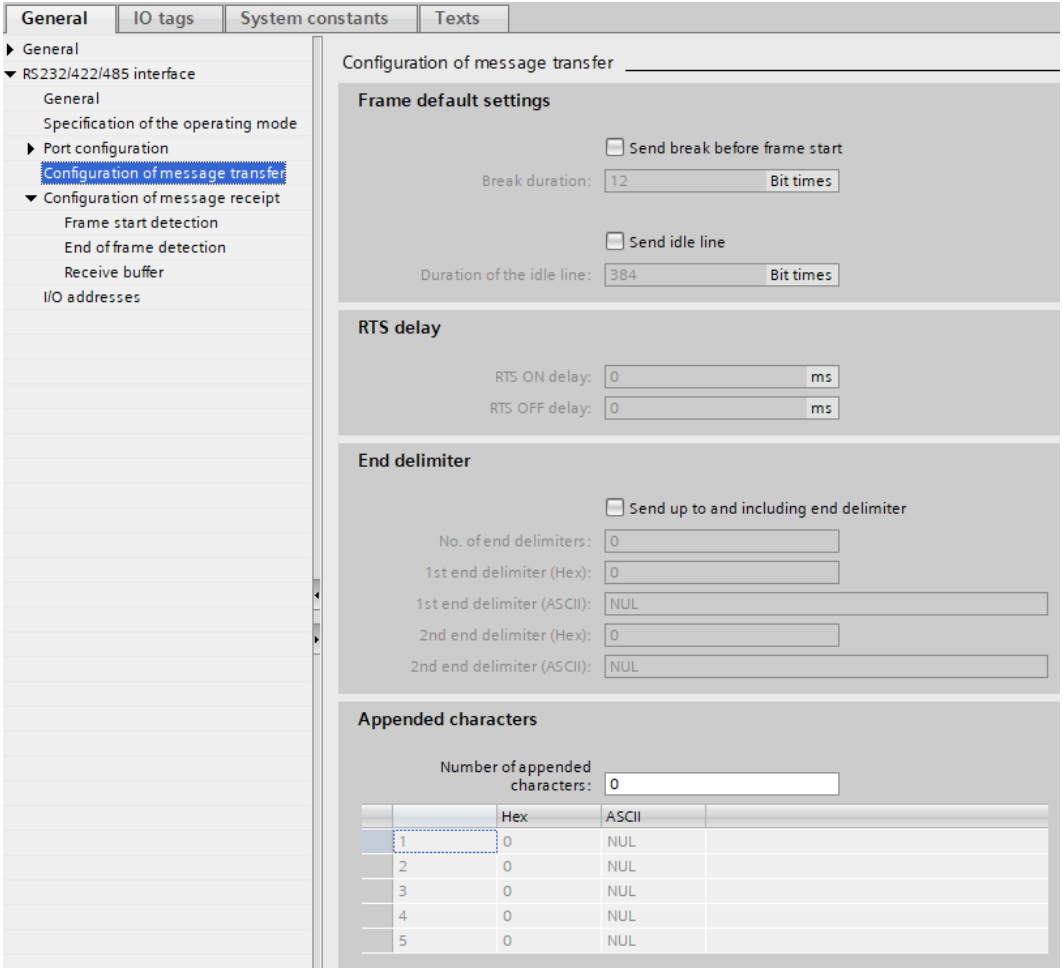
Software flow control requires full-duplex communication, as the receiving partner must be able to send XOFF to the transmitting partner while a transmission is in progress. Software flow control is only possible with messages that contain only ASCII characters. Binary protocols cannot utilize software flow control.

7.12.5.3 Configuring transmit (send) and receive parameters

Before the CPU can engage in PtP Freeport communications, you must configure parameters for transmitting (or sending) messages and receiving messages. These parameters dictate how communications operate when messages are being transmitted to or received from a target device.

7.12.5.4 Configuring transmit (send) parameters

From the device configuration of the CPU, you configure how a communication interface transmits data by setting the "Configuration of message transfer" properties for the selected interface.



You can also dynamically configure or change the message transfer parameters from the STEP 7 program by using the Send_Config instruction (Page 284).

NOTE

Parameter values set from the Send_Config instruction in the STEP 7 program override the "Configuration of message transfer" properties. Note that the CPU does not retain parameters set from the Send_Config instruction in the event of power down or transition to STOP.

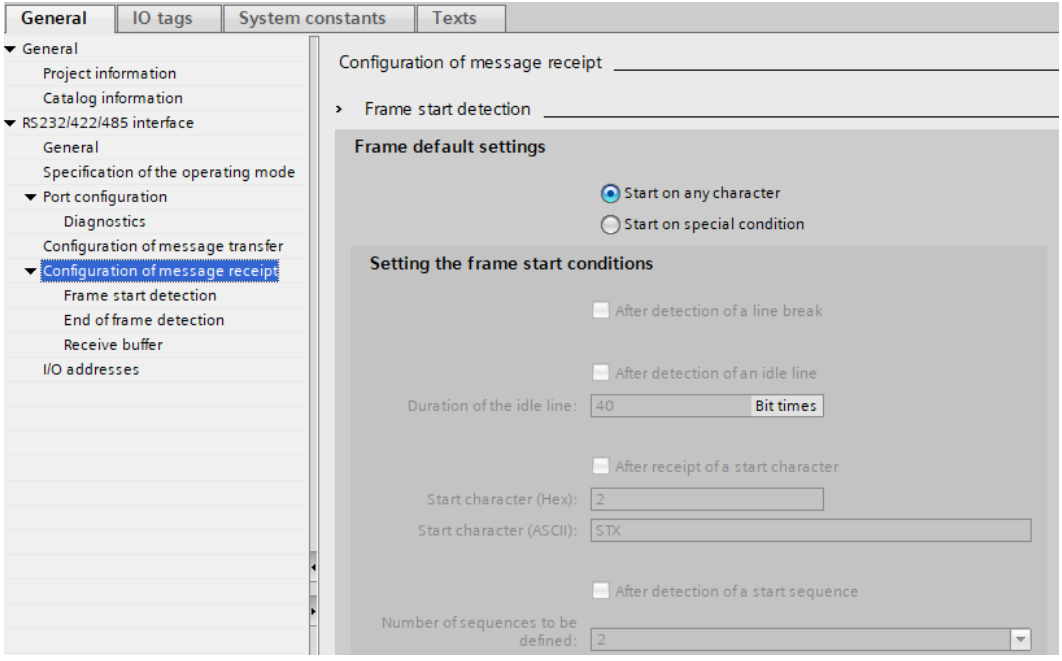
Parameter	Definition
Send break before frame start Break duration	Specifies that upon the start of each frame, a break will be sent after the RTS On delay (if configured) has expired and CTS is active. You specify how many bit times constitute a break where the line is held in a spacing condition. The default is 12 and the maximum is 65535, up to a limit of eight seconds.

Parameter	Definition
Send idle line Duration of the idle line	Specifies that an idle line will be sent before message start. It is sent after the break, if a break is configured. The "Duration of the idle line" parameter specifies how many bit times constitute an idle line where the line is held in a marking condition. The default is 384 and the maximum is 65535, up to a limit of eight seconds.
RTS ON delay	Specifies the amount of time to wait after activating RTS before transmission is initiated. The range is 0 to 65535 ms, with a default value of 0. This parameter is valid only when the port configuration (Page 266) specifies hardware flow control. CTS is evaluated after the RTS On delay time has expired. This parameter is applicable for the RS232 mode of CM 1241 RS232/422/485 only.
RTS OFF delay	Specifies the amount of time to wait before deactivating RTS after completion of transmission. The range is 0 to 65535 ms, with a default value of 0. This parameter is valid only when the port configuration (Page 266) specifies hardware flow control. This parameter is applicable for RS232 mode of CM 1241 RS232/422/485 only.
Send up to and including end delimiter No. of end delimiters	You can configure the number of end delimiters (1 or 2) and their value. All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the delimiter, even if the specified data length is longer.
1st end delimiter (Hex) 1st end delimiter (ASCII)	Entry of the first end delimiter of a maximum of two end delimiters for the end criteria "Send up to and including end delimiter". The selected end delimiter or the selected end delimiter combination limits the length of the frame.
2nd end delimiter (Hex) 2nd end delimiter (ASCII)	Entry of the second end delimiter of a maximum of two end delimiters for the end criteria "Send up to and including end delimiter". The selected end delimiter combination limits the length of the frame.
Number of appended characters	Input of the number of appended characters. Sending takes place up to the configured length. The end delimiter(s) is/are appended automatically. Depending on the number of end delimiters, the CM sends one to five characters more than the number specified at the instruction to the partner.

7.12.5.5 Configuring receive parameters

The configuration options for a communication interface include settings for receiving data and recognizing the start and end of a message.

Set these parameters in the "Configuration of message receipt" properties for the selected interface.



You can also dynamically configure or change the receive message parameters from the STEP 7 program by using the Receive_Config instruction (Page 284).

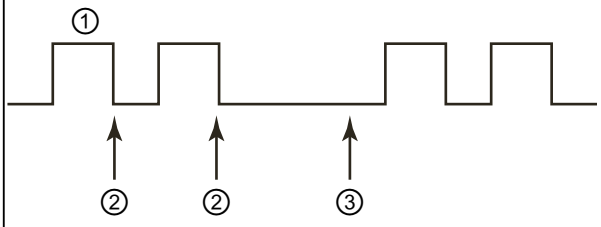
NOTE

Parameter values set from the Receive_Config instruction in the STEP 7 program override the "Receive message configuration" properties. Note that the CPU does not retain parameters set from the Receive_Config instruction in the event of power down or transition to STOP.

Frame start detection

You can determine how the communication interface recognizes the start of a message. The start characters and the characters comprising the message go into the receive buffer until a configured end condition is met.

You can specify multiple start conditions. If you specify more than one start condition, all of the start conditions must be met before the message is considered started. For example, if you configure an idle line time and a specific start character, the CM or CB will first look for the idle line time requirement to be met and then the CM or CB will look for the specified start character. If some other character is received (not the specified start character), the CM or CB will restart the start of message search by again looking for an idle line time.

Parameter	Definition
Start on any character	The "Start on any character" condition specifies that any successfully received character indicates the start of a message. This character is the first character within a message.
Start on special condition	The start of the message is detected based on the following specified conditions: • After detection of a line break • After detection of an idle line • After receipt of a start character • After receipt of a start sequence
Special condition: After detection of a line break	Specifies that a message receive operation starts after a break character is received.
Special condition: After detection of an idle line	Specifies that a message reception starts once the receive line has been idle or quiet for the number of specified bit times. Once this condition occurs, the start of a message begins.  ① Characters ② Restarts the idle line timer ③ Idle line is detected and message receive is started
Special condition: After receipt of a start character	Specifies that a particular character indicates the start of a message. This character is then the first character within a message. Any character that is received before this specific character is discarded. The default character is STX.
Special condition: After detection of a start sequence	Specifies that a particular character sequence from up to four configured sequences indicates the start of a message. For each sequence, you can specify up to five characters. For each character position, you specify either a specific hex character, or that the character is ignored in sequence matching (wildcard character). The last specific character of a character sequence terminates that start condition sequence. Incoming sequences are evaluated against the configured start conditions until a start condition has been satisfied. Once the start sequence has been satisfied, evaluation of end conditions begins. You can configure up to four specific character sequences. You use a multiple-sequence start condition when different sequences of characters can indicate the start of a message. If any one of the character sequences is matched, the message is started.

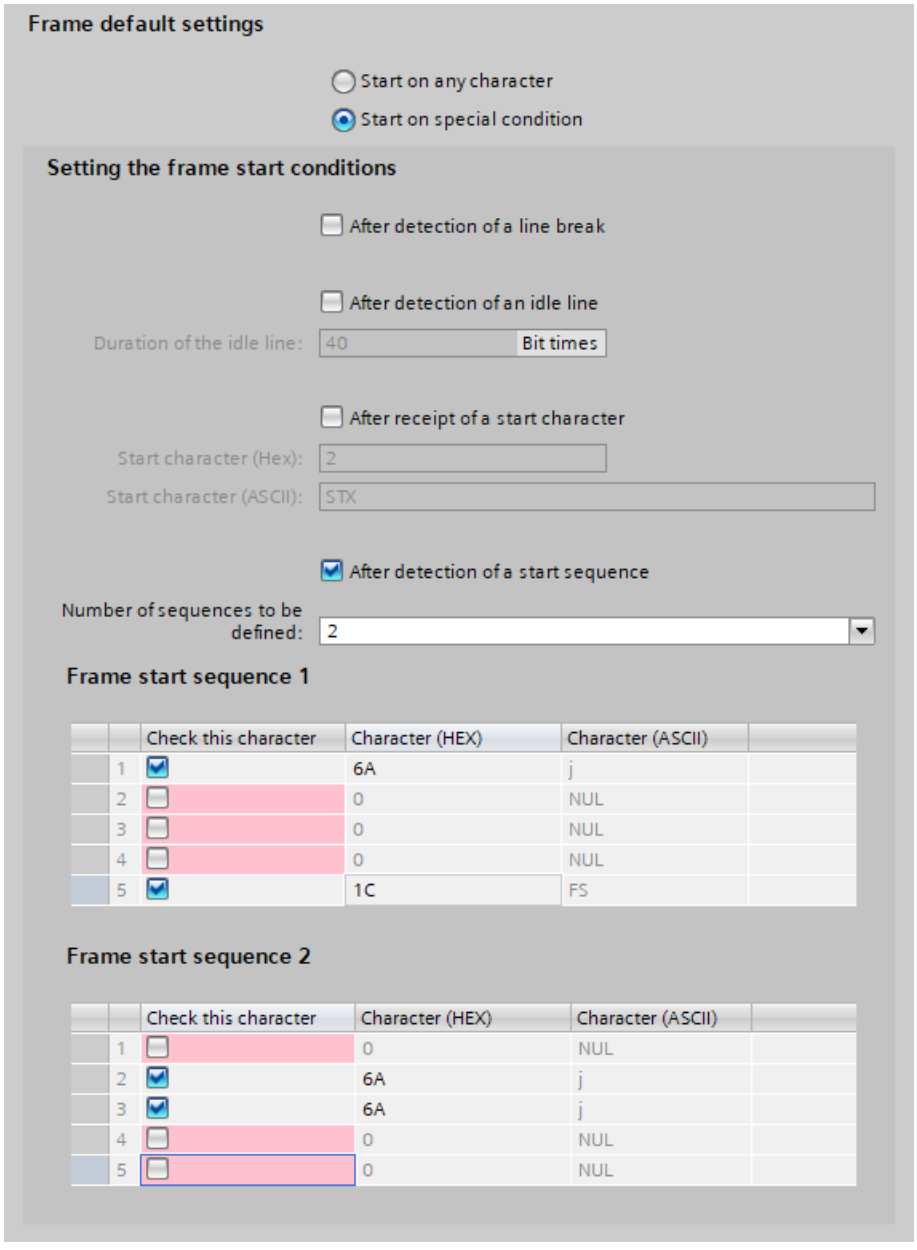
The communication interface checks start conditions in the following order:

- Idle line
- Broken line
- Character or character sequences

While checking for multiple start conditions, if one of the conditions is not met, the CM or CB restarts the checking with the first required condition. After the CM or CB establishes that the start conditions have been met, it begins evaluating end conditions.

Example configuration: Start message on one of two character sequences

Consider the following start message condition configuration:



With this configuration, the start condition is satisfied when either pattern occurs:

- When a five-character sequence is received where the first character is 0x6A and the fifth character is 0x1C. The characters at positions 2, 3, and 4 can be any character with this configuration. After the fifth character is received, evaluation of end conditions begins.
- When two consecutive 0x6A characters are received, preceded by any character. In this case, evaluation of end conditions begins after the second 0x6A is received (3 characters). The character preceding the first 0x6A is included in the start condition.

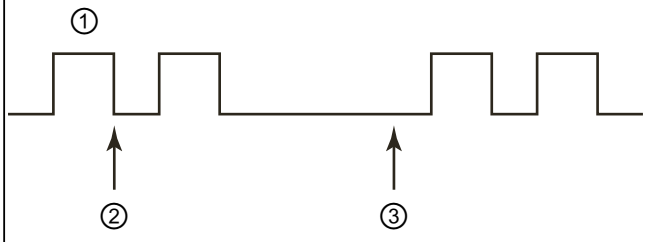
The following are example sequences that would satisfy this start condition:

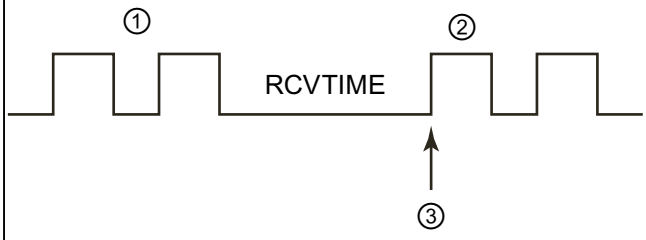
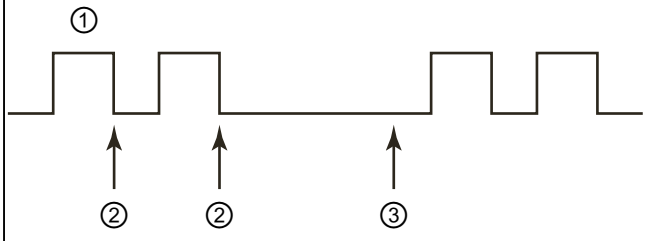
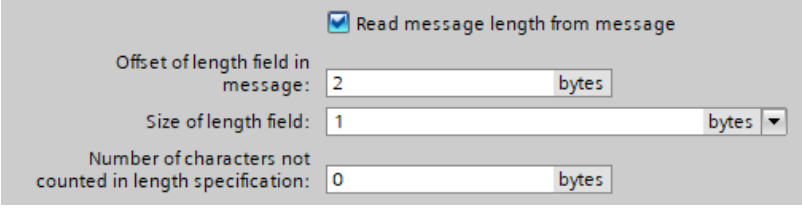
- <any character> 6A 6A
- 6A 12 14 18 1C
- 6A 44 A5 D2 1C

End of frame detection

You also configure how the communication interface recognizes the end of a message. You can configure multiple message end conditions. If any one of the configured conditions occurs, the message ends.

For example, you could specify an end condition with an end of message timeout of 300 milliseconds, an inter-character timeout of 40 bit times, and a maximum length of 50 bytes. The message ends if the message takes longer than 300 milliseconds to receive, or if the gap between any two characters exceeds 40 bit times, or if 50 bytes are received.

Parameter	Definition
Recognize message end by message timeout	The message end occurs when the configured amount of time to wait for the message end has expired. The message timeout period begins when a start condition has been satisfied. The default is 200 ms and the range is 1 to 65535 ms.  ① Received characters ② Start Message condition satisfied: message timer starts ③ Message timer expires and terminates the message
Recognize message end by response timeout	The message end occurs when the configured amount of time to wait for a response expires before a valid start sequence is received. The response timeout period begins when a transmission ends and the CM or CB begins the receive operation. The default response timeout is 200 ms and the range is 1 to 65535 ms. If a character is not received within the response time period, RCVTIME, then an error is returned to the corresponding Receive_P2P instruction. The response timeout does not define a specific end condition. It only specifies that a character must be successfully received within the specified time. You must configure another end condition to indicate the actual end of a message.

Parameter	Definition
	 ① Transmitted characters ② Received characters ③ First character must be successfully received by this time.
After character delay time elapses	The message end occurs when the maximum configured timeout between any two consecutive characters of a message has expired. The default value for the inter-character gap is 288 bit times and the maximum number is 65535 bit times, up to a maximum of eight seconds.  ① Received characters ② Restarts the intercharacter timer ③ The intercharacter timer expires and terminates the message.
After receipt of a fixed frame length	The message end occurs after a fixed frame length has been received. The valid range for the fixed length is 1 to 4096. The default is 1.
After receipt of a maximum number of characters	The message end occurs when the specified number of characters has been received. The valid range for the number of specified characters is 1 to 4096. the default is 1.
Read message length from message	The message specifies the length of the message. The message end occurs when a message of the specified length has been received. When you select the special condition where the message length is included in the message, you must provide three parameters that define information about the message length. The actual message structure varies according to the protocol in use. The three parameters are as follows: • Offset of length field in message: Set the character position (1-based) within the message that starts the length specifier. The valid range is 0-4095 with a default of 0 bytes. • Size of length field: Set the number of bytes (one, two, or four) of the length specifier. • Number of characters not counted in length specification: Set the number of characters following the length specifier that are not included in the length count. The valid range 0-255 with a default of 0 bytes. The ending characters do not need to be contiguous. The "Number of characters not counted in length specification" value can be used to specify the length of a checksum field whose size is not included in the length field. 

Parameter	Definition
After receipt of an end sequence	The message end occurs when a specified character sequence is received. You can specify a sequence of up to five characters. For each character position, you specify either a specific hex character, or that the character is ignored in sequence matching. Leading characters that are ignored characters are not part of the end condition. Trailing characters that are ignored characters are part of the end condition.

Example configuration: Read message length from message

Example 1: Consider a message structured according to the following protocol:

STX	Len (n)	Characters 3 to 14 counted by the length												
		ADR	PKE		INDEX		PWD		STW		HSW		BCC
1	2	3	4	5	6	7	8	9	10	11	12	13	14
STX	0x0C	xx	xxxx		xxxx		xxxx		xxxx		xxxx		xx

Configure the receive message length parameters for this message as follows:

- n = 2 (The message length starts with byte 2.)
- Length size = 1 (The message length is defined in one byte.)
- Length m = 0 (There are no additional characters following the length specifier that are not counted in the length count. Twelve characters follow the length specifier.)

In this example, the characters from 3 to 14 inclusive are the characters counted by Len (n).

Example 2: Consider another message structured according to the following protocol:

SD1	Len (n)	Len (n)	SD2	Characters 5 to 10 counted by length						FCS	ED
				DA	SA	FA	Data unit=3 bytes				
1	2	3	4	5	6	7	8	9	10	11	12
xx	0x06	0x06	xx	xx	xx	xx	xx	xx	xx	xx	xx

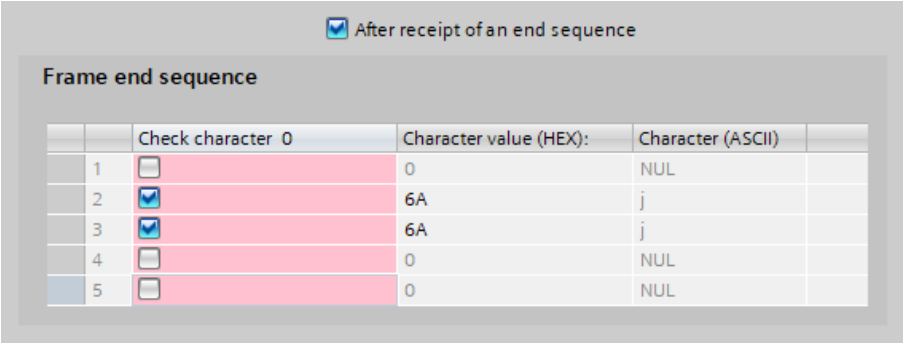
Configure the receive message length parameters for this message as follows:

- n = 3 (The message length starts at byte 3.)
- Length size = 1 (The message length is defined in one byte.)
- Length m = 3 (There are three characters following the length specifier that are not counted in the length. In the protocol of this example, the characters SD2, FCS, and ED are not counted in the length count. The other six characters are counted in the length count; therefore the total number of characters following the length specifier is nine.)

In this example, the characters from 5 to 10 inclusive are the characters counted by Len (n).

Example configuration: After receipt of an end sequence

Consider the following end message condition configuration:



In this case, the end condition is satisfied when two consecutive 0x6A characters are received, followed by any two characters. The character preceding the 0x6A 0x6A pattern is not part of the end character sequence. Two characters following the 0x6A 0x6A pattern are required to terminate the end character sequence. The values received at character positions 4 and 5 are irrelevant, but they must be received to satisfy the end condition.

NOTE

If you want your character sequence to indicate the end of the message, put the sequence in the last character positions. In the example above, if you wanted 0x6A 0x6A to end the message with no trailing characters, you would configure 0x6A in character positions 4 and 5.

7.12.6 3964(R) communication

The S7-1200 G2 CPU supports the 3964(R) protocol (RS232 or RS422 only) to enable communication between a CM 1241 RS232/422/485 and a communication partner that uses the 3964(R) protocol. Unlike PtP Freeport communication, where you define specific send (transmit) and receive characteristics for the messages, the 3964(R) protocol requires the following control characters:

- STX Start of text
  Start of character string to be transmitted
- DLE Data Link Escape
  Data transmission switchover
- ETX End of Text
  End of character string to be transmitted
- BCC Block check character
- NAK Negative Acknowledge

Refer to the chapter describing serial data transmission principles in the S7-300 CP 341 Point-to-Point Communication, Installation, and Parameter Assignment Manual (https://support.industry.siemens.com/cs/us/en/view/1117397) for a complete description of the protocol.

Configuring the communication interface

To communicate to a partner using the 3964(R) protocol, you must include the CM 1241 RS232/422/485 (Page 460) in your device configuration in STEP 7. You then configure the communication ports (Page 266), priority, and protocol parameters (Page 282).

Communication to a partner with the 3964(R) protocol

When you configure a CM for 3964(R) protocol, you use the standard point-to-point send and receive instructions to transfer data between the CPU and its communication partner.

The CM embeds your data from the BUFFER parameter of the send instruction into the 3964(R) protocol and sends the data to the communication partner.

The CM receives data from the communication partner by means of the 3964(R) protocol, removes the protocol information, and returns the data in the BUFFER parameter of the receive instruction.

Refer to the following point-to-point instructions in the TIA Portal Information System:

- "Send_P2P: Sending data (S7-1200, S7-1500)" (https://docs.tia.siemens.cloud/access?ft:originId=./39512235019/CM1500_Prog_Send_P2P_enUS.htm&ft:clusterId./39512235019/CM1500_Prog_Send_P2P.htm)
- "Receive_P2P: Receiving data (S7-1200, S7-1500)" (https://docs.tia.siemens.cloud/access?ft:originId=./39512235019/CM1500_Prog_Receive_P2P_enUS.htm&ft:clusterId./39512235019/CM1500_Prog_Receive_P2P.htm)

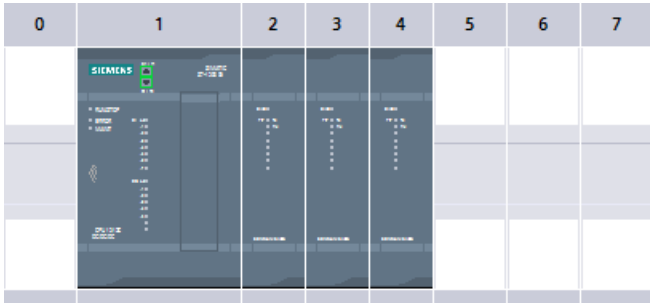
7.12.7 Configuring the 3964(R) communication

7.12.7.1 Configuring the 3964(R) communication ports

You can use either of the following methods to configure the communication interfaces for 3964(R) communication:

- Use the device configuration in STEP 7 to configure the port parameters. The CPU stores the device configuration settings and applies the settings after a power cycle.
- Use the Port_Config instruction to set the port parameters. The port settings set by the instructions are valid while the CPU is in RUN mode. The port settings revert to the device configuration settings after a power cycle.

After adding the communication interfaces to the device configuration (Page 157), you configure parameters for the communication interfaces by selecting one of the configured CMs.



The "Properties" tab of the inspector window displays the parameters of the selected CM. Select "Port configuration" to edit the following parameters:

- Protocol: 3964(R) with "Performance optimized for many short frames" optional
- Data transfer rate
- Parity
- Data bits
- Stop bits
- "Activate break detection" optional (RS232 only)

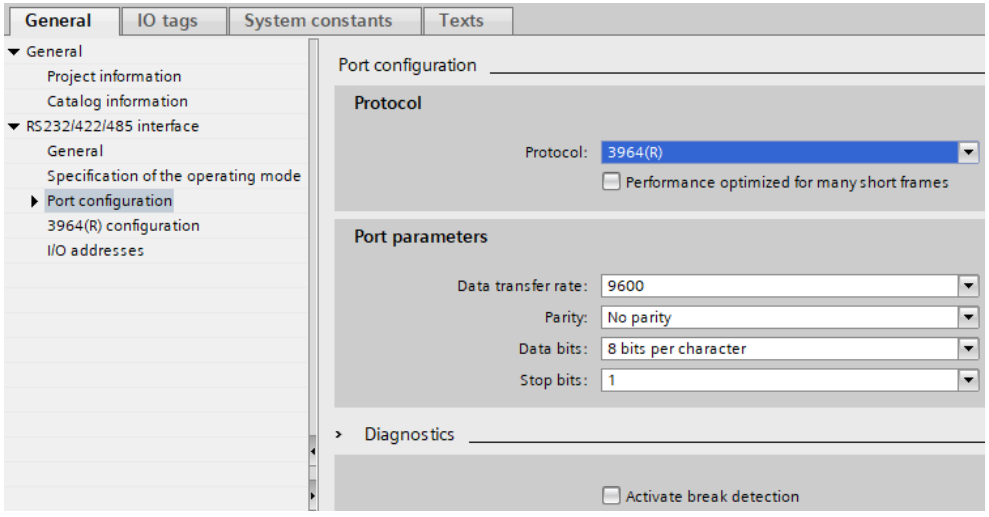


Table 1-190 Parameter definitions

Parameter	Definition
Protocol	3964R or Freeport/Modbus. Select 3964R to configure port for 3964(R) communication. Select the checkbox to optimize performance for many short frames.
Data transfer rate	The default value for the data transmission rate is 9600 bits/s. Valid choices in bits/s are: • 300 • 600 • 1200 • 2400 • 4800 • 9600 • 19200 • 38400 • 57600 • 76800 • 115200 • 250000 (RS422 only)
Parity	The default value for parity is no parity. Valid choices are: • No parity • Even parity • Odd parity • Mark (set parity bit to 1) • Space (set parity bit to 0)

Parameter	Definition
Data bits	The number of data bits in a character. Valid choices are 7 or 8.
Stop bits	The number of stop bits can be either 1 or 2. The default is 1.
Activate break detection	Select the "Activate break detection" checkbox (RS232 only) to allow the CM to continuously monitor the communication line for any breaks or interruptions in the data transmission.

NOTE

Set the "Specification of the operating mode" for 3964R to one of the following two modes:

- RS232 mode
- Full duplex (RS422) 4-wire operation point to point

7.12.7.2 Configuring the 3964(R) priority and protocol parameters

You can use either of the following methods to configure the communication interfaces for 3964(R) communication:

- In the device configuration of the communication interface, click "3964(R) configuration" to set the priority and configure the protocol parameters. The CPU stores the device configuration settings and applies the settings after a power cycle.
- Use the P3964_Config instruction (Page 284) to set the priority and protocol configuration parameters. The values set by the instructions are valid while the CPU is in RUN mode. The values revert to the device configuration settings after a power cycle.

The "Properties" tab of the inspector window displays the parameters of the selected CM. Select "3964(R) configuration" to edit the parameters.

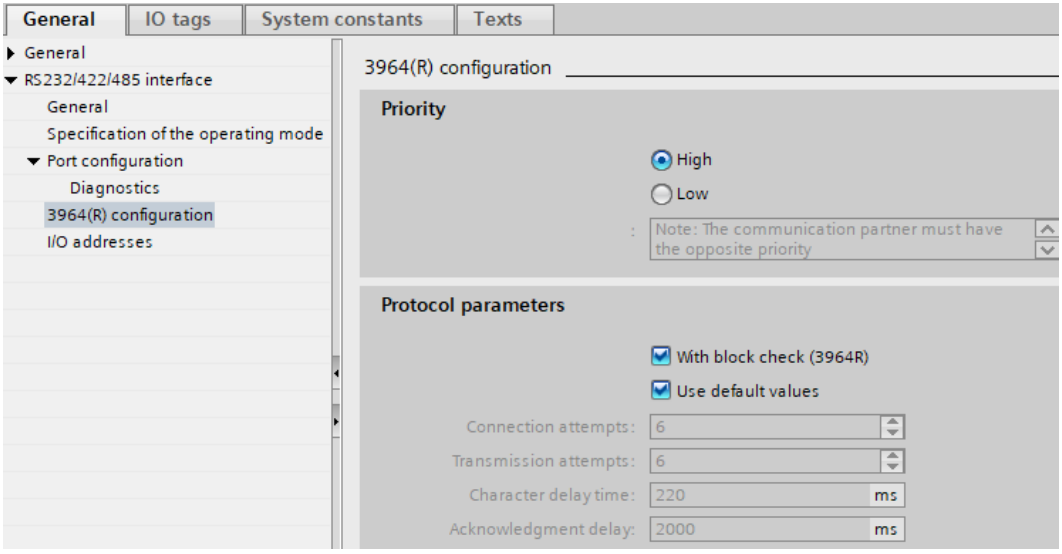


Table 1-191 Parameter definitions

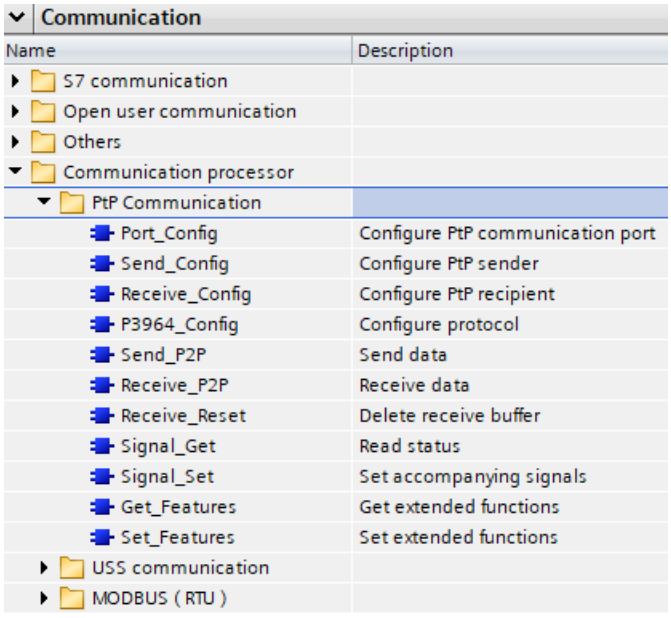
Parameter	Definition
Priority	High or low: The CM will be either high or low and the communication partner must be the opposite.
With block check (3964R)	If selected, 3964(R) communication employs transmission security by including a block check character (BCC). If not selected transmission security does not include a block check character.
Use default values	If selected, 3964(R) uses default values for the following protocol parameters: • Connection attempts • Transmission attempts • Character delay time • Acknowledgement delay If not selected, you can configure values for each of these parameters.
Connection attempts	Number of connection attempts (default value: 6 connection attempts) 1 to 255
Transmission attempts	Number of transmission attempts (default value: 6 transmission attempts) 1 to 255
Character delay time	Character delay time setting (depending on the set data transmission rate) (default value: 220 ms) 20 ms to 65535 ms
Acknowledgement delay	Acknowledgment delay time setting (depending on the set data transmission rate) (default value: 2000 ms when block check is enabled; 550 ms when block check is not enabled) 20 ms to 65535 ms

NOTE

With the exception of Priority, the protocol settings must be the same for the CM module and the communication partner.

7.12.8 Point-to-Point Instructions

The PtP instructions (https://docs.tia.siemens.cloud/access?ft:originId=./39512235019/39512235019_enUS.htm&ft:clusterId./39512235019/39512235019.htm) provide for communication using various network protocols and include the following folder:



NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently based on PLC family, follow the S7-1500 option for the instructon topic.

7.12.9 Programming the PtP communications

7.12.9.1 Programming overview

The Point-to-Point instructions (Page 284) fall into two categories:

- Configuration instructions
- Communication instructions

Configuration instructions

Before your STEP 7 program can engage in PtP communication, you must configure the communication interface port and the parameters for sending data and receiving data.

You can perform the port configuration and message configuration for each CM or CB through the device configuration or through these instructions in your STEP 7 program:

- Port_Config
- Send_Config
- Receive_Config
- P3964_Config

Communication instructions

The PtP communication instructions enable the STEP 7 program to send messages to and receive messages (https://docs.tia.siemens.cloud/access?ft:originId=./15891429899/20448736523_enUS.htm&ft:clusterId./15891429899/20448736523.htm) from the communication interfaces.

All of the PtP functions operate asynchronously. The STEP 7 program can use a polling architecture to determine the status of transmissions and receptions. Send_P2P and Receive_P2P can execute concurrently. The communication modules and communication board buffer the transmit and receive messages as necessary up to a maximum buffer size of 1024 bytes.

CMs and CBs send messages to and receive messages from the actual point-to-point devices. The message protocol is in a buffer that is either received from or sent to a specific communication port. The buffer and port are parameters of the send and receive instructions:

- Send_P2P
- Receive_P2P

Additional instructions provide the capability to reset the receive buffer, and to get and set specific CM signals and features:

- Receive_Reset
- Signal_Get
- Signal_Set
- Get_Features
- Set_Features

7.12.9.2 Polling architecture

The STEP 7 program must call the point-to-point instructions cyclically or periodically to check for received messages. Polling the send cyclically or periodically determines when the transmit has completed.

Polling architecture: client

The typical sequence for a client is as follows:

1. A Send_P2P instruction initiates a transmission to the CM or CB.
2. The Send_P2P instruction executes on subsequent scans to poll for the transmit complete status.
3. When the Send_P2P instruction indicates that the transmission is complete, the STEP 7 program logic can prepare to receive the response.
4. The Receive_P2P instruction executes repeatedly to check for a response. When the CM or CB has collected a response message, the Receive_P2P instruction copies the response to the CPU and indicates that new data have been received.
5. The STEP 7 program can process the response.
6. Go to step 1 and repeat the cycle.

Polling architecture: server

The typical sequence for a server is as follows:

1. The STEP 7 program executes the Receive_P2P instruction every scan.
2. When the CM or CB has received a request, the Receive_P2P instruction indicates the availability of new data and the request is copied into the CPU.
3. The STEP 7 program services the request and generates a response.
4. Use a Send_P2P instruction to send the response back to the client.
5. Repeatedly execute Send_P2P to be sure the transmit occurs.
6. Go to step 1 and repeat the cycle.

The server must be responsible for calling Receive_P2P frequently enough to receive a transmission from the client before the client times out while waiting for a response. To accomplish this task, the STEP 7 program can call Receive_P2P from a cyclic OB, where the cycle time is sufficient to receive a transmission from the client before the timeout period expires. If you set the cycle time for the OB to provide for two executions within the timeout period of the client, the STEP 7 program can receive transmissions without missing any.

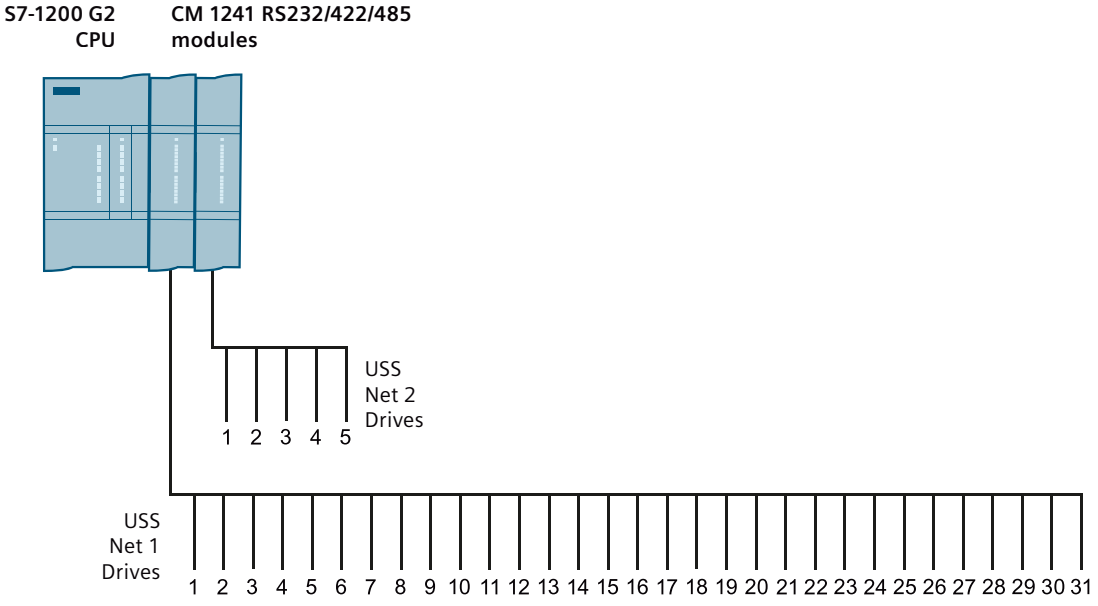
7.13 Universal serial interface (USS) communication

The USS instructions (Page 289) control the operation of motor drives which support the universal serial interface (USS) protocol. You can use the USS instructions to communicate with multiple drives through RS485 connections. Each RS485 port can operate up to 31 drives.

You can use the USS instructions to communicate with multiple drives through RS485 connections to CM 1241 RS232/422/485 communication modules or CB 1241 RS485 communication boards. The following CM/CB combinations can be installed:

- For 1212C and 1212FC CPUs, up to three CM 1241 RS232/422/485 modules and one CB 1241 RS485 for a total of four communication interfaces
- For 1214C and 1214FC CPUs, up to three CM 1241 RS232/422/485 modules and up to two CBs 1241 RS485 for a total of five communication interfaces

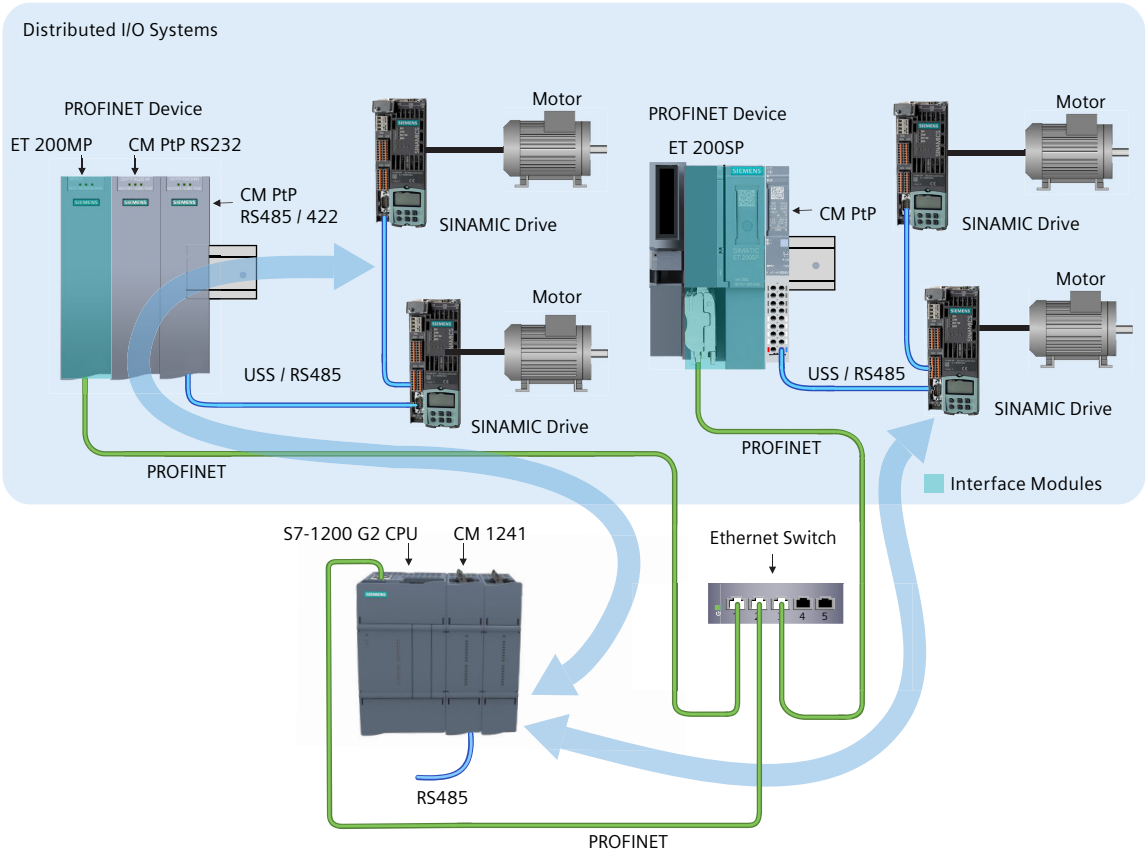
The USS protocol uses a master-slave network for communications over a serial bus. The master uses an address parameter to send a message to a selected slave. A slave itself can never transmit without first receiving a request to do so. Direct message transfer between the individual slaves is not possible. USS communication operates in half-duplex mode. The following USS illustration shows a network diagram for an example drive application.



USS communications through PROFINET

USS communication enables you to use a PROFINET distributed I/O rack to communicate to various devices (RFID readers, GPS device, and others). You connect the Ethernet interface of the S7 1200 G2 CPU to a PROFINET interface module. PtP communication modules in the rack with the interface module provide serial communications to USS drives.

USS instructions allow you to configure the communications between the PtP communication modules in the distributed I/O rack and the USS drives.



The blue arrows indicate the flow of bidirectional communication between devices.

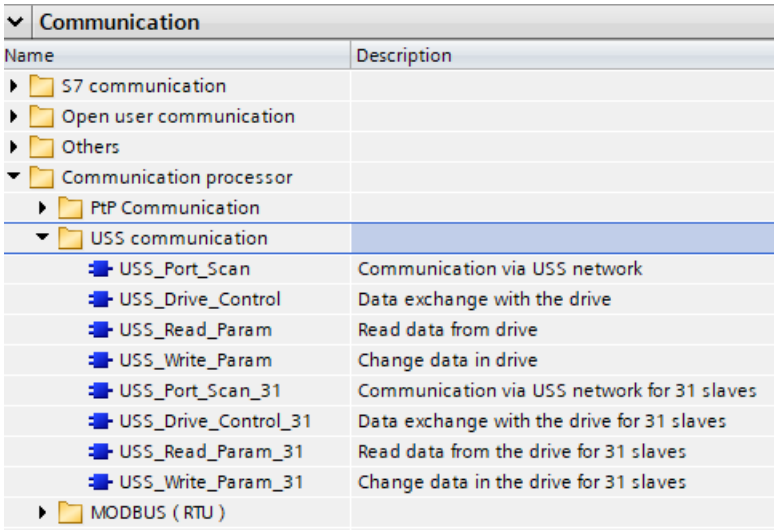
Note that STEP 7 provides different versions (https://docs.tia.siemens.cloud/access?ft:originId=./75629918475/95949438091_enUS.htm&ft:clusterId=./75629918475/95949438091.htm) of the USS instructions (Page 289)depending on the number of drives.

Requirements for using the USS protocol

The USS communication instructions support the USS protocol with usage requirements (https://docs.tia.siemens.cloud/access?ft:originId=./39512292235/40514327819_enUS.htm&ft:clusterId=./39512292235/40514327819.htm). For each USS network, one instance data block (DB) is used for USS_Port_Scan and one instance data block for all calls of USS_Drive_Control.

7.13.1 USS instructions

USS instructions (https://docs.tia.siemens.cloud/access?ft:originId=./39512292235/39512292235_enUS.htm&ft:clusterId./39512292235/39512292235.htm) provide for communication using various network protocols and include the following folder groups:



The following instructions operate a maximum of 16 USS drives:

- USS-Port_Scan
- USS_Drive_Control
- USS_Read_Param
- USS_Write_Param

The following instructions operate a maximum of 31 USS drives:

- USS-Port_Scan_31
- USS_Drive_Control_31
- USS_Read_Param_31
- USS_Write_Param_31

NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently based on PLC family, follow the S7-1500 option for the instructon topic.

7.13.2 USS status codes

The STATUS output of the USS functions returns the USS instruction status codes.

Table 1-192 STATUS codes [1]

STATUS (W#16#....)	Description
0000	No error
8180	The length of the drive response did not match the characters received from the drive. The drive number where the error occurred is returned in the "USS_Extended_Error" variable. See the extended error description below this table.
8181	VALUE parameter was not a Word, Real or DWord data type.
8182	The instruction supplied a Word for a parameter value and received a DWord or Real from the drive in the response.
8183	The instruction supplied a DWord or Real for a parameter value and received a Word from the drive in the response.
8184	The response telegram from drive had a bad checksum. The drive number where the error occurred is returned in the "USS_Extended_Error" variable. See the extended error description below this table.
8185	Illegal drive address. Valid drive address range: 1 to16 (or 1-31 if using the _31 instructions).
8186	The speed set point is out of the valid range (valid speed SP range: -200% to 200%).
8187	The wrong drive number responded to the request sent. The drive number where the error occurred is returned in the "USS_Extended_Error" variable. See the extended error description below this table.
8188	Illegal Programmable Zero Delay (PZD) word length specified (valid range = 2, 4, 6 or 8 words).
8189	Illegal Baud Rate was specified.
818A	The parameter request channel is in use by another request for this drive.
818B	The drive has not responded to requests and retries. The drive number where the error occurred is returned in the "USS_Extended_Error" variable. See the extended error description below this table.
818C	The drive returned an extended error on a parameter request operation. See the extended error description below this table.
818D	The drive returned an illegal access error on a parameter request operation. See your drive manual for information of why parameter access may be limited.
818E	The drive has not been initialized. This error code is returned to USS_Read_Param or USS_Write_Param when USS_Drive_Control, for that drive, has not been called at least once. This keeps the initialization on first scan of USS_Drive_Control from overwriting a pending parameter read or write request, since it initializes the drive as a new entry. To fix this error, call USS_Drive_Control for this drive number.
8280	Negative acknowledgment when reading module.
8281	Negative acknowledgment when writing module.
8FFF	The module is not ready temporarily due to a reset.
80Ax-80Fx	Specific errors returned from PtP communication instructions called by the USS Library - These error code values are not modified by the USS library and are defined in the PtP instruction descriptions.

[1] In addition to the USS instruction errors listed above, errors can be returned from the underlying PtP communication instructions.

For several STATUS codes, additional information is provided in the USS_Extended_Error variable of the USS_Drive_Control Instance DB. For STATUS codes hexadecimal 8180, 8184, 8187, and 818B, USS_Extended_Error contains the drive number where the communication error occurred. For STATUS code hexadecimal 818C, USS_Extended_Error contains a drive error code returned from the drive when using a USS_Read_Param or USS_Write_Param instruction.

Read and write access to a drive's internal parameters

USS drives support read and write access to a drive's internal parameters. This feature allows remote control and configuration of the drive. Drive parameter access operations can fail due to errors such as values out of range or illegal requests for a drive's current mode. The drive generates an error code value that is returned in the USS_Extended_Error variable when the STATUS code value is hexadecimal 818C. This error code value is only valid for the last execution of a USS_Read_Param or USS_Write_Param instruction. The error code value of USS_Extended_Error depends on the drive model. See the drive's manual for a description of the extended error codes for read and write parameter operations.

7.13.3 USS general drive setup requirements

USS general drive setup requirements consist of the following points:

- The drives must be set to use 4 Parameter Control Words (PKW).
- The drives can be configured for 2, 4, 6, or 8 Programmable Zero Delay (PZD) words.
- The number of PZD words in the drive must match PZD_LEN input on the USS_Drive_Control instruction for that drive.
- The baud rate in all the drives must match the BAUD input on the USS_Port_Scan instruction.
- The drive must be set for remote control.
- The drive must be set for frequency set-point to USS on COM Link.
- The drive address must be set to 1 to 16 (or 1-31 if using the _31 instructions) and match the DRIVE input on the USS_Drive_Control block for that drive.
- The drive direction control must be set to use the polarity of the drive set-point.
- The RS485 network must be terminated properly.

7.14 Modbus communication

Modbus function codes

A CPU operating as a Modbus TCP client or Modbus RTU master can read/write both data and I/O states in a remote Modbus TCP server or Modbus RTU slave. Remote data can be read and then processed in your program logic.

A CPU operating as a Modbus TCP server or Modbus RTU slave allows a supervisory device to read/write both data and I/O states in CPU memory. A Modbus TCP client or Modbus RTU master can write new values into server/slave CPU memory that is available to your program logic.

⚠ WARNING

Avoiding security risks from network attacks

If an attacker can access your networks, the attacker can possibly read and write data.

For example, I/O exchange through PROFINET, PUT/GET (Page 252), T-Block, and communication modules (CMs) have no security features. You must protect these forms of communication.

If you fail to protect these forms of communication, death or severe personal injury can result.

For security information and recommendations, see the "Operational Guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html)" white paper on the Siemens Industrial Cybersecurity Web site.

Table 1-193 Read data functions: Read remote I/O and program data

Modbus function code	Read slave (server) functions - standard addressing
01	Read output bits: 1 to 2000 bits per request
02	Read input bits: 1 to 2000 bits per request
03	Read holding registers: 1 to 125 words per request
04	Read input words: 1 to 125 words per request

Table 1-194 Write data functions: Write remote I/O and modify program data

Modbus function code	Write slave (server) functions - standard addressing
05	Write one output bit: 1 bit per request
06	Write one holding register: 1 word per request
15	Write one or more output bits: 1 to 1968 bits per request
16	Write one or more holding registers: 1 to 123 words per request

Modbus function codes 08 and 11 provide slave device communication diagnostic information.

Modbus function code 0 broadcasts a message to all slaves (with no slave response). The broadcast function is not available for Modbus TCP, because communication is connection based.

Modbus function code 23 can write and read one or more holding registers: 1 to 121/125 (Write/Read) words per request. This function code is only available for Modbus TCP.

Modbus network station addresses

In a Modbus TCP network, each device is uniquely addressed using its IP address and port number. To establish a connection, enter these details into the appropriate configuration field. The Modbus protocol then uses this address information to access and communicate with devices over the network.

Table 1-195 Modbus memory addresses

Station		Address range
TCP station	Station address	IP address and port number
RTU station	Standard station address	1 to 247
	Extended station address	1 to 65535

Modbus memory addresses

The actual number of available Modbus memory addresses depends on the CPU model, how much work memory exists, and how much CPU memory is used by other program data. The table below gives the nominal value of the address range.

Table 1-196 Modbus memory addresses

Station		Address range
TCP station	Standard memory address	10K
	Extended memory address	64K
RTU station	Standard memory address	10K
	Extended memory address	64K

7.14.1 Modbus TCP

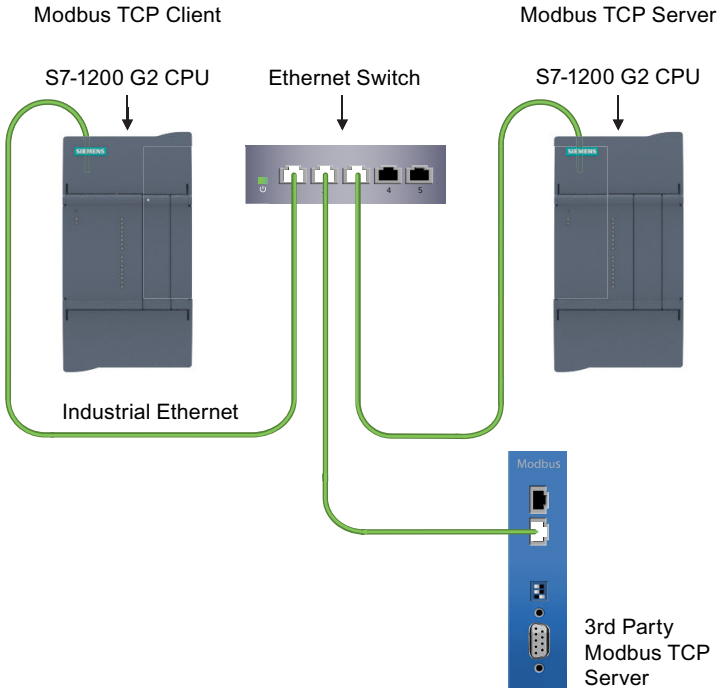
Modbus TCP (Transmission Control Protocol) is a standard network communication protocol that uses the PROFINET connector on the CPU for TCP/IP communication.

Modbus TCP uses Open User Communication (OUC) connections as a Modbus communication path. Multiple client-server connections can exist in addition to the connection between STEP 7 and the CPU. Mixed client and server connections are supported up to the maximum number of connections allowed by the CPU model (Page 207).

Each MB_SERVER connection must use a unique instance DB and port number. Only one connection per port number is supported. Each MB_SERVER (with its unique instance DB, IP address, and port number) must be executed individually for each connection.

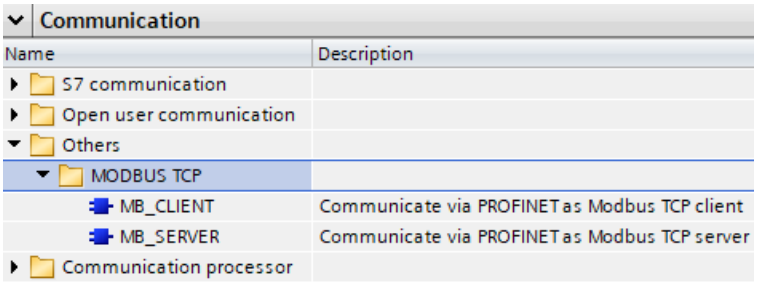
A Modbus TCP client must control the client-server connection with the DISCONNECT parameter. The basic Modbus client actions are shown below:

1. Initiate a connection to a particular server IP address and port number.
2. Initiate client transmission of a Modbus message and receive the server responses.
3. Initiate the disconnection of client and server to enable connection with a different server.



7.14.1.1 Modbus TCP Instructions

The Modbus TCP instructions (https://docs.tia.siemens.cloud/access?ft:originId=./30931262347/53718390539_enUS.htm&ft:clusterId=./30931262347/53718390539.htm) provide the capability to communicate between Modbus TCP clients, Modbus TCP servers, and third-party Modbus TCP devices through a switch. These can be found in the following folders:



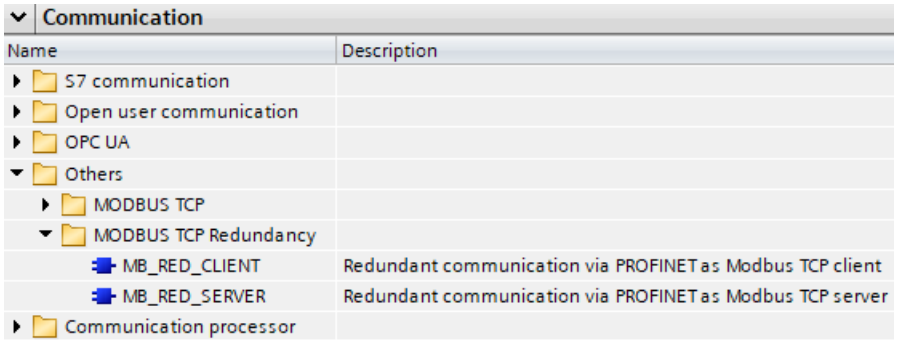
NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently based on PLC family and "S7-1200 G2" is not an option , follow the S7-1500 option for the instruction topic.

Modbus TCP Redundancy instructions

The Modbus TCP Redundancy instructions (https://docs.tia.siemens.cloud/access?ft:originId=./30931262347/104082829707_enUS.htm&ft:clusterId./30931262347/104082829707.htm) provide the capability to ensure continuous and reliable communication between devices even in the event of a network or device failure. These can be found in the following folders:



NOTE

Choosing an instruction by PLC family

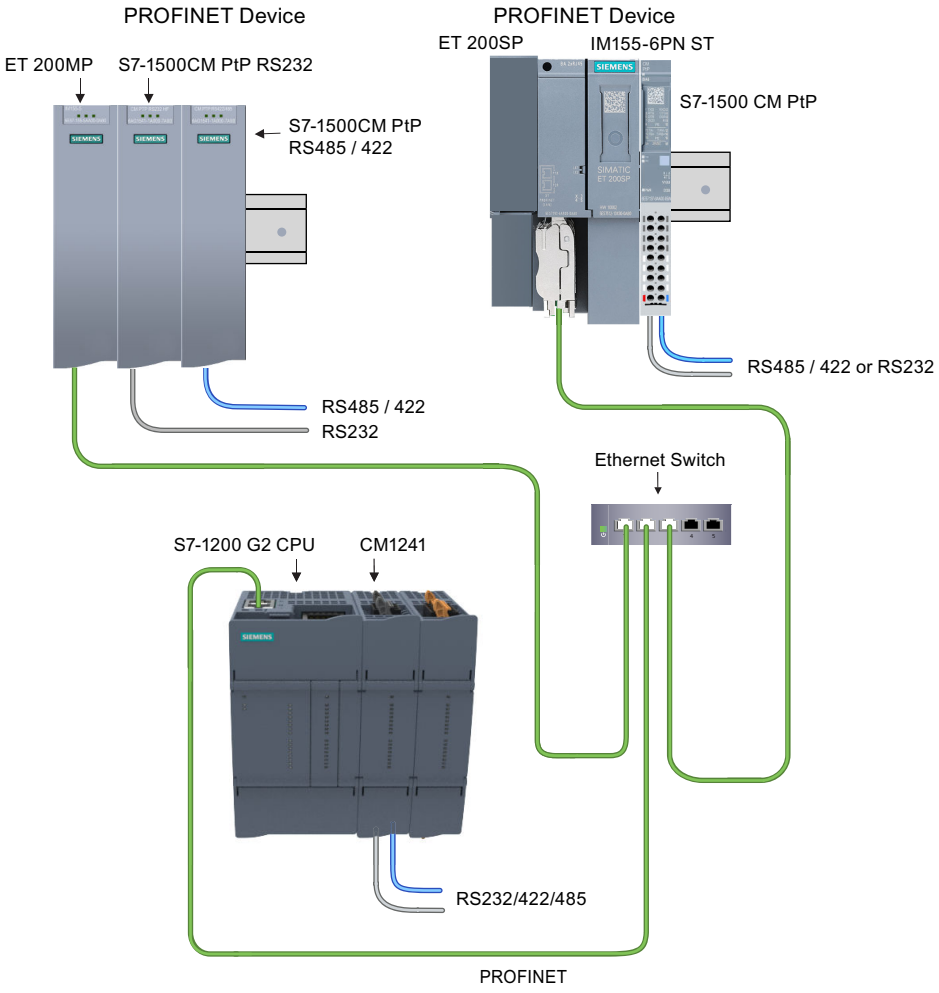
If the TIA Portal Information System presents an instruction differently based on PLC family and "S7-1200 G2" is not an option, follow the S7-1500 option for the instruction topic.

7.14.2 Modbus RTU

Modbus RTU (Remote Terminal Unit) is a standard network communication protocol that uses the RS232, RS422, or RS485 electrical connection for serial data transfer between Modbus network devices. You can add PtP (Point to Point) network ports to a CPU with a CM 1241 RS232/422/485 or a CB 1241 RS485.

Modbus RTU uses a master/slave network where all communications are initiated by a single Master device and slaves can only respond to a master's request. The master sends a request to one slave address and only that slave address responds to the command.

Modbus RTU enables you to use PROFINET distributed I/O to communicate to various devices (RFID readers, GPS device, and others). You connect the Ethernet interface of the S7-1200 G2 CPU to a PROFINET interface module. PtP communication modules in the rack with the interface module can then provide serial communications to external Modbus devices.



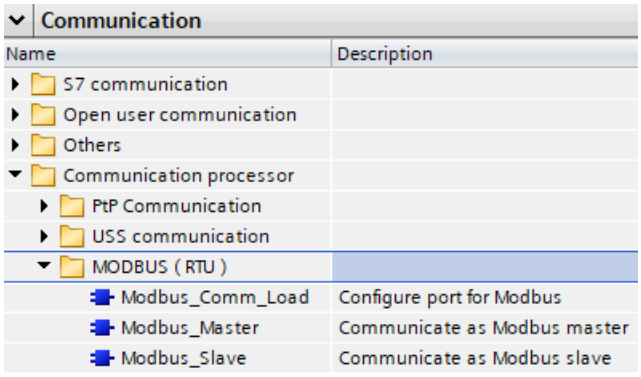
Modbus RTU communications hardware compatibility

The following table outlines the Modbus RTU protocol along with the available instruction set and communication hardware options for the protocol.

Protocol	Instruction Folder	Local CM 1241 RS232/422/485	Local CB 1241 RS485	Distributed CM PtP (example: ET 200MP CM or ET 200SP CM)
Modbus RTU	Communication > Communication processor > MODBUS (RTU)	Yes	Yes	Yes

7.14.2.1 Modbus RTU instructions and versions

The Modbus RTU instructions provide the ability to communicate between PtP communication modules or boards and Modbus devices in the network using RS232, RS422, or RS485.



For more information on the Modbus RTU instructions and their uses, see the following topics in the TIA Portal Information System:

- "Modbus_Comm_Load: Configure communication module for Modbus" (https://docs.tia.siemens.cloud/access?ft:originId=./39512297483/CM1500_Prog_Modbus_Comm_Load_enUS.htm&ft:clusterId./39512297483/CM1500_Prog_Modbus_Comm_Load.htm)
- "Modbus_Master: Communicate as Modbus master" (https://docs.tia.siemens.cloud/access?ft:originId=./39512297483/CM1500_Prog_Modbus_Master_enUS.htm&ft:clusterId./39512297483/CM1500_Prog_Modbus_Master.htm)
- "Modbus_Slave: Communicate as Modbus slave" (https://docs.tia.siemens.cloud/access?ft:originId=./39512297483/CM1500_Prog_Modbus_Slave_enUS.htm&ft:clusterId./39512297483/CM1500_Prog_Modbus_Slave.htm)

NOTE

STEP 7 provides different library versions of the Modbus RTU instructions. For correct information on S7-1200 G2 Modbus RTU instruction library versions, refer to "Dependencies between library versions (https://docs.tia.siemens.cloud/access?ft:originId=./39512297483/127801431179_enUS.htm&ft:clusterId./39512297483/127801431179.htm)" in the TIA Portal Information System.

NOTE

Choosing an instruction by PLC family

If the TIA Portal Information System presents an instruction differently based on PLC family and "S7-1200 G2" is not an option, follow the S7-1500 option for the instructon topic.

7.14.2.2 Maximum number of supported Modbus slaves

Modbus addressing supports a maximum of 247 slaves (slave numbers 1 through 247). Each Modbus network segment can have a maximum of 32 devices, based upon the loading and drive capabilities of the RS485 interface. When you reach the 32-device limit, you must use a repeater to expand to the next segment. You need seven repeaters to support the 247 slaves connected to one master for RS485.

You cannot use Siemens repeaters with PROFINET. You require third party repeaters for Modbus.

Modbus timeouts are long by default; the use of multiple repeaters does not create a time-delay problem. Response delays do not affect the Modbus master.

Near Field Communication (NFC) 8

The S7-1200 G2 CPUs are equipped with embedded Near Field Communication (NFC) tags. This allows you to scan the passive tag in your CPU and access information via the S7-1200 G2 NFC application (app) from a smartphone device.

By default, NFC is disabled in a new STEP 7 project. If you want to use NFC in your STEP 7 project, you must enable it in the project before downloading the project to your CPU.

NOTE

if you disable NFC in your STEP 7 project and perform a new download to the CPU, the CPU clears the data on the NFC tag.

Installing the S7-1200 G2 NFC app on your smartphone device allows you to read information from the CPU.

For more information on using the Near Field Communication feature with S7-1200 G2, see the Near Field Communication (NFC) Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109994538).

⚠ WARNING

Risks when using a cellular phone in close proximity to the S7-1200 G2 CPU

Using a cellular phone in close proximity to the S7-1200 G2 system with cellular and Wi-Fi communications active could cause unpredictable behavior.

To reduce any influence of a cellular phone on the S7-1200 G2 system, and to ensure proper operation of your CPU, place the phone in "Airplane mode" to disable cellular and Wi-Fi before bringing the phone into proximity (<10 cm) of the CPU.

Failure to comply with these guidelines can cause damage or unpredictable operation which could result in severe personal injury, property damage, and/or death.

⚠ WARNING

Risks when operating a cellular phone in a hazardous or explosive environment

Do not use a cellular phone in a hazardous or explosive environment unless the phone has been approved for use in such environments.

Failure to comply with these guidelines can cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.

Web server

9

The S7-1200 G2 CPU Web server provides system Web pages (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/comprehensive-information/cpu-function-manuals/web-server/system-web-pages) and a Web API (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/comprehensive-information/cpu-function-manuals/web-server/api-application-programming-interface/web-api) for you to develop custom Web pages that can read and write process data.

Your STEP 7 project enables system Web pages by default. You can find or change this setting from Web applications in the project tree.

Differences from the S7-1500 Web server

The S7-1200 G2 Web server implements the functionality of the S7-1500 Web server, with the following difference: The number of concurrent API sessions is 30.

Default page for Web application

You can set a default page from STEP 7 from Web applications in the project tree.

You can also use the following methods to set a default page for Web pages that you create with the Web API:

- WebServer.SetDefaultPage
- WebApp.SetDefaultPage

If you have not created a Web application and configured a default page, the Web browser returns a 404 error. For information on configuring and setting default pages, refer to the Web server manual (https://docs.tia.siemens.cloud/r/simatic_s7_1500_et_200mp_manual_collection_enus_20/comprehensive-information/cpu-function-manuals/web-server). Use the Edition dropdown menu to select the correct version of the manual.

Examples

Refer to the online examples (https://support.industry.siemens.com/cs/ww/en/view/68011496) for developing Web pages. The examples demonstrate a variety of functions.

Additional information

With the functionality of the Web API, S7-1200 G2 does not support the former AWP commands for developing user-defined Web pages.

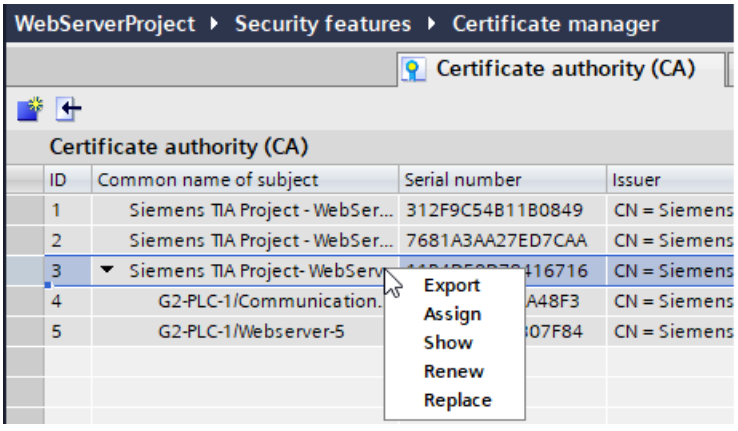
The Web API does not include a method for updating firmware.

9.1 Certificate requirements for the Web server

To communicate with the S7-1200 G2 Web API using a web browser, you must have a trusted Certificate Authority (CA) installed on your programming device. The trusted Certificate Authority (CA) enables secure communications over HTTPs.

The process includes the following tasks:

- Protecting the TIA Portal project from Security settings > Settings > Protect this project, as described in the TIA Portal Information System, Activating project protection topic
- Selecting "Use global security settings for certificate manager" for your CPU in the device configuration properties, Protection & Security > Certificate manager
- Creating a PLC communication certificate (Page 209)
- Enabling the Web server in the device configuration of the CPU (Page 158)
- Using the Security settings > Security features > Certificate manager to install or export the PLC communication certificate and Web server certificate, as described in the TIA Portal Information System, Certificate manager chapter



- Following the FAQ (https://support.industry.siemens.com/cs/ww/en/view/103528224) beginning with Step 2 to install, store, and trust the certificates you installed or exported from the TIA Portal project.

References

For additional information on managing certificates for the Web server, refer to the TIA Portal Information System and these documents:

- Web server manual (https://support.industry.siemens.com/cs/ww/en/view/59193560)
- How to install a certificate for the Web server (https://support.industry.siemens.com/cs/ww/en/view/103528224)

These documents are applicable to S7-1500 CPUs, but most of the content is applicable to S7-1200 G2 CPUs.

Motion control 10

10.1 Introducing S7-1200 G2 Motion Control

Motion Control allows users to accomplish specific tasks that require movement of tools or materials, such as bottling, machining, or welding.

Machines and production lines must increasingly be adapted to different formats, sizes, product types, and production processes. S7-1200 G2 Motion Control offers a precise, dynamic, and easy-to-implement solution.

Motion Control instructions control drives with PROFIdrive capability, drives with analog setpoint interface, servo motors, and stepper motors in accordance with the PLCopen standard. The axis control panel and comprehensive online and diagnostic functions support commissioning and optimization of drives. S7-1200 G2 Motion Control is fully integrated into the S7-1200 G2 CPU.

Achieving motion control

You can achieve Motion Control with the S7-1200 G2 CPU using the following concepts:

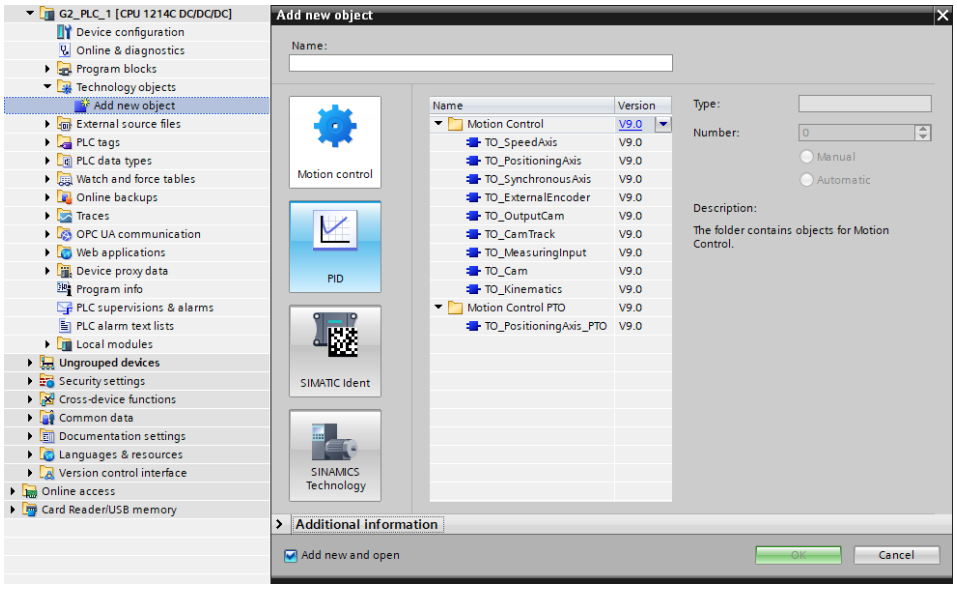
- Technology Objects serve as links to the drive and allow for configuration of dynamic behavior.
- Motion Control instructions allow you to control each Technology Object.
- Organization Blocks execute the Motion Control instructions of the user program in a structured manner.

10.2 Motion Control Technology Objects (TOs)

In S7-1200 G2 Motion Control, the technology objects (TO) represent control elements of Motion Control, such as a position axis or an output cam. A TO establishes a logical relationship between the user program and the physical device and defines the motion profile by allowing for parameterization, such as setting limits like acceleration, deceleration, and jerk. This information is stored in a corresponding technology data block (DB), where you can read information about the status of the motion control job, such as speed, position, or error status.

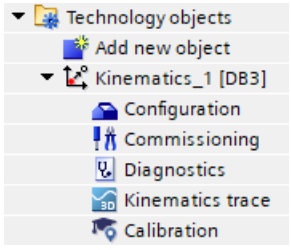
Creating a new TO

You can add a TO to your STEP 7 project by selecting "Add new object" under the Technology objects folder in the project tree.



Configuration and commissioning

Within STEP 7, multiple tools exist to help configure, commission, and debug TOs in your motion control project.



Motion resources

When you create a motion control TO, that TO draws from a pool of resources that represents the resources available within the CPU for motion tasks. There are two pools, one each for Motion Control and Extended Motion Control. If you exceed the number of resources available from either pool, an error occurs when you compile your program in the TIA Portal.

You can add up to 16 Pulse Train Output (PTO) TOs, which are independent of all other types of TOs. The PTO TOs do not draw from either pool of Motion Control resources.

The costs associated with each TO are additive in some cases. For example, implementing a three-axis Cartesian Portal solution requires one Kinematics TO, costing 30 Extended Motion

Control resources, and three PositioningAxis TOs, costing 80 Motion Control resources each. In this case, the total cost is 30 Extended resources and 240 Motion resources.

You can find more information about motion resources in the Technical Specifications (Page 337).

NOTE
While S7-1200 CPUs allow for the sharing of a single PTO output between two configured positioning axes, this functionality might not function as intended in S7-1200 G2 projects. The first configured positioning axis behaves as expected, but the second configured positioning axis does not move.

Supported TOs

The S7-1200 G2 CPU provides varying levels of support for a range of Motion Control TOs, as described in the table below:

TO	Supported	Motion Control resources required (out of 800 provided by the CPU)	Extended Motion Control resources required (out of 40 provided by the CPU)
TO_SpeedAxis	✓	40	
TO_PositioningAxis	✓	80	
TO_SynchronousAxis	✓	160	
TO_ExternalEncoder	✓	80	
TO_OutputCam	✓	20	
TO_CamTrack	✓	160	
TO_MeasuringInput	✓	40	
TO_Cam	✓		2
TO_Kinematics	Partially supported		30
TO_PositioningAxis_PTO	✓	0	0

You can find help on programming each Motion Control TO in the TIA Portal Information System, as defined for the S7-1500/S7-1500T. These TOs are equivalent in S7-1200 G2.

10.3 Motion Control instructions

The STEP 7 program calls the Motion Control (MC) instructions and acts upon configured TOs. These blocks exist within the motion library as function blocks (FB) and create a data instance when they are placed into the user program in STEP 7.

You can use MC instructions to accomplish motion tasks of varying complexity, such as setting a constant velocity, moving a tool to a desired position, or synchronizing two axes.

Supported instructions

The following MC instructions are available for the S7-1200 G2 CPU:

MC instruction	Motion Control	Extended Motion Control	PTO Motion Control
MC_Power	✓		
MC_Reset	✓		
MC_Home	✓		
MC_Halt	✓		
MC_MoveAbsolute	✓		
MC_MoveRelative	✓		
MC_MoveVelocity	✓		
MC_MoveJog	✓		
MC_MoveSuperimposed	✓		
MC_HaltSuperimposed	✓		
MC_Stop	✓		
MC_SetAxisSTW	✓		
MC_SaveAbsoluteEncoderData	✓		
MC_WriteParameter	✓		
MC_SetSensor		✓	
MC_MeasuringInput	✓		
MC_MeasuringInputCyclic	✓		
MC_AbortMeasuringInput	✓		
MC_OutputCam	✓		
MC_CamTrack	✓		
MC_GearIn	✓		
MC_GearInVelocity		✓	
MC_GearInPos		✓	
MC_PhasingRelative		✓	
MC_PhasingAbsolute		✓	
MC_CamIn		✓	

[1] You can find this instruction under the main "Motion Control" Technology folder in STEP 7.

MC instruction	Motion Control	Extended Motion Control	PTO Motion Control
MC_GearOut		✓	
MC_CamOut		✓	
MC_InterpolateCam		✓	
MC_GetCamLeadingValue		✓	
MC_GetCamFollowingValue		✓	
MC_GetCamFollowingValueCyclic[1]		✓	
MC_CopyCamData		✓	
MC_TorqueAdditive	✓		
MC_TorqueRange	✓		
MC_TorqueLimiting	✓		
MC_GroupInterrupt		✓	
MC_GroupContinue		✓	
MC_GroupStop		✓	
MC_MoveLinearAbsolute		✓	
MC_MoveLinearRelative		✓	
MC_MoveCircularAbsolute		✓	
MC_MoveCircularRelative		✓	
MC_MoveDirectAbsolute		✓	
MC_MoveDirectRelative		✓	
MC_DefineWorkspaceZone		✓	
MC_SetWorkspaceZoneActive		✓	
MC_SetWorkspaceZoneInactive		✓	
MC_DefineTool		✓	
MC_SetTool		✓	
MC_Power_PTO			✓
MC_Reset_PTO			✓
MC_MoveAbsolute_PTO			✓
MC_MoveRelative_PTO			✓
MC_MoveVelocity_PTO			✓
MC_MoveJog_PTO			✓
MC_Halt_PTO			✓
MC_Home_PTO			✓

[1] You can find this instruction under the main "Motion Control" Technology folder in STEP 7.

MC instruction	Motion Control	Extended Motion Control	PTO Motion Control
MC_ChangeDynamic_PTO			✓
MC_ReadParam_PTO			✓
MC_WriteParam_PTO			✓

[1] You can find this instruction under the main "Motion Control" Technology folder in STEP 7.

You can find help on programming each MC instruction in the TIA Portal Information System, as defined for the S7-1500/S7-1500T. These instructions are equivalent in S7-1200 G2. "_PTO" instructions, however, are unique to S7-1200 G2 and are defined as such in the TIA Portal Information System.

10.4 Motion Control Organization Blocks (OBs)

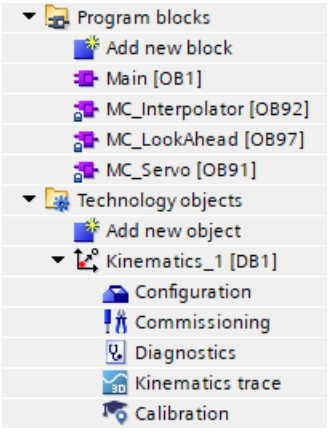
You can use an organization block (OB) to control how the CPU executes STEP 7 programs and handles interrupts and events. For Motion Control, this might mean executing closed-loop position control algorithms of TOs, monitoring and generating setpoints, or executing logic to create the desired movement of the axis.

Generated OBs

There are two types of OBs related to motion control. User OBs allow you to enter your motion control logic. Compiler-generated OBs are protected blocks and cannot be edited.

Supporting OBs

STEP 7 creates supporting organization blocks (OB) when you create a TO in your project.



G2-supported OBs

The S7-1200 G2 CPU provides support for the following Motion Control OBs:

- MC_PreServo (Page 113) - the CPU calls MC_PreServo immediately before MC_Servo, allowing you to make adjustments before the Servo logic executes.
- MC_Servo (Page 112) - performs calculations required to control the speed and position of axes. This block is protected.

- MC_PostServo (Page 114) - the CPU calls MC_PostServo immediately after MC_Servo executes, allowing you to modify outputs.
- MC_PreInterpolator - the CPU calls MC_PreInterpolator immediately before MC_Interpolator executes, allowing you to adjust inputs used by MC_Interpolator. These inputs will be IPO-synchronous.
- MC_Interpolator (Page 112) - evaluates Motion Control instructions, generates setpoints, and monitors inputs. This block is protected.
- MC_LookAhead (Page 114) - calculates motion processing for the Kinematics TO. This block is protected.

You can find help on programming each Motion Control OB in the TIA Portal Information System, as defined for the S7-1500/S7-1500T. These OBs are equivalent in S7-1200 G2.

10.5 Differences between S7-1200 G2 and S7-1500/S7-1500T

S7-1200 G2 Motion Control is similar In function to that of the S7-1500/1500T, with the following notable additions:

- Support for a subset of Extended Motion Control
- Support for a subset of Kinematics devices
  - Kinematics Cartesian Portal up to 3D with Orientation
  - SCARA up to 3D with Orientation
- Support for a subset of Cam TOs
- Support for Cam segments and VDI optimization

S7-1200 G2 Motion Control is similar In function to that of the S7-1500/1500T, with the following notable differences:

- No support for Kinematics Zones
- No support for User Defined Kinematics; however, Workspaces are supported
- No support for distributed motion control
- No support for TO_Cam_10k, TO_Cam_6kSeg, or TO_Cam_600Seg

10.5.1 Adapting Motion Control to S7-1200 G2

S7-1200 G2 motion control differs from that of the S7-1200. The S7-1200 G2 CPU uses Motion Control based upon the same technology used by the S7-1500/S7-1500T. In addition, however, the S7-1200 G2 uses a modified Basic Motion Control, which differs from the S7-1200 implementation. For these reasons, you cannot load an S7-1200 project with motion control into an S7-1200 G2 CPU.

There are differences between servo and PTO axes, such as the PLCOpen block layout and error codes. Refer to the PLCOpen standards for more information.

To learn about how Basic Motion Control operates in the S7-1200 G2 CPU, see the S7-1200 G2 Motion Control Function Manual (https://support.industry.siemens.com/cs/us/en/view/109995039).

Migration paths

You must manually port your S7-1200 motion control projects into S7-1200 G2. Consider the following when performing this migration:

- The TOs are different
  - BMC objects are now contained within the folder "Motion PTO" and possess the suffix "_PTO".
  - Only PTO is supported. If you used PTO in your S7-1200 project, choose the relevant "_PTO" block. If you used Analog or PROFIdrive in your S7-1200 project, select the relevant block from the Standard Motion Control library.
  - TO_CommandTable is not supported.
  - Configuration interfaces in STEP 7 differ.
- The MC library is different
  - The "Motion Control" folder now contains both SMC and AMC blocks, while you can find the new BMC blocks in "Motion PTO".
  - You must drop and replace new blocks from the new library.
  - The behavior of most blocks is the same across libraries, though some names have changed.
  - Some MC instructions no longer exist.

You must manually port your S7-1500(T) motion control projects into S7-1200 G2. Consider the following when performing this migration:

- The TOs are different
  - Select the relevant blocks from the S7-1200 G2 Standard Motion Control library to replace those in your S7-1500(T) project using Analog or PROFIdrive.
  - Configuration interfaces in STEP 7 differ. While the functionality of both CPUs is identical, in some instances the S7-1200 G2 supports fewer configuration options.
- The MC library is different
  - You must drop and replace new blocks from the new library.
  - The behavior of most blocks is the same across libraries.
  - Some MC instructions are not available.
- Some tags in the PositioningAxis_PTO TO must be activated in the user program

To active these tags, do the following:

1. Disable the PositioningAxis_PTO TO.
2. Download your new PositioningAxis_PTO configuration.
3. Execute MC_Reset_PTO with Restart = TRUE or transition the PLC from STOP to RUN.

NOTE
This is not a comprehensive list of differences.

NOTE

Compiling errors when copying Basic Motion Control blocks

Whenever you attempt to copy a Basic Motion Control block from an S7-1200 project to an S7-1200 G2 project in STEP 7 and download to your CPU, compiling errors occur. To avoid errors, you should instead first create a new TO_PositioningAxis_PTO in your S7-1200 G2 project before adding Basic Motion Control blocks.

10.6 Additional information

Siemens offers additional support for S7-1200 G2 Motion Control.

See also

You can learn more about Motion Control topics through the TIA Portal Information System.

You can also refer to the family of Motion Control V9.0 manuals available through Siemens Industry Online Support (https://support.industry.siemens.com/cs/us/en/view/109974347).

PID

11

11.1 PID functionality

STEP 7 provides the following PID instructions for the S7-1200 G2 CPU:

- The PID_Compact instruction is used to control technical processes with continuous or PWM input variables.
- The PID_3Step instruction is used to control motor-actuated devices, such as valves that require discrete signals for open- and close actuation or analog signal for specification of the target position.
- The PID_Temp instruction provides a universal PID controller that allows handling of the specific requirements of temperature control.

NOTE

Changes that you make to the PID configuration and download in RUN do not take effect until the CPU transitions from STOP to RUN mode. Changes that you make in the "PID parameters" dialog might not take effect immediately.

All three PID instructions (PID_Compact, PID_3Step, and PID_Temp) can calculate the proportional, integral, and derivative parameters for your controlled system during pretuning. You can also use fine tuning to tune the parameters further. You do not need to manually determine the parameters.

NOTE

Execute the PID instruction at constant intervals of the sampling time, preferably in a cyclic OB. Do not execute the PID instruction in the main program cycle OB, such as OB 1.

The sampling time of the PID algorithm represents the time between two calculations of the output value (control value). The sampling time of the PID algorithm is calculated during self-tuning and rounded to a multiple of the cycle time. All other functions of PID instruction are executed at every call.

PID algorithm

The output value for the PID controller consists of three components:

- P (proportional): When calculated with the "P" component, the output value is proportional to the difference between the setpoint and the process value (input value).
- I (integral): When calculated with the "I" component, the output value increases in proportion to the duration and value of the difference between the setpoint and the process value (input value) to correct the difference.
- D (derivative): When calculated with the "D" component, the output value increases as a function of the rate of change of the difference between the setpoint and the process value (input value). The process value is corrected to the setpoint as quickly as possible.

The PID controller uses the following formula to calculate the output value for the PID_Compact and PID_Temp instructions.

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

y	Output value	x	Process value
w	Setpoint value	s	Laplace operator
K_p	Proportional gain (P, I, D components)	a	Derivative delay coefficient (D component)
T_I	Integral action time (I component)	b	Proportional action weighting (P component)
T_D	Derivative action time (D component)	c	Derivative action weighting (D component)

The PID controller uses the following formula to calculate the output value for the PID_3Step instruction.

$$\Delta y = K_p \cdot s \cdot \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

y	Output value	x	Process value
w	Setpoint value	s	Laplace operator
K_p	Proportional gain (P, I, D components)	a	Derivative delay coefficient (D component)
T_I	Integral action time (I component)	b	Proportional action weighting (P component)
T_D	Derivative action time (D component)	c	Derivative action weighting (D component)

See also

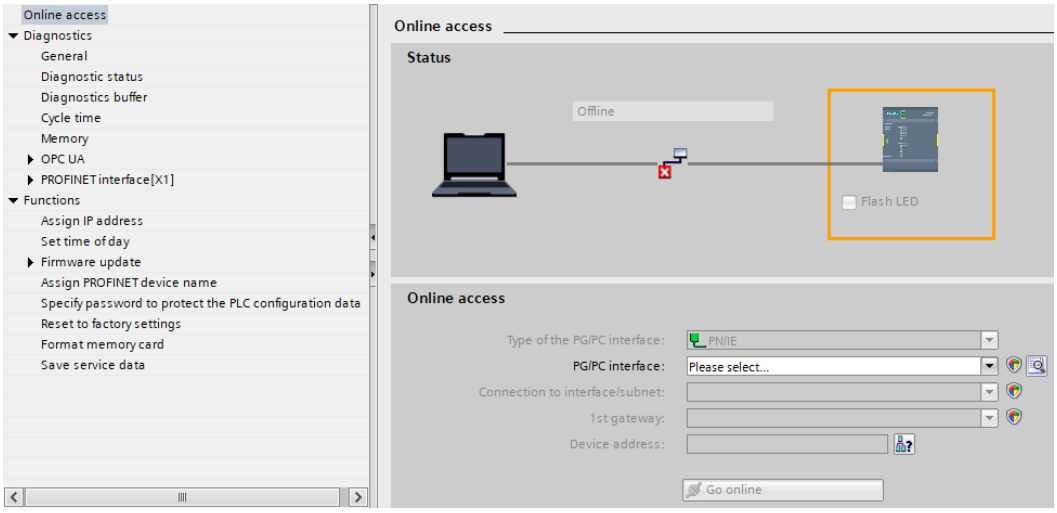
For a comprehensive explanation of PID functions and instructions, see the "SIMATIC S7-1200, S7-1500 PID control" Function Manual (https://support.industry.siemens.com/cs/us/en/view/108210036), or find more information in the TIA Portal Information System.

Online and diagnostic tools

12

TIA Portal enables you to set diagnostic parameters and modify settings for the online behavior of your S7-1200 G2 CPU by using the tools listed below. You can update firmware, monitor cycle time and memory usage, and monitor or modify values in the CPU, in addition to other valuable functions.

To configure these parameters, select the CPU in the Project tree and select "Online & diagnostics" from the drop-down menu.



Tool	Description
Online access	
Online access	You can establish an online connection between the programming device and CPU for loading programs and project engineering data. For protected CPUs, you must enter either the access level CPU password or a user and user password. User roles and passwords are part of User Management and Access Control (UMAC) (Page 150) in the STEP 7 project.
Diagnostics	
General	Displays general information about the modules in your project.
Diagnostic status	Displays the status of diagnostic processes.
Diagnostics buffer (Page 126)	Use the diagnostics buffer to review the recent activity in the CPU. The diagnostics buffer is accessible from "Online & diagnostics" for an online CPU in the Project tree. It contains the following entries: • Diagnostic events • Changes in the CPU operating mode (transitions to STOP or RUN mode)
Cycle time	You can monitor the cycle time of an online CPU. After connecting to the online CPU, open the Online tools task card to view the relevant measurements.
Memory	You can monitor the memory usage (Page 123) of an online CPU. After connecting to the online CPU, open the Online tools task card to view the relevant measurements.
PROFINET interface	You can use the PROFINET interface to view MAC addresses, IP Addresses, and Port settings.

Tool	Description
OPC UA	You can configure the CPU as an OPC UA server for data access and view the status of the server, as well as diagnostic information about the sessions running on the server.
Functions	
Assign IP address	After accessing "Online & diagnostics" from the Project tree for an online CPU, you can display or change the IP address.
Set time	You can display or set the time and date parameters of the online CPU.
Firmware update	You can update the firmware of a connected CPU from the TIA Portal online and diagnostics tools using one of two methods: • Updating from the CPU in the project • Updating from the accessible devices in the project tree
Assign PROFINET device name	The devices on your PROFINET network must have an assigned name before you can connect with the CPU. Use the "Devices & networks" editor to assign names to your PROFINET devices if the devices have not already been assigned a name, or if the name of the device is to be changed.
Specify password to protect the PLC configuration data	The "Protection of confidential PLC configuration data" feature allows you to protect each CPU in your project individually. From the device configuration, you can enable this protection and set a password for the "protection of confidential PLC configuration data". Clients such as TIA Portal and the SIMATIC Automation Tool can only access the confidential data in the PLC through use of the password. You can also use the security wizard to enable this feature and set the password for the "Protection of confidential PLC configuration data".
Reset to factory settings	You can reset an S7-1200 G2 CPU to its original factory settings under the following conditions: • The CPU has an online connection. • The CPU is in STOP mode. If you reset the CPU to factory defaults, the CPU time will be reset to its default value.
Format memory card	You can format the memory card in a connected CPU from the TIA Portal online and diagnostic tools.
Save service data	In the event of servicing, the SIEMENS Customer Support requires information about the state of a module of your system for diagnostic purposes. If such a case occurs in your system, Customer Support can ask you to save the service data of the module and send the resulting file to them.
Online	
Backup and restore	You can create backups of your CPU configuration and software in the TIA Portal to be restored at a later point. This feature is available through the TIA Portal, the Web server, and the SIMATIC Automation Tool.

You can learn more about the above Tool properties by referring to the related topics in the TIA Portal Information System.

12.1 Status LEDs

The CPU and the I/O modules use LEDs to provide information about the operating state of the CPU and status of the devices.

Status LEDs on a CPU

The CPU provides the following status indicators:

- STOP/RUN
  - Solid yellow indicates STOP mode
  - Solid green indicates RUN mode
  - Flashing (alternating green and yellow) indicates that the CPU is in the STARTUP operating state
- ERROR
  - Flashing red indicates an error, such as an internal error in the CPU, an error with the memory card, or a configuration error (mismatched modules)
  - Flashing red for three seconds indicates a temporary error. An example is if the real-time clock (RTC) resets to the default time due to a power loss. Another example would be the failure of an NFC transaction.
  - Defective state:
    - STOP (ON), ERROR (Blinking), MAINT (Blinking)
- MAINT (Maintenance) is ON whenever maintenance is required, or if the NFC tag is defective while NFC is enabled in Device Configuration.

You can also use the LED instruction to determine the status of the LEDs.

Table 1-197 Status LEDs for a CPU

Description	RUN/STOP Green / Yellow	ERROR Red	MAINT Yellow
CPU power off	Off	Off	Off
CPU power up	Flashing (alternating yellow and green)[1]	Flashing[1]	Flashing[1]
STARTUP state	Flashing (alternating yellow and green)	-	Off
Firmware update in progress	Flashing (yellow)	-	-
Firmware update complete	-	-	Flashing
STOP state	On (yellow)	-	-
RUN state	On (green)	-	-
Missing program memory card (Page 136) (if External Load Memory used)	On (yellow)	Flashing	-
Memory card evaluation	Flashing (yellow)	-	-
Error	On (either yellow or green)	Flashing	-

1 When power is applied to the CPU, all three system-status indicators flash such that ERROR and MAINT are both ON when RUN/STOP is yellow and both OFF when RUN/STOP is green.

2 Cyclically; three seconds Flashing, one second pause.

3 For each NFC transaction failure between CPU and NFC tag, the ERROR LED flashes three times.

Description	RUN/STOP Green / Yellow	ERROR Red	MAINT Yellow
Forced I/O	On (either yellow or green)	-	On
NFC defective, NFC enabled in configuration	On (either yellow or green)	-	On
NFC transaction failure	On (either yellow or green)	Flashing (3x)[3]	-
Defective hardware (Page 319)	On (yellow)	On	Off
LED test or defective CPU firmware (Page 319)	Flashing (alternating yellow and green)	Flashing	Flashing
Unknown or incompatible version of CPU configuration (Page 319)	On (yellow)	Flashing	Flashing
Flash LED (Online access feature to identify CPU)[2]	Flashing (alternating yellow and green)	Flashing	Flashing
Internal Load Memory was erased	Flashing (yellow)	Off	Flashing
Internal Load Memory is empty	Flashing (3 seconds) (yellow)	Off	Flashing (3 seconds)
Low battery powering the real-time clock (2.5 V or less remaining)	-	-	On

1 When power is applied to the CPU, all three system-status indicators flash such that ERROR and MAINT are both ON when RUN/STOP is yellow and both OFF when RUN/STOP is green.

2 Cyclically; three seconds Flashing, one second pause.

3 For each NFC transaction failure between CPU and NFC tag, the ERROR LED flashes three times.

Status LEDs for onboard I/O

Each CPU shall provide an I/O channel indicator for each onboard digital input and output, according to the table below:

Description	Digital I/O Channel (Green)
CPU power off	Off
Input or output point is Off	Off
Input or output point is On	On

Status LEDs for communication on the CPU

The CPU also provides two LEDs that indicate the status of the PROFINET communications. These LEDs are visible from the top of the CPU near the PROFINET connectors. Each PROFINET port has one LED which behaves according to the table below:

Description	PROFINET port (Green)
CPU power off	Off
Link down (no connection established)	Off
Link up (connection established)	On
Communication activity	Flashing

Status LEDs on a Signal Module (SM) and a Signal Board (SB)

Each digital or analog SM/SB provides a DIAG LED that indicates the status of the module or board:

- Green indicates that the module or board is operational
- Red indicates that the module or board is defective or non-operational

Each digital module or board provides an I/O Channel LED for each of the digital inputs and outputs.

- Green indicates the channel is ON
- OFF indicates the channel is OFF

Each analog module or board provides an I/O Channel LED for each of the analog inputs and outputs.

- Green indicates that the channel has been configured and is active
- Red indicates an error condition of the individual analog input or output

Each analog SB/SM provides an I/O Channel LED for each of the analog inputs and outputs, according to the following table:

Table 1-198 Status LEDs for an analog signal board (SB) or analog signal module (SM)

Description	DIAG (Green/Red)	Analog I/O Channel (Green/Red)
I/O bus power off, user power either on or off	Off	Off
I/O bus power on, user power off		
• Power fault diagnostic is enabled	Flashing (red)	Off
• Power fault diagnostic is disabled	On (green)	On (green)
STARTUP, but not yet logged into the CPU	Flashing (red)	Off
Logged in, but not yet configured	Flashing (green)	Off
Module configured with no errors	On (green)	On (green), all enabled channels
Error[1] [2]		

[1] Flashing the LED is only possible when the firmware is operational.

[2] The red DIAG LED acts like a summary fault indication which includes module errors and channel errors with channel diagnostics enabled.

Description	DIAG (Green/Red)	Analog I/O Channel (Green/Red)
• Module error	Flashing (red)	Flashing (red), all channels
• Channel error with channel diagnostic enabled	Flashing (red)	Flashing (red), affected channel
• Channel error with channel diagnostic disabled	On (green)	On (green), affected channel
Firmware update is running	Flashing (green)	Off

[1] Flashing the LED is only possible when the firmware is operational.

[2] The red DIAG LED acts like a summary fault indication which includes module errors and channel errors with channel diagnostics enabled.

Each digital SB/SM provides an I/O Channel LED for each of the digital inputs and outputs, according to the following table:

Table 1-199 Status LEDs for a digital signal board (SB) or digital signal module (SM)

Description	DIAG (Green/Red)	Digital I/O Channel (Green)
I/O bus power off, user power either on or off	Off	Off
I/O bus power on, user power off		
• Power fault diagnostic is enabled	Flashing (red)	Off
• Power fault diagnostic is disabled	On (green)	Off
STARTUP, but not yet logged into the CPU	Flashing (red)	Off
Logged in, but not yet configured	Flashing (green)	Off
Module configured with no errors		
• Input or output point is Off	On (green)	Off
• Input or output point is On	On (green)	On
Error	Flashing (red)	Off
Firmware update is running	Flashing (green)	Off

Serial communications indicators on a Communication Module (CM)/Communication Board (CB)

Each serial communications CM/CB provides a single DIAG indicator (green/red), plus a TxD transmit (yellow) and a RxD receive (yellow) indicator, according to the following table:

Description	DIAG Green / Red	TxD (yellow)	RxD (yellow)
I/O bus power off	Off	Off	Off
STARTUP, but not yet logged into CPU	Flashing (red)	-	-
Logged in, but not yet configured	Flashing (green)	-	-

Description	DIAG Green / Red	TxD (yellow)	RxD (yellow)
Module configured with no errors • Transmit data in process • Receive data in process	On (green)	On -	- On
Error	Flashing (red)	-	-
Firmware update is running	Flashing (green)	Off	Off

Battery Board (BB) indicator

The battery board provides a single DIAG indicator (green/red), according to the following table:

Description	DIAG Green / Red
CPU power off	Off
STARTUP, but not yet logged into CPU	Flashing (red)
Logged in, but not yet configured	Flashing (green)
Configured with no errors	On (green)
Error: voltage detected to be below the allowed threshold	Flashing (red)

12.2 CPU error behavior

"Unknown or incompatible version of CPU configuration" error

The diagnostics buffer can report an "Unknown or incompatible version of CPU configuration" error, which can occur in one of the following ways:

- Attempting to load an invalid project.
- Attempting to download a project with different protection of confidential PLC configuration data (Page 313) between the CPU and the project

If you reached this state by using an invalid version transfer card (Page 139), follow these steps to recover:

1. Remove the transfer card.
2. Perform a STOP to RUN transition.
3. Reset the memory (MRES) or cycle power.

If you reach this state by using an invalid project on a program card (Page 141), reset the CPU to factory settings (Page 313) using the "Format memory card" option .

If your reach this state from a mismatch between the CPU and the project for the protection of confidential PLC configuration data, use the Online & Diagnostics tools (Page 313) to set the online CPU's password for protection of confidential PLC configuration data to the password in the project, or delete it from the online CPU.

After you recover the CPU from the error condition, you can download a valid program.

S7-1200 G2 behavior following a fatal error

If the CPU firmware detects a fatal error, it attempts a defect-mode restart, and if successful, signals the defective mode by continually flashing the STOP/RUN, ERROR and MAINT LEDs.

If the CPU successfully completes the defect-mode restart, the CPU performs these actions:

- Sets the CPU and signal board outputs to the configured value
- Sets the outputs of local rack signal modules and distributed I/O to the selection for "Reaction to CPU STOP" in the device configuration of the digital outputs of the module

If the defect-mode restart fails, (for example, due to a hardware fault), the STOP and ERROR LEDs are ON and the MAINT LED is OFF.

⚠ WARNING

Operation in defect state cannot be guaranteed
Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment.
Use an emergency stop function, electromechanical overrides or other redundant safeguards that are independent of the PLC.
Such unexpected operations can result in death or serious injury to personnel, and/or damage to equipment.

12.3 Analog module diagnostics

Analog modules have multiple diagnostics depending on the module and channel type. You can separately enable or disable these diagnostics for each module and channel by using the TIA Portal under the project's device configuration/general properties of the module.

Power supply errors are reported as follows:

Power supply error	Error reported
Analog module with a power supply diagnostic error reports:	Overflow: 32767 for all input channels
	Missing power supply diagnostic, if enabled for output modules

You can enable these diagnostics separately by channel and type for each channel. See the table below:

Channel type	Error reported
Voltage input	Overflow: 32767
	Underflow: -32768
Current input (0 to 20 mA)	Overflow: 32767
	Underflow: -32768
Current input (4 to 20 mA) (for < 1.185 mA input)	Broken wire: 32767
	Overflow: 32767
Voltage output (for > 0.5 V output)	Short circuit diagnostic, if enabled
Current output (for > 1.0 mA output)	Open circuit diagnostic, if enabled
RTD input	Broken wire: 32767
	Overflow: 32767
	Underflow: -32768

Channel type	Error reported
Resistor input	Broken wire: 32767
	Overflow: 32767
Thermocouple input	Broken wire: 32767
	Overflow: 32767
	Underflow: -32768

An analog input module with a diagnostic error on any channel reports 32767 or -32768 on that channel even if the diagnostics is not enabled. Analog input channels report 32767 when deactivated.

12.4 Comparing offline and online CPUs

You can compare the code blocks in an online CPU with the code blocks in your project. If the code blocks of your project do not match the code blocks of the online CPU, the "Compare" editor allows you to synchronize your project with the online CPU by downloading the code blocks of your project to the CPU, or by deleting blocks from the project that do not exist in the online CPU.

NOTE

Read access required on protected CPU for the Offline/Online compare operations
For TIA Portal, the "HMI access" security level is insufficient to perform the Offline/Online compare operations. You must have "Read access" or "Full access", to do Offline/Online compare operations.
See also Protection & Security in CPU properties (Page 158).

You can learn more about comparing offline/online CPUs, as well as their related topologies in your network, by referring to the TIA Portal Information System.

12.5 Monitoring and modifying values in the CPU

12.5.1 Overview of the online monitoring and modification tools

TIA Portal provides online tools for monitoring the CPU:

- You can display or monitor the current values of the tags. The monitoring function does not change the program sequence. It presents you with information about the program sequence and the data of the program in the CPU.
- You can also use other functions to control the sequence and the data of the user program:
  - You can modify the value for the tags in the online CPU to see how the user program responds.
  - You can force a peripheral output (such as Q0.1:P or "Start":P) to a specific value.

NOTE

Always exercise caution when using control functions. These functions can influence the execution of the user/system program.

Table 1-200 Online capabilities of the TIA Portal editors

Editor	Monitor	Modify	Force
Watch table	Yes	Yes	No
Force table	Yes	No	Yes
Program editor	Yes	Yes	No
Tag table	Yes	No	No
DB editor	Yes	Yes	No

You can learn more about online tools for monitoring the CPU by referring to the related topics in the TIA Portal Information System.

12.5.2 Watch tables for monitoring the user program

A watch table allows you to perform monitoring and control functions on data points as the CPU executes your program. These data points can be process image (I or Q), M, DB or physical inputs (I_:P), depending on the monitor or control function. You cannot accurately monitor the physical outputs (Q_:P) because the monitor function can only display the last value written from Q memory and does not read the actual value from the physical outputs.

The monitoring function does not change the program sequence. It presents you with information about the program sequence and the data of the program in the CPU.

Control functions enable the user to control the sequence and the data of the program. You must exercise caution when using control functions. These functions can influence the execution of the user/system program. The two control functions are Modify and Force.

With the watch table, you can perform the following online functions:

- Monitoring the status of the tags
- Modifying values for the individual tags

You can learn more about using a watch table for monitoring and modifying values in the CPU by referring to the related topics in the TIA Portal Information System.

12.5.3 Using the force table

A force table provides a "force" function that overwrites the value for an input or output point to a specified value for the peripheral input or peripheral output address. The CPU applies this forced value to the input process image prior to the execution of the user program and to the output process image before the outputs are written to the modules.

You can learn more about forcing values in the CPU with the Force function by referring to the related topics in the TIA Portal Information System.

12.6 Downloading in RUN mode

12.6.1 Overview

The CPU supports "Download in RUN mode". This capability allows you to download program changes while the program is running.

⚠ WARNING

Risks when downloading in RUN mode
When you download changes to the CPU in RUN mode, the changes immediately affect process operation. Changing the program in RUN mode can result in unexpected system operation.
Only authorized personnel who understand the effects of RUN mode changes on system operation should perform a download in RUN mode.
Unexpected system operation can cause death or serious injury to personnel, and/or damage to equipment.

The "Download in RUN mode" feature allows you to make changes to a program and download them to your CPU without switching to STOP mode:

- You can make minor changes to your current process without having to shut down (for example, change a parameter value).
- You can debug a program more quickly with this feature (for example, invert the logic for a normally open or normally closed switch).

You can make the following program block and tag changes and download them in RUN mode:

- Create, overwrite, and delete Functions (FC), Function Blocks (FB), and Tag tables.
- Create, delete, and overwrite Data Blocks (DB) and instance data blocks for Function Blocks (FB). You can add to DB structures and download them in RUN mode. The CPU can maintain the values of existing block tags and initialize the new data block tags to their initial values, or the CPU can set all data block tags to initial values, depending on your configuration settings.
- Create, overwrite, modify, and delete Organization Blocks (OB).

You can download a maximum number of 20 blocks in RUN mode at one time. If you need to download more than 20 blocks, you must place the CPU in STOP mode.

If you download changes to a running process, you must think through the possible safety consequences to machines and machine operators before you download.

NOTE

If the CPU is in RUN mode and program changes have been made, TIA Portal always tries to download in RUN first. If you do not want this to happen, you must put the CPU into STOP.
If the changes made are not supported in "Download in RUN", TIA Portal prompts you that the CPU must go to STOP.

12.6.2 Prerequisites for "Download in RUN mode"

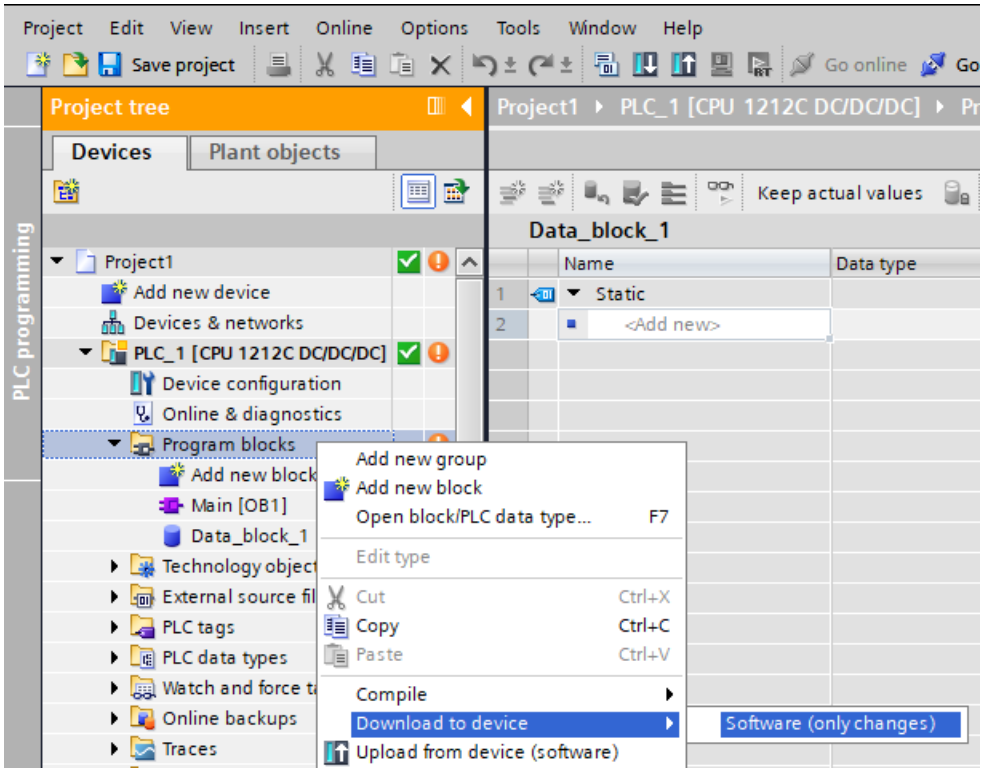
To be able to download your program changes to a CPU that is in RUN mode, you must meet these prerequisites:

- Your program blocks must compile successfully.
- You must have successfully established communication between the CPU and the programming device.

12.6.3 Changing your program in RUN mode

To change the program in RUN mode, you must first ensure that the CPU and program meet the prerequisites (Page 324), and then follow these steps:

1. To download your program in RUN mode, select one of the following methods:
   - Select the "Download to device" command from the "Online" menu.
   - Click the "Download to device" button in the toolbar.
   - In the "Project tree", right-click "Program blocks" and select the "Download to device > Software (only changes)" command.



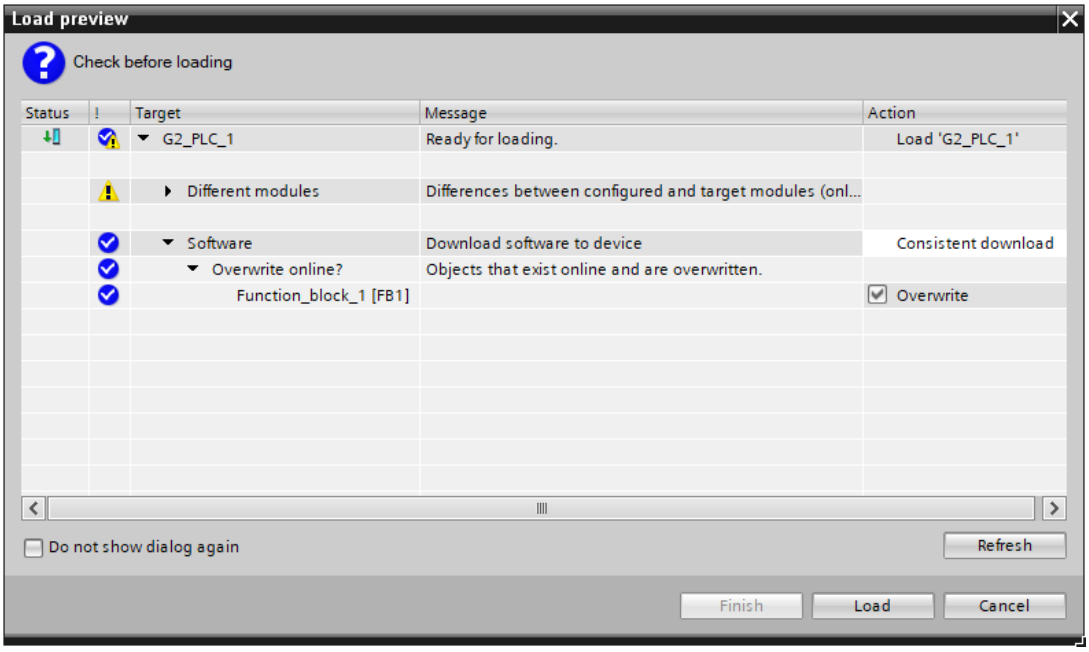
   If the program compiles successfully, TIA Portal starts to download the program to the CPU. You might be prompted for choices about synchronization.
2. When TIA Portal prompts you to load your program or cancel the operation, click "Load" to download the program to the CPU.

12.6.4 Downloading selected blocks

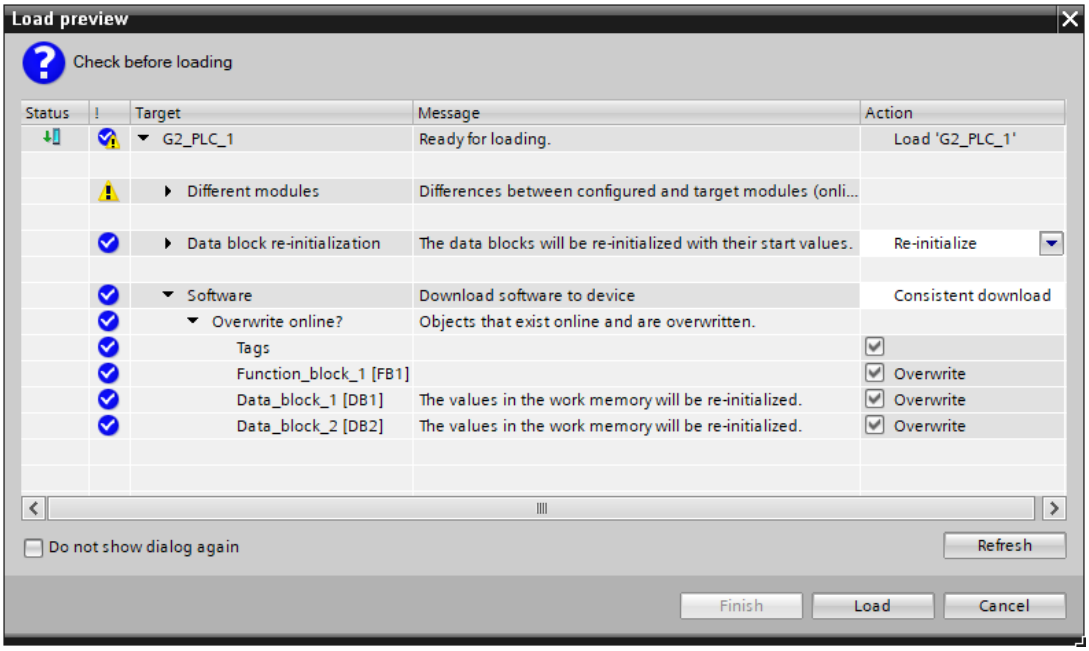
From the Program blocks folder, you can select a single block or a selection of blocks for downloading.

If you select a single block for downloading, then the only option in the "Action" column is "Consistent download".

You can expand the category line to be sure what blocks are to be loaded. In this example, a small change was made to the offline block, and no other blocks need to be loaded.



In this example, more than one block is needed for downloading.



NOTE

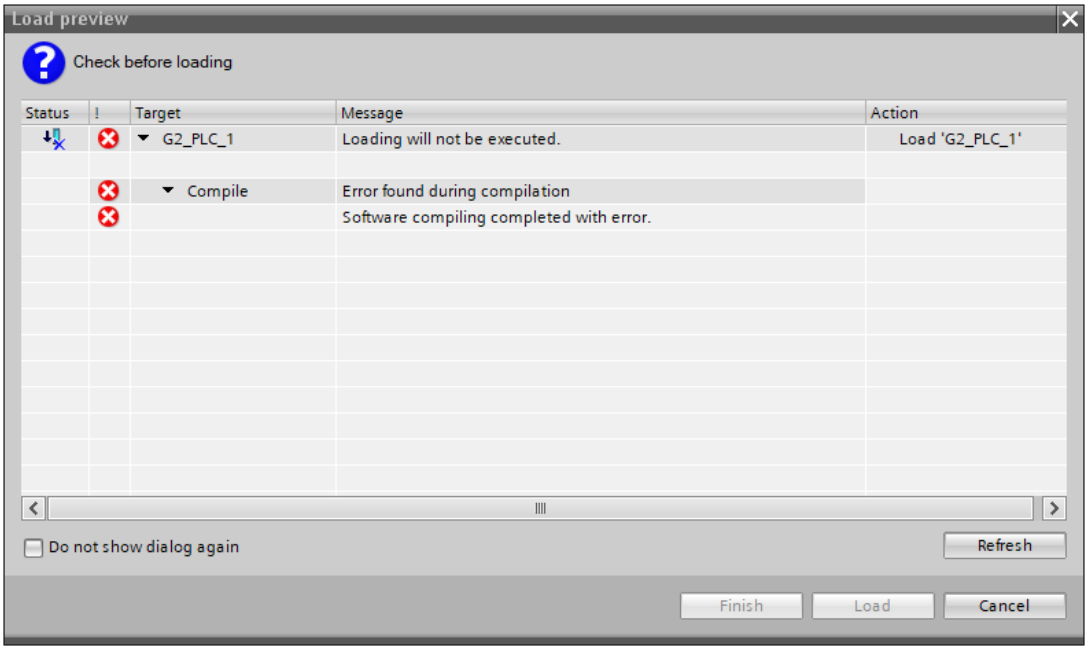
You can download a maximum number of 20 blocks in RUN mode at one time. If you need to download more than 20 blocks, you must place the CPU in STOP mode.

If you attempt to download in RUN, but the system detects that this is not possible, you must put the CPU in STOP mode.

Click the "Load" button, and the "Load results" dialog appears. Click the "Finish" button to complete the download.

12.6.5 Downloading a single selected block with a compile error in another block

If you attempt a consistent download with a compile error in another block, then the dialog indicates an error, and the load button is disabled.



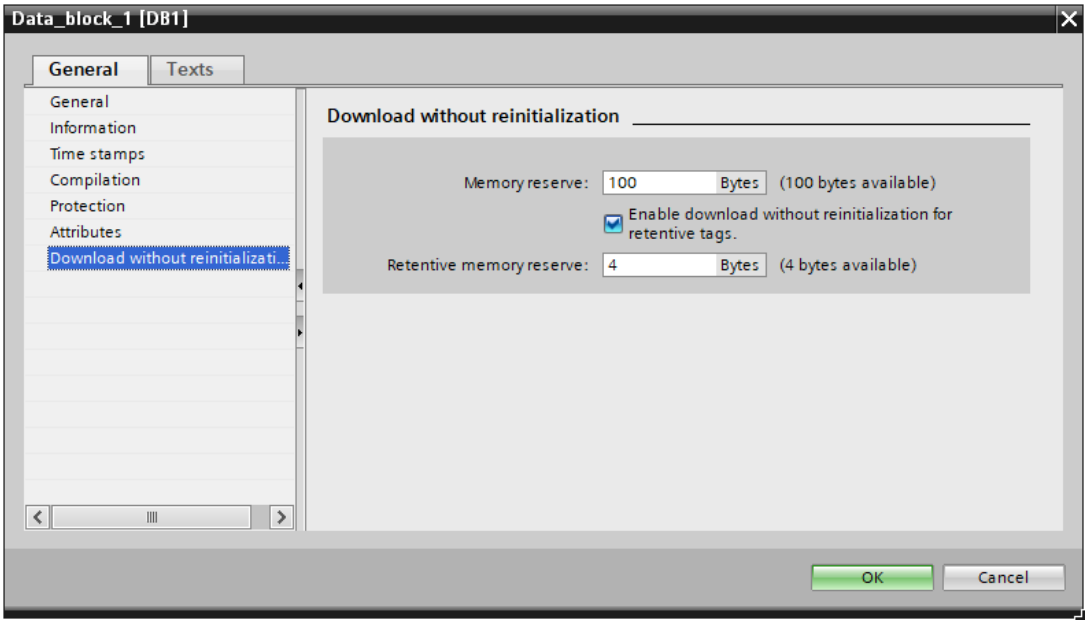
You must correct the compile error in the other block. Then, the "Load" button becomes active.

12.6.6 Modifying and downloading existing tags in RUN mode

The Download in Run feature allows you to add and modify tags in data blocks and function blocks and then download the changed block to the CPU in RUN mode.

Download without reinitialization

Each DB and FB has an amount of reserved memory, which you can use for adding tags to the block that you can subsequently download in RUN mode. By default, the initial size of the memory reserve is 100 bytes. You can add additional tags to your data up to the size of the memory reserve and download the extended block to the CPU in RUN mode. You can also increase the memory reserve if you need more memory for additional tags in your block. If you add more tags than the amount of memory you have allocated, you cannot download the extended block to the CPU in RUN mode.



The "Download without reinitialization" feature allows you to extend a data block by adding more data block tags and download the extended data block in RUN mode. In this way, you can add tags to a data block and download it without reinitializing your program. The CPU retains the values of the existing data block tags and initializes the newly-added tags to their start values.

To enable this function for an online project with a CPU in RUN mode, follow these steps:

1. From the Program blocks folder in the TIA Portal project tree, right-click the block and select "Properties".
2. Click "Download without reinitialization" and select the "Enable download without reinitialization for retentive tags" checkbox in the block editor to enable the function.
3. Click "OK" on the prompt to confirm your choice.
4. Add tags to the block interface and download the block in RUN mode. You can add and download as many new tags as your memory reserve allows.

If you have added more bytes to your block than you have configured for the memory reserve, TIA Portal displays an error when you attempt to download the block in RUN mode. You must edit the block properties to increase the amount. You cannot delete existing entries or modify the “Memory reserve” of the block while the “Download without reinitialization”

function is enabled. To disable the "Download without reinitialization" function, follow these steps:

1. From the Program blocks folder in the TIA Portal project tree, right-click the block and select "Properties".
2. Click "Download without reinitialization" and de-select the "Enable download without reinitialization for retentive tags" checkbox in the block editor to disable the function.
3. Click "OK" on the prompt to confirm your choice.
4. Download the block. On the download dialog, you must select "reinitialize" in order to download the extended block.

The download then reinitializes all existing and new block tags to their start values.

Downloading retentive block tags

Downloading retentive block tags in RUN mode requires the allocation of a retentive memory reserve. To configure this retentive memory reserve, follow these steps:

1. From the Program blocks folder in the TIA Portal project tree, right-click the block and select "Properties" from the context menu.
2. Select the "Download without reinitialization" property.
3. Select the check box for "Enable download without reinitialization for retentive tags".
4. Configure the number of bytes available for the retentive memory reserve.
5. Click "OK" to save your changes.
6. Add retentive data block tags to the data block and download the data block in RUN mode.

To add and download as many new retentive data block tags as your retentive memory reserve allows, click "Activate memory reserve" on the toolbar. For more information, refer to "Basic information on loading block extensions without reinitialization" in the TIA Portal Information System.

If you have added more retentive bytes to your data block than you have configured for the retentive memory reserve, TIA Portal displays an error when you attempt to download the block in RUN mode. You can only add retentive block tags up to the retentive memory reserve in order to be able to download them in RUN mode.

When you download the extended retentive block tags, the tags contain their current values.

Configuring amount of reserved memory for new blocks

The default memory reserve size for new data blocks is 100 bytes. When you create a new block, it has 100 bytes available in reserve. If you want the memory reserve size to be different for new blocks, you can change the setting in the PLC programming settings:

1. From TIA Portal, select the **Options > Settings** menu command.
2. From the Settings dialog, expand "PLC programming" and select "General".
3. In the "Download without reinitialization" section, enter the number of bytes for the memory reserve.

When you create new blocks, TIA Portal uses the memory reserve configuration that you entered for the new blocks.

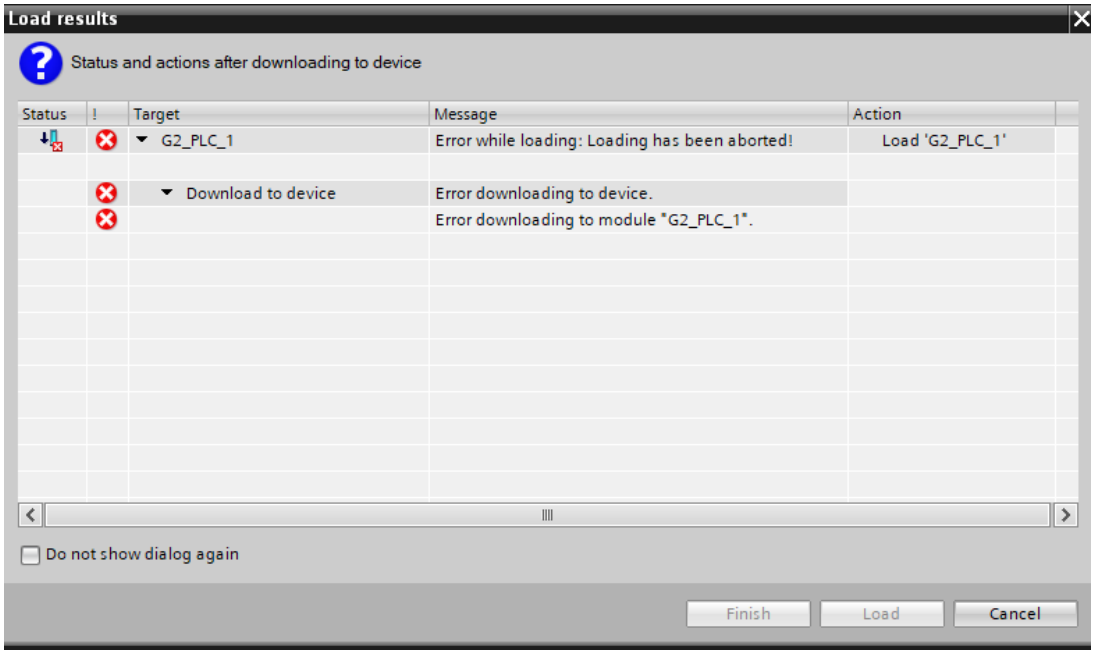
Restrictions

The following restrictions apply to editing and downloading blocks in RUN mode:

- Extending the block interface by adding new tags and downloading in RUN mode is only available for optimized blocks.
- You cannot change the structure of a block and download the changed block in RUN mode without reinitializing. Adding new members to a Struct tag, changing tag names, array sizes, data types, or retentive status all require that you reinitialize the block if you download it in RUN mode. The only modifications to existing block tags that you can perform and still download the block in RUN mode without reinitialization are changes to start values (data blocks), default values (function blocks) or comments.
- You cannot download more new block tags in RUN mode than the memory reserve can accommodate.
- You cannot download more new retentive block tags in RUN mode than the retentive memory reserve can accommodate.

12.6.7 System reaction if the download process fails

During the initial Download in RUN operation, if a network connection failure occurs, STEP 7 displays the following "Load results" dialog:



12.6.8 Considerations when downloading in RUN mode

Before downloading the program in RUN mode, consider the effect of a RUN-mode modification on the operation of the CPU for the following situations:

- If you deleted the control logic for an output, the CPU maintains the last state of the output until the next power cycle or transition to STOP mode.
- If you deleted a high-speed counter or pulse output functions which were running, the high-speed counter or pulse output continues to run until the next power cycle or transition to STOP mode.

- Any logic that is conditional on the state of the first scan bit will not be executed until the next power cycle or transition from STOP to RUN mode. The first scan bit is set only by the transition to RUN mode and is not affected by a download in RUN mode.
- The current values of data blocks (DBs) and/or tags can be overwritten.

Requirements

Before you can download your program in RUN mode, the program must compile with no errors, and the communication between TIA Portal and the CPU must be error-free.

You can make the following changes in program blocks and tags and download them in RUN mode:

- Create, overwrite, and delete Functions (FCs), Function Blocks (FBs), and Tag tables.
- Create and delete Data Blocks (DBs); however, DB structure changes cannot be overwritten. Initial DB values can be overwritten. You cannot download a Web server DB (control or fragment) in RUN mode.
- Create, overwrite, and delete Organization Blocks (OBs).

You can download a maximum number of 20 blocks in RUN mode at one time. If you need to download more than 20 blocks, you must place the CPU in STOP mode.

Once you initiate a download, you cannot perform other tasks in TIA Portal until the download completes.

Instructions that might fail due to "Download in RUN mode"

The following instructions might experience a temporary error when download in RUN mode changes are being activated in the CPU. The error occurs when the instruction is initiated while the CPU is preparing to activate the downloaded changes. During this time, the CPU suspends initiation of user-program access to the Load Memory, while it completes in-progress user program access to Load Memory. This is done so that downloaded changes can be activated consistently.

Instruction	Response while Activation is Pending
DataLogCreate	STATUS = W#16#80C0, ERROR = TRUE
DataLogOpen	STATUS = W#16#80C0, ERROR = TRUE
DataLogWrite	STATUS = W#16#80C0, ERROR = TRUE
DataLogClose	STATUS = W#16#80C0, ERROR = TRUE
DataLogNewFile	STATUS = W#16#80C0, ERROR = TRUE
DataLogClear	STATUS = W#16#80C0, ERROR = TRUE
DataLogDelete	STATUS = W#16#80C0, ERROR = TRUE
READ_DBL	RET_VAL = W#16#82C0
WRIT_DBL	RET_VAL = W#16#82C0
CREATE_DB	RET_VAL = W#16#80C0
DELETE_DB	RET_VAL = W#16#80C0
RTM	RET_VAL = W#16#80C0

In all cases the RLO output from the instruction will be false when the error occurs. The error is temporary. If it occurs, the instruction should be retried later.

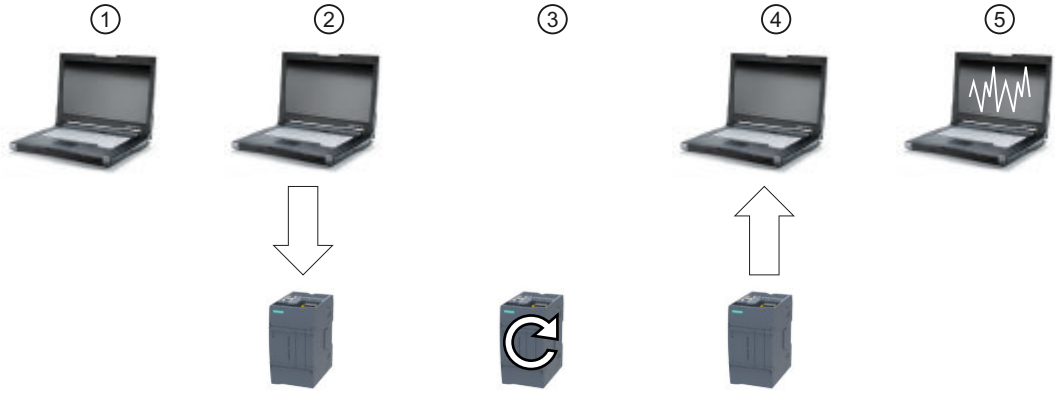
If one of the above instructions fails to execute because a download in RUN mode was in process, retry the failed instruction in a subsequent execution of that OB. If you retry the instruction in the same OB execution, it will fail.

12.7 Tracing and recording CPU data on trigger conditions

TIA Portal provides trace and logic analyzer functions with which you can configure variables for the PLC to trace and record. You can then upload the recorded trace measurement data to your programming device and use TIA Portal tools to analyze, manage, and graph your data. You use the Traces folder in the TIA Portal project tree to create and manage traces.

NOTE
The trace measurement data is available only within the TIA Portal project and is not available for processing by other tools.

The following figure shows the various steps of the trace feature:



① Configure the trace in the trace editor of TIA Portal You can configure the following options:
- Data values to record
- Recording duration
- Recording frequency
- Trigger condition

② Transfer the trace configuration from TIA Portal to the PLC.

③ The PLC executes the program, and when the trigger condition occurs, begins recording the trace data.

④ Transfer the recorded values from the PLC to TIA Portal.

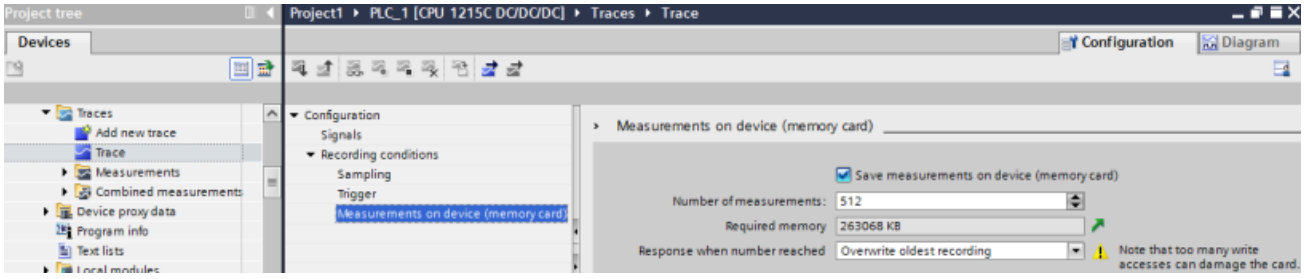
⑤ Use the tools in TIA Portal to analyze, graphically display, and save the data.

The S7-1200 G2 supports four trace jobs with a maximum of 16 variables captured per trigger event. Each trace job provides 512 Kbytes of RAM for the recording of trace values and associated overhead, for example variable addresses and time stamps.

Saving trace measurements to the memory card

The S7-1200 G2 CPU can only save trace measurements to the SIMATIC memory card. If you do not have a memory card in your CPU, the CPU will log a diagnostics buffer entry if the program attempts to save trace measurements. The CPU limits the space allocated to trace measurements such that 1 MB of external load memory must always be available. If a trace measurement would require more memory than the maximum allowance, the CPU will not save the measurement and will log a diagnostics buffer entry.

In addition, if you select "Overwrite oldest recording" in TIA Portal, the continual writing can reduce the lifetime of load memory. When you select "Overwrite oldest recording", the CPU replaces the oldest measurement with the newest measurement after it has stored the configured number of trace measurements, and continues tracing and saving measurements. Overwriting the oldest measurements is useful in capturing intermittent problems.



The CPU supports a maximum of 1000 trace measurement results. During the time that the CPU is saving the trace measurements to external load memory, the CPU does not check the trigger condition for the trace job. Once the CPU finishes saving the trace measurements, the CPU resumes checking for trigger conditions.

Access to examples

See the TIA Portal Information System for details about how to program a trace, how to download the configuration, upload the trace data, and display the data in the logic analyzer. You can find detailed examples there in the "Using the trace and logic analyzer function (https://docs.tia.siemens.cloud/access?ft:originId=./29275874699/29275874699_enUS.htm&ft:clusterId./29275874699/29275874699.htm)" chapter.

In addition, the online manual "Industry Automation SINAMICS/SIMATIC Using the trace and logic analyzer function" (https://support.industry.siemens.com/cs/us/en/view/64897128) is an excellent reference.

12.8 Determining the type of error from an analog module

As described in the topic Analog module diagnostics (Page 320), an analog module returns an analog input value of 32767 (16#7FFF) for both a wire break condition and an overflow condition. These conditions apply to the channel only and not to the module. If you want to determine which of these two conditions occurred, you can include logic in your STEP 7 program to make the determination. The method to determine the condition type consists of these tasks:

- Create a Diagnostic error interrupt OB to be called whenever there is an incoming or outgoing diagnostic event.
- Include a call to the RALRM instruction.
- Set up an array of bytes for the AINFO parameter, which includes the information about the condition type.
- Evaluate bytes 32 and 33 of the AINFO structure of the RALRM_DB when the CPU triggers the Diagnostic Interrupt OB..

Creating a Diagnostic error interrupt OB

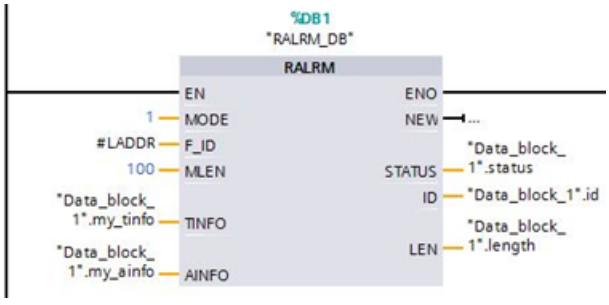
To be able to determine when a wire break condition occurs, create a Diagnostic error interrupt OB. The CPU calls this OB whenever an incoming or outgoing diagnostic event occurs.

When the CPU calls the Diagnostic error interrupt OB, the input parameter LADDR will contain the hardware identifier for the module with the error. You can find the hardware identifier for the SM 1231 module in the STEP 7 device configuration for the SM 1231 module.

Calling the RALRM instruction

To program the RALRM instruction call, follow these steps:

1. Add a call to RALRM in your STEP 7 program.
2. Set the F_ID input parameter to the hardware identifier in the LADDR parameter of the Diagnostic error interrupt OB.
3. Use an array of bytes for the TINFO and AINFO input parameters. Use an array size of 34 bytes or greater.



Interpreting AINFO after a diagnostic interrupt has occurred

The AINFO byte array will contain the information about the module diagnostics after the Diagnostic error interrupt OB executes.

Bytes 0 - 25 are header information. The bytes pertaining to the module diagnostic are as follows:

Byte	Description	
26 and 27	Word value 16#8000 - indicates the diagnostic is a PROFINET style diagnostic	
28 and 29	Word containing channel number responsible for this diagnostic	
30	Bit pattern aaabb000 that indicates the type of channel (aaa) and type of error (bb)	
	aaa	bb
	000: reserved	00: reserved
	001: input channel	01: incoming error
	010: output channel	10: outgoing error
	011: input/output channel	11: outgoing error, other errors present
31	Indication of data format 0: Free data format 1: Bit 2: Two bits 3: Four bits 4: Byte 5: Word (two bytes) 6: Double word (four bytes) 7: Two double words (eight bytes)	
32 and 33	Word that defines the type of error: 16#0000: reserved 16#0001: short circuit 16#0002: undervoltage 16#0003: overvoltage 16#0004: overload 16#0005: over temperature 16#0006: wire break 16#0007: high limit exceeded 16#0008: low limit exceeded 16#0009: error	

For example, consider bytes 26 - 33 of this AINFO structure:

29		my_ainfo[26]	Byte	16#0	16#80
30		my_ainfo[27]	Byte	16#0	16#00
31		my_ainfo[28]	Byte	16#0	16#00
32		my_ainfo[29]	Byte	16#0	16#00
33		my_ainfo[30]	Byte	16#0	16#28
34		my_ainfo[31]	Byte	16#0	16#05
35		my_ainfo[32]	Byte	16#0	16#00
36		my_ainfo[33]	Byte	16#0	16#07

- The Word at bytes 26 and 27 is 16#8000, which indicates that this is a PROFINET style diagnostic.
- The Word at bytes 28 and 29 indicates this is a diagnostic for channel 0 or the module.
- Byte 30 is 16#28, which when interpreted as the bit pattern aaa bb 00 is 001 01 000. This value indicates that this diagnostic is for an input channel and is an incoming error.
- Byte 31 is 5, which indicates a Word value
- The word value at bytes 32 and 33 is 16#0007, which indicates high limit exceeded.

By capturing the AINFO information from a Diagnostic error interrupt event, you can thus determine the nature of the diagnostic event.

12.9 Backup and restore options

You can create a backup of your CPU. You can then restore this backup file to the CPU or to another CPU. You can find the backups in the project tree under the CPU in the "Online backups" folder.

Scope of the backup

The backup file contains the following:

- Contents of the memory card, if present
- Retentive memory areas (for example, data blocks, counters, and bit memory)
- Other retentive memory contents, such as IP address parameters

The backup is performed with the current values of the CPU. Entries in the diagnostics buffer are not included in the backup, and neither is the current time.

The backup does not contain the password to protect confidential PLC configuration data.

Backup and restore operations

STEP 7 and the S7-1200 G2 CPU offer the following options for backing up and restoring the hardware configuration and software:

- Snapshot of the actual values
- Upload from device (software)
- Upload device as new station (hardware and software)
- Backup from online device

To learn more about options for backing up and restoring your CPU, refer to the following:

- The topic "Creating a backup of an S7 CPU (https://docs.tia.siemens.cloud/access?ft:originId=ProgOnlineBackupenUS_20.00.00.00_release&ft:clusterIdProgOnlineBackup)" in the TIA Portal Information System
- The S7-1500/ET 200, SIMATIC Drive Controller Web server (https://support.industry.siemens.com/cs/ww/en/view/109977246) function manual
- The SIMATIC Automation Tool user guide (https://support.industry.siemens.com/cs/us/en/view/109986787)

Technical specifications

A

A.1 General technical specifications

Standards compliance

The S7-1200 G2 automation system design conforms with the following standards and test specifications. The test criteria for the S7-1200 G2 automation system are based on these standards and test specifications.

NOTE

Some S7-1200 G2 devices are not certified to all the following standards, and certification status can change without notice. Most certification approval markings are listed on the device or packaging. You are responsible for determining whether the devices in your system meet the required certifications for your application. For additional information on the certifications of a specific device, consult with a local Siemens representative or visit the Siemens Industry Online Support Web site (https://sieportal.siemens.com/en-ww/support). Device certificates can be downloaded from the Siemens Industry Online Support Web site.

CE approval

CE

The S7-1200 G2 automation system satisfies requirements and safety related objectives according to the EC directives listed below, and conforms to the harmonized European standards (EN) for the programmable controllers listed in the Official Journals of the European Community.

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2014/53/EU "Radio Equipment" (RED Directive)
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (ATEX Directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
- 2006/42/EC "Machinery Directive" for S7-1200 G2 F-CPU, F-SM, and F-SB modules

EU declarations of conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
P.O. Box 1963
D-92209 Amberg

The EU declarations of conformity are also available for download from the Siemens Industry Online Support Web site (https://sieportal.siemens.com/en-ww/support), under the keyword “Declaration of Conformity”.

Radio Equipment Directive (RED) compliance

The S7-1200 G2 automation system complies with the Radio Equipment Directive (RED) 2014/53/EU. The RED defines NFC tags as radio equipment. The frequency 13.56 MHz is regulated under ETSI EN 300 330 v2.1.1.

UK Conformity Assessed marking

The S7-1200 G2 automation system complies with the designated British standards (BS) for programmable controllers published in the official consolidated list of the British Government. The S7-1200 G2 automation system meets the requirements and protection targets of the following regulations and related amendments:

- Electromagnetic Compatibility Regulations 2016 (EMC)
- Radio Equipment Regulations 2017
- Equipment and Protective Systems Intended for use in Potentially Explosive Atmospheres Regulations 2016 (ATEX)
- Regulations on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2012 (RoHS)
- Supply of Machinery (Safety) Regulations 2008 for S7-1200 G2 F-CPU, F-SM, and F-SB modules

UK Declarations of Conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
P.O. Box 1963
D-92209 Amberg

The UK Declaration of Conformity is also available for download from the Siemens Industry Online Support Web site (https://sieportal.siemens.com/en-ww/support) under the keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc. complying with:

- Underwriters Laboratories, Inc.: UL 61010-1, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements and UL 61010-2-201, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 2-201: Particular Requirements for Control Equipment.
- Canadian Standards Association: CAN/CSA-C22.2 No. 61010-1-12, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements and CSA C22.2 No. 61010-2-201, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 2-201: Particular Requirements for Control Equipment.

NOTE

The SIMATIC S7-1200 G2 series meets the CSA standard.
The cULus logo indicates that the S7-1200 G2 has been examined and certified by Underwriters Laboratories (UL) to the standards referenced above.

cULus HAZ. LOC. approval



Underwriters Laboratories Inc. in accordance with:

- UL 121201
- CAN/CSA C22.2 No. 213 (Hazardous Location) APPROVED for use in Class I, Division 2, Group A, B, C, D T4C; Class I, Zone 2, Group IIC T4 Installation Instructions for cULus haz.loc.
- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING – Explosion Hazard – Substitution of components can impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

IMPORTANT EXCEPTION: Some models are de-rated for Ta = 60 °C. See the Technical Specifications of each device for derating information.

ATEX approval



According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres – Part 7: Increased safety “e”), EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres – Part 0: General requirements), and IEC 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Equipment protection by type of protection "n").

II 3 G Ex ec IIC T4 Gc (some models are II 3 G Ex ec nC IIC T4 Gc, see product marking) (Page 347)

UL 24 ATEX 3237X

Special conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with EN 60079-7.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

IECEx approval



According to IEC 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e"), IEC 60079-0 (Explosive atmospheres – Part 0: Equipment – General requirements), and IEC 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Equipment protection by type of protection "n").

II 3 G Ex ec IIC T4 Gc (some models are II 3 G Ex ec nC IIC T4 Gc, see product marking) (Page 347)

IECEx UL 24.0044X

Specific conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in IEC 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with EN IEC 60079-0.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

UKEX approval



According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e"), EN IEC 60079-0 (Explosive atmospheres – Part 0: Equipment – General requirements), and IEC 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Equipment protection by type of protection "n").

II 3 G Ex ec IIC T4 Gc (some models are II 3 G Ex ec nC IIC T4 Gc, see product marking) (Page 347)

UL 24UKEX2991X

Specific conditions of use:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with EN 60079-7.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

CCCEx approval



According to GB/T 3836.1 (Explosive atmospheres – Part 1: Equipment – General requirements), GB/T 3836.3 (Explosive atmospheres – Part 3: Equipment protection by increased safety "e"), and GB/T 3836.8 (Explosive atmospheres – Part 8: Equipment protection by type of protection "n" see product marking) (Page 347)

Specific conditions of safety use:

- The equipment shall only be used in an area of at least pollution degree 2, as defined in GB/T 16935.1.
- The equipment shall be installed in an enclosure that provides a degree of protection not less than IP54 in accordance with GB/T 3836.3.
- Transient protection shall be provided that is set at a level not exceeding 140% of the peak rated voltage value at the supply terminals to the equipment.

Australia and New Zealand - RCM Mark (Regulatory Compliance Mark)



The S7-1200 G2 automation system satisfies the requirements of AS/NZS 2064 standards (Class A).

Korea Certification



The S7-1200 G2 automation system satisfies the requirements of the Korean Certification (KC Mark). It has been defined as Class A Equipment and is intended for industrial applications and has not been considered for home use.

Eurasian Customs Union approval



EAC (Eurasian Conformity): Declaration of Conformity according to Technical Regulation of Customs Union (TR CU)

Industrial environments

The S7-1200 G2 automation system is designed for use in industrial environments.

Table 1-201 Industrial environments

Application field	Emission requirements	Immunity requirements
Industrial	EN 61000-6-4	EN 61000-6-2

Environmental conditions

The S7-1200 G2 automation system is suitable for use in weather-proof, fixed locations. The operating conditions are based on requirements of IEC 61131-2:2017.

Table 1-202 Shipping and storage

Environmental conditions – Shipping and storage conditions (TTH4 and STH4)	
EN 60068-2-1, Test Ab, Cold EN 60068-2-2, Test Dc, Dry heat	-40 °C to 70 °C
EN 60068-2-30, Test Db, Damp heat	25 °C to 55 °C, 95% RH
EN 60068-2-14, Test Na, Temperature shock	-40 °C to 70 °C, dwell time 3 hours, 2 cycles
EN 60068-2-31, Free fall	0.3 m, 5 times, product packaging
Atmospheric pressure	1140 to 540 hPa (corresponding to an altitude of -1000 to 5000 m)

Table 1-203 Climatic ambient conditions

Environmental conditions – Climatic ambient operating conditions (OTH4)	
Ambient temperature (Inlet Air 25 mm below unit)	-20 °C to 40 °C Max. specifications[1] -20 °C to 60 °C With derating[2] For vertical mounting see individual device specifications. Minimum temperature for fail-safe SMs/SBs is 0 °C.
	95% non-condensing humidity
Atmospheric pressure	1140 to 540 hPa (corresponding to an altitude from -1000 to 5000 m) For altitudes above 2000 m, the maximum permissible ambient temperature must be derated: >2000 m 0.9 factor, >3000 m 0.8 factor, >4000 m 0.7 factor. 5000 m is max allowed altitude.
Effects on the availability of modules at altitude	The higher cosmic radiation present during operation at altitudes above 2000 m affects the failure rate of electronic components. This is what is called a soft-error rate. In rare cases, this can result in a transition of modules to the safe state, especially for fail-safe modules. However, the functional safety of the modules is fully retained.
Concentration of contaminants	$S0_2$: < 0.5 ppm; H_2S: < 0.1 ppm; RH < 60% non-condensing
	ISA-S71.04 severity level G1, G2, G3
EN 60068-2-14, Test Nb (Temperature change)	-20 °C to 60 °C, dwell time 3 hours, 5 cycles
EN 60068-2-78, Test Cab (Damp heat)	30 °C, 95% RH, 16 hours
EN 60068-2-27 (Shock)	15 g, 11 ms pulse, 6 shocks in each of 3 axes (when panel mounted)
EN 60068-2-6 (Sinusoidal vibration)	3.5 mm from 5 to 8.4 Hz, 1g from 8.4 to 150 Hz 10 sweeps each axis, 1 octave per minute (when panel or DIN rail mounted) Note: In high vibration applications, Siemens recommends panel mounting or the use of a Siemens DIN Rail with DIN Rail End Retainers to secure devices.

[1] Operating temperature range using maximum voltages and maximum specifications.

[2] Operating temperature range using the rated voltages, 50% of maximum specifications with alternate I/O active:

50% of maximum specifications includes half of the following values with alternate I/O active:

- Current available for expansion devices
- Current available on sensor supply
- Current for the digital outputs (includes relay outputs)

Alternate I/O active means that every other input or output is active. Using alternate I/O reduces the concentration of heat around active circuits. Refer to the specifications of your CPU for the number of supported inputs and outputs.

Maximum installation altitude

You can install all S7-1200 G2 devices at a maximum altitude of 5000 m except for the following devices:

Description	Article number	Version	Maximum installation altitude
SM 1222 DQ 16xRLY	6ES7222-5HH50-0XB0	FS01 or higher	4000 m
SM 1223 DI 8x24VDC / DQ 8x RLY	6ES7223-5PH50-0XB0	FS01 or higher	4000 m
SM 1223 DI 16x24VDC / DQ 1-6xRLY	6ES7223-5PL50-0XB0	FS01 or higher	4000 m

Electromagnetic compatibility

Electromagnetic Compatibility (EMC) is the ability of an electrical device to operate as intended in an electromagnetic environment and to operate without emitting levels of electromagnetic interference (EMI) that can disturb other electrical devices in the vicinity.

Table 1-204 Immunity

Electromagnetic compatibility - Immunity per EN 61000-6-2	
EN 61000-4-2[1] Electrostatic discharge	8 kV air discharge to all surfaces 6 kV contact discharge to exposed conductive surfaces
EN 61000-4-3[2] Radiated, radio-frequency, electromagnetic field immunity test	80 MHz to 1000 MHz, 10 V/m, 80% AM (1 kHz) 1.4 GHz to 6 GHz, 3 V/m, 80% AM (1 kHz)
EN 61000-4-4[1] Fast transient bursts	2 kV, 5 kHz with coupling network to AC and DC system power 2 kV, 5 kHz with coupling clamp to I/O
EN 61000-4-5[1] Surge immunity	AC systems - 2 kV common mode, 1 kV differential mode DC systems - 1 kV common mode, 0.5 kV differential mode
EN 61000-4-6[2] Conducted disturbances	150 kHz to 80 MHz, 10 V RMS, 80% AM at 1 kHz
EN 61000-4-11 Voltage dips	AC systems 0% for 1 cycle, 40% for 12 cycles, and 70% for 30 cycles at 60 Hz

[1] The maximum short-term influence on analog modules during the duration of the EMC tests can be +/- 10% of the full-scale value.

[2] The maximum short-term influence on analog modules during the duration of the EMC tests can be +/- 1% of the full-scale value.

Table 1-205 Emissions

Electromagnetic compatibility - Conducted and radiated emissions per EN 61000-6-4		
Conducted emissions AC power ports	0.15 MHz to 0.5 MHz	< 79 dBµV quasi-peak, < 66 dBµV average
	0.5 MHz to 30 MHz	< 73 dBµV quasi-peak, < 60 dBµV average
Conducted emissions DC power ports	0.15 MHz to 0.5 MHz	< 89 dBµV quasi-peak, < 76 dBµV average
	0.5 MHz to 30 MHz	< 83 dBµV quasi-peak, < 70 dBµV average
Radiated emissions	30 MHz to 230 MHz	< 40 dBµV/m quasi-peak at 10 m
	230 MHz to 1000 MHz	< 47 dBµV/m quasi-peak at 10 m
	1000 MHz to 3000 MHz	< 76 dBµV/m peak, < 56 dBµV/m average at 3 m
	3000 MHz to 6000 MHz	< 80 dBµV/m peak, < 60 dBµV/m average at 3 m

Insulation

The insulation is designed in accordance with the requirements of IEC 61010-2-201.

NOTE
For modules having 24 V DC (SELV / PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Pollution degree / overvoltage category in accordance with IEC 61131-2 and IEC 61010-2-201

- Pollution degree 2
- Overvoltage category II

Protection class according to IEC 61131-2 and IEC 61010-2-201

- Protection class II

Degree of protection

- IP20 Mechanical Protection, EN 60529
- Protects against finger contact with high voltage as tested by standard probe. External protection required for dust, dirt, water and foreign objects of < 12.5 mm in diameter.

Rated voltages

The rated voltages are:

- 24 V DC
- 120/240 V AC

⚠ WARNING

Risks when turning on output power
When a mechanical contact turns on output power to the S7-1200 G2 CPU, or any digital expansion module or board, it sends a “1” signal to the digital outputs for approximately 50 microseconds.
This could cause unexpected machine or process operation, which could result in death or serious injury to personnel and/or damage to equipment.
You must plan for the "1" signal to the digital outputs.

Reverse voltage protection

Reverse voltage protection circuitry is provided on each terminal pair of +24 V DC power or user input power for CPUs, signal modules (SMs), and signal boards (SBs). It is still possible to damage the system by wiring different terminal pairs in opposite polarities.

Some of the 24 V DC power input ports in the S7-1200 G2 system are interconnected, with a common logic circuit connecting multiple M terminals. For example, the following circuits are interconnected when designated as "not isolated": the 24 V DC power supply of the CPU, the sensor power of the CPU, the power input for the relay coil of an SM, and the power supply for a non-isolated analog input. All non-isolated M terminals must connect to the same external reference potential.

⚠ WARNING

Risks when connecting non-isolated M terminals to different reference potentials
Connecting non-isolated M terminals to different reference potentials causes unintended current flows that can cause damage or unpredictable operation in the PLC and any connected equipment.
Always ensure that all non-isolated M terminals in an S7-1200 G2 system are connected to the same reference potential.
Failure to comply with these guidelines could cause damage or unpredictable operation, which can result in death or severe personal injury and/or property damage.

DC Outputs

Short-circuit protection circuitry is not provided for DC outputs on CPUs, signal modules (SMs), and signal boards (SBs).

Relay electrical service life

The typical performance data estimated from sample tests is shown below. Actual performance can vary depending upon your specific application. An external protection circuit that is adapted to the load enhances the service life of the contacts. Normally closed contacts have a typical service life of about one-third that of normally open contacts under inductive and lamp load conditions.

Table 1-206 Typical performance data

Data for selecting an actuator			
Continuous thermal current	2 A max.		
Switching capacity and life of the contacts			
For ohmic load	Voltage	Current	Number of operating cycles (typical)
	24 V DC	2.0 A	0.1 million
	24 V DC	1.0 A	0.2 million
	24 V DC	0.5 A	1.0 million
	48 V AC	1.5 A	1.5 million
	60 V AC	1.5 A	1.5 million
	120 V AC	2.0 A	1.0 million
	120 V AC	1.0 A	1.5 million
	120 V AC	0.5 A	2.0 million

Data for selecting an actuator			
For ohmic load	230 V AC	2.0 A	1.0 million
	230 V AC	1.0 A	1.5 million
	230 V AC	0.5 A	2.0 million
For inductive load (according to IEC 947-5-1 DC13/AC15)	Voltage	Current	Number of operating cycles (typical)
	24 V DC	2.0 A	0.05 million
	24 V DC	1.0 A	0.1 million
	24 V DC	0.5 A	0.5 million
	24 V AC	1.5 A	1.0 million
	48 V AC	1.5 A	1.0 million
	60 V AC	1.5 A	1.0 million
	120 V AC	2.0 A	0.7 million
	120 V AC	1.0 A	1.0 million
	120 V AC	0.5 A	1.5 million
	230 V AC	2.0 A	0.7 million
	230 V AC	1.0 A	1.0 million
	230 V AC	0.5 A	1.5 million
Activating a digital input	Possible		
Switching frequency			
Mechanical	Max. 10 Hz		
At ohmic load	Max. 1 Hz		
At inductive load (according to IEC 947-5-1 DC13/AC15)	Max. 0.5 Hz		
At lamp load	Max. 1Hz		

Internal CPU memory retention

The CPU performs operations to extend the life of the internal memory devices that contain the application data. Below is the life expectancy of the internal memory.

- Lifetime of retentive data and data log data: 10 years
- Power down retentive data, write cycle endurance: 2 million cycles
- Data log data, write cycle endurance: 500 million data log entries

NOTE

Effect of data logs on internal CPU memory

Each data log write consumes at a minimum 2 KB of memory. If your program writes small amounts of data frequently, it is consuming at least 2 KB of memory on each write. A better implementation would be to accumulate the small data items in a data block (DB), and to write the data block to the data log at less frequent intervals.

If your program writes many data log entries at a high frequency, consider using a replaceable SD memory card.

Use of cellular phones

You can read information from the CPU and write operations to the CPU from the passive Near Field Communication (NFC) (Page 299) tag in your S7-1200 G2 CPU by placing your iPhone near the NFC symbol on the CPU.

All S7-1200 G2 CPUs and modules have a scannable QR code lasered on the housing. Use your smartphone's camera to read the QR code. The QR code provides a direct link to the Siemens Industrial Online Support information for your device.

⚠ WARNING

Risks when using a cellular phone in close proximity to the S7-1200 G2 CPU
Using a cellular phone in close proximity to an S7-1200 G2 system with cellular and Wi-Fi communications active can cause unpredictable behavior.
To reduce any influence of a cellular phone on the S7-1200 G2 system, and to ensure proper operation of your CPU, place the phone in “Airplane mode” to disable cellular and Wi-Fi before bringing the phone into proximity (<10 cm) of the CPU.
Failure to comply with these guidelines can cause damage or unpredictable operation which could result in severe personal injury, property damage, and/or death.

⚠ WARNING

Risks when operating a cellular phone in a hazardous or explosive environment
Do not use a cellular phone in a hazardous or explosive environment unless the phone has been approved for use in such environments.
Failure to comply with these guidelines can cause damage or unpredictable operation which could result in severe personal injury, property damage, and/or death.

A.2 Protection methods

The S7-1200 G2 automation system is covered by two protection methods:

Article numbers covered by II 3 G Ex ec IIC T4 Gc / Ex ec IIC T4 Gc	Article numbers covered by II 3 G Ex ec nC IIC T4 Gc / Ex ec nC IIC T4 Gc
6ES7212-1AG50-0XB0	6ES7212-1HG50-0XB0
6ES7214-1AH50-0XB0	6ES7212-1BG50-0XB0
6ES7212-1AF50-0XB0	6ES7214-1HH50-0XB0
6ES7214-1AF50-0XB0	6ES7214-1BH50-0XB0
6ES7221-1BH50-0XB0	6ES7212-1HF50-0XB0
6ES7222-5BH50-0XB0	6ES7214-1HF50-0XB0
6ES7223-5BH50-0XB0	6ES7222-5HH50-0XB0
6ES7232-4HF50-0XB0	6ES7223-5PH50-0XB0
6ES7221-3BF50-0XB0	6ES7231-4HF50-0XB0
6ES7222-5BF50-0XB0	6ES7233-4HF50-0XB0
6ES7223-7BF50-0XB0	6ES7231-4HD50-0XB0
6ES7223-7AF50-0XB0	6ES7233-4HD50-0XB0
6ES7232-4HD50-0XB0	6ES7223-5PL50-0XB0
6ES7231-5QF50-0XB0	

Article numbers covered by II 3 G Ex ec IIC T4 Gc / Ex ec IIC T4 Gc	Article numbers covered by II 3 G Ex ec nC IIC T4 Gc / Ex ec nC IIC T4 Gc
6ES7231-5PD50-0XB0	
6ES7241-1EA50-0XB0	
6ES7231-5QD50-0XB0	
6ES7231-5PB50-0XB0	
6ES7241-1CA50-0XB0	
6ES7223-5BL50-0XB0	
6ES7223-5BL50-1XB0	
6ES7297-4AX50-0XA0	
6ES7226-6ME50-0XB0	

A.3 CPU 1212C

A.3.1 General specifications and features

Table 1-207 General

Technical data	CPU 1212C AC/DC/RLY	CPU 1212C DC/DC/RLY	CPU 1212C DC/DC/DC
Article number	6ES7212-1BG50-0XB0	6ES7212-1HG50-0XB0	6ES7212-1AG50-0XB0
Dimensions W x H x D	70 x 125 x 100 mm		
Weight (product/shipping)	373 grams / 420 grams	333 grams / 380 grams	319 grams / 366 grams
Power dissipation	4.0 W	3.0 W	
Current available for expansion devices	1000 mA max. (5 V DC)		
Current available on sensor supply	300 mA (24 V DC sensor power, current limited)		
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]		
	Vertical mounting -20 °C to 50 °C[2]		Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum		

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-208 CPU features

Technical data	Description	
User memory	Work Memory	150 Kbytes (Program) 500 Kbytes (Data)
	Load Memory	8 Mbytes (Internal) 32 Gbytes (using SD card)
	Retentive Memory	20 Kbytes
Onboard digital I/O	8 inputs / 6 outputs	
Process image size	1024 bytes of inputs (I) / 1024 bytes of outputs (Q)	

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

Technical data	Description	
Bit memory size	8192 bytes (M)	
Temporary (local) memory	Per priority class, max.	64 Kbytes
	Per block, max.	16 Kbytes
Communication module/processor expansion	3 max. (must connect to the right of the CPU or to the right of another CM/CP)	
Signal module expansion (SM plus CM)	6 max.	
Signal board or Communication board expansion	1 max.	
High-speed counters	Max. number of high-speed counters	8 (any CPU or SB digital input)
	Max. rate, CPU inputs Ia.0 to Ia.5	100 kHz (80 kHz in quadrature mode)
	Max. rate, CPU inputs Ia.6 to Ia.7	30 kHz (20 kHz in quadrature mode)
	Max. rate, SB inputs	See SB specifications
Pulse outputs[1]	Max. number of pulse outputs	8 (any CPU or SB digital output)
	Max. rate, CPU outputs Qa.0 to Qa.3	100 kHz
	Max. rate, CPU outputs Qa.4 to Qa.5	20 kHz
	Max. rate, SB outputs	See SB specifications
Pulse catch inputs	Yes, each onboard CPU digital input and SB digital input	
Time delay interrupts	20 total with 1 ms resolution	
Cyclic interrupts	20 total with 1 µs resolution	
Edge interrupts	Rising and falling for each onboard CPU digital input and SB digital input	
Memory card (Page 468)	SIMATIC memory card (optional).	
Motion control	Available Resources	800
	Required Resources	40 per speed-controlled axis
		80 per positioning axis
		160 per synchronous axis
		80 per external encoder
		20 per output cam
		160 per cam track
		40 per measuring input
	Available Extended Resources	40
	Required Extended Resources	2 per cam (1000 points)
		30 for each set of kinematics
PID	PID Compact	Yes, universal PID controller with integrated optimization
	PID 3Step	Yes, PID controller with integrated optimization for valves
	PID Temp	Yes, PID controller with integrated optimization for temperature
Real-time clock	Accuracy	+/- 60 seconds per month
	Retention time, super capacitor	20 days typical at 40 °C, 12 days minimum at 40 °C

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

A.3.2 Performance

Table 1-209 Performance

Type of instruction[1]	Direct addressing (I, Q, and M)	DB accesses
Boolean	0.037 µs/instruction	
Move_Bool	0.067 µs/instruction	0.066 µs/instruction
Move_Word	0.027 µs/instruction	0.030 µs/instruction
Move_Real	0.027 µs/instruction	0.030 µs/instruction
Add_Real	0.119 µs/instruction	0.074 µs/instruction

[1] Many variables affect measured times. The above performance times are for the fastest instructions in each category and error-free programs.

A.3.3 Blocks, timers, and counters

Table 1-210 Blocks, times, and counters

Element	Description	
Blocks	Type	OB, FB, FC, DB
	Max. number of elements	4000; Blocks (OB, FB, FC, DB) and UDTs
	Max. OB, FB, FC size	64 Kbytes
	Max. DB size (Optimized)	500 Kbytes Work Memory 16 Mbytes Load Memory
	Max. DB size (Non-optimized)	64 Kbytes (DBs with absolute addressing)
	Address range for FBs and FCs	1 to 65535
	Address range for DBs	1 to 59999
	Nesting depth per priority class[1]	24 (OB plus 23 more levels)
	Monitoring	Status of 8 code blocks can be monitored simultaneously.
Number of OBs per event class	Program cycle	100
	Startup	100
	Time delay interrupt	20 (one per event)
	Cyclic interrupt	20 (one per event)
	Hardware interrupt	50
	Time error interrupt	1
	Diagnostic error interrupt	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	20 (one per event)
	Synchronous Cycle	1
	Status	1
	Update	1
	Profile	1
	MC-Interpolator	1
	MC-Servo	1
	MC-PreServo	1
	MC-PostServo	1

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Number of OBs per event class	MC-LookAhead	1
	MC-PreInterpolator	1
	Programming error	1
	I/O access error	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon time type
	IEC_TIMER	16 bytes
	IEC_LTIMER	28 bytes
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon count type
	IEC_SCOUNTER, IEC_USCOUNTER	3 bytes
	IEC_COUNTER, IEC_UCOUNTER	6 bytes
	IEC_DCOUNTER, IEC_UDCOUNTER	12 bytes
	IEC_LCOUNTER, IEC_ULCOUNTER	24 bytes
Runtime Meters	Quantity	16

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

A.3.4 Communications

Table 1-211 Communications

Technical data	Description	
Number of ports	2 with an integrated switch	
Type	Ethernet (RJ-45 connector)	
Connections	88 connections max. (integrated into CPU) 10 reserved for ES/HMI/web	
Data rates	100 Mb/s	
Isolation (Page 81) (external signal to logic)	Transformer isolated, 1500 V AC (type test)[1]	
Cable type	CAT5e shielded	
Interfaces	1 PROFINET	
	0 PROFIBUS	
PROFINET Protocols	PROFINET IO controller	Yes
	PROFINET IO device	Yes
	SIMATIC communication	Yes
	Open IE communication	Yes
	Web server	Yes
	Media redundancy	Yes
PROFINET IO controller services	PG/OP communication	Yes

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
PROFINET IO controller services	S7 routing	Yes (requires more than one communication interface)
	Isochronous mode	Yes
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	MRPD	Yes – Requires an IRT sync domain
	PROFIenergy	Yes (per user program)
	Prioritized startup	Yes (max. 16 PROFINET devices)
	Number of connectable I/O devices, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of submodules, max.	512
	Number of IO devices that you can connect for RT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of in line IO devices that you can connect for RT, max.	31
	Number of IO devices that you can connect for IRT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of IO devices that can be activated/deactivated simultaneously, max.	8
	The minimum update time depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.	RT Send clock: 1 ms to 512 ms IRT Send clock: 1 ms to 512 ms (1 ms resolution)
PROFINET I-Device	Number of connections, max.	2
PROFINET I-Device services	PG/OP communication	Yes
	S7 routing	No
	Isochronous mode	No
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	PROFIenergy	Yes (per user program)
	Shared device	Yes
	Number of IO controllers with shared device, max.	2
SIMATIC communication	S7 communication as server	Yes
	S7 communication as client	Yes
	User data per job, max.	See TIA Portal information system (S7 communication, user data size)
Open IE communication	TCP/IP	Yes, 64 Kbytes max. data length Several passive connections per port
	ISO-on-TCP (RFC1006)	Yes, 64 Kbytes max. data length
	UDP	Yes, 2048 bytes max. data length 1472 bytes max. for UDP broadcast
	DHCP	Yes
	SNMP	Yes

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
Open IE communication	DCP	Yes
	LLDP	Yes
Near Field Communication (NFC)	Yes, with the S7-1200 G2 NFC app	
S7 message functions	Number of login stations for message functions, max.	32
	Program alarms	Yes
	Number of configurable program messages, max.	5000
	Number of loadable program messages in RUN, max.	2500
	Number of simultaneously active program alarms	600 program alarms 100 alarms for system diagnostics 160 for motion technology objects
Test commissioning functions	Joint commission (Team Engineering)	Yes, parallel online access possible for up to 5 engineering systems
	Program status	Yes, up to 8 blocks simultaneously (in total across all ES clients)
	Single step	No
	Breakpoints	No
	SIMATIC Controller Profiling	Yes
Monitor/modify	Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
	Number of monitor variables, max.	200 per job
	Number of modify variables, max.	200 per job
Force	Variables	Peripheral inputs/outputs
	Number of variables, max.	200
Trace	Number of configurable traces	4
	Variables captured per trace, max.	16
	Data captured per trace, max.	512 KB
Diagnostics buffer	Number of entries, max.	500
	Retentive	100

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

A.3.5 Power supply and sensor power

Table 1-212 Power supply

Technical data	CPU 1212C AC/DC/RLY	CPU 1212C DC/DC/RLY	CPU 1212C DC/DC/DC
Rated voltage	120/240 V AC	24 V DC	
Voltage range	85 to 264 V AC	20.4 to 28.8 V DC	
Reverse voltage protection	--	Yes	
Line frequency	47 to 63 Hz	--	
Input current (CPU only)	70 mA at 120 V AC 38 mA at 240 V AC	185 mA at 24 V DC	125 mA at 24 V DC
Input current (with all accessories)	330 mA at 120 V AC 200 mA at 240 V AC	765 mA at 24 V DC	700 mA at 24 V DC

Technical data	**CPU 1212C AC/DC/RLY**	**CPU 1212C DC/DC/RLY**	**CPU 1212C DC/DC/DC**
Inrush current	20 A max. at 264 V AC	12 A max. at 28.8 V DC	
I^2t	0.8 A^2 s	0.5 A^2 s	
Isolation (input power to logic)	1500 V AC	Not isolated	
Ground leakage (AC line to functional earth)	0.5 mA max.	--	
Hold up time (loss of power)	20 ms at 120 V AC 80 ms at 240 V AC	10 ms at 24 V DC	
Internal fuse	3 A, 250 V, slow blow not user replaceable		

Table 1-213 Sensor power

Technical data	**CPU 1212C AC/DC/RLY**	**CPU 1212C DC/DC/RLY**	**CPU 1212C DC/DC/DC**
Rated voltage	24 V DC		
Voltage range	20.4 to 28.8 V DC	L+ minus 4 V DC min.	
Output current rating	300 mA max. (short-circuit protected)		
Ripple noise (<10 MHz)	< 1 V peak to peak max.	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated		
Cable length	500 m shielded		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

A.3.6 Digital inputs and outputs

Table 1-214 Digital inputs

Technical data	**CPU 1212C AC/DC/RLY**	**CPU 1212C DC/DC/RLY**	**CPU 1212C DC/DC/DC**
Number of inputs	8, in 1 isolation group of 8 inputs		
Assignment	Ia.0 to Ia.5 (high-speed) Ia.6 to Ia.7 (standard)		
Type	Sink/Source (IEC Type 1 sink)		
Rated voltage	24 V DC at 6 mA, nominal (high-speed) 24 V DC at 4 mA, nominal (standard)		
Continuous permissible voltage	30 V DC, max. at 8 mA, max. (high-speed) 30 V DC, max. at 6 mA, max. (standard)		
Logic 1 signal	15 V DC min. at 2.5 mA		
Logic 0 signal	5 V DC max. or 0.5 mA		
Isolation (field side to logic)	707 V DC (type test)		
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0		
HSC clock input rates (Logic 1 level = 15 to 30 V DC)	Single phase: 100 kHz (Ia.0 to Ia.5) Single phase: 30 kHz (Ia.6 to Ia.7) Quadrature phase: 80 kHz (Ia.0 to Ia.5) Quadrature phase: 20 kHz (Ia.6 to Ia.7)		
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

Table 1-215 Digital outputs

Technical data	**CPU 1212C AC/DC/RLY**	**CPU 1212C DC/DC/RLY**	**CPU 1212C DC/DC/DC**
Number of outputs	6, in 1 isolation group of 6 outputs		
Assignment	Qa.0 to Qa.5		Qa.0 to Qa.3 (high-speed) Qa.4 to Qa.5 (standard)
Type	Relay, dry contact		Solid state – MOSFET (sourcing)
Rated voltage	--		24 V DC
Voltage range	5 to 30 V DC or 5 to 250 V AC		20.4 to 28.8 V DC
Logic 1 signal at max. current	--		20 V DC min.
Logic 0 signal with 10 kΩ load	--		0.1 V DC max.
Current	2.0 A max.		0.5 A max.
Minimum load[1]	125 mW DC / 500 mW AC		--
Lamp load	30 W DC / 200 W AC		5 W
ON state resistance	0.2 Ω max. when new		0.6 Ω max.
Leakage current per point	--		10 µA max.
Overload protection	No		
Isolation (field side to logic)	1500 V AC (type test)		707 V DC (type test)
Isolation (coil to logic)	None		--
Current per common	12 A max. (10 A max. per pin)		3 A max.
Inductive clamp voltage	--		L+ minus 40 V, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.		1.0 µs max., OFF to ON 3.0 µs max., ON to OFF
Switching delay (Qa.4 to Qa.5)	10 ms max.		5 µs max., OFF to ON 20 µs max., ON to OFF
Maximum relay switching frequency	1 Hz		--
Pulse Train Output (PTO) rate	Not recommended[2]		100 kHz max. (Qa.0 to Qa.3) 20 kHz max. (Qa.4 to Qa.5) 2 Hz min.[3]
Lifetime mechanical (no load)	10000000 open/close cycles		--
Lifetime contacts at rated load	100000 open/close cycles		--
Behavior on RUN to STOP	Last value or substitute value (default value 0)		
Control of a digital input	Yes		
Parallel outputs for redundant load control	Yes (with same common)		
Parallel outputs for increased load	No		
Cable length	500 m shielded, 150 m unshielded		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

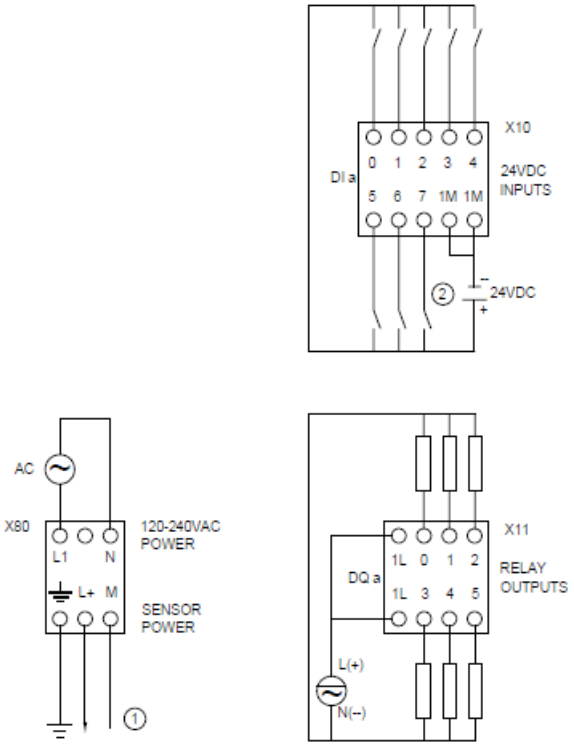
[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

A.3.7 Wiring diagrams

The wiring diagrams and pin connector locations are shown below:

CPU 1212C AC/DC/RLY



X80: AC power wiring terminal (Orange, Type-A keying)					
AC power	L1		N		
Pin #	1	3	5		
Pin #	2	4	6		
Sensor power	GND	L+	M		
X10: DC input wiring terminal (Gray, No keying)					
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4
Pin #	1	3	5	7	9
Pin #	2	4	6	8	10
Signal	DI a.5	DI a.6	DI a.7	1M	1M
X11: Relay output wiring terminal (Orange, Type-A keying)					
Signal	1L	DQ a.0	DQ a.1	DQ a.2	
Pin #	1	3	5	7	
Pin #	2	4	6	8	
Signal	1L	DQ a.3	DQ a.4	DQ a.5	

① For additional noise immunity, jumper the Sensor Power "M" to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

NOTE

You can connect either the L1 or N (L2) terminal to a voltage source up to 240 V AC. The N terminal can be considered L2 and is not required to be grounded. No polarization is required for L1 and N (L2) terminals.

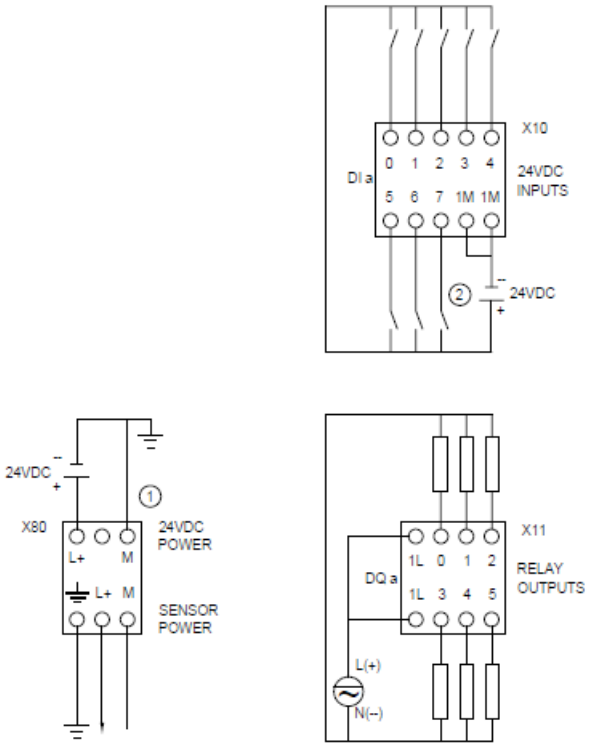
CPU 1212C DC/DC/RLY

X80: DC power wiring terminal (Gray, No keying)					
DC power	L+		M		
Pin #	1	3	5		
Pin #	2	4	6		
Sensor power	GND	L+	M		
X10: DC input wiring terminal (Gray, No keying)					

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1212C DC/DC/RLY



Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4
Pin #	1	3	5	7	9
Pin #	2	4	6	8	10
Signal	DI a.5	DI a.6	DI a.7	1M	1M

X11: Relay output wiring terminal (Orange, Type-A keying)

Signal	1L	DQ a.0	DQ a.1	DQ a.2
Pin #	1	3	5	7
Pin #	2	4	6	8
Signal	1L	DQ a.3	DQ a.4	DQ a.5

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1212C DC/DC/DC

X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin #	2	4	6
Sensor power	GND	L+	M

X10: DC input wiring terminal (Gray, No keying)

Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4
Pin #	1	3	5	7	9
Pin #	2	4	6	8	10
Signal	DI a.5	DI a.6	DI a.7	1M	1M

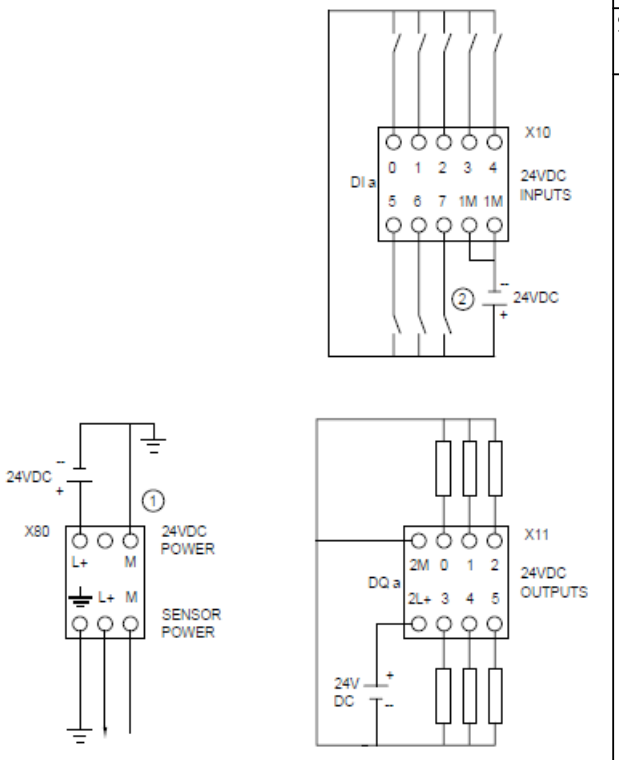
X11: DC output wiring terminal (Gray, No keying)

Signal	2M	DQ a.0	DQ a.1	DQ a.2
Pin #	1	3	5	7

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1212C DC/DC/DC



Pin #	2	4	6	8
Signal	2L+	DQ a.3	DQ a.4	DQ a.5

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.4 CPU 1212FC

A.4.1 General specifications and features

Table 1-216 General

Technical data	**CPU 1212FC DC/DC/RLY**	**CPU 1212FC DC/DC/DC**
Article number	6ES7212-1HF50-0XB0	6ES7212-1AF50-0XB0
Dimensions W x H x D	70 x 125 x 100 mm	
Weight (product/shipping)	333 grams / 380 grams	319 grams / 366 grams
Power dissipation	3.0 W	
Current available for expansion devices	1000 mA max. (5 V DC)	
Current available on sensor supply	300 mA (24 V DC sensor power, current limited)	
Safety class (highest)	PL e (performance level according to ISO 13849-1) SIL 3 (safety integrity level according to IEC 61508)	
Probability of failure	Low demand mode: PFDavg in accordance with SIL 3	

Technical data	CPU 1212FC DC/DC/RLY	CPU 1212FC DC/DC/DC
	< 2.00E-05 High demand/continuous mode: PFH in accordance with SIL 3 < 1.00E-09 (altitude -1000 m to 3000 m) < 2.00E-09 (altitude >3000 m to 5000 m) For service life of 20 years and repair time of 100 hours	
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]	
	Vertical mounting -20 °C to 50 °C[2]	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum	

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-217 CPU features

Technical data	Description	
User memory	Work Memory	200 Kbytes (Program) 500 Kbytes (Data)
	Load Memory	8 Mbytes (Internal) 32 Gbytes (using SD card)
	Retentive Memory	20 Kbytes
Onboard digital I/O	8 inputs / 6 outputs	
Process image size	1024 bytes of inputs (I) / 1024 bytes of outputs (Q)	
Bit memory size	8192 bytes (M)	
Temporary (local) memory	Per priority class, max.	64 Kbytes
	Per block, max.	16 Kbytes
Communication module/processor expansion	3 max. (must connect to the right of the CPU or to the right of another CM/CP)	
Signal module expansion (SM plus CM)	6 max.	
Signal board or Communication board expansion	1 max.	
High-speed counters	Max. number of high-speed counters	8 (any CPU or SB digital input)
	Max. rate, CPU inputs Ia.0 to Ia.5	100 kHz (80 kHz in quadrature mode)
	Max. rate, CPU inputs Ia.6 to Ia.7	30 kHz (20 kHz in quadrature mode)
	Max. rate, SB inputs	See SB specifications
Pulse outputs[1]	Max. number of pulse outputs	8 (any CPU or SB digital output)
	Max. rate, CPU outputs Qa.0 to Qa.3	100 kHz
	Max. rate, CPU outputs Qa.4 to Qa.5	20 kHz
	Max. rate, SB outputs	See SB specifications
Pulse catch inputs	Yes, each onboard CPU digital input and SB digital input	
Time delay interrupts	20 total with 1 ms resolution	
Cyclic interrupts	20 total with 1 µs resolution	
Edge interrupts	Rising and falling for each onboard CPU digital input and SB digital input	

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

Technical data	Description	
Memory card (Page 468)	SIMATIC memory card (optional).	
Motion control	Available Resources	800
	Required Resources	40 per speed-controlled axis
		80 per positioning axis
		160 per synchronous axis
		80 per external encoder
		20 per output cam
		160 per cam track
		40 per measuring input
	Available Extended Resources	40
	Required Extended Resources	2 per cam (1000 points)
		30 for each set of kinematics
PID	PID Compact	Yes, universal PID controller with integrated optimization
	PID 3Step	Yes, PID controller with integrated optimization for valves
	PID Temp	Yes, PID controller with integrated optimization for temperature
Real-time clock	Accuracy	+/- 60 seconds per month
	Retention time, super capacitor	20 days typical at 40 °C, 12 days minimum at 40 °C

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

A.4.2 Performance

Table 1-218 Performance

Type of instruction[1]	Direct addressing (I, Q, and M)	DB accesses
Boolean	0.037 µs/instruction	
Move_Bool	0.067 µs/instruction	0.066 µs/instruction
Move_Word	0.027 µs/instruction	0.030 µs/instruction
Move_Real	0.027 µs/instruction	0.030 µs/instruction
Add_Real	0.119 µs/instruction	0.074 µs/instruction

[1] Many variables affect measured times. The above performance times are for the fastest instructions in each category and error-free programs.

A.4.3 Blocks, timers, and counters

Table 1-219 Blocks, times, and counters

Element	Description	
Blocks	Type	OB, FB, FC, DB
	Max. number of elements	4000; Blocks (OB, FB, FC, DB) and UDTs
	Max. OB, FB, FC size	64 Kbytes

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Blocks	Max. DB size (Optimized)	500 Kbytes Work Memory 16 Mbytes Load Memory
	Max. DB size (Non-optimized)	64 Kbytes (DBs with absolute addressing)
	Address range for FBs and FCs	1 to 65535
	Address range for DBs	1 to 59999
	Nesting depth per priority class[1]	24 (OB plus 23 more levels)
	Monitoring	Status of 8 code blocks can be monitored simultaneously.
Number of OBs per event class	Program cycle	100
	Startup	100
	Time delay interrupt	20 (one per event)
	Cyclic interrupt	20 (one per event)
	Hardware interrupt	50
	Time error interrupt	1
	Diagnostic error interrupt	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	20 (one per event)
	Synchronous Cycle	1
	Status	1
	Update	1
	Profile	1
	MC-Interpolator	1
	MC-Servo	1
	MC-PreServo	1
	MC-PostServo	1
	MC-LookAhead	1
	MC-PreInterpolator	1
	Programming error	1
	I/O access error	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon time type
	IEC_TIMER	16 bytes
	IEC_LTIMER	28 bytes
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon count type
	IEC_SCOUNTER, IEC_USCOUNTER	3 bytes
	IEC_COUNTER, IEC_UCOUNTER	6 bytes

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Counters	IEC_DCOUNTER, IEC_UDCOUNTER	12 bytes
	IEC_LCOUNTER, IEC_ULCOUNTER	24 bytes
Runtime Meters	Quantity	16

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

A.4.4 Communications

Table 1-220 Communications

Technical data	Description	
Number of ports	2 with an integrated switch	
Type	Ethernet (RJ-45 connector)	
Connections	88 connections max. (integrated into CPU) 10 reserved for ES/HMI/web	
Data rates	100 Mb/s	
Isolation (Page 81) (external signal to logic)	Transformer isolated, 1500 V AC (type test)[1]	
Cable type	CAT5e shielded	
Interfaces	1 PROFINET	
	0 PROFIBUS	
PROFINET Protocols	PROFINET IO controller	Yes
	PROFINET IO device	Yes
	SIMATIC communication	Yes
	Open IE communication	Yes
	Web server	Yes
	Media redundancy	Yes
PROFINET IO controller services	PG/OP communication	Yes
	S7 routing	Yes (requires more than one communication interface)
	Isochronous mode	Yes
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	MRPD	Yes – Requires an IRT sync domain
	PROFIenergy	Yes (per user program)
	Prioritized startup	Yes (max. 16 PROFINET devices)
	Number of connectable I/O devices, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of submodules, max.	512
	Number of IO devices that you can connect for RT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of in line IO devices that you can connect for RT, max.	31
	Number of IO devices that you can connect for IRT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
PROFINET IO controller services	Number of IO devices that can be activated/deactivated simultaneously, max.	8
	The minimum update time depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.	RT Send clock: 1 ms to 512 ms IRT Send clock: 1 ms to 512 ms (1 ms resolution)
PROFINET I-Device	Number of connections, max.	2
PROFINET I-Device services	PG/OP communication	Yes
	S7 routing	No
	Isochronous mode	No
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	PROFIenergy	Yes (per user program)
	Shared device	Yes
	Number of IO controllers with shared device, max.	2
SIMATIC communication	S7 communication as server	Yes
	S7 communication as client	Yes
	User data per job, max.	See TIA Portal information system (S7 communication, user data size)
Open IE communication	TCP/IP	Yes, 64 Kbytes max. data length Several passive connections per port
	ISO-on-TCP (RFC1006)	Yes, 64 Kbytes max. data length
	UDP	Yes, 2048 bytes max. data length 1472 bytes max. for UDP broadcast
	DHCP	Yes
	SNMP	Yes
	DCP	Yes
	LLDP	Yes
Near Field Communication (NFC)	Yes, with the S7-1200 G2 NFC app	
S7 message functions	Number of login stations for message functions, max.	32
	Program alarms	Yes
	Number of configurable program messages, max.	5000
	Number of loadable program messages in RUN, max.	2500
	Number of simultaneously active program alarms	600 program alarms 100 alarms for system diagnostics 160 for motion technology objects
Test commissioning functions	Joint commission (Team Engineering)	Yes, parallel online access possible for up to 5 engineering systems
	Program status	Yes, up to 8 blocks simultaneously (in total across all ES clients)
	Single step	No

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
Test commissioning functions	Breakpoints	No
	SIMATIC Controller Profiling	Yes
Monitor/modify	Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
	Number of monitor variables, max.	200 per job
	Number of modify variables, max.	200 per job
Force	Variables	Peripheral inputs/outputs
	Number of variables, max.	200
Trace	Number of configurable traces	4
	Variables captured per trace, max.	16
	Data captured per trace, max.	512 KB
Diagnostics buffer	Number of entries, max.	500
	Retentive	100

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

A.4.5 Power supply and sensor power

Table 1-221 Power supply

Technical data	CPU 1212FC DC/DC/RLY	CPU 1212FC DC/DC/DC
Rated voltage	24 V DC	
Voltage range	20.4 to 28.8 V DC	
Reverse voltage protection	Yes	
Input current (CPU only)	185 mA at 24 V DC	125 mA at 24 V DC
Input current (with all accessories)	765 mA at 24 V DC	700 mA at 24 V DC
Inrush current	12 A max. at 28.8 V DC	
I^2t	0.5 A^2 s	
Isolation (input power to logic)	Not isolated	
Hold up time (loss of power)	10 ms at 24 V DC	
Internal fuse	3 A, 250 V, slow blow not user replaceable	

Table 1-222 Sensor power

Technical data	CPU 1212FC DC/DC/RLY	CPU 1212FC DC/DC/DC
Rated voltage	24 V DC	
Voltage range	L+ minus 4 V DC min.	
Output current rating	300 mA max. (short-circuit protected)	
Ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	
Cable length	500 m shielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

A.4.6 Digital inputs and outputs

Table 1-223 Digital inputs

Technical data	CPU 1212FC DC/DC/RLY	CPU 1212FC DC/DC/DC
Number of inputs	8, in 1 isolation group of 8 inputs	
Assignment	Ia.0 to Ia.5 (high-speed) Ia.6 to Ia.7 (standard)	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 V DC at 6 mA, nominal (high-speed) 24 V DC at 4 mA, nominal (standard)	
Continuous permissible voltage	30 V DC, max. at 8 mA, max. (high-speed) 30 V DC, max. at 6 mA, max. (standard)	
Logic 1 signal	15 V DC min. at 2.5 mA	
Logic 0 signal	5 V DC max. or 0.5 mA	
Isolation (field side to logic)	707 V DC (type test)	
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (Logic 1 level = 15 to 30 V DC)	Single phase: 100 kHz (Ia.0 to Ia.5) Single phase: 30 kHz (Ia.6 to Ia.7) Quadrature phase: 80 kHz (Ia.0 to Ia.5) Quadrature phase: 20 kHz (Ia.6 to Ia.7)	
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

Table 1-224 Digital outputs

Technical data	CPU 1212FC DC/DC/RLY	CPU 1212FC DC/DC/DC
Number of outputs	6, in 1 isolation group of 6 outputs	
Assignment	Qa.0 to Qa.5	Qa.0 to Qa.3 (high-speed) Qa.4 to Qa.5 (standard)
Type	Relay, dry contact	Solid state – MOSFET (sourcing)
Rated voltage	--	24 V DC
Voltage range	5 to 30 V DC or 5 to 250 V AC	20.4 to 28.8 V DC
Logic 1 signal at max. current	--	20 V DC min.
Logic 0 signal with 10 kΩ load	--	0.1 V DC max.
Current	2.0 A max.	0.5 A max.
Minimum load[1]	125 mW DC / 500 mW AC	--
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Overload protection	No	
Isolation (field side to logic)	1500 V AC (type test)	707 V DC (type test)
Isolation (coil to logic)	None	--
Current per common	12 A max. (10 A max. per pin)	3 A max.

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

Technical data	**CPU 1212FC DC/DC/RLY**	**CPU 1212FC DC/DC/DC**
Inductive clamp voltage	--	L+ minus 40 V, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., OFF to ON 3.0 µs max., ON to OFF
Switching delay (Qa.4 to Qa.5)	10 ms max.	5 µs max., OFF to ON 20 µs max., ON to OFF
Maximum relay switching frequency	1 Hz	--
Pulse Train Output (PTO) rate	Not recommended[2]	100 kHz max. (Qa.0 to Qa.3) 20 kHz max. (Qa.4 to Qa.5) 2 Hz min.[3]
Lifetime mechanical (no load)	10000000 open/close cycles	--
Lifetime contacts at rated load	100000 open/close cycles	--
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Control of a digital input	Yes	
Parallel outputs for redundant load control	Yes (with same common)	
Parallel outputs for increased load	No	
Cable length	500 m shielded, 150 m unshielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

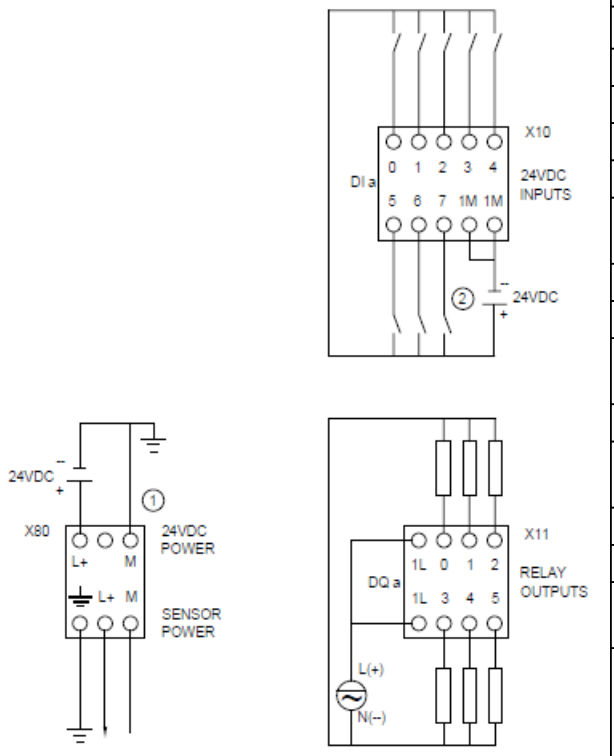
[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

A.4.7 Wiring diagrams

The wiring diagrams and pin connector locations are shown below:

CPU 1212FC DC/DC/RLY



X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin #	2	4	6
Sensor power	GND	L+	M

X10: DC input wiring terminal (Gray, No keying)

Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4
Pin #	1	3	5	7	9
Pin #	2	4	6	8	10
Signal	DI a.5	DI a.6	DI a.7	1M	1M

X11: Relay output wiring terminal (Orange, Type-A keying)

Signal	1L	DQ a.0	DQ a.1	DQ a.2
Pin #	1	3	5	7
Pin #	2	4	6	8
Signal	1L	DQ a.3	DQ a.4	DQ a.5

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1212FC DC/DC/DC

X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin #	2	4	6
Sensor power	GND	L+	M

X10: DC input wiring terminal (Gray, No keying)

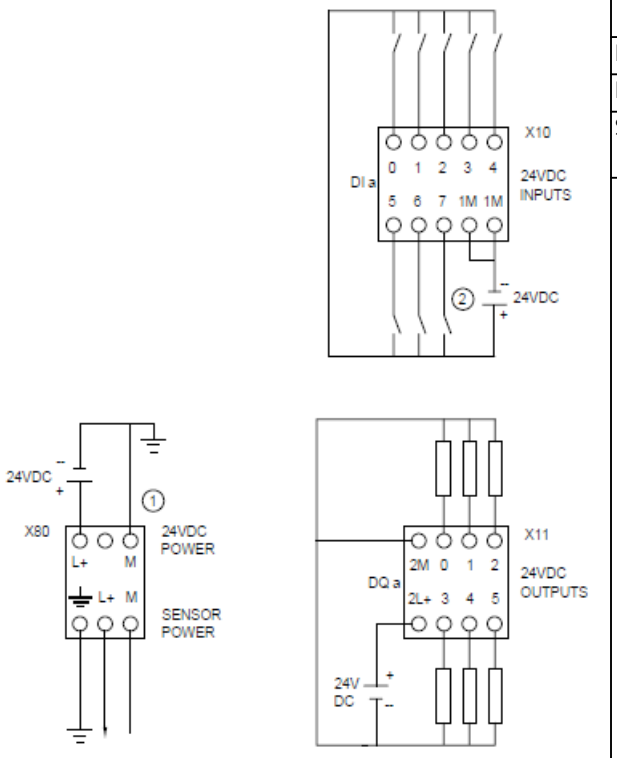
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4
Pin #	1	3	5	7	9
Pin #	2	4	6	8	10
Signal	DI a.5	DI a.6	DI a.7	1M	1M

X11: DC output wiring terminal (Gray, No keying)

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1212FC DC/DC/DC



Signal	2M	DQ a.0	DQ a.1	DQ a.2
Pin #	1	3	5	7
Pin #	2	4	6	8
Signal	2L+	DQ a.3	DQ a.4	DQ a.5

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.5 CPU 1214C

A.5.1 General specifications and features

Table 1-225 General

Technical data	CPU 1214C AC/DC/RLY	CPU 1214C DC/DC/RLY	CPU 1214C DC/DC/DC
Article number	6ES7214-1BH50-0XB0	6ES7214-1HH50-0XB0	6ES7214-1AH50-0XB0
Dimensions W x H x D	80 x 125 x 100 mm		
Weight (product/shipping)	417 grams / 474 grams	376 grams / 433 grams	352 grams / 409 grams
Power dissipation	4.0 W	3.5 W	
Current available for expansion devices	1600 mA max. (5 V DC)		
Current available on sensor supply	400 mA (24 V DC sensor power, current limited)		

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	**CPU 1214C AC/DC/RLY**	**CPU 1214C DC/DC/RLY**	**CPU 1214C DC/DC/DC**
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]		
	Vertical mounting -20 °C to 50 °C[2]		Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum		

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-226 CPU features

Technical data	**Description**	
User memory	Work Memory	250 Kbytes (Program) 750 Kbytes (Data)
	Load Memory	8 Mbytes (Internal) 32 Gbytes (using SD card)
	Retentive Memory	20 Kbytes
Onboard digital I/O	14 inputs / 10 outputs	
Process image size	1024 bytes of inputs (I) / 1024 bytes of outputs (Q)	
Bit memory size	8192 bytes (M)	
Temporary (local) memory	Per priority class, max.	64 Kbytes
	Per block, max.	16 Kbytes
Communication module/processor expansion	3 max. (must connect to the right of the CPU or to the right of another CM/CP)	
Signal module expansion (SM plus CM)	10 max.	
Signal board or Communication board expansion	2 max.	
High-speed counters	Max. number of high-speed counters	8 (any CPU or SB digital input)
	Max. rate, CPU inputs Ia.0 to Ia.5	100 kHz (80 kHz in quadrature mode)
	Max. rate, CPU inputs Ia.6 to Ib.5	30 kHz (20 kHz in quadrature mode)
	Max. rate, SB inputs	See SB specifications
Pulse outputs[1]	Max. number of pulse outputs	8 (any CPU or SB digital output)
	Max. rate, CPU outputs Qa.0 to Qa.3	100 kHz
	Max. rate, CPU outputs Qa.4 to Qb.1	20 kHz
	Max. rate, SB outputs	See SB specifications
Pulse catch inputs	Yes, each onboard CPU digital input and SB digital input	
Time delay interrupts	20 total with 1 ms resolution	
Cyclic interrupts	20 total with 1 µs resolution	
Edge interrupts	Rising and falling for each onboard CPU digital input and SB digital input	
Memory card (Page 468)	SIMATIC memory card (optional).	
Motion control	Available Resources	800
	Required Resources	40 per speed-controlled axis
		80 per positioning axis
		160 per synchronous axis

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

Technical data	Description	
Motion control	Required Resources	80 per external encoder
		20 per output cam
		160 per cam track
		40 per measuring input
	Available Extended Resources	40
	Required Extended Resources	2 per cam (1000 points)
		30 for each set of kinematics
PID	PID Compact	Yes, universal PID controller with integrated optimization
	PID 3Step	Yes, PID controller with integrated optimization for valves
	PID Temp	Yes, PID controller with integrated optimization for temperature
Real-time clock	Accuracy	+/- 60 seconds per month
	Retention time, super capacitor	20 days typical at 40 °C, 12 days minimum at 40 °C

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

A.5.2 Performance

Table 1-227 Performance

Type of instruction[1]	Direct addressing (I, Q, and M)	DB accesses
Boolean	0.037 µs/instruction	
Move_Bool	0.067 µs/instruction	0.066 µs/instruction
Move_Word	0.027 µs/instruction	0.030 µs/instruction
Move_Real	0.027 µs/instruction	0.030 µs/instruction
Add_Real	0.119 µs/instruction	0.074 µs/instruction

[1] Many variables affect measured times. The above performance times are for the fastest instructions in each category and error-free programs.

A.5.3 Blocks, timers, and counters

Table 1-228 Blocks, times, and counters

Element	Description	
Blocks	Type	OB, FB, FC, DB
	Max. number of elements	4000; Blocks (OB, FB, FC, DB) and UDTs
	Max. OB, FB, FC size	64 Kbytes
	Max. DB size (Optimized)	750 Kbytes Work Memory 16 Mbytes Load Memory
	Max. DB size (Non-optimized)	64 Kbytes (DBs with absolute addressing)
	Address range for FBs and FCs	1 to 65535
	Address range for DBs	1 to 59999
	Nesting depth per priority class[1]	24 (OB plus 23 more levels)

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Blocks	Monitoring	Status of 8 code blocks can be monitored simultaneously.
Number of OBs per event class	Program cycle	100
	Startup	100
	Time delay interrupt	20 (one per event)
	Cyclic interrupt	20 (one per event)
	Hardware interrupt	50
	Time error interrupt	1
	Diagnostic error interrupt	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	20 (one per event)
	Synchronous Cycle	1
	Status	1
	Update	1
	Profile	1
	MC-Interpolator	1
	MC-Servo	1
	MC-PreServo	1
	MC-PostServo	1
	MC-LookAhead	1
	MC-PreInterpolator	1
	Programming error	1
	I/O access error	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon time type
	IEC_TIMER	16 bytes
	IEC_LTIMER	28 bytes
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon count type
	IEC_SCOUNTER, IEC_USCOUNTER	3 bytes
	IEC_COUNTER, IEC_UCOUNTER	6 bytes
	IEC_DCOUNTER, IEC_UDCOUNTER	12 bytes
	IEC_LCOUNTER, IEC_ULCOUNTER	24 bytes
Runtime Meters	Quantity	16

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

A.5.4 Communications

Table 1-229 Communications

Technical data	Description	
Number of ports	2 with an integrated switch	
Type	Ethernet (RJ-45 connector)	
Connections	88 connections max. (integrated into CPU) 10 reserved for ES/HMI/web	
Data rates	100 Mb/s	
Isolation (Page 81) (external signal to logic)	Transformer isolated, 1500 V AC (type test)[1]	
Cable type	CAT5e shielded	
Interfaces	1 PROFINET	
	0 PROFIBUS	
PROFINET Protocols	PROFINET IO controller	Yes
	PROFINET IO device	Yes
	SIMATIC communication	Yes
	Open IE communication	Yes
	Web server	Yes
	Media redundancy	Yes
PROFINET IO controller services	PG/OP communication	Yes
	S7 routing	Yes (requires more than one communication interface)
	Isochronous mode	Yes
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	MRPD	Yes – Requires an IRT sync domain
	PROFIenergy	Yes (per user program)
	Prioritized startup	Yes (max. 16 PROFINET devices)
	Number of connectable I/O devices, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of submodules, max.	512
	Number of IO devices that you can connect for RT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of in line IO devices that you can connect for RT, max.	31
	Number of IO devices that you can connect for IRT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of IO devices that can be activated/deactivated simultaneously, max.	8
	The minimum update time depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.	RT Send clock: 1 ms to 512 ms IRT Send clock: 1 ms to 512 ms (1 ms resolution)
PROFINET I-Device	Number of connections, max.	2

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
PROFINET I-Device services	PG/OP communication	Yes
	S7 routing	No
	Isochronous mode	No
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	PROFIenergy	Yes (per user program)
	Shared device	Yes
	Number of IO controllers with shared device, max.	2
SIMATIC communication	S7 communication as server	Yes
	S7 communication as client	Yes
	User data per job, max.	See TIA Portal information system (S7 communication, user data size)
Open IE communication	TCP/IP	Yes, 64 Kbytes max. data length Several passive connections per port
	ISO-on-TCP (RFC1006)	Yes, 64 Kbytes max. data length
	UDP	Yes, 2048 bytes max. data length 1472 bytes max. for UDP broadcast
	DHCP	Yes
	SNMP	Yes
	DCP	Yes
	LLDP	Yes
Near Field Communication (NFC)	Yes, with the S7-1200 G2 NFC app	
S7 message functions	Number of login stations for message functions, max.	32
	Program alarms	Yes
	Number of configurable program messages, max.	5000
	Number of loadable program messages in RUN, max.	2500
	Number of simultaneously active program alarms	600 program alarms 100 alarms for system diagnostics 160 for motion technology objects
Test commissioning functions	Joint commission (Team Engineering)	Yes, parallel online access possible for up to 5 engineering systems
	Program status	Yes, up to 8 blocks simultaneously (in total across all ES clients)
	Single step	No
	Breakpoints	No
	SIMATIC Controller Profiling	Yes
Monitor/modify	Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
	Number of monitor variables, max.	200 per job
	Number of modify variables, max.	200 per job
Force	Variables	Peripheral inputs/outputs

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
Force	Number of variables, max.	200
Trace	Number of configurable traces	4
	Variables captured per trace, max.	16
	Data captured per trace, max.	512 KB
Diagnostics buffer	Number of entries, max.	500
	Retentive	100

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

A.5.5 Power supply and sensor power

Table 1-230 Power supply

Technical data	CPU 1214C AC/DC/RLY	CPU 1214C DC/DC/RLY	CPU 1214C DC/DC/DC
Rated voltage	120/240 V AC	24 V DC	
Voltage range	85 to 264 V AC	20.4 to 28.8 V DC	
Reverse voltage protection	--	Yes	
Line frequency	47 to 63 Hz	--	
Input current (CPU only)	80 mA at 120 V AC 44 mA at 240 V AC	245 mA at 24 V DC	145 mA at 24 V DC
Input current (with all accessories)	480 mA at 120 V AC 275 mA at 240 V AC	1100 mA at 24 V DC	1000 mA at 24 V DC
Inrush current	20 A max. at 264 V AC	12 A max. at 28.8 V DC	
I^2t	0.8 A^2 s	0.5 A^2 s	
Isolation (input power to logic)	1500 V AC	Not isolated	
Ground leakage (AC line to functional earth)	0.5 mA max.	--	
Hold up time (loss of power)	20 ms at 120 V AC 80 ms at 240 V AC	10 ms at 24 V DC	
Internal fuse	3 A, 250 V, slow blow not user replaceable		

Table 1-231 Sensor power

Technical data	CPU 1214C AC/DC/RLY	CPU 1214C DC/DC/RLY	CPU 1214C DC/DC/DC
Rated voltage	24 V DC		
Voltage range	20.4 to 28.8 V DC	L+ minus 4 V DC min.	
Output current rating	400 mA max. (short-circuit protected)		
Ripple noise (<10 MHz)	< 1 V peak to peak max.	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated		
Cable length	500 m shielded		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

A.5.6 Digital inputs and outputs

Table 1-232 Digital inputs

Technical data	CPU 1214C AC/DC/RLY	CPU 1214C DC/DC/RLY	CPU 1214C DC/DC/DC
Number of inputs	14, in 1 isolation group of 14 inputs		
Assignment	Ia.0 to Ia.5 (high-speed) Ia.6 to Ib.5 (standard)		
Type	Sink/Source (IEC Type 1 sink)		
Rated voltage	24 V DC at 6 mA, nominal (high-speed) 24 V DC at 4 mA, nominal (standard)		
Continuous permissible voltage	30 V DC, max. at 8 mA, max. (high-speed) 30 V DC, max. at 6 mA, max. (standard)		
Logic 1 signal	15 V DC min. at 2.5 mA		
Logic 0 signal	5 V DC max. or 0.5 mA		
Isolation (field side to logic)	707 V DC (type test)		
Current per common	20 A mix. (10 A max. per pin)		5 A max.
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0		
HSC clock input rates (Logic 1 level = 15 to 30 V DC)	Single phase: 100 kHz (Ia.0 to Ia.5) Single phase: 30 kHz (Ia.6 to Ib.5) Quadrature phase: 80 kHz (Ia.0 to Ia.5) Quadrature phase: 20 kHz (Ia.6 to Ib.5)		
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

Table 1-233 Digital outputs

Technical data	CPU 1214C AC/DC/RLY	CPU 1214C DC/DC/RLY	CPU 1214C DC/DC/DC
Number of outputs	10, in 1 isolation group of 10 outputs		
Assignment	Qa.0 to Qb.1		Qa.0 to Qa.3 (high-speed) Qa.4 to Qb.1 (standard)
Type	Relay, dry contact		Solid state – MOSFET (sourcing)
Rated voltage	--		24 V DC
Voltage range	5 to 30 V DC or 5 to 250 V AC		20.4 to 28.8 V DC
Logic 1 signal at max. current	--		20 V DC min.
Logic 0 signal with 10 kΩ load	--		0.1 V DC max.
Current	2.0 A max.		0.5 A max.
Minimum load[1]	125 mW DC / 500 mW AC		--
Lamp load	30 W DC / 200 W AC		5 W
ON state resistance	0.2 Ω max. when new		0.6 Ω max.
Leakage current per point	--		10 µA max.
Overload protection	No		
Isolation (field side to logic)	1500 V AC (type test)		707 V DC (type test)
Isolation (coil to logic)	None		--

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

Technical data	**CPU 1214C AC/DC/RLY**	**CPU 1214C DC/DC/RLY**	**CPU 1214C DC/DC/DC**
Current per common	20 A max. (10 A. max. per pin)		5 A. max.
Inductive clamp voltage	--		L+ minus 40 V, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.		1.0 µs max., OFF to ON 3.0 µs max., ON to OFF
Switching delay (Qa.4 to Qb.1)	10 ms max.		5 µs max., OFF to ON 20 µs max., ON to OFF
Maximum relay switching frequency	1 Hz		--
Pulse Train Output (PTO) rate	Not recommended[2]		100 kHz max. (Qa.0 to Qa.3) 20 kHz max. (Qa.4 to Qb.1) 2 Hz min.[3]
Lifetime mechanical (no load)	10000000 open/close cycles		--
Lifetime contacts at rated load	100000 open/close cycles		--
Behavior on RUN to STOP	Last value or substitute value (default value 0)		
Control of a digital input	Yes		
Parallel outputs for redundant load control	Yes (with same common)		
Parallel outputs for increased load	No		
Cable length	500 m shielded, 150 m unshielded		
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)		

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

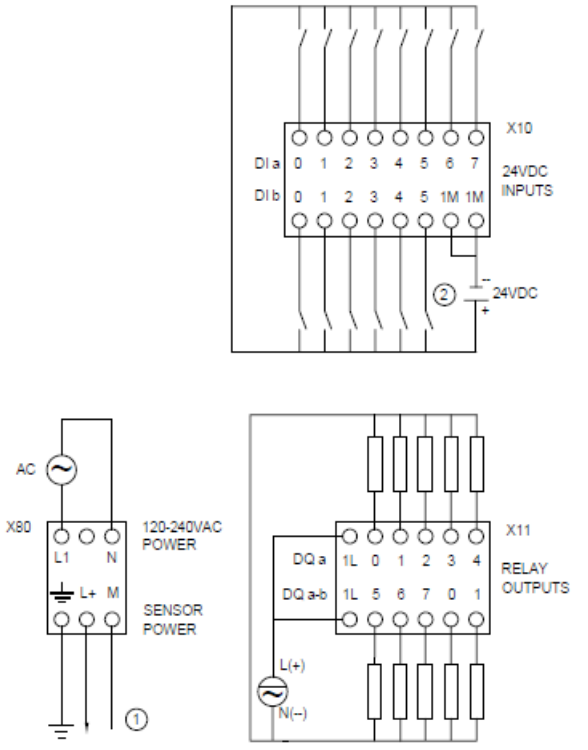
[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

A.5.7 Wiring diagrams

The wiring diagrams and pin connector locations are shown below:

CPU 1214C AC/DC/RLY



X80: AC power wiring terminal (Orange, Type-A keying)								
AC power	L1		N					
Pin #	1	3	5					
Pin #	2	4	6					
Sensor power	GND	L+	M					
X10: DC input wiring terminal (Gray, No keying)								
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4	DI a.5	DI a.6	DI a.7
Pin #	1	3	5	7	9	11	13	15
Pin #	2	4	6	8	10	12	14	16
Signal	DI b.0	DI b.1	DI b.2	DI b.3	DI b.4	DI b.5	1M	1M
X11: Relay output wiring terminal (Orange, Type-A keying)								
Signal	1L	DQ a.0	DQ a.1	DQ a.2	DQ a.3	DQ a.4		
Pin #	1	3	5	7	9	11		
Pin #	2	4	6	8	10	12		
Signal	1L	DQ a.5	DQ a.6	DQ a.7	DQ b.0	DQ b.1		

① For additional noise immunity, jumper the Sensor Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

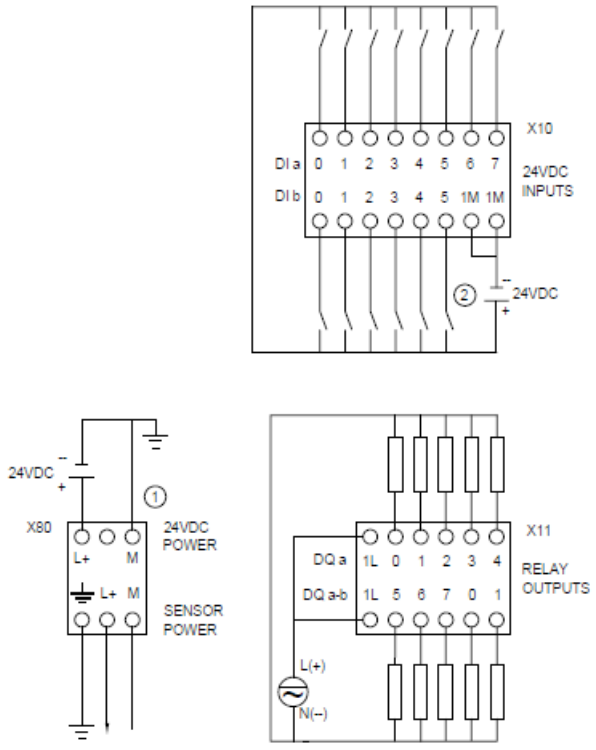
CPU 1214C DC/DC/RLY

X80: DC power wiring terminal (Gray, No keying)								
DC power	L+		M					
Pin #	1	3	5					
Pin #	2	4	6					
Sensor power	GND	L+	M					
X10: DC input wiring terminal (Gray, No keying)								
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4	DI a.5	DI a.6	DI a.7
Pin #	1	3	5	7	9	11	13	15
Pin #	2	4	6	8	10	12	14	16
Signal	DI b.0	DI b.1	DI b.2	DI b.3	DI b.4	DI b.5	1M	1M
X11: Relay output wiring terminal (Orange, Type-A keying)								

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1214C DC/DC/RLY



Signal	1L	DQ a.0	DQ a.1	DQ a.2	DQ a.3	DQ a.4
Pin #	1	3	5	7	9	11
Pin #	2	4	6	8	10	12
Signal	1L	DQ a.5	DQ a.6	DQ a.7	DQ b.0	DQ b.1

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

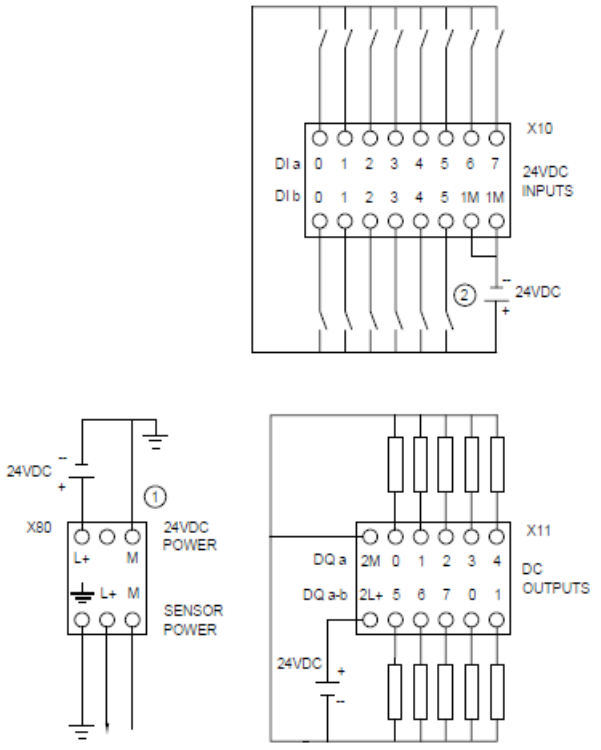
CPU 1214C DC/DC/DC

X80: DC power wiring terminal (Gray, No keying)								
DC power	L+		M					
Pin #	1	3	5					
Pin #	2	4	6					
Sensor power	GND	L+	M					
X10: DC input wiring terminal (Gray, No keying)								
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4	DI a.5	DI a.6	DI a.7
Pin #	1	3	5	7	9	11	13	15
Pin #	2	4	6	8	10	12	14	16
Signal	DI b.0	DI b.1	DI b.2	DI b.3	DI b.4	DI b.5	1M	1M
X11: DC output wiring terminal (Gray, No keying)								
Signal	2M	DQ a.0	DQ a.1	DQ a.2	DQ a.3	DQ a.4		
Pin #	1	3	5	7	9	11		

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1214C DC/DC/DC



Pin #	2	4	6	8	10	12
Signal	2L+	DQ a.5	DQ a.6	DQ a.7	DQ b.0	DQ b.1

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.6 CPU 1214FC

A.6.1 General specifications and features

Table 1-234 General

Technical data	**CPU 1214FC DC/DC/RLY**	**CPU 1214FC DC/DC/DC**
Article number	6ES7214-1HF50-0XB0	6ES7214-1AF50-0XB0
Dimensions W x H x D	80 x 125 x 100 mm	
Weight (product/shipping)	376 grams / 433 grams	352 grams / 409 grams
Power dissipation	3.5 W	
Current available for expansion devices	1600 mA max. (5 V DC)	
Current available on sensor supply	400 mA (24 V DC sensor power, current limited)	
Safety class (highest)	PL e (performance level according to ISO 13849-1) SIL 3 (safety integrity level according to IEC 61508)	
Probability of failure	Low demand mode: PFDavg in accordance with SIL 3	

Technical data	**CPU 1214FC DC/DC/RLY**	**CPU 1214FC DC/DC/DC**
	< 2.00E-05 High demand/continuous mode: PFH in accordance with SIL 3 < 1.00E-09 (altitude -1000 m to 3000 m) < 2.00E-09 (altitude >3000 m to 5000 m) For service life of 20 years and repair time of 100 hours	
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]	
	Vertical mounting -20 °C to 50 °C[2]	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum	

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-235 CPU features

Technical data	**Description**	
User memory	Work Memory	300 Kbytes (Program) 750 Kbytes (Data)
	Load Memory	8 Mbytes (Internal) 32 Gbytes (using SD card)
	Retentive Memory	20 Kbytes
Onboard digital I/O	14 inputs / 10 outputs	
Process image size	1024 bytes of inputs (I) / 1024 bytes of outputs (Q)	
Bit memory size	8192 bytes (M)	
Temporary (local) memory	Per priority class, max.	64 Kbytes
	Per block, max.	16 Kbytes
Communication module/processor expansion	3 max. (must connect to the right of the CPU or to the right of another CM/CP)	
Signal module expansion (SM plus CM)	10 max.	
Signal board or Communication board expansion	2 max.	
High-speed counters	Max. number of high-speed counters	8 (any CPU or SB digital input)
	Max. rate, CPU inputs Ia.0 to Ia.5	100 kHz (80 kHz in quadrature mode)
	Max. rate, CPU inputs Ia.6 to Ib.5	30 kHz (20 kHz in quadrature mode)
	Max. rate, SB inputs	See SB specifications
Pulse outputs[1]	Max. number of pulse outputs	8 (any CPU or SB digital output)
	Max. rate, CPU outputs Qa.0 to Qa.3	100 kHz
	Max. rate, CPU outputs Qa.4 to Qb.1	20 kHz
	Max. rate, SB outputs	See SB specifications
Pulse catch inputs	Yes, each onboard CPU digital input and SB digital input	
Time delay interrupts	20 total with 1 ms resolution	
Cyclic interrupts	20 total with 1 µs resolution	
Edge interrupts	Rising and falling for each onboard CPU digital input and SB digital input	

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

Technical data	Description	
Memory card (Page 468)	SIMATIC memory card (optional).	
Motion control	Available Resources	800
	Required Resources	40 per speed-controlled axis
		80 per positioning axis
		160 per synchronous axis
		80 per external encoder
		20 per output cam
		160 per cam track
		40 per measuring input
	Available Extended Resources	40
	Required Extended Resources	2 per cam (1000 points)
		30 for each set of kinematics
PID	PID Compact	Yes, universal PID controller with integrated optimization
	PID 3Step	Yes, PID controller with integrated optimization for valves
	PID Temp	Yes, PID controller with integrated optimization for temperature
Real-time clock	Accuracy	+/- 60 seconds per month
	Retention time, super capacitor	20 days typical at 40 °C, 12 days minimum at 40 °C

[1] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

A.6.2 Performance

Table 1-236 Performance

Type of instruction[1]	Direct addressing (I, Q, and M)	DB accesses
Boolean	0.037 µs/instruction	
Move_Bool	0.067 µs/instruction	0.066 µs/instruction
Move_Word	0.027 µs/instruction	0.030 µs/instruction
Move_Real	0.027 µs/instruction	0.030 µs/instruction
Add_Real	0.119 µs/instruction	0.074 µs/instruction

[1] Many variables affect measured times. The above performance times are for the fastest instructions in each category and error-free programs.

A.6.3 Blocks, timers, and counters

Table 1-237 Blocks, times, and counters

Element	Description	
Blocks	Type	OB, FB, FC, DB
	Max. number of elements	4000; Blocks (OB, FB, FC, DB) and UDTs
	Max. OB, FB, FC size	64 Kbytes

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Blocks	Max. DB size (Optimized)	750 Kbytes Work Memory 16 Mbytes Load Memory
	Max. DB size (Non-optimized)	64 Kbytes (DBs with absolute addressing)
	Address range for FBs and FCs	1 to 65535
	Address range for DBs	1 to 59999
	Nesting depth per priority class[1]	24 (OB plus 23 more levels)
	Monitoring	Status of 8 code blocks can be monitored simultaneously.
Number of OBs per event class	Program cycle	100
	Startup	100
	Time delay interrupt	20 (one per event)
	Cyclic interrupt	20 (one per event)
	Hardware interrupt	50
	Time error interrupt	1
	Diagnostic error interrupt	1
	Pull or plug of modules	1
	Rack or station failure	1
	Time of day	20 (one per event)
	Synchronous Cycle	1
	Status	1
	Update	1
	Profile	1
	MC-Interpolator	1
	MC-Servo	1
	MC-PreServo	1
	MC-PostServo	1
	MC-LookAhead	1
	MC-PreInterpolator	1
	Programming error	1
	I/O access error	1
Timers	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon time type
	IEC_TIMER	16 bytes
	IEC_LTIMER	28 bytes
Counters	Type	IEC
	Quantity	Limited only by memory size
	Storage	Structure in DB, size depends upon count type
	IEC_SCOUNTER, IEC_USCOUNTER	3 bytes
	IEC_COUNTER, IEC_UCOUNTER	6 bytes

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

Element	Description	
Counters	IEC_DCOUNTER, IEC_UDCOUNTER	12 bytes
	IEC_LCOUNTER, IEC_ULCOUNTER	24 bytes
Runtime Meters	Quantity	16

[1] Safety programs use 2 nesting levels; the user program, therefore, has a nesting depth of 22 in safety programs.

A.6.4 Communications

Table 1-238 Communications

Technical data	Description	
Number of ports	2 with an integrated switch	
Type	Ethernet (RJ-45 connector)	
Connections	88 connections max. (integrated into CPU) 10 reserved for ES/HMI/web	
Data rates	100 Mb/s	
Isolation (Page 81) (external signal to logic)	Transformer isolated, 1500 V AC (type test)[1]	
Cable type	CAT5e shielded	
Interfaces	1 PROFINET	
	0 PROFIBUS	
PROFINET Protocols	PROFINET IO controller	Yes
	PROFINET IO device	Yes
	SIMATIC communication	Yes
	Open IE communication	Yes
	Web server	Yes
	Media redundancy	Yes
PROFINET IO controller services	PG/OP communication	Yes
	S7 routing	Yes (requires more than one communication interface)
	Isochronous mode	Yes
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	MRPD	Yes – Requires an IRT sync domain
	PROFIenergy	Yes (per user program)
	Prioritized startup	Yes (max. 16 PROFINET devices)
	Number of connectable I/O devices, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of submodules, max.	512
	Number of IO devices that you can connect for RT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)
	Number of in line IO devices that you can connect for RT, max.	31
	Number of IO devices that you can connect for IRT, max.	31 (30 if I-Device is used, 29 if shared I-Device is used)

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
PROFINET IO controller services	Number of IO devices that can be activated/deactivated simultaneously, max.	8
	The minimum update time depends on the communication component set for PROFINET IO, on the number of IO devices, and the quantity of configured user data.	RT Send clock: 1 ms to 512 ms IRT Send clock: 1 ms to 512 ms (1 ms resolution)
PROFINET I-Device	Number of connections, max.	2
PROFINET I-Device services	PG/OP communication	Yes
	S7 routing	No
	Isochronous mode	No
	Open IE communication	Yes
	IRT	Yes
	MRP	Yes
	PROFIenergy	Yes (per user program)
	Shared device	Yes
	Number of IO controllers with shared device, max.	2
SIMATIC communication	S7 communication as server	Yes
	S7 communication as client	Yes
	User data per job, max.	See TIA Portal information system (S7 communication, user data size)
Open IE communication	TCP/IP	Yes, 64 Kbytes max. data length Several passive connections per port
	ISO-on-TCP (RFC1006)	Yes, 64 Kbytes max. data length
	UDP	Yes, 2048 bytes max. data length 1472 bytes max. for UDP broadcast
	DHCP	Yes
	SNMP	Yes
	DCP	Yes
	LLDP	Yes
Near Field Communication (NFC)	Yes, with the S7-1200 G2 NFC app	
S7 message functions	Number of login stations for message functions, max.	32
	Program alarms	Yes
	Number of configurable program messages, max.	5000
	Number of loadable program messages in RUN, max.	2500
	Number of simultaneously active program alarms	600 program alarms 100 alarms for system diagnostics 160 for motion technology objects
Test commissioning functions	Joint commission (Team Engineering)	Yes, parallel online access possible for up to 5 engineering systems
	Program status	Yes, up to 8 blocks simultaneously (in total across all ES clients)
	Single step	No

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

Technical data	Description	
Test commissioning functions	Breakpoints	No
	SIMATIC Controller Profiling	Yes
Monitor/modify	Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
	Number of monitor variables, max.	200 per job
	Number of modify variables, max.	200 per job
Force	Variables	Peripheral inputs/outputs
	Number of variables, max.	200
Trace	Number of configurable traces	4
	Variables captured per trace, max.	16
	Data captured per trace, max.	512 KB
Diagnostics buffer	Number of entries, max.	500
	Retentive	100

[1] Ethernet port isolation limits hazards during short term network faults to hazardous voltages. It does not conform to safety requirements for routine AC line voltage isolation.

A.6.5 Power supply and sensor power

Table 1-239 Power supply

Technical data	CPU 1214FC DC/DC/RLY	CPU 1214FC DC/DC/DC
Rated voltage	24 V DC	
Voltage range	20.4 to 28.8 V DC	
Reverse voltage protection	Yes	
Input current (CPU only)	245 mA at 24 V DC	145 mA at 24 V DC
Input current (with all accessories)	1100 mA at 24 V DC	1000 mA at 24 V DC
Inrush current	12 A max. at 28.8 V DC	
I^2t	0.5 A^2 s	
Isolation (input power to logic)	Not isolated	
Hold up time (loss of power)	10 ms at 24 V DC	
Internal fuse	3 A, 250 V, slow blow not user replaceable	

Table 1-240 Sensor power

Technical data	CPU 1214FC DC/DC/RLY	CPU 1214FC DC/DC/DC
Rated voltage	24 V DC	
Voltage range	L+ minus 4 V DC min.	
Output current rating	400 mA max. (short-circuit protected)	
Ripple noise (<10 MHz)	Same as input line	
Isolation (CPU logic to sensor power)	Not isolated	
Cable length	500 m shielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

A.6.6 Digital inputs and outputs

Table 1-241 Digital inputs

Technical data	CPU 1214FC DC/DC/RLY	CPU 1214FC DC/DC/DC
Number of inputs	14, in 1 isolation group of 14 inputs	
Assignment	Ia.0 to Ia.5 (high-speed) Ia.6 to Ib.5 (standard)	
Type	Sink/Source (IEC Type 1 sink)	
Rated voltage	24 V DC at 6 mA, nominal (high-speed) 24 V DC at 4 mA, nominal (standard)	
Continuous permissible voltage	30 V DC, max. at 8 mA, max. (high-speed) 30 V DC, max. at 6 mA, max. (standard)	
Logic 1 signal	15 V DC min. at 2.5 mA	
Logic 0 signal	5 V DC max. or 0.5 mA	
Isolation (field side to logic)	707 V DC (type test)	
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0	
HSC clock input rates (Logic 1 level = 15 to 30 V DC)	Single phase: 100 kHz (Ia.0 to Ia.5) Single phase: 30 kHz (Ia.6 to Ib.5) Quadrature phase: 80 kHz (Ia.0 to Ia.5) Quadrature phase: 20 kHz (Ia.6 to Ib.5)	
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

Table 1-242 Digital outputs

Technical data	CPU 1214FC DC/DC/RLY	CPU 1214FC DC/DC/DC
Number of outputs	10, in 1 isolation group of 10 outputs	
Assignment	Qa.0 to Qb.1	Qa.0 to Qa.3 (high-speed) Qa.4 to Qb.1 (standard)
Type	Relay, dry contact	Solid state – MOSFET (sourcing)
Rated voltage	--	24 V DC
Voltage range	5 to 30 V DC or 5 to 250 V AC	20.4 to 28.8 V DC
Logic 1 signal at max. current	--	20 V DC min.
Logic 0 signal with 10 kΩ load	--	0.1 V DC max.
Current	2.0 A max.	0.5 A max.
Minimum load[1]	125 mW DC / 500 mW AC	--
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	--	10 µA max.
Overload protection	No	
Isolation (field side to logic)	1500 V AC (type test)	707 V DC (type test)
Isolation (coil to logic)	None	--
Current per common	20 A max. (10 A max. per pin)	5 A max.

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

Technical data	**CPU 1214FC DC/DC/RLY**	**CPU 1214FC DC/DC/DC**
Inductive clamp voltage	--	L+ minus 40 V, 1 W dissipation
Switching delay (Qa.0 to Qa.3)	10 ms max.	1.0 µs max., OFF to ON 3.0 µs max., ON to OFF
Switching delay (Qa.4 to Qb.1)	10 ms max.	5 µs max., OFF to ON 20 µs max., ON to OFF
Maximum relay switching frequency	1 Hz	--
Pulse Train Output (PTO) rate	Not recommended[2]	100 kHz max. (Qa.0 to Qa.3) 20 kHz max. (Qa.4 to Qb.1) 2 Hz min.[3]
Lifetime mechanical (no load)	10000000 open/close cycles	--
Lifetime contacts at rated load	100000 open/close cycles	--
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Control of a digital input	Yes	
Parallel outputs for redundant load control	Yes (with same common)	
Parallel outputs for increased load	No	
Cable length	500 m shielded, 150 m unshielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

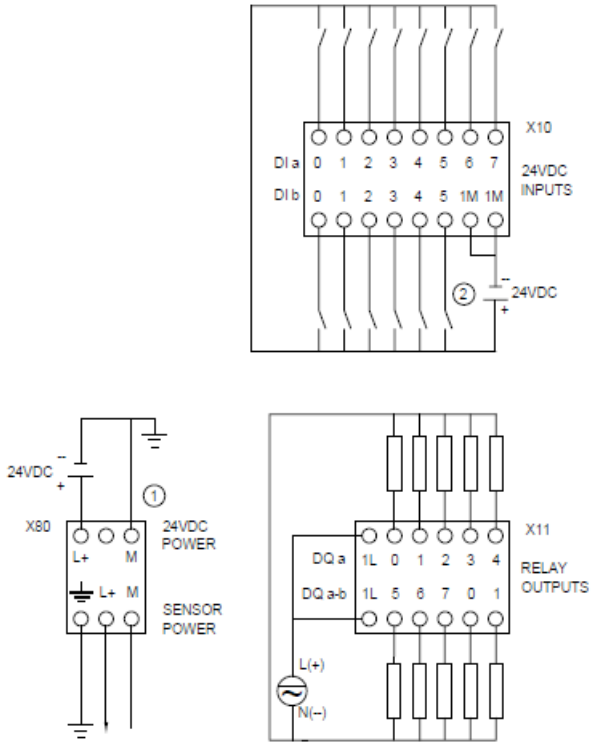
[2] For CPU models with relay outputs, you must install a signal board (SB) containing DC digital outputs to use the pulse outputs.

[3] Depending on your pulse receiver and cable, an additional load resistor (at least 10% of rated current) can improve pulse signal quality and noise immunity.

A.6.7 Wiring diagrams

The wiring diagrams and pin connector locations are shown below:

CPU 1214FC DC/DC/RLY



X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin #	2	4	6
Sensor power	GND	L+	M

X10: DC input wiring terminal (Gray, No keying)

Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4	DI a.5	DI a.6	DI a.7
Pin #	1	3	5	7	9	11	13	15
Pin #	2	4	6	8	10	12	14	16
Signal	DI b.0	DI b.1	DI b.2	DI b.3	DI b.4	DI b.5	1M	1M

X11: Relay output wiring terminal (Orange, Type-A keying)

Signal	1L	DQ a.0	DQ a.1	DQ a.2	DQ a.3	DQ a.4
Pin #	1	3	5	7	9	11
Pin #	2	4	6	8	10	12
Signal	1L	DQ a.5	DQ a.6	DQ a.7	DQ b.0	DQ b.1

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1214FC DC/DC/DC

X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin #	2	4	6
Sensor power	GND	L+	M

X10: DC input wiring terminal (Gray, No keying)

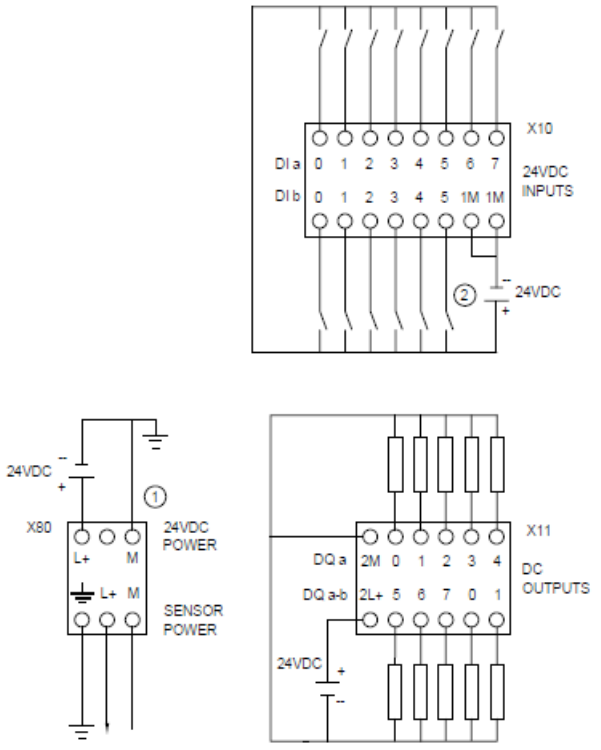
Signal	DI a.0	DI a.1	DI a.2	DI a.3	DI a.4	DI a.5	DI a.6	DI a.7
Pin #	1	3	5	7	9	11	13	15
Pin #	2	4	6	8	10	12	14	16
Signal	DI b.0	DI b.1	DI b.2	DI b.3	DI b.4	DI b.5	1M	1M

X11: DC output wiring terminal (Gray, No keying)

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

CPU 1214FC DC/DC/DC



Signal	2M	DQ a.0	DQ a.1	DQ a.2	DQ a.3	DQ a.4
Pin #	1	3	5	7	9	11
Pin #	2	4	6	8	10	12
Signal	2L+	DQ a.5	DQ a.6	DQ a.7	DQ b.0	DQ b.1

① For additional noise immunity, jumper the 24 V DC Power “M” to Chassis Ground on the connector.

② For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7 Digital signal modules (SMs)

A.7.1 SM 1221 DI 16x24VDC

Table 1-243 General specifications

Technical data	SM 1221 DI 16x24VDC
Article number	6ES7221-1BH50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	166 grams / 203 grams
Power dissipation	3.2 W
Current consumption (bus)	90 mA max. (5 V DC)
Current consumption (24 V DC)	4.1 mA / input used
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

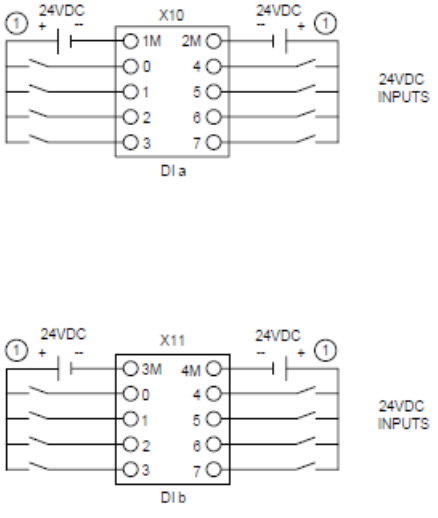
Table 1-244 Digital inputs

Technical data	**SM 1221 DI 16x24VDC**
Number of inputs	16, in 4 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4.1 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Diagnostics	No
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1221 DI 16x24VDC



X10: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7

X11: Lower User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
3M	1	2	4M
DI b.0	3	4	DI b.4
DI b.1	5	6	DI b.5
DI b.2	7	8	DI b.6
DI b.3	9	10	DI b.7

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7.2 SM 1222 DQ 16x24VDC

Table 1-245 General specifications

Technical data	SM 1222 DQ 16x24VDC
Article number	6ES7222-5BH50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	173 grams / 210 grams
Power dissipation	3.5 W
Current consumption (bus)	120 mA max. (5 V DC)
Current consumption (24 V DC)	45 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

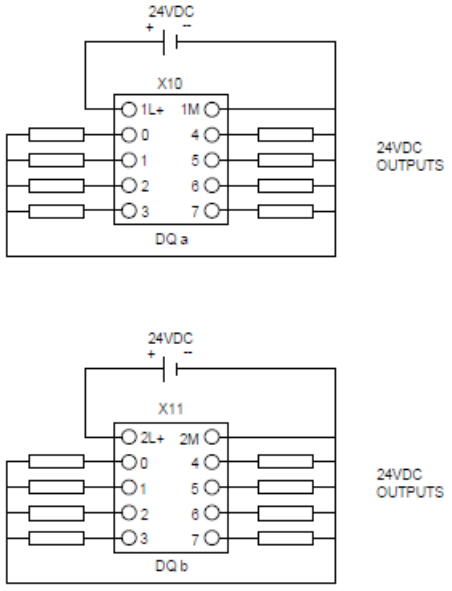
Table 1-246 Digital outputs

Technical data	SM 1222 DQ 16x24VDC
Number of outputs	16, in 2 isolation groups of 8 outputs each
Type	Solid state – MOSFET (sourcing)
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	L+ (-0.5 V)
Logic 0 signal with 10 kΩ load	0.1 V DC max.
Current	0.5 A max.
Lamp load	5 W
ON state resistance	0.6 Ω max.
Leakage current per point	10 µA max.
Overload protection	No
Isolation (field side to logic)	707 V DC (type test)
Current per common	4 A max.
Inductive clamp voltage	L+ minus 40 V, 1 W dissipation
Switching delay	50 µs max. OFF to ON 200 µs max. ON to OFF
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1222 DQ 16x24VDC



X10: Upper user wiring terminal (Gray, No keying)

Signal	Pin #		Signal
1L+	1	2	1M
DQ a.0	3	4	DQ a.4
DQ a.1	5	6	DQ a.5
DQ a.2	7	8	DQ a.6
DQ a.3	9	10	DQ a.7

X11: Lower user wiring terminal (Gray, No keying)

Signal	Pin #		Signal
2L+	1	2	2M
DQ b.0	3	4	DQ b.4
DQ b.1	5	6	DQ b.5
DQ b.2	7	8	DQ b.6
DQ b.3	9	10	DQ b.7

A.7.3 SM 1222 DQ 16xRLY

Table 1-247 General specifications

Technical data	SM 1222 DQ 16xRLY
Article number	6ES7222-5HH50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	217 grams / 254 grams
Power dissipation	4.2 W
Current consumption (bus)	115 mA max. (5 V DC)
Current consumption (24 V DC)	10 mA plus 9 mA / relay coil used
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	SM 1222 DQ 16xRLY
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-248 Digital outputs

Technical data	SM 1222 DQ 16xRLY
Number of outputs	16, in 2 isolation groups of 8 outputs each
Type	Relay, mechanical
Voltage range	5 to 30 V DC or 5 to 250 V AC
Current	2.0 A max.
Minimum load[1]	125 mW DC / 500 mW AC
Lamp load	30 W DC / 200 W AC
ON state resistance	0.2 Ω max. when new
Overload protection	No
Isolation (field side to logic)	1500 V AC (type test)
Isolation (coil to logic)	None
Isolation between groups	1500 V AC
Current per common	16 A max. (10 A max. per pin)
Switching delay	10 ms max.
Maximum relay switching frequency	1 Hz
Lifetime mechanical (no load)	10000000 open/close cycles
Lifetime contacts at rated load (N.O. contact)	100000 open/close cycles
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

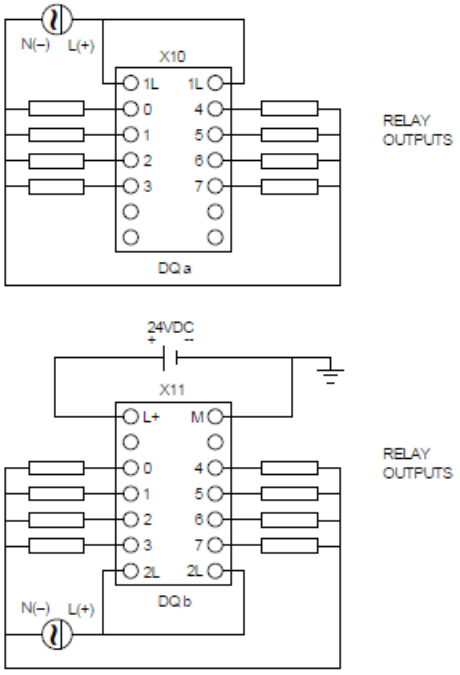
[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1222 DQ 16xRLY					
	X10: Upper User Wiring Terminal (Orange, Type-A Keying)				
	Signal	Pin #		Signal	
	1L	1	2	1L	

SM 1222 DQ 16xRLY



DQ a.0	3	4	DQ a.4
DQ a.1	5	6	DQ a.5
DQ a.2	7	8	DQ a.6
DQ a.3	9	10	DQ a.7
	11	12	
	13	14	

X11: Lower User Wiring Terminal (Orange, Type-A Keying)

Signal	Pin #		Signal
L+	1	2	M
	3	4	
DQ b.0	5	6	DQ b.4
DQ b.1	7	8	DQ b.5
DQ b.2	9	10	DQ b.6
DQ b.3	11	12	DQ b.7
2L	13	14	2L

A.7.4 SM 1223 DI 8x24VDC / DQ 8x24VDC

Table 1-249 General specifications

Technical data	SM 1223 DI 8x24VDC / DQ 8x24VDC
Article number	6ES7223-5BH50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	170 grams / 207 grams
Power dissipation	4.0 W
Current consumption (bus)	110 mA max. (5 V DC)
Current consumption (24 V DC)	60 mA plus 4.1 mA / input used
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-250 Digital inputs

Technical data	**SM 1223 DI 8x24VDC / DQ 8x24VDC**
Number of inputs	8, in 2 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Table 1-251 Digital outputs

Technical data	**SM 1223 DI 8x24VDC / DQ 8x24VDC**
Number of outputs	8, in 1 isolation group of 8 outputs
Type	Solid state – MOSFET (sourcing)
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	L+ (-0.5 V)
Logic 0 signal with 10 kΩ load	0.1 V DC max.
Current	0.5 A max.
Lamp load	5 W
ON state resistance	0.6 Ω max.
Leakage current per point	10 µA max.
Overload protection	No
Isolation (field side to logic)	707 V DC (type test)
Current per common	4 A max.
Inductive clamp voltage	L+ minus 40 V, 1 W dissipation
Switching delay	50 µs max. OFF to ON 200 µs max. ON to OFF
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

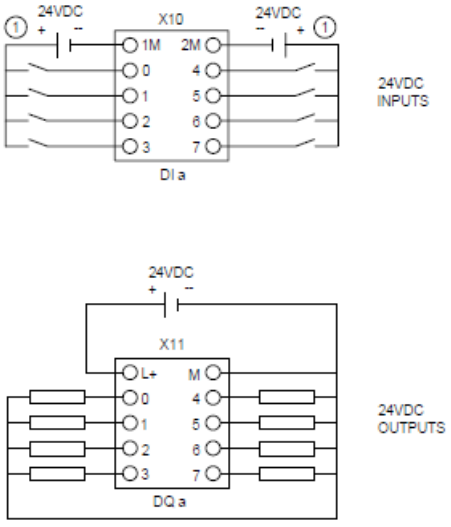
Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1223 DI 8x24VDC / DQ 8x24VDC	
	X10: Upper User Wiring Terminal (Gray, No Keying)

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

SM 1223 DI 8x24VDC / DQ 8x24VDC



Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7

X11: Lower User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
L+	1	2	M
DQ a.0	3	4	DQ a.4
DQ a.1	5	6	DQ a.5
DQ a.2	7	8	DQ a.6
DQ a.3	9	10	DQ a.7

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7.5 SM 1223 DI 8x24VDC / DQ 8xRLY

Table 1-252 General specifications

Technical data	SM 1223 DI 8x24VDC / DQ 8xRLY
Article number	6ES7223-5PH50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	194 grams / 231 grams
Power dissipation	4.8 W
Current consumption (bus)	105 mA max. (5 V DC)
Current consumption (24 V DC)	10 mA plus 4.1 mA / input used 9 mA / relay coil used
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	SM 1223 DI 8x24VDC / DQ 8xRLY
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-253 Digital inputs

Technical data	SM 1223 DI 8x24VDC / DQ 8xRLY
Number of inputs	8, in 2 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Table 1-254 Digital outputs

Technical data	SM 1223 DI 8x24VDC / DQ 8xRLY
Number of outputs	8, in one isolation group of 8 outputs
Type	Relay, mechanical
Voltage range	5 to 30 V DC or 5 to 250 V AC
Current	2.0 A max.
Minimum load[1]	125 mW DC / 500 mW AC
Lamp load	30 W DC / 200 W AC
ON state resistance	0.2 Ω max. when new
Overload protection	No
Isolation (field side to logic)	1500 V AC (type test)
Isolation (coil to logic)	None
Current per common	16 A max. (10 A. max per pin)
Switching delay	10 ms max.
Maximum relay switching frequency	1 Hz
Lifetime mechanical (no load)	10000000 open/close cycles
Lifetime contacts at rated load (N.O. contact)	100000 open/close cycles
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

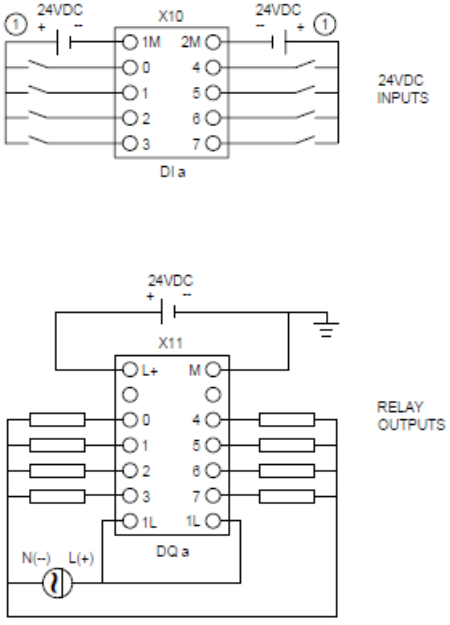
Technical data	SM 1223 DI 8x24VDC / DQ 8xRLY
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

[1] When using relays at minimum load, avoid ambient temperatures below 0 °C.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1223 DI 8x24VDC / DQ 8xRLY



X10: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7

X11: Lower User Wiring Terminal (Orange, Type-A Keying)

Signal	Pin #		Signal
L+	1	2	M
	3	4	
DQ a.0	5	6	DQ a.4
DQ a.1	7	8	DQ a.5
DQ a.2	9	10	DQ a.6
DQ a.3	11	12	DQ a.7
1L	13	14	1L

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7.6 SM 1223 DI 16x24VDC / DQ 16x24VDC

Table 1-255 General specifications

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC
Article number	6ES7223-5BL50-0XB0
Dimensions W x H x D	50 x 125 x 100 mm
Weight (product/shipping)	262 grams / 305 grams
Power dissipation	4.6 W

[1] Operating temperature range using maximum voltages and maximum specifications

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC
Current consumption (bus)	165 mA max. (5 V DC)
Current consumption (24 V DC)	45 mA plus 4.1 mA / input used
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting 20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-256 Digital inputs

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC
Number of inputs	16, in 4 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Table 1-257 Digital outputs

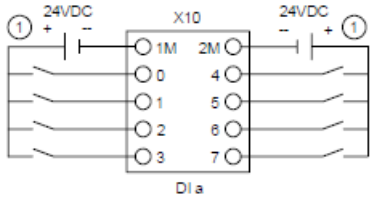
Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC
Number of outputs	16, in 2 isolation groups of 8 outputs each
Type	Solid state – MOSFET (sourcing)
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	20 V DC min.
Logic 0 signal with 10 kΩ load	0.1 V DC max.
Current	0.5 A max.
Lamp load	5 W
ON state resistance	0.6 Ω max.
Leakage current per point	10 µA max.
Overload protection	No
Isolation (field side to logic)	707 V DC (type test)
Current per common	4 A max.
Inductive clamp voltage	L+ minus 40 V, 1 W dissipation
Switching delay	50 µs max. OFF to ON 200 µs max. ON to OFF
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Wiring diagram

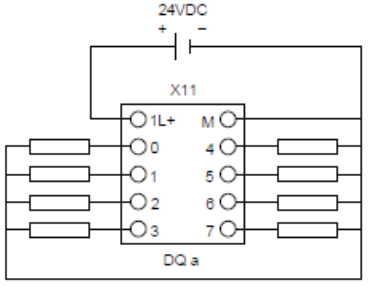
The wiring diagram and pin connector locations are shown below:

SM 1223 DI 16x24VDC / DQ 16x24VDC



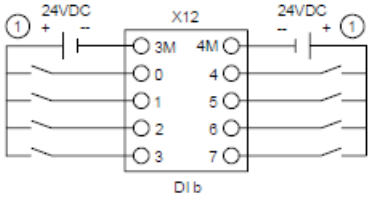
X10: Upper Left User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7



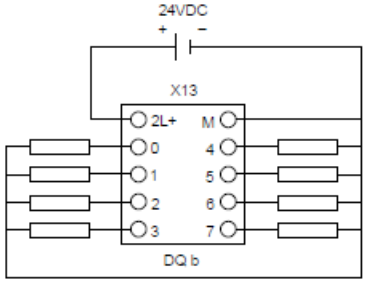
X11: Lower Left User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1L+	1	2	M
DQ a.0	3	4	DQ a.4
DQ a.1	5	6	DQ a.5
DQ a.2	7	8	DQ a.6
DQ a.3	9	10	DQ a.7



X12: Upper Right User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
3M	1	2	4M
DI b.0	3	4	DI b.4
DI b.1	5	6	DI b.5
DI b.2	7	8	DI b.6
DI b.3	9	10	DI b.7



X13: Lower Right User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
2L+	1	2	M
DQ b.0	3	4	DQ b.4
DQ b.1	5	6	DQ b.5
DQ b.2	7	8	DQ b.6
DQ b.3	9	10	DQ b.7

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7.7 SM 1223 DI 16x24VDC / DQ 16x24VDC Sink

Table 1-258 General specifications

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC Sink
Article number	6ES7223-5BL50-1XB0
Dimensions W x H x D	50 x 125 x 100 mm
Weight (product/shipping)	258 grams / 301 grams
Power dissipation	4.4 W
Current consumption (bus)	165 mA max. (5 V DC)
Current consumption (24 V DC)	40 mA plus 4.1 mA / input used
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-259 Digital inputs

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC Sink
Number of inputs	16, in 4 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Table 1-260 Digital outputs

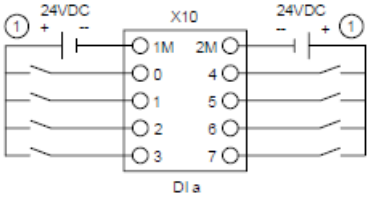
Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC Sink
Number of outputs	16, in 2 isolation groups of 8 outputs each
Type	Solid state – MOSFET (sinking)
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	0.5 V DC
Logic 0 signal with 10 kΩ load	24 V (typical) minus 0.75 V DC
Current	0.5 A max.
Lamp load	5 W
ON state resistance	0.5 Ω max.
Leakage current per point	75 µA max.
Overload protection	Yes, current limit protected range 1 A to 3.5 A
Isolation (field side to logic)	707 V DC (type test)
Current per common	4 A max.
Inductive clamp voltage	45 V

Technical data	SM 1223 DI 16x24VDC / DQ 16x24VDC Sink
Switching delay	20 µs max. OFF to ON 350 µs max. ON to OFF
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes (sourcing input)
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Wiring diagram

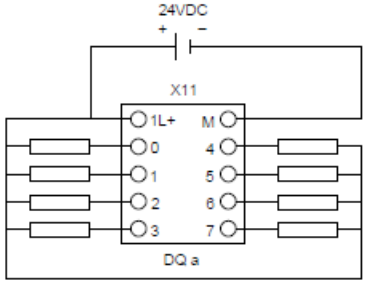
The wiring diagram and pin connector locations are shown below:

SM 1223 DI 16x24VDC / DQ 16x24VDC Sink



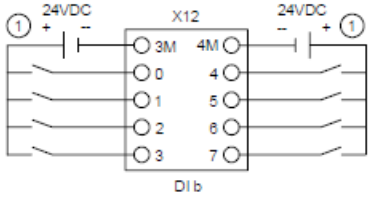
X10: Upper Left User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7



X11: Lower Left User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1L+	1	2	M
DQ a.0	3	4	DQ a.4
DQ a.1	5	6	DQ a.5
DQ a.2	7	8	DQ a.6
DQ a.3	9	10	DQ a.7



X12: Upper Right User Wiring Terminal (Gray, No Keying)

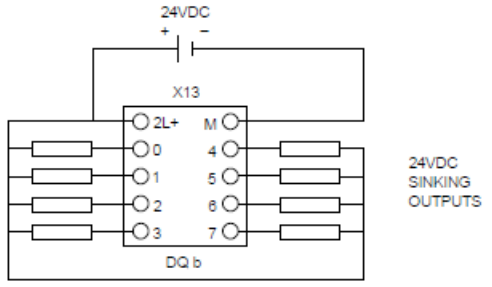
Signal	Pin #		Signal
3M	1	2	4M
DI b.0	3	4	DI b.4
DI b.1	5	6	DI b.5
DI b.2	7	8	DI b.6
DI b.3	9	10	DI b.7

X13: Lower Right User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
2L+	1	2	M
DQ b.0	3	4	DQ b.4
DQ b.1	5	6	DQ b.5

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

SM 1223 DI 16x24VDC / DQ 16x24VDC Sink



DQ b.2	7	8	DQ b.6
DQ b.3	9	10	DQ b.7

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.7.8 SM 1223 DI 16x24VDC / DQ 16xRLY

Table 1-261 General specifications

Technical data	SM 1223 DI 16x24VDC / DQ 16xRLY
Article number	6ES7223-5PL50-0XB0
Dimensions W x H x D	50 x 125 x 100 mm
Weight (product/shipping)	311 grams / 354 grams
Power dissipation	8.2 W
Current consumption (bus)	160 mA max. (5 V DC)
Current consumption (24 V DC)	175 mA plus 4.1 mA / input used plus 9.3 mA / relay coil used
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-262 Digital inputs

Technical data	SM 1223 DI 16x24VDC / DQ 16xRLY
Number of inputs	16, in 4 isolation groups of 4 inputs each
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable in groups of 4)	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms
Cable length	500 m shielded, 300 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

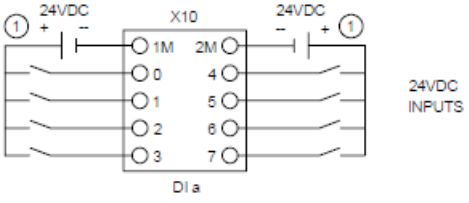
Table 1-263 Digital outputs

Technical data	SM 1223 DI 16x24VDC / DQ 16xRLY
Number of outputs	16, in 2 isolation groups of 8 outputs each
Type	Relay, mechanical
Voltage range	5 to 30 V DC or 5 to 250 V AC
Current	2.0 A max.
Minimum load[1]	125 mW DC / 500 mW AC
Lamp load	30 W DC / 200 W AC
ON state resistance	0.2 Ω max. when new
Overload protection	No
Isolation (field side to logic)	1500 V AC (type test)
Isolation (coil to logic)	None
Current per common	16 A max. (10 A max. per pin)
Switching delay	10 ms max.
Maximum relay switching frequency	1 Hz
Lifetime mechanical (no load)	10,000,000 open/close cycles
Lifetime contacts at rated load (N.O. contact)	100,000 open/close cycles
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes (with same common)
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1223 DI 16x24VDC / DQ 16xRLY



X10: Upper Left User Wiring Terminal (Gray, No Keying)

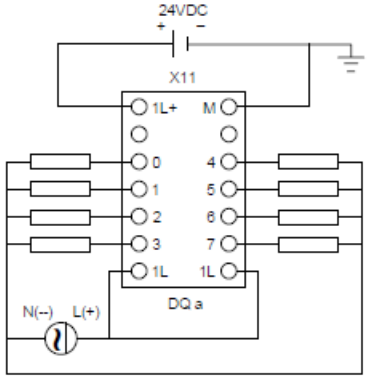
Signal	Pin #		Signal
1M	1	2	2M
DI a.0	3	4	DI a.4
DI a.1	5	6	DI a.5
DI a.2	7	8	DI a.6
DI a.3	9	10	DI a.7

X11: Lower Left User Wiring Terminal (Orange, Type-A Keying)

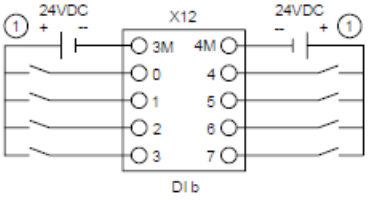
Signal	Pin #		Signal
1L+	1	2	M
	3	4	
DQ a.0	5	6	DQ a.4

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

SM 1223 DI 16x24VDC / DQ 16xRLY

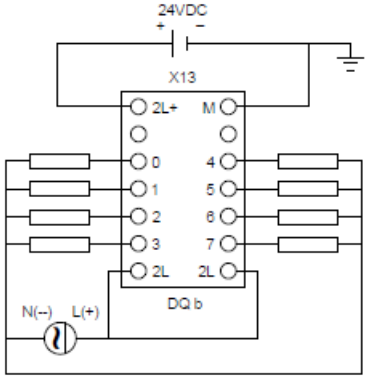


DQ a.1	7	8	DQ a.5
DQ a.2	9	10	DQ a.6
DQ a.3	11	12	DQ a.7
1L	13	14	1L



X12: Upper Right User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
3M	1	2	4M
DI b.0	3	4	DI b.4
DI b.1	5	6	DI b.5
DI b.2	7	8	DI b.6
DI b.3	9	10	DI b.7



X13: Lower Right User Wiring Terminal (Orange, Type-A Keying)

Signal	Pin #		Signal
2L+	1	2	M
	3	4	
DQ b.0	5	6	DQ b.4
DQ b.1	7	8	DQ b.5
DQ b.2	9	10	DQ b.6
DQ b.3	11	12	DQ b.7
2L	13	14	2L

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.8 Analog signal modules (SMs)

A.8.1 SM 1231 AI 8x14bit

Table 1-264 General specifications

Technical data	SM 1231 AI 8x14bit
Article number	6ES7231-4HF50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	175 grams / 212 grams

[1] Operating temperature range using maximum voltages and maximum specifications

Technical data	**SM 1231 AI 8x14bit**
Power dissipation	2.5 W
Current consumption (bus)	75 mA max. (5 V DC)
Current consumption (24 V DC)	45 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

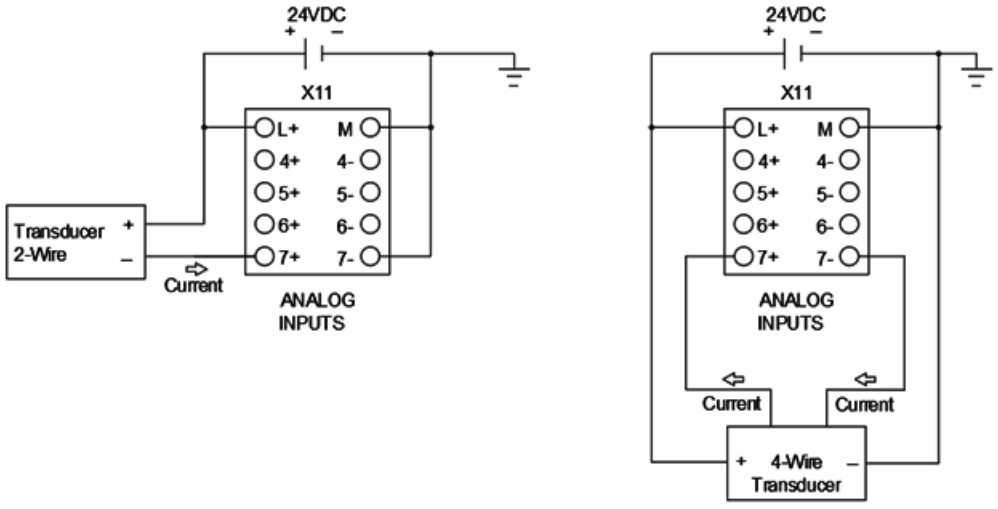
Table 1-265 Analog inputs

Technical data	**SM 1231 AI 8x14bit**	
Number of inputs	8	
Type	Voltage or current (differential), selectable in groups of 2	
Range	±10 V, ±5 V, ±2.5 V, 0 to 20 mA or 4 to 20 mA	
Full scale range (data word)	-27648 to 27648 voltage / 0 to 27648 current	
Overshoot/undershoot range (data word)	Voltage: 32511 to 27649 / -27649 to -32512 Current: 32511 to 27649 / 0 to -4864	
Overflow/underflow (data word)	Voltage: 32767 to 32512 / -32513 to -32768 Current 0 to 20 mA: 32767 to 32512 / -4865 to -32768 Current 4 to 20 mA: 32767 to 32512 (values below -4864 indicate open wire)	
Resolution	13 bits plus sign bit	
Maximum withstand voltage/current	±35 V / ±40 mA	
Smoothing	None, weak, medium, or strong	
Noise rejection	400, 60, 50, or 10 Hz	
Input impedance	Before parameterization	>= 1 MΩ
	Voltage	>= 1 MΩ
	Current	< 290 Ω, > 270 Ω
Isolation	Field side to logic	None
	Logic to 24 V DC	None
	Field side to 24 V DC	None
	Channel to channel	None
Accuracy (25 °C / -20 to 60 °C)	±0.1% / ±0.2% of full scale	
Measuring principle	Successive approximation	
Common mode rejection	40 dB, DC to 60 Hz	
Operational signal range[1]	Signal plus common mode voltage must be less than +12 V and greater than -12 V	
Diagnostics	Overflow/underflow	
	24 V DC low voltage	
	Open wire, 4 to 20 mA range only (if input is below -4864; 1.185 mA)	
Cable length	100 m, twisted and shielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

[1] Voltages outside the operational range applied to one channel can cause interference on other channels.

Current measurement

You can implement current measurement with either a 2-wire transducer or a 4-wire transducer as shown below:



Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1231 AI 8x14bit

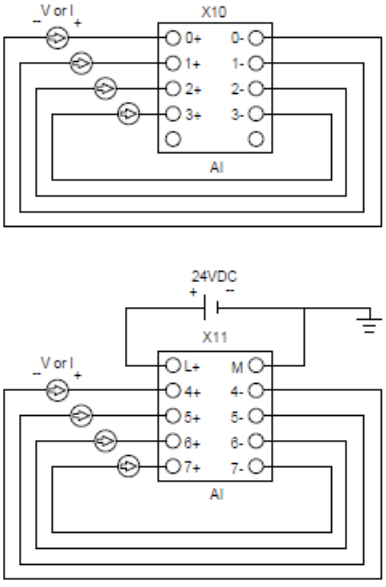
X10: Upper User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
AI 0+	1	2	AI 0-
AI 1+	3	4	AI 1-
AI 2+	5	6	AI 2-
AI 3+	7	8	AI 3-
	9	10	

X11: Lower User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
L+	1	2	M
AI 4+	3	4	AI 4-
AI 5+	5	6	AI 5-

SM 1231 AI 8x14bit



AI 6+	7	8	AI 6-
AI 7+	9	10	AI 7-

NOTE

When wiring and configuring analog input channels consider the following:

- Connect the positive input terminal to the negative input terminal on each unused voltage input channel.
- Set unused current input channels to the 0 to 20 mA range and/or disable broken wire error reporting.

Inputs configured for current mode do not conduct loop current if the module is not powered and configured.

Current input channels are operable only when you supply external power to the transmitter.

A.8.2 SM 1232 AQ 8x14bit

Table 1-266 General specifications

Technical data	SM 1232 AQ 8x14bit
Article number	6ES7232-4HF50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	173 grams / 210 grams
Power dissipation	5.6 W

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	SM 1232 AQ 8x14bit
Current consumption (bus)	90 mA max. (5 V DC)
Current consumption (24 V DC)	45 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-267 Analog outputs

Technical data	SM 1232 AQ 8x14bit	
Number of outputs	8	
Type	Voltage or current	
Range	±10 V, 0 to 20 mA, or 4 to 20 mA	
Resolution	Voltage: 14 bits Current: 13 bits	
Full scale range (data word)	Voltage: -27648 to 27648 Current: 0 to 27648	
Accuracy (25 °C / -20 to 60 °C)	±0.3% / ±0.6% of full scale	
Settling time (95% of new value)	Voltage: 300 µs (R), 750 µs (1 µF) Current: 600 µs (1 mH), 2 ms (10 mH)	
Load impedance	Voltage: >= 1000 Ω Current: <= 600 Ω	
Maximum output short circuit current	Voltage: <= 24 mA Current: <= 24 mA	
Behavior on RUN to STOP	Last value or substitute value (default value 0)	
Isolation	Field side to logic	None
	24 V to output	None
Diagnostics	Overflow/underflow	
	Short to ground (voltage mode only)[1]	
	Wire break (current mode only)[2]	
	24 V DC low voltage	
Cable length	100 m, twisted and shielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

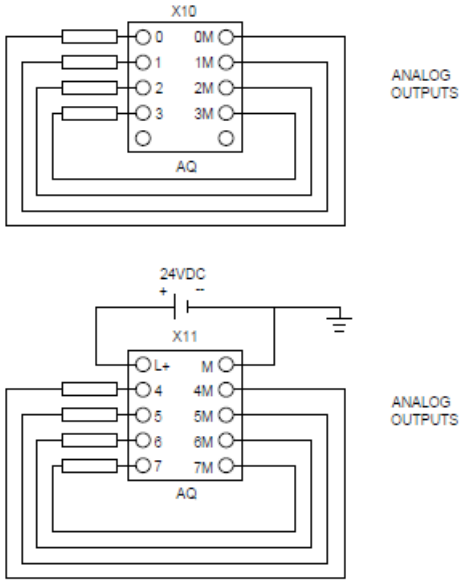
[1] Short circuit detection is only possible when the output voltage is less than -0.5 V or greater than +0.5 V.

[2] Wire break detection is only possible when the output current is greater than 1 mA.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1232 AQ 8x14bit



X10: Upper User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
AQ 0	1	2	0M
AQ 1	3	4	1M
AQ 2	5	6	2M
AQ 3	7	8	3M
	9	10	

X11: Lower User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
L+	1	2	M
AQ 4	3	4	4M
AQ 5	5	6	5M
AQ 6	7	8	6M
AQ 7	9	10	7M

A.8.3 SM 1233 AI 4x14bit / AQ 4x14bit

Table 1-268 General specifications

Technical data	SM 1233 AI 4x14bit / AQ 4x14bit
Article number	6ES7233-4HF50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	174 grams / 211 grams
Power dissipation	4.7 W
Current consumption (bus)	80 mA max. (5 V DC)
Current consumption (24 V DC)	40 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	**SM 1233 AI 4x14bit / AQ 4x14bit**
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-269 Analog inputs

Technical data	**SM 1233 AI 4x14bit / AQ 4x14bit**	
Number of inputs	4	
Type	Voltage or current (differential)	
Range	±10 V, ±5 V, ±2.5 V, 0 to 20 mA or 4 to 20 mA	
Full scale range (data word)	-27648 to 27648 voltage / 0 to 27648 current	
Overshoot/undershoot range (data word)	Voltage: 32511 to 27649 / -27649 to -32512 Current: 32511 to 27649 / 0 to -4864	
Overflow/underflow (data word)	Voltage: 32767 to 32512 / -32513 to -32768 Current 0 to 20 mA: 32767 to 32512 / -4865 to -32768 Current 4 to 20 mA: 32767 to 32512 (values below -4864 indicate open wire)	
Resolution	13 bits plus sign bit	
Maximum withstand voltage/current	±35 V / ±40 mA	
Smoothing	None, weak, medium, or strong	
Noise rejection	400, 60, 50, or 10 Hz	
Input impedance	Before parameterization	>= 1 MΩ
	Voltage	>= 1 MΩ
	Current	< 290 Ω, > 270 Ω
Isolation	Field side to logic	None
	Logic to 24 V DC	None
	Field side to 24 V DC	None
	Channel to channel	None
Accuracy (25 °C / -20 to 60 °C)	±0.1% / ±0.2% of full scale	
Measuring principle	Successive approximation	
Common mode rejection	40 dB, DC to 60 Hz	
Operational signal range[1]	Signal plus common mode voltage must be less than +12 V and greater than -12 V	
Diagnostics	Overflow/underflow	
	24 V DC low voltage	
	Open wire, 4 to 20 mA range only (if input is below -4864; 1.185 mA)	
Cable length	100 m, twisted and shielded	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

[1] Voltages outside the operational range applied to one channel can cause interference on other channels.

Table 1-270 Analog outputs

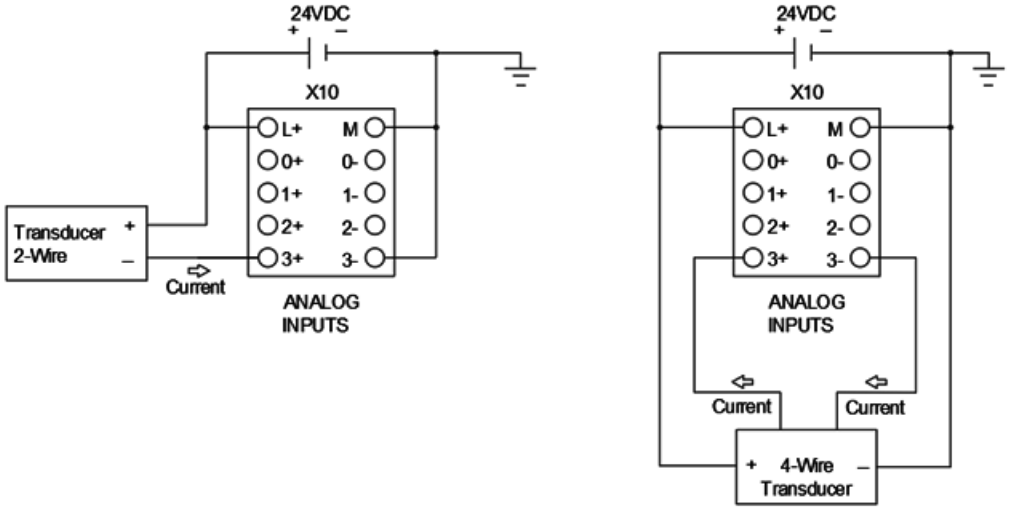
Technical data	**SM 1233 AI 4x14bit / AQ 4x14bit**
Number of outputs	4
Type	Voltage or current
Range	± 10 V, 0 to 20 mA, or 4 to 20 mA
Resolution	Voltage: 14 bits Current: 13 bits
Full scale range (data word)	Voltage: -27648 to 27648 Current: 0 to 27648
Accuracy (25 °C / -20 to 60 °C)	±0.3% / ±0.6% of full scale
Settling time (95% of new value)	Voltage: 300 µs (R), 750 µs (1 µF) Current: 600 µs (1 mH), 2 ms (10 mH)
Load impedance	Voltage: >= 1000 Ω Current: <= 600 Ω
Maximum output short circuit current	Voltage: <= 24 mA Current: <= 24 mA
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Isolation (field side to logic)	None
Isolation (24 V to output)	None
Diagnostics	Overflow/underflow
	Short to ground (voltage mode only)[1]
	Wire break (current mode only)[2]
	24 V DC low voltage
Cable length	100 m, twisted and shielded
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

[1] Short circuit detection is only possible when the output voltage is less than -0.5 V or greater than +0.5 V.

[2] Wire break detection is only possible when the output current is greater than 1 mA

Current measurement

You can implement current measurement with either a 2-wire transducer or a 4-wire transducer as shown below:



Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1233 AI 4x14bit / AQ 4x14bit

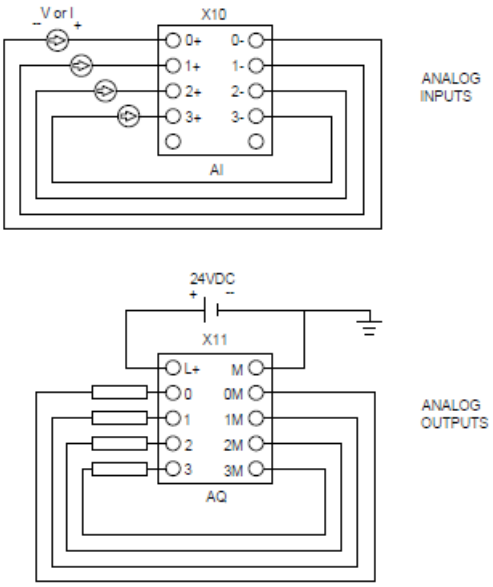
X10: Upper User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
AI 0+	1	2	AI 0-
AI 1+	3	4	AI 1-
AI 2+	5	6	AI 2-
AI 3+	7	8	AI 3-
	9	10	

X11: Lower User Wiring Terminal (Light Gray, Type-B Keying)

Signal	Pin #		Signal
L+	1	2	M
AQ 0	3	4	0M
AQ 1	5	6	1M

SM 1233 AI 4x14bit / AQ 4x14bit



AQ 2	7	8	2M
AQ 3	9	10	3M

NOTE

When wiring and configuring analog input channels consider the following:

- Connect the positive input terminal to the negative input terminal on each unused voltage input channel.
- Set unused current input channels to the 0 to 20 mA range and/or disable broken wire error reporting.

Inputs configured for current mode do not conduct loop current if the module is not powered and configured.

Current input channels are operable only when you supply external power to the transmitter.

A.8.4 Step response of the analog inputs

Table 1-271 Step response (ms), 0 to full scale measured at 95%

Smoothing selection (sample averaging)	Noise reduction/rejection frequency (Integration time selection)			
	400 Hz (2.5 ms)	60 Hz (16.6 ms)	50 Hz (20 ms)	10 Hz (100 ms)
None (1 cycle): No averaging	4 ms	18 ms	22 ms	100 ms
Weak (4 cycles): 4 samples	9 ms	52 ms	63 ms	320 ms
Medium (16 cycles): 16 samples	32 ms	203 ms	241 ms	1200 ms
Strong (32 cycles): 32 samples	61 ms	400 ms	483 ms	2410 ms

A.8.5 Sample time and update times for the analog inputs

Table 1-272 Sample time and update times for the analog inputs, all channels

Rejection frequency (Integration time)	Sample and module update times for all channels			
	400 Hz (2.5 ms)	60 Hz (16.6 ms)	50 Hz (20 ms)	10 Hz (100 ms)
4 channels	0.625 ms	4.17 ms	5 ms	25 ms
8 channels	1.25 ms	4.17 ms	5 ms	25 ms

A.8.6 Measurement ranges of the analog inputs for voltage and current

Table 1-273 Analog input representation for voltage

System		Voltage measuring range				
Decimal	Hexadecimal	+/- 10 V	+/- 5 V	+/- 2.5 V	+/- 1.25 V	
32767	7FFF[1]	11.851 V	5.926 V	2.963 V	1.481 V	Overflow
32512	7F00					
32511	7EFF	11.759 V	5.879 V	2.940 V	1.470 V	Overshoot range
27649	6C01					
27648	6C00	10 V	5 V	2.5 V	1.250 V	Rated range
20736	5100	7.5 V	3.75 V	1.875 V	0.938 V	
1	1	361.7 µV	180.8 µV	90.4 µV	45.2 µV	
0	0	0 V	0 V	0 V	0 V	
-1	FFFF					
-20736	AF00	-7.5 V	-3.75 V	-1.875 V	-0.938 V	
-27648	9400	-10 V	-5 V	-2.5 V	-1.250 V	
-27649	93FF					Undershoot range
-32512	8100	-11.759 V	-5.879 V	-2.940 V	-1.470 V	
-32513	80FF					Underflow
-32768	8000	-11.851 V	-5.926 V	-2.963 V	-1.481 V	

[1] The channel can return 7FFF for one of the following reasons: overflow (as noted in this table), before valid values are available (for example, immediately upon a power up), or if a wire break is detected.

Table 1-274 Analog input representation for current

System		Current measuring range		
Decimal	**Hexadecimal**	**0 mA to 20 mA**	**4 mA to 20 mA**	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Undershoot range
-4864	ED00	-3.52 mA	1.185 mA	
32767[1]	7FFF		< 1.185 mA	Wire break (4 to 20 mA)
-32768	8000	< -3.52 mA		Underflow (0 to 20 mA)

[1] The wire break value of 32767 (16#7FFF) is always returned regardless of the state of the wire break alarm.

See also

Determining the type of error from an analog module (Page 334)

A.8.7 Measurement ranges of the analog outputs for voltage and current

Table 1-275 Analog output representation for voltage

System		Voltage output range	
Decimal	**Hexadecimal**	**+/- 10 V**	
32767	7FFF	See note 1	Overflow
32512	7F00	See note 1	
32511	7EFF	11.76 V	Overshoot range
27649	6C01		
27648	6C00	10 V	Rated range
20736	5100	7.5 V	
1	0001	361.7 µV	
0	0000	0 V	
-1	FFFF	-361.7 µV	
-20736	AF00	-7.5 V	
-27648	9400	-10 V	
-27649	93FF		Undershoot range
-32512	8100	-11.76 V	
-32513	80FF	See note 1	Underflow
-32768	8000	See note 1	

[1] In an overflow or underflow condition, analog outputs take on the substitute value of the STOP mode.

Table 1-276 Analog output representation for current

System		Current output range		
Decimal	**Hexadecimal**	**0 mA to 20 mA**	**4 mA to 20 mA**	
32767	7FFF	See note 1	See note 1	Overflow
32512	7F00	See note 1	See note 1	
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Rated range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF		4 mA to 578.7 nA	Undershoot range
-6912	E500		0 mA	
-6913	E4FF			Not possible. Output value limited to 0 mA.
-32512	8100			
-32513	80FF	See note 1	See note 1	Underflow
-32768	8000	See note 1	See note 1	

[1] In an overflow or underflow condition, analog outputs take on the substitute value of the STOP mode.

A.8.8 Basic operation of a thermocouple

A thermocouple is formed whenever two dissimilar metals are electrically bonded to each other. A voltage is generated across the bonded junction that is proportional to the junction temperature. This voltage is small; one microvolt could represent many degrees. Measuring the voltage from a thermocouple, compensating for extra junctions, and then linearizing the result forms the basis of temperature measurement using thermocouples.

The place where the two dissimilar wires are attached to each other forms the sensor thermocouple. The other ends of the thermocouple wires are each attached to a module or board at the signal connector.

Two more thermocouples are formed where the two wires are attached to the signal connector. The connector temperature causes a voltage that adds to the voltage from the sensor thermocouple. If this voltage is not corrected, then the temperature reported will deviate from the sensor temperature.

Cold junction compensation is used to compensate for the connector thermocouples. Thermocouple tables are based on a reference junction temperature, usually zero degrees Celsius. The cold junction compensation compensates the connector to zero degrees Celsius.

The cold junction compensation restores the voltage added by the connector thermocouples. The temperature of the module or board is measured internally, and then converted to a value to be added to the sensor conversion. The corrected sensor conversion is then linearized using the thermocouple tables.

For optimum operation of the cold junction compensation, the thermocouple module or board must be located in a thermally stable environment. Slow variation (less than 0.1 °C/minute) in ambient temperature is correctly compensated within the module or board specifications. Air movement across the module or board will also cause cold junction compensation errors.

If better cold junction error compensation is needed, an external iso-thermal terminal block can be used. The thermocouple board provides for use of a 0 °C referenced or 50 °C referenced terminal block.

A.8.9 SM 1231 AI 8xTC

Table 1-277 General specifications

Technical data	SM 1231 AI 8xTC
Article number	6ES7231-5QF50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	171 grams / 208 grams
Power dissipation	0.6 W
Current consumption (bus)	60 mA max. (5 V DC)
Current consumption (24 V DC)	15 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-278 Analog inputs

Technical data	SM 1231 AI 8xTC	
Number of inputs	8	
Sensor types	J, K, T, E, R & S, B, N, C, TXK/XK(L), voltage	
Ranges	See Selection tables for thermocouple sensors.	
Resolution Temperature	0.1 °C / 0.1 °F	
Resolution Voltage	15 bits plus sign	
Maximum withstand voltage	±35 V	
Noise rejection	85 dB for selected filter setting (10 Hz, 50 Hz, 60 Hz or 400 Hz)	
Common mode rejection	> 120 dB at 120 V AC	
Impedance	>= 10 MΩ	
Isolation	Field side to logic	707 V DC (type test)
	Logic to 24 V DC	707 V DC (type test)
	Field side to 24 V DC	707 V DC (type test)
	Channel to channel	120 V AC
Accuracy	See Selection tables for thermocouple sensors.	
Repeatability	±0.05% of full scale	
Measuring principle	Integrating	
Module update time	See Noise reduction and update times for the Termocouple module.	
Cold junction error	±1.5 °C	
Wire resistance	100 Ω max.	
Diagnostics	Overflow/underflow[1]	
	Wire break[2, 3]	

Technical data	SM 1231 AI 8xTC
Diagnostics	24 V DC low voltage[1]
Cable length	100 m to sensor max.
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

[1] The overflow, underflow, and low voltage diagnostic alarm information is reported in the analog data values, even if the alarms are disabled in the module configuration.

[2] When wire break alarm is disabled and an open wire condition exists in the sensor wiring, the module can report random values.

[3] The module performs wire break testing every 6 seconds, which extends the update time by 9 ms for each enabled channel once every 6 seconds.

The SM 1231 Thermocouple (TC) analog signal module measures the value of voltage connected to the module inputs. The temperature measurement type can be either "Thermocouple" or "Voltage".

- "Thermocouple": The value is reported in degrees multiplied by ten. (For example, 25.3 degrees is reported as decimal 253).
- "Voltage": The nominal range full scale value is decimal 27648.

Selection tables for thermocouple sensors

Table 1-279 Thermocouple selection table

Type	Under-range minimum[1]	Nominal range low limit	Nominal range high limit	Over-range maximum[2]	Normal range accuracy @ 25 °C[3]	Normal range accuracy -20 °C to 60 °C[1, 2, 5]
J	-210.0 °C -346.0 °F	-150.0 °C -238.0 °F	1200.0 °C 2192.0 °F	1450.0 °C 2642.0 °F	±0.3 °C ±0.5 °F	±1.2 °C ±2.2 °F
K	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1372.0 °C 2501.6 °F	1622.0 °C 2951.6 °F	±0.4 °C ±0.7 °F	±2.0 °C ±3.6 °F
T	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	400.0 °C 752.0 °F	540.0 °C 1004.0 °F	±0.5 °C ±0.9 °F	±1.0 °C ±1.8 °F
E	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1000.0 °C 1832.0 °F	1200.0 °C 2192.0 °F	±0.3 °C ±0.5 °F	±0.6 °C ±1.1 °F
R & S	-50.0 °C -58.0 °F	100.0 °C 212.0 °F	1768.0 °C 3214.4 °F	2019.0 °C 3276.6 °F[4]	±1.0 °C ±1.8 °F	±2.5 °C ±4.5 °F
B	0.0 °C 32.0 °F -- --	200.0 °C 392.0 °F 800.0 °C 1472.0 °F	800.0 °C 1472.0 °F 1820.0 °C 3276.6 °F[4]	-- -- 1820.0 °C 3276.6 °F[4]	±2.0 °C ±3.6 °F ±1.0 °C ±1.8 °F	±2.5 °C ±4.5 °F ±2.3 °C ±4.1 °F
N	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1300.0 °C 2372.0 °F	1550.0 °C 2822.0 °F	±1.0 °C ±1.8 °F	±1.6 °C ±2.9 °F

[1] Thermocouple values below the under-range minimum value are reported as -32768.

[2] Thermocouple values above the over-range maximum value are reported as 32767.

[3] Internal cold junction error is ±1.5 °C for all ranges. This adds to the error values in this table. The module requires at least 30 minutes of warm-up time to meet this specification. For module ambient temperatures below -10 °C internal cold junction error can be greater than 1.5 °C.

[4] Lower limit of 3276.6 °F with °F reporting

[5] Cold junction compensation error has not been characterized for module ambient temperatures below 0 °C, and can exceed the specified value.

Type	Under-range minimum[1]	Nominal range low limit	Nominal range high limit	Over-range maximum[2]	Normal range accuracy @ 25 °C[3]	Normal range accuracy -20 °C to 60 °C[1, 2, 5]
C	0.0 °C 32.0 °F	100.0 °C 212.0 °F	2315.0 °C 3276.6 °F[4]	2500.0 °C 3276.6 °F[4]	±0.7 °C ±1.3 °F	±4.5 °C ±8.1 °F
TXK/XK(L)	-200.0 °C -328.0 °F	-150.0 °C 302.0 °F	800.0 °C 1472.0 °F	1050.0 °C 1922.0 °F	±0.6 °C ±1.1 °F	±1.2 °C ±2.2 °F
Voltage	-32512	-27648 -80mV	27648 80mV	32511	±0.05%	±0.1%

[1] Thermocouple values below the under-range minimum value are reported as -32768.

[2] Thermocouple values above the over-range maximum value are reported as 32767.

[3] Internal cold junction error is ±1.5 °C for all ranges. This adds to the error values in this table. The module requires at least 30 minutes of warm-up time to meet this specification. For module ambient temperatures below -10 °C internal cold junction error can be greater than 1.5 °C.

[4] Lower limit of 3276.6 °F with °F reporting

[5] Cold junction compensation error has not been characterized for module ambient temperatures below 0 °C, and can exceed the specified value.

NOTE

Thermocouple channel

Each channel on the Thermocouple signal module can be configured with a different thermocouple type (selectable in the software during configuration of the module).

Table 1-280 Noise reduction and update times for the Thermocouple module

Rejection frequency selection	Integration time	Module update time (seconds)
400 Hz (2.5 ms)	10 ms[1]	0.285
60 Hz (16.67 ms)	16.67 ms	0.445
50 Hz (20 ms)	20 ms	0.525
10 Hz (100 ms)	100 ms	2.450

[1] To maintain resolution and accuracy when the 400 Hz filter is selected, the integration time is 10 ms. This selection also rejects 100 Hz and 200 Hz noise.

Siemens recommends using a 100 ms integration time for measuring thermocouples. The use of smaller integration times increases the repeatability error of the temperature readings.

Internal calibration

After power is applied, the module performs internal calibration for the analog-to-digital converter. During this time the module reports a value of 32767 on each channel until the channel provides valid data. The STEP 7 program might need to allow for this initialization time. Because the initialization time varies based on the module's configuration, you must verify the behavior of the module in your system. If required, you can include logic in the STEP 7 program to accommodate the initialization time of the module.

You can implement this logic using a polling read in the "Startup OB" which blocks operation until the initialization is complete. You must implement the polling read with an immediate access. If the value of the thermocouple polling read is 32767, you must repeat the read until the value changes. For each module, use only the input channel with the greatest value for the thermocouple polling read. For example, if input channel number 2 is the highest used input channel, you should execute the thermocouple polling read on channel number 2. The module initializes the channels in order from 0 to 7.

Representation of analog values for Thermocouple Type J

A representation of the analog values of thermocouples type J is shown in the table below:

Table 1-281 Representation of analog values of thermocouple type J

Type J in °C[1]	Units		Type J in °F[1]	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.2	26420 : 21922	6734 : 55A2	Over-range
1200.0 : -150	12000 : 1500	2EE0 : FA24	2192.0 : -238.0	21920 : -2380	55A0 : F6B4	Rated range
-150.1 : -210	-1501 : -2100	FA23 : F7CC	-238.1 : -346.0	-2381 : -3460	F6B3 : F27C	Under-range
< -210.0	-32768	8000	< -346.0	-32768	8000	Underflow[2]

[1] A value change of 1 indicates a temperature change of +/- one-tenth degree.

[2] Faulty wiring (for example, polarity reversal, or open inputs) or sensor error in the negative range (for example, wrong type of thermocouple) can cause the thermocouple module to signal underflow.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1231 AI 8xTC

X10: Upper user wiring terminal (Light gray, Type-B keying)

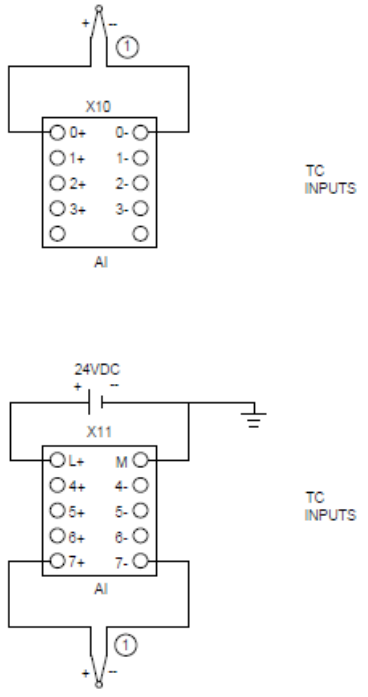
Signal	Pin #		Signal
AI 0+	1	2	AI 0-
AI 1+	3	4	AI 1-
AI 2+	5	6	AI 2-
AI 3+	7	8	AI 3-
	9	10	

X11: Lower user wiring terminal (Light gray, Type-B keying)

Signal	Pin #		Signal
L+	1	2	M
AI 4+	3	4	AI 4-
AI 5+	5	6	AI 5-

① TC 1, 2, 3, 4, 5, and 6 are not shown for clarity.

SM 1231 AI 8xTC



AI 6+	7	8	AI 6-
AI 7+	9	10	AI 7-

① TC 1, 2, 3, 4, 5, and 6 are not shown for clarity.

NOTE

Connect the positive input terminal to the negative input terminal on each unused TC input channel. You can deactivate unused thermocouple channels. Deactivated channels do not report errors.

A.8.10 SM 1231 AI 4xRTD

Table 1-282 General specifications

Technical data	SM 1231 AI 4xRTD
Article number	6ES7231-5PD50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	169 g / 206 grams
Power dissipation	0.6 W
Current consumption (bus)	65 mA max. (5 V DC)
Current consumption (24 V DC)	15 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes

[1] Operating temperature range using maximum voltages and maximum specifications

Technical data	SM 1231 AI 4xRTD
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

Table 1-283 Analog inputs

Technical data	SM 1231 AI 4xRTD	
Number of inputs	4	
Sensor types	See Selection table for the RTD sensors.	
Ranges	See Selection table for the RTD sensors.	
Resolution	Temperature	0.1 °C / 0.1 °F
	Resistance	15 bits plus sign
Maximum withstand voltage	± 35 V	
Noise rejection	85 dB for the selected noise reduction (10 Hz, 50 Hz, 60 Hz or 400 Hz)	
Common mode rejection	> 120 dB	
Impedance	>= 10 MΩ	
Isolation	Field side to logic	707 V DC (type test)
	Logic to 24 V DC	707 V DC (type test)
	Field side to 24 V DC	707 V DC (type test)
	Channel to channel	none
Accuracy	See Selection table for the RTD sensors.[4]	
Repeatability	±0.05% of full scale	
Maximum sensor dissipation	0.2 mW	
Measuring principle	Integrating	
Module update time	See Noise reduction and update times for the RTD module.	
Diagnostics	Overflow/underflow[1, 2]	
	Wire break[3]	
	24 V DC low voltage[1]	
Wire resistance	20 Ω, 2.7 Ω for 10 Ω RTD max.	
Cable length	100 m to sensor max.	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

[1] The overflow, underflow and low voltage diagnostic alarm information is reported in the analog data values even if the alarms are disabled in the module configuration.

[2] For resistance ranges underflow detection is never enabled.

[3] When wire break alarm is disabled and an open wire condition exists in the sensor wiring, the module can report random values.

[4] Accuracy can be affected when the signal module is subjected to radio frequency radiation between 480 MHz to 800 MHz or when the signal module's ambient temperature changes at a rate of 3 °C per minute or faster.

The SM 1231 AI 4xRTD measures the value of resistance connected to the module inputs. The measurement type can be selected as either "Resistor" or "Thermal resistor".

- "Resistor": The nominal range full scale value is decimal 27648.
- "Thermal resistor": The value is reported in degrees multiplied by ten. (For example, 25.3 degrees is reported as decimal 253.) The climatic range values are reported in degrees multiplied by one hundred. (For example, 25.34 degrees is reported as decimal 2534.)

The SM 1231 AI 4xRTD uses a current to measure the resistance of the sensor. For resistance ranges and the RTD ranges of 200 ohms or less the current is 0.25 mA. For the 500- and 1000-ohm RTD ranges the current is 0.20 mA. This current is pulsed depending on the number of active channels on the module. For two active channels, the duty cycle for one channel is 50%. If four channels are active, the duty cycle for one channel is 25%. The maximum output voltage for an open circuit condition on the sensor is 3.3 V DC (measured between the I+ and I- terminals).

The SM 1231 AI 4xRTD supports measurements with 2-wire, 3-wire and 4-wire connections to the sensor resistor.

Selection table for the RTD sensors

Table 1-284 Ranges and accuracy for the different sensors supported by the RTD module

Temperature coefficient	RTD type	Under range minimum[1]	Nominal range low limit	Nominal range high limit	Over range maximum[2]	Normal range accuracy @ 25 °C	Normal range accuracy -20 °C to 60 °C
Pt 0.003850 ITS90 DIN EN 60751	Pt 100 climatic	-145.00 °C	-120.00 °C	145.00 °C	155.00 °C	±0.20 °C	±0.40 °C
	Pt 10	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±1.0 °C	±2.0 °C
	Pt 50	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±0.5 °C	±1.0 °C
	Pt 100						
	Pt 200						
	Pt 500						
	Pt 1000						
Pt 0.003902 Pt 0.003916 Pt 0.003920	Pt 100	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±0.5 °C	±1.0 °C
	Pt 200						
	Pt 500						
	Pt 1000						
Pt 0.003910	Pt 10	-273.2 °C	-240.0 °C	1100.0 °C	1295.0 °C	±1.0 °C	±2.0 °C
	Pt 50	-273.2 °C	-240.0 °C	1100.0 °C	1295.0 °C	±0.8 °C	±1.6 °C
	Pt 100						
	Pt 500						
Ni 0.006720 Ni 0.006180	Ni 100	-105.0 °C	-60.0 °C	250.0 °C	295.0 °C	±0.5 °C	±1.0 °C
	Ni 120						
	Ni 200						
	Ni 500						
	Ni 1000						
LG-Ni 0.005000	LG-Ni 1000	-105.0 °C	-60.0 °C	250.0 °C	295.0 °C	±0.5 °C	±1.0 °C
Ni 0.006170	Ni 100	-105.0 °C	-60.0 °C	180.0 °C	212.4 °C	±0.5 °C	±1.0 °C
Cu 0.004270	Cu 10	-240.0 °C	-200.0 °C	260.0 °C	312.0 °C	±1.0 °C	±2.0 °C
Cu 0.004260	Cu 10	-60.0 °C	-50.0 °C	200.0 °C	240.0 °C	±1.0 °C	±2.0 °C
	Cu 50	-60.0 °C	-50.0 °C	200.0 °C	240.0 °C	±0.6 °C	±1.2 °C
	Cu 100						

[1] RTD values below the under-range minimum value report -32768.

[2] RTD values above the over-range maximum value report +32767.

Temperature coefficient	RTD type	Under range minimum[1]	Nominal range low limit	Nominal range high limit	Over range maximum[2]	Normal range accuracy @ 25 °C	Normal range accuracy -20 °C to 60 °C
Cu 0.004280	Cu 10	-240.0 °C	-200.0 °C	200.0 °C	240.0 °C	±1.0 °C	±2.0 °C
	Cu 50	-240.0 °C	-200.0 °C	200.0 °C	240.0 °C	±0.7 °C	±1.4 °C
	Cu 100						

[1] RTD values below the under-range minimum value report -32768.

[2] RTD values above the over-range maximum value report +32767.

Table 1-285 Resistance

Range	Under range minimum	Nominal range low limit	Nominal range high limit	Over range maximum[1]	Normal range accuracy @ 25 °C	Normal range accuracy -20 °C to 60 °C
150 Ω	n/a	0 (0 Ω)	27648 (150 Ω)	176.383 Ω	±0.05%	±0.1%
300 Ω	n/a	0 (0 Ω)	27648 (300 Ω)	352.767 Ω	±0.05%	±0.1%
600 Ω	n/a	0 (0 Ω)	27648 (600 Ω)	705.534 Ω	±0.05%	±0.1%

[1] Resistance values above the over-range maximum value are reported as +32767.

The module reports 32767 on any activated channel with no sensor connected. If open wire detection is also enabled, the module flashes the appropriate red LEDs.

When 500 Ω and 1000 Ω RTD ranges are used with other lower value resistors, the error can increase to two times the specified error.

Best accuracy is achieved for the 10 Ω RTD ranges if 4 wire connections are used.

The resistance of the connection wires in 2 wire mode causes an error in the sensor reading; therefore, accuracy is not guaranteed.

Table 1-286 Noise reduction and update times for the RTD module

Rejection frequency selection	Integration time	Module update time (seconds)
400 Hz (2.5 ms)	10 ms[1]	4- / 2-wire: 0.142 3-wire: 0.285
60 Hz (16.67 ms)	16.67 ms	4- / 2-wire: 0.222 3-wire: 0.445
50 Hz (20 ms)	20 ms	4- / 2-wire: 0.262 3-wire: 0.505
10 Hz (100 ms)	100 ms	4- / 2-wire: 1.222 3-wire: 2.445

[1] To maintain resolution and accuracy when the 400 Hz filter is selected, the integration time is 10 ms. This selection also rejects 100 Hz and 200 Hz noise.

Internal calibration

After power is applied, the module performs internal calibration for the analog-to-digital converter. During this time the module reports a value of 32767 on each channel until the channel provides valid data. The STEP 7 program might need to allow for this initialization time. Because the initialization time varies based on the module's configuration, you must verify the behavior of the module in your system. If required, you can include logic in the STEP 7 program to accommodate the initialization time of the module.

You can implement this logic using a polling read in the "Startup OB" which blocks operation until the initialization is complete. You must implement the polling read with an immediate

access. If the value of the RTD polling read is 32767, you must repeat the read until the value changes. For each module, use only the input channel with the greatest value for the RTD polling read. For example, if input channel number 2 is the highest used input channel, you should execute the RTD polling read on channel number 2. The module initializes the channels in order from 0 to 3.

Representation of analog values for RTDs

A representation of the digitized measured value for the RTD standard temperature range sensors is shown in the table below:

Table 1-287 Representation of analog values for resistance temperature detectors PT 100, 200, 500, 1000 and PT 10, 50, 100, 500 GOST (0.003850) standard

Pt x00 standard in °C[1]	Units		Pt x00 standard in °F[1]	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	Over-range
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	Rated range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	Under-range
< -243.0	-32768	8000	< -405.4	-32768	8000	Underflow

[1] A value change of 1 indicates a temperature change of +/- one-tenth degree.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SM 1231 AI 4xRTD

X10: Upper user wiring terminal (Light gray, Type-B keying)

Signal	Pin #		Signal
AI I0+	1	2	AI I1+
AI I0-	3	4	AI I1-
AI M0+	5	6	AI M1+
AI M0-	7	8	AI M1-
	9	10	

X11: Lower user wiring terminal (Light gray, Type-B keying)

Signal	Pin #		Signal
L+	1	2	M
AI I2+	3	4	AI I3+

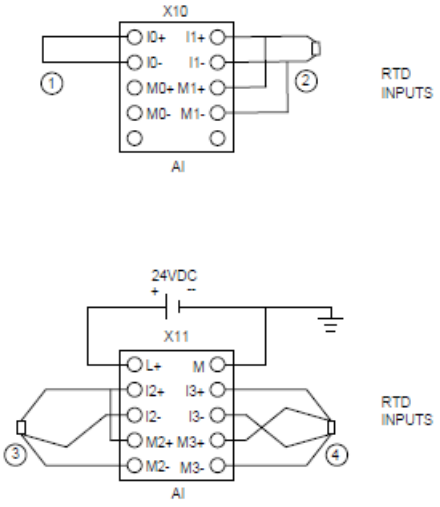
① Loop-back unused RTD inputs

② 2-wire RTD connection represented

③ 3-wire RTD connection represented

④ 4-wire RTD connection represented

SM 1231 AI 4xRTD



AI I2-	5	6	AI I3-
AI M2+	7	8	AI M3+
AI M2-	9	10	AI M3-

① Loop-back unused RTD inputs

② 2-wire RTD connection represented

③ 3-wire RTD connection represented

④ 4-wire RTD connection represented

NOTE

You can deactivate unused RTD channels. Deactivated channels do not report errors.
To avoid extra stabilization time, which is automatically added to an active unused channel, make the current loop continuous. For consistency, connect a resistor like the 2-wire RTD connection to the RTD module.

A.9 Digital signal boards (SBs)

A.9.1 SB 1221 DI 8x24VDC

Table 1-288 General specifications

Technical data	SB 1221 DI 8x24VDC
Article number	6ES7221-3BF50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	26 grams / 53 grams
Power dissipation	2.4 W
Current consumption (bus)	108 mA max. (5 V DC)
Current consumption (24 V DC)	6 mA / input used
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-289 Digital inputs

Technical data	SB 1221 DI 8x24VDC
Number of inputs	8, in 1 isolation group of 8 inputs
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 5.8 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0,12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0
HSC clock input rates (Logic 1 Level = 15 to 30 V DC)	Single phase: 100 kHz max. Quadrature phase: 80 kHz max.
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

NOTE

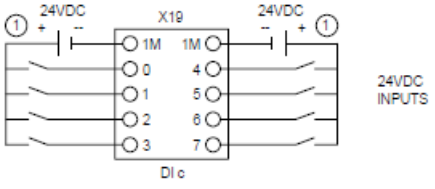
When switching frequencies above 20 kHz, you must have a clean square wave. Consider the following options to improve the signal quality:

- Minimize the cable length.
- Change the driver from a sink or source only to a push-pull driver.
- Change to a higher quality cable.
- Reduce the circuit/components from 24 V to 5 V.
- Add an external load at the input.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1221 DI 8x24VDC



X19: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
1M	1	2	1M
DI c.0	3	4	DI c.4
DI c.1	5	6	DI c.5
DI c.2	7	8	DI c.6
DI c.3	9	10	DI c.7

① For sinking inputs, connect "-" to "M" (shown). For sourcing inputs, connect "+" to "M".

A.9.2 SB 1222 DQ 8x24VDC

Table 1-290 General specifications

Technical data	SB 1222 DQ 8x24VDC
Article number	6ES7222-5BF50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	29 grams / 53 grams
Power dissipation	1.0 W
Current consumption (bus)	30 mA max. (5 V DC)
Current consumption (24 V DC)	15 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-291 Digital outputs

Technical data	SB 1222 DQ 8x24VDC
Number of outputs	8, in 1 isolation group of 8 outputs
Type	Push-pull
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	L+ minus 1.5 V
Logic 0 signal at max. current	1.0 V DC max.

Technical data	SB 1222 DQ 8x24VDC
Current	0.1 A max.
ON state resistance	6 Ω max.
OFF state resistance	10 Ω max.
Leakage current per point	10 µA max.
Pulse Train Output (PTO) rate	100 kHz max., 2 Hz min.
Overload protection	Yes
Isolation (field side to logic)	707 V DC (type test)
Current per common	0.8 A max.
Inductive clamp voltage	0 V, 1 W dissipation
Switching delay	1.5 µs + 300 ns rise 1.5 µs + 300 ns fall
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded, 50 m shielded for PTO outputs
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

NOTE

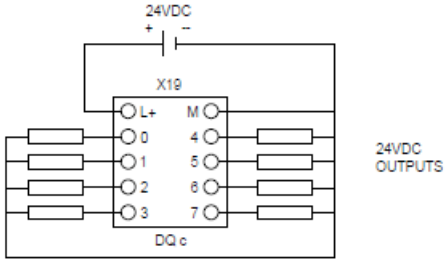
When switching frequencies above 20 kHz, you must have a clean square wave. Consider the following options to improve the signal quality:

- Minimize the cable length.
- Change the driver from a sink or source only to a push-pull driver.
- Change to a higher quality cable.
- Reduce the circuit/components from 24 V to 5 V.
- Add an external load at the input.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1222 DQ 8x24VDC



X19: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
L+	1	2	M
DQ c.0	3	4	DQ c.4
DQ c.1	5	6	DQ c.5
DQ c.2	7	8	DQ c.6
DQ c.3	9	10	DQ c.7

⚠ WARNING

Risk of current leakage from ungrounded connections
Loss of the ground wire connection to the high-speed DQ SBs can allow enough leakage current to activate a DC load resulting in unexpected equipment operation.
Ensure that the M connection wire is securely grounded. If the outputs are used for critical DC load applications, exercise extra caution by using a redundant ground wire to the SB.
Unexpected equipment operation can result in property damage, severe personal injury, and death.

A.9.3 SB 1223 DI 4x24VDC / DQ 4x24VDC

Table 1-292 General specifications

Technical data	SB 1223 DI 4x24VDC / DQ 4x24VDC
Article number	6ES7223-7BF50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	28 grams / 55 grams
Power dissipation	1.7 W
Current consumption (bus)	48 mA max. (5 V DC)
Current consumption (24 V DC)	15 mA plus 6 mA / input used
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-293 Digital inputs

Technical data	**SB 1223 DI 4x24VDC / DQ 4x24VDC**
Number of inputs	4, in 1 isolation group of 4 inputs (no isolation inputs to outputs)
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 V DC at 4 mA nominal
Continuous permissible voltage	30 V DC max.
Logic 1 signal	15 V DC min. at 2.5 mA
Logic 0 signal	5 V DC max. or 0.5 mA
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0
HSC clock input rates (Logic 1 Level = 15 to 30 V DC)	Single phase: 100 kHz max. Quadrature phase: 80 kHz max.
Cable length	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

Table 1-294 Digital outputs

Technical data	**SB 1223 DI 4x24VDC / DQ 4x24VDC**
Number of outputs	4, in 1 isolation group of 4 outputs (no isolation outputs to inputs)
Type	Push-pull
Rated voltage	24 V DC
Voltage range	20.4 to 28.8 V DC
Logic 1 signal at max. current	L+ minus 1.5 V
Logic 0 signal at max. current	1.0 V DC max.
Current	0.1 A max.
ON state resistance	6 Ω max.
OFF state resistance	10 Ω max.
Leakage current per point	10 µA max.
Pulse Train Output (PTO) rate	100 kHz max., 2 Hz min.
Overload protection	Yes
Isolation (field side to logic)	707 V DC (type test)
Current per common	0.4 A max.
Inductive clamp voltage	0 V, 1 W dissipation
Switching delay	1.5 µs + 300 ns rise 1.5 µs + 300 ns fall
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	Yes
Parallel outputs for increased load	No
Diagnostics	24 V DC low voltage
Cable length	500 m shielded, 150 m unshielded, 50 m shielded for PTO outputs
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

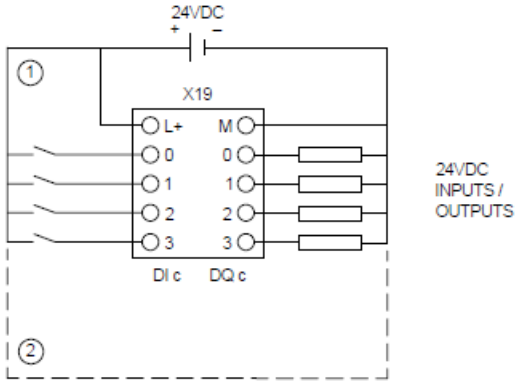
NOTE
When switching frequencies above 20 kHz, you must have a clean square wave. Consider the following options to improve the signal quality:

- Minimize the cable length.
- Change the driver from a sink or source only to a push-pull driver.
- Change to a higher quality cable.
- Reduce the circuit/components from 24 V to 5 V.
- Add an external load at the input.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1223 DI 4x24VDC / DQ 4x24VDC



X19: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
L+	1	2	M
DI c.0	3	4	DQ c.0
DI c.1	5	6	DQ c.1
DI c.2	7	8	DQ c.2
DI c.3	9	10	DQ c.3

① Wire the input common to (+) when configuring sinking inputs in TIA Portal (shown).

② Wire the input common to (-) when configuring sourcing inputs in TIA Portal.

⚠ WARNING

Risk of current leakage from ungrounded connections
Loss of the ground wire connection to the high-speed DQ SBs can allow enough leakage current to activate a DC load resulting in unexpected equipment operation.
Ensure that the M connection wire is securely grounded. If the outputs are used for critical DC load applications, exercise extra caution by using a redundant ground wire to the SB.
Unexpected equipment operation can result in property damage, severe personal injury, and death.

A.9.4 SB 1223 DI 4x5VDC / DQ 4x5VDC

Table 1-295 General specifications

Technical data	SB 1223 DI 4x5VDC / DQ 4x5VDC
Article number	6ES7223-7AF50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	28 grams / 55 grams
Power dissipation	1.0 W
Current consumption (bus)	60 mA max. (5 V DC)
Current consumption (5 V DC)	12 mA plus 15 mA per point used (source)
Rated supply voltage	5 V DC
Supply voltage range	4.25 to 6 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-296 Digital inputs

Technical data	SB 1223 DI 4x5VDC / DQ 4x5VDC
Number of inputs	4, in 1 isolation group of 4 inputs (no isolation inputs to outputs)
Type	Source
Rated voltage	5 V DC at 15 mA nominal
Continuous permissible voltage	6 V DC max.
Logic 1 signal	0 V (20 mA) to L+ minus 2.0 V (5.1 mA) min.
Logic 0 signal	L+ minus 1.0 V (2.2 mA) to L+ (0 mA) max.
Isolation (field side to logic)	707 V DC (type test)
Filter times (selectable by channel)	µs settings: 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0 ms settings: 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 10.0, 12.8, 20.0
HSC clock input rates (Logic 1 Level = 2.5 to 6 V DC)	Single phase: 200 kHz max. Quadrature phase: 160 kHz max.
Cable length	50 m shielded twisted pair
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

Table 1-297 Digital outputs

Technical data	SB 1223 DI 4x5VDC / DQ 4x5VDC
Number of outputs	4, in 1 isolation group of 4 outputs (no isolation outputs to inputs)
Type	Push-pull
Rated voltage	5 V DC
Voltage range	4.25 to 6.0 V DC
Logic 1 signal at max. current	L+ minus 0.7 V
Logic 0 signal at max. current	0.2 V DC max.
Current	0.1 A max.

Technical data	SB 1223 DI 4x5VDC / DQ 4x5VDC
ON state resistance	7 Ω max.
OFF state resistance	0.2 Ω max.
Pulse Train Output (PTO) rate	200 kHz max., 2 Hz min.
Overload protection	No
Isolation (field side to logic)	707 V DC (type test)
Current per common	0.4 A max.
Switching delay	200 ns + 300 ns rise 200 ns + 300 ns fall
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Control of a digital input	Yes
Parallel outputs for redundant load control	No
Parallel outputs for increased load	No
Diagnostics	5 V DC low voltage
Cable length	50 m shielded twisted pair
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

NOTE

When switching frequencies above 20 kHz, you must have a clean square wave. Consider the following options to improve the signal quality:

- Minimize the cable length.
- Change the driver from a sink or source only to a push-pull driver.
- Change to a higher quality cable.
- Add an external load at the input.

Wiring diagram

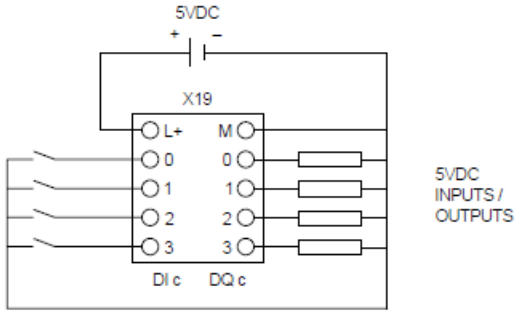
The wiring diagram and pin connector locations are shown below:

SB 1223 DI 4x5VDC / DQ 4x5VDC

X19: Upper User Wiring Terminal (Gray, No Keying)

Signal	Pin #		Signal
L+	1	2	M
DI c.0	3	4	DQ c.0
DI c.1	5	6	DQ c.1

SB 1223 DI 4x5VDC / DQ 4x5VDC



DI c.2	7	8	DQ c.2
DI c.3	9	10	DQ c.3

A.10 Analog signal boards (SBs)

A.10.1 SB 1231 AI 4x14bit

Table 1-298 General specifications

Technical data	SB 1231 AI 4x14bit
Article number	6ES7231-4HD50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	30 grams / 57 grams
Power dissipation	1.4 W
Current consumption (bus)	28 mA max. (5 V DC)
Current consumption (24 V DC)	30 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-299 Analog inputs

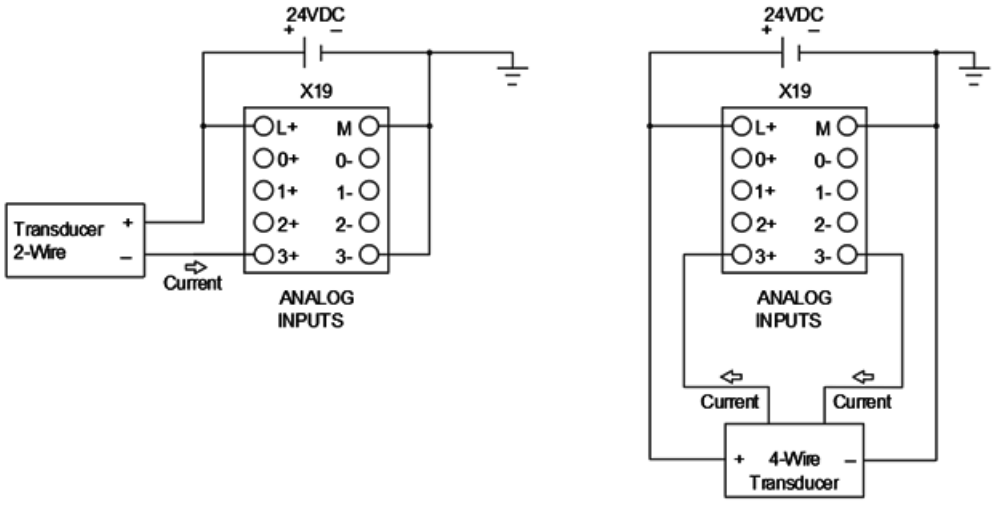
Technical data	**SB 1231 AI 4x14bit**	
Number of inputs	4	
Type	Voltage or current (differential)	
Range	±10 V, ±5 V, ±2.5 V, 0 to 20 mA or 4 to 20 mA	
Full scale range (data word)	-27648 to 27648 voltage / 0 to 27648 current	
Overshoot/undershoot range (data word)	Voltage: 32511 to 27649 / -27649 to -32512 Current: 32511 to 27649 / 0 to -4864	
Overflow/underflow (data word)	Voltage: 32767 to 32512 / -32513 to -32768 Current 0 to 20 mA: 32767 to 32512 / -4865 to -32768 Current 4 to 20 mA: 32767 to 32512 (values below -4864 indicate open wire)	
Resolution	13 bits plus sign bit	
Maximum withstand voltage/current	±35 V / ±40 mA	
Smoothing	None, weak, medium, or strong	
Noise rejection	400, 60, 50, or 10 Hz	
Input impedance	Before parameterization	>= 1 MΩ
	Voltage	>= 1 MΩ
	Current	< 290 Ω, > 270 Ω
Isolation	Field side to logic	None
	Logic to 24 V DC	None
	Field side to 24 V DC	None
	Channel to channel	None
Accuracy[1] (25 °C / -20 to 60 °C)	±0.1% / ±0.2% of full scale	
Measuring principle	Actual value conversion	
Common mode rejection	40 dB, DC to 60 Hz	
Operational signal range[2]	Signal plus common mode voltage must be less than +12 V and greater than -12 V	
Diagnostics	Overflow/underflow	
	24 V DC low voltage	
	Open wire, 4 to 20 mA range only (if input is below -4864; 1.185 mA)	
Cable length	100 m, twisted and shielded	
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)	
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)	

[1] The presence of radio frequencies of 500 MHz to 600 MHz can degrade accuracy.

[2] Voltages outside the operational range applied to one channel can cause interference on other channels.

Current measurement

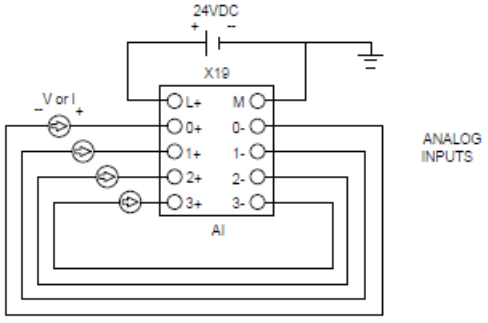
You can implement current measurement with either a 2-wire transducer or a 4-wire transducer as shown below:



Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1231 AI 4x14bit



X19: Upper user wiring terminal (Light gray, No keying)

Signal	Pin #		Signal
L+	1	2	M
AI 0+	3	4	AI 0-
AI 1+	5	6	AI 1-
AI 2+	7	8	AI 2-
AI 3+	9	10	AI 3-

NOTE

When wiring and configuring analog input channels consider the following:

- Connect the positive input terminal to the negative input terminal on each unused voltage input channel.
- Set unused current input channels to the 0 to 20 mA range and/or disable broken wire error reporting.

Inputs configured for current mode do not conduct loop current if the module is not powered and configured.

Current input channels are operable only when you supply external power to the transmitter.

A.10.2 SB 1232 AQ 4x14bit

Table 1-300 General specifications

Technical data	SB 1232 AQ 4x14bit
Article number	6ES7232-4HD50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	28 grams / 55 grams
Power dissipation	3.0 W
Current consumption (bus)	25 mA max. (5 V DC)
Current consumption (24 V DC)	30 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	SB 1232 AQ 4x14bit
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-301 Analog outputs

Technical data	SB 1232 AQ 4x14bit
Number of outputs	4
Type	Voltage or current
Range	±10 V, 0 to 20 mA, or 4 to 20 mA
Resolution	Voltage: 14 bits Current: 13 bits
Full scale range (data word)	Voltage: -27648 to 27648 Current: 0 to 27648
Accuracy (25 °C / -20 to 60 °C)	±0.3% / ±0.6% of full scale
Settling time (95% of new value)	Voltage: 300 µs (R), 750 µs (1 µF) Current: 600 µs (1 mH), 2 ms (10 mH)
Load impedance	Voltage: >= 1000 Ω Current: <= 600 Ω
Maximum output short circuit current	Voltage: <= 24 mA Current: <= 24 mA
Behavior on RUN to STOP	Last value or substitute value (default value 0)
Isolation (field side to logic)	None
Isolation (24 V to output)	None
Diagnostics	Overflow/underflow
	Short to ground (voltage mode only)[1]
	Wire break (current mode only)[2]
	24 V DC low voltage
Cable length	100 m, twisted and shielded
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

[1] Short circuit detection is only possible when the output voltage is less than -0.5 V or greater than +0.5 V.

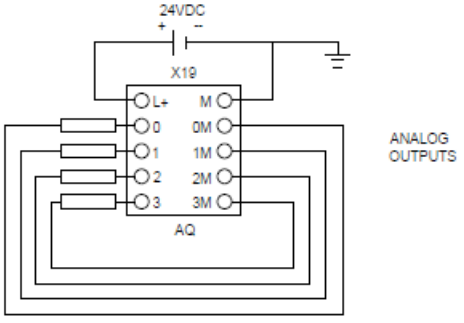
[2] Wire break detection is only possible when the output current is greater than 1 mA.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1232 AQ 4x14bit				
	X19: Upper User Wiring Terminal (Light Gray, No Keying)			
	Signal	Pin #		Signal
	L+	1	2	M
	AQ 0	3	4	AQ 0M
	AQ 1	5	6	AQ 1M

SB 1232 AQ 4x14bit



AQ 2	7	8	AQ 2M
AQ 3	9	10	AQ 3M

A.10.3 SB 1233 AI 2x14bit / AQ 2x14bit

Table 1-302 General specifications

Technical data	SB 1233 AI 2x14bit / AQ 2x14bit
Article number	6ES7233-4HD50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	30 grams / 57 grams
Power dissipation	2.0 W
Current consumption (bus)	29 mA max. (5 V DC)
Current consumption (24 V DC)	25 mA
Rated supply voltage	24 V DC
Supply voltage range	20.4 to 28.8 V DC
Reverse supply voltage protection	Yes
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-303 Analog inputs

Technical data	SB 1233 AI 2x14bit / AQ 2x14bit
Number of inputs	2
Type	Voltage or current (differential)
Range (Page 445)	±10 V, ±5 V, ±2.5 V, 0 to 20 mA or 4 to 20 mA
Full scale range (data word)	-27648 to 27648 voltage / 0 to 27648 current

[1] Voltages outside the operational range applied to one channel can cause interference on other channels.

Technical data	SB 1233 AI 2x14bit / AQ 2x14bit	
Overshoot/undershoot range (data word)	Voltage: 32511 to 27649 / -27649 to -32512 Current: 32511 to 27649 / 0 to -4864	
Overflow/underflow (data word)	Voltage: 32767 to 32512 / -32513 to -32768 Current 0 to 20 mA: 32767 to 32512 / -4865 to -32768 Current 4 to 20 mA: 32767 to 32512 (values below -4864 indicate open wire)	
Resolution	13 bits plus sign bit	
Maximum withstand voltage/current	±35 V / ±40 mA	
Smoothing	None, weak, medium, or strong	
Noise rejection	400, 60, 50, or 10 Hz	
Input impedance	Before parameterization	>= 1 MΩ
	Voltage	>= 1 MΩ
	Current	< 290 Ω, > 270 Ω
Isolation	Field side to logic	None
	Logic to 24 V DC	None
	Field side to 24 V DC	None
	Channel to channel	None
Accuracy (25 °C / -20 to 60 °C)	±0.1% / ±0.2% of full scale	
Measuring principle	Actual value conversion	
Common mode rejection	40 dB, DC to 60 Hz	
Operational signal range[1]	Signal plus common mode voltage must be less than +12 V and greater than -12 V	
Diagnostics	Overflow/underflow	
	24 V DC low voltage	
	Open wire, 4 to 20 mA range only (if input is below -4864; 1.185 mA)	
Cable length	100 m, twisted and shielded	
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)	
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)	

[1] Voltages outside the operational range applied to one channel can cause interference on other channels.

Table 1-304 Analog outputs

Technical data	SB 1233 AI 2x14bit / AQ 2x14bit
Number of outputs	2
Type	Voltage or current
Range (Page 446)	±10 V, 0 to 20 mA, or 4 to 20 mA
Resolution	Voltage: 14 bits Current: 13 bits
Full scale range (data word)	Voltage: -27648 to 27648 Current: 0 to 27648
Accuracy (25 °C / -20 to 60 °C)	±0.3% / ±0.6% of full scale
Settling time (95% of new value)	Voltage: 300 µs (R), 750 µs (1 µF) Current: 600 µs (1 mH), 2 ms (10 mH)
Load impedance	Voltage: >= 1000 Ω Current: <= 600 Ω
Maximum output short circuit current	Voltage: <= 24 mA Current: <= 24 mA
Behavior on RUN to STOP	Last value or substitute value (default value 0)

[1] Short circuit detection is only possible when the output voltage is less than -0.5 V or greater than +0.5 V.

[2] Wire break detection is only possible when the output current is greater than 1 mA.

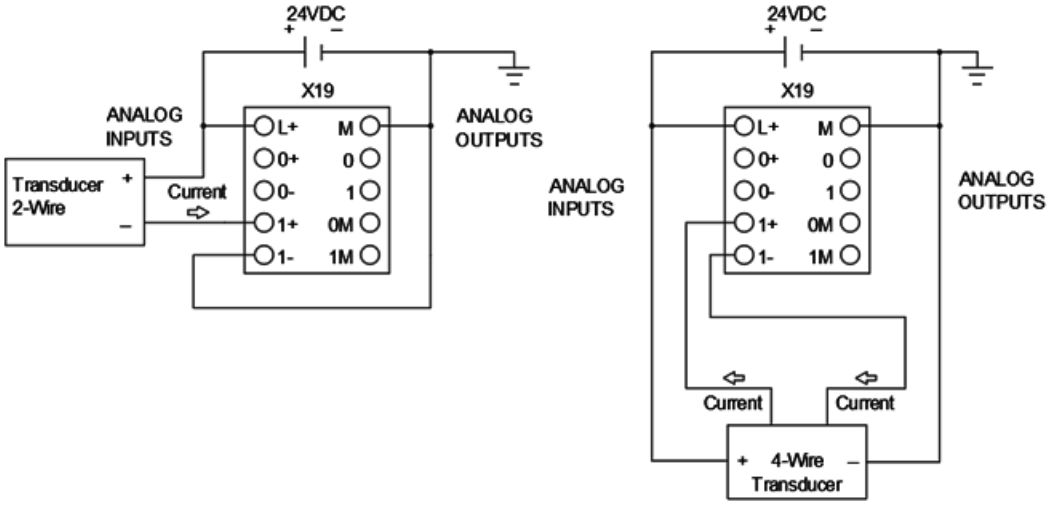
Technical data	SB 1233 AI 2x14bit / AQ 2x14bit
Isolation (field side to logic)	None
Isolation (24 V to output)	None
Diagnostics	Overflow/underflow
	Short to ground (voltage mode only)[1]
	Wire break (current mode only)[2]
	24 V DC low voltage
Cable length	100 m, twisted and shielded
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)

[1] Short circuit detection is only possible when the output voltage is less than -0.5 V or greater than +0.5 V.

[2] Wire break detection is only possible when the output current is greater than 1 mA.

Current measurement

You can implement current measurement with either a 2-wire transducer or a 4-wire transducer as shown below:

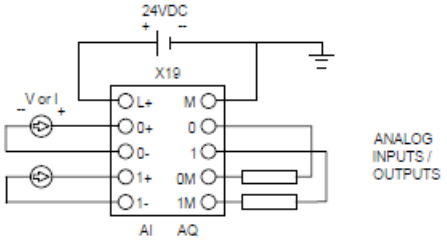


Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1233 AI 2x14bit / AQ 2x14bit				
	X19: Upper User Wiring Terminal (Light Gray, No Keying)			
	Signal	Pin #		Signal
	L+	1	2	M
	AI 0+	3	4	AQ 0
	AI 0-	5	6	AQ 1

SB 1233 AI 2x14bit / AQ 2x14bit



AI 1+	7	8	AQ 0M
AI 1-	9	10	AQ 1M

NOTE

When wiring and configuring analog input channels consider the following:

- Connect the positive input terminal to the negative input terminal on each unused voltage input channel.
- Set unused current input channels to the 0 to 20 mA range and/or disable broken wire error reporting.

Inputs configured for current mode do not conduct loop current if the module is not powered and configured.

Current input channels are operable only when you supply external power to the transmitter.

A.10.4 Step response of the analog inputs

Table 1-305 Step response (ms), 0 to full scale measured at 95%

Smoothing selection (sample averaging)	Noise reduction/rejection frequency (Integration time selection)			
	400 Hz (2.5 ms)	60 Hz (16.6 ms)	50 Hz (20 ms)	10 Hz (100 ms)
None (1 cycle): No averaging	4 ms	18 ms	22 ms	100 ms
Weak (4 cycles): 4 samples	9 ms	52 ms	63 ms	320 ms
Medium (16 cycles): 16 samples	32 ms	203 ms	241 ms	1200 ms
Strong (32 cycles): 32 samples	61 ms	400 ms	483 ms	2410 ms

A.10.5 Sample time and update times for the analog inputs

Table 1-306 Sample time and update times

Rejection frequency (Integration time)	Sample and board update times for all channels			
	400 Hz (2.5 ms)	60 Hz (16.6 ms)	50 Hz (20 ms)	10 Hz (100 ms)
2 or 4 channels	0.625 ms	4.17 ms	5 ms	25 ms

A.10.6 Measurement ranges of the analog inputs for voltage and current

Table 1-307 Analog input representation for voltage

System		Voltage measuring range				
Decimal	Hexadecimal	+/- 10 V	+/- 5 V	+/- 2.5 V	+/- 1.25 V	
32767	7FFF[1]	11.851 V	5.926 V	2.963 V	1.481 V	Overflow
32512	7F00					
32511	7EFF	11.759 V	5.879 V	2.940 V	1.470 V	Overshoot range
27649	6C01					
27648	6C00	10 V	5 V	2.5 V	1.250 V	Rated range
20736	5100	7.5 V	3.75 V	1.875 V	0.938 V	
1	1	361.7 µV	180.8 µV	90.4 µV	45.2 µV	
0	0	0 V	0 V	0 V	0 V	
-1	FFFF					
-20736	AF00	-7.5 V	-3.75 V	-1.875 V	-0.938 V	
-27648	9400	-10 V	-5 V	-2.5 V	-1.250 V	
-27649	93FF					Under-shoot range
-32512	8100	-11.759 V	-5.879 V	-2.940 V	-1.470 V	
-32513	80FF					Underflow
-32768	8000	-11.851 V	-5.926 V	-2.963 V	-1.481 V	

[1] The channel can return 7FFF for one of the following reasons: overflow (as noted in this table), before valid values are available (for example, immediately upon a power up), or if a wire break is detected.

Table 1-308 Analog input representation for current

System		Current measuring range		
Decimal	Hexadecimal	0 mA to 20 mA	4 mA to 20 mA	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Undershoot range

[1] The wire break value of 32767 (16#7FFF) is always returned regardless of the state of the wire break alarm.

System		Current measuring range		
Decimal	**Hexadecimal**	**0 mA to 20 mA**	**4 mA to 20 mA**	
-4864	ED00	-3.52 mA	1.185 mA	Undershoot range
32767[1]	7FFF		< 1.185 mA	Wire break (4 to 20 mA)
-32768	8000	< -3.52 mA		Underflow (0 to 20 mA)

[1] The wire break value of 32767 (16#7FFF) is always returned regardless of the state of the wire break alarm.

A.10.7 Measurement ranges of the analog outputs for voltage and current

Table 1-309 Analog output representation for voltage

System		Voltage output range	
Decimal	**Hexadecimal**	**+/- 10 V**	
32767	7FFF	See note 1	Overflow
32512	7F00	See note 1	
32511	7EFF	11.76 V	Overshoot range
27649	6C01		
27648	6C00	10 V	Rated range
20736	5100	7.5 V	
1	0001	361.7 µV	
0	0000	0 V	
-1	FFFF	-361.7 µV	
-20736	AF00	-7.5 V	
-27648	9400	-10 V	
-27649	93FF		Undershoot range
-32512	8100	-11.76 V	
-32513	80FF	See note 1	Underflow
-32768	8000	See note 1	

[1] In an overflow or underflow condition, analog outputs take on the substitute value of the STOP mode.

Table 1-310 Analog output representation for current

System		Current output range		
Decimal	**Hexadecimal**	**0 mA to 20 mA**	**4 mA to 20 mA**	
32767	7FFF	See note 1	See note 1	Overflow
32512	7F00	See note 1	See note 1	
32511	7EFF	23.52 mA	22.81 mA	Overshoot range
27649	6C01			
27648	6C00	20 mA	20 mA	Rated range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF		4 mA to 578.7 nA	Undershoot range
-6912	E500		0 mA	
-6913	E4FF			Not possible. Output

[1] In an overflow or underflow condition, analog outputs take on the substitute value of the STOP mode.

System		Current output range		
Decimal	Hexadecimal	0 mA to 20 mA	4 mA to 20 mA	
-32512	8100			value limited to 0 mA.
-32513	80FF	See note 1	See note 1	Underflow
-32768	8000	See note 1	See note 1	

[1] In an overflow or underflow condition, analog outputs take on the substitute value of the STOP mode.

A.10.8 Basic operation of a thermocouple

A thermocouple is formed whenever two dissimilar metals are electrically bonded to each other. A voltage is generated across the bonded junction that is proportional to the junction temperature. This voltage is small; one microvolt could represent many degrees. Measuring the voltage from a thermocouple, compensating for extra junctions, and then linearizing the result forms the basis of temperature measurement using thermocouples.

The place where the two dissimilar wires are attached to each other forms the sensor thermocouple. The other ends of the thermocouple wires are each attached to a module or board at the signal connector.

Two more thermocouples are formed where the two wires are attached to the signal connector. The connector temperature causes a voltage that adds to the voltage from the sensor thermocouple. If this voltage is not corrected, then the temperature reported will deviate from the sensor temperature.

Cold junction compensation is used to compensate for the connector thermocouples. Thermocouple tables are based on a reference junction temperature, usually zero degrees Celsius. The cold junction compensation compensates the connector to zero degrees Celsius.

The cold junction compensation restores the voltage added by the connector thermocouples. The temperature of the module or board is measured internally, and then converted to a value to be added to the sensor conversion. The corrected sensor conversion is then linearized using the thermocouple tables.

For optimum operation of the cold junction compensation, the thermocouple module or board must be located in a thermally stable environment. Slow variation (less than 0.1 °C/minute) in ambient temperature is correctly compensated within the module or board specifications. Air movement across the module or board will also cause cold junction compensation errors.

If better cold junction error compensation is needed, an external iso-thermal terminal block can be used. The thermocouple board provides for use of a 0 °C referenced or 50 °C referenced terminal block.

A.10.9 SB 1231 AI 4xTC

Table 1-311 General specifications

Technical data	SB 1231 AI 4xTC
Article number	6ES7231-5QD50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	29 grams / 56 grams
Power dissipation	0.4 W
Current consumption (bus)	65 mA max. (5 V DC)

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Technical data	SB 1231 AI 4xTC
Current consumption (24 V DC)	None
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-312 Analog inputs

Technical data	SB 1231 AI 4xTC	
Number of inputs	4	
Sensor types	J, K, T, E, R & S, B, N, C, TXK/XK(L), voltage	
Ranges	See Selection tables for thermocouple sensors.	
Resolution	Temperature	0.1 °C / 0.1 °F
	Voltage	15 bits plus sign
Maximum withstand voltage	±35 V	
Noise rejection	85 dB for selected filter setting (10 Hz, 50 Hz, 60 Hz or 400 Hz)	
Common mode rejection	> 120 dB at 120 V AC	
Impedance	>= 10 MΩ	
Isolation	Field side to logic	707 V DC (type test)
	Logic to 24 V DC	707 V DC (type test)
	Field side to 24 V DC	707 V DC (type test)
	Channel to channel	120 V AC
Accuracy	See Selection tables for thermocouple sensors.	
Repeatability	±0.05% of full scale	
Measuring principle	Integrating	
Board update time	See Noise reduction and update times for the Thermocouple board.	
Cold junction error (Page 447)	±1.5 °C	
Wire resistance	100 Ω max.	
Diagnostics	Overflow/underflow[1]	
	Wire break[2, 3]	
Cable length	100 m to sensor max.	
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)	
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)	

[1] The overflow and underflow diagnostic alarm information is reported in the analog data values even if the alarms are disabled in the board configuration.

[2] When wire break alarm is disabled and an open wire condition exists in the sensor wiring, the board can report random values.

[3] The board performs wire break testing every 6 seconds, which extends the update time by 9 ms for each enabled channel once every 6 seconds.

The SB 1231 Thermocouple (TC) analog signal board measures the value of voltage connected to the board inputs. The temperature measurement type can be either "Thermocouple" or "Voltage".

- "Thermocouple": The value is reported in degrees multiplied by ten. (For example, 25.3 degrees is reported as decimal 253).
- "Voltage": The nominal range full scale value is decimal 27648.

Selection tables for thermocouple sensors

Table 1-313 Thermocouple selection table

Type	Under-range minimum[1]	Nominal range low limit	Nominal range high limit	Over-range maximum[2]	Normal range accuracy @ 25 °C[3]	Normal range accuracy -20 °C to 60 °C[1, 2, 5]
J	-210.0 °C -346.0 °F	-150.0 °C -238.0 °F	1200.0 °C 2192.0 °F	1450.0 °C 2642.0 °F	±0.3 °C ±0.5 °F	±1.2 °C ±2.2 °F
K	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1372.0 °C 2501.6 °F	1622.0 °C 2951.6 °F	±0.4 °C ±0.7 °F	±2.0 °C ±3.6 °F
T	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	400.0 °C 752.0 °F	540.0 °C 1004.0 °F	±0.5 °C ±0.9 °F	±1.0 °C ±1.8 °F
E	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1000.0 °C 1832.0 °F	1200.0 °C 2192.0 °F	±0.3 °C ±0.5 °F	±0.6 °C ±1.1 °F
R & S	-50.0 °C -58.0 °F	100.0 °C 212.0 °F	1768.0 °C 3214.4 °F	2019.0 °C 3276.6 °F[4]	±1.0 °C ±1.8 °F	±2.5 °C ±4.5 °F
B	0.0 °C 32.0 °F -- --	200.0 °C 392.0 °F 800.0 °C 1472.0 °F	800.0 °C 1472.0 °F 1820.0 °C 3276.6 °F[4]	-- -- 1820.0 °C 3276.6 °F[4]	±2.0 °C ±3.6 °F ±1.0 °C ±1.8 °F	±2.5 °C ±4.5 °F ±2.3 °C ±4.1 °F
N	-270.0 °C -454.0 °F	-200.0 °C -328.0 °F	1300.0 °C 2372.0 °F	1550.0 °C 2822.0 °F	±1.0 °C ±1.8 °F	±1.6 °C ±2.9 °F
C	0.0 °C 32.0 °F	100.0 °C 212.0 °F	2315.0 °C 3276.6 °F[4]	2500.0 °C 3276.6 °F[4]	±0.7 °C ±1.3 °F	±4.5 °C ±8.1 °F
TXK/XK(L)	-200.0 °C -328.0 °F	-150.0 °C 302.0 °F	800.0 °C 1472.0 °F	1050.0 °C 1922.0 °F	±0.6 °C ±1.1 °F	±1.2 °C ±2.2 °F
Voltage	-32512	-27648 -80mV	27648 80mV	32511	±0.05%	±0.1%

[1] Thermocouple values below the under-range minimum value are reported as -32768.

[2] Thermocouple values above the over-range maximum value are reported as 32767.

[3] Internal cold junction error is ±1.5 °C for all ranges. This adds to the error in this table. The board requires at least 30 minutes of warm-up time to meet this specification. For board ambient temperatures below -10 °C, internal cold junction error can be greater than 1.5 °C.

[4] Lower limit of 3276.6 °F with °F reporting

[5] Cold junction compensation error has not been characterized for board ambient temperatures below 0 °C, and can exceed the specified value.

NOTE

You can configure each channel on the Thermocouple signal board with a different thermocouple type (selectable in the software during configuration of the board).

Table 1-314 Noise reduction and update times for the Thermocouple board

Rejection frequency selection	Integration time	Board update time (seconds)
400 Hz (2.5 ms)	10 ms[1]	0.285
60 Hz (16.67 ms)	16.67 ms	0.445
50 Hz (20 ms)	20 ms	0.525
10 Hz (100 ms)	100 ms	2.450

[1] To maintain resolution and accuracy when the 400 Hz filter is selected, the integration time is 10 ms. This selection also rejects 100 Hz and 200 Hz noise.

Siemens recommends using a 100 ms integration time for measuring thermocouples. The use of smaller integration times increases the repeatability error of the temperature readings.

Internal calibration

After power is applied, the board performs internal calibration for the analog-to-digital converter. During this time, the board reports a value of 32767 on each channel until the channel provides valid data. The STEP 7 program might need to allow for this initialization time. Because the initialization time varies based on the board's configuration, you must verify the behavior of the board in your system. If required, you can include logic in the STEP 7 program to accommodate the initialization time of the board.

You can implement this logic using a polling read in the "Startup OB" which blocks operation until the initialization is complete. You must implement the polling read with an immediate access. If the value of the thermocouple polling read is 32767, you must repeat the read until the value changes. For each board, use only the input channel with the greatest value for the thermocouple polling read. For example, if input channel number 2 is the highest used input channel, you should execute the thermocouple polling read on channel number 2. The board initializes the channels in order from 0 to 3.

Representation of analog values for Thermocouple Type J

A representation of the analog values of thermocouple type J is shown in the table below:

Table 1-315 Representation of analog values of thermocouple type J

Type J in °C[1]	Units		Type J in °F[1]	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.2	26420 : 21922	6734 : 55A2	Over-range
1200.0 : -150	12000 : 1500	2EE0 : FA24	2192.0 : -238.0	21920 : -2380	55A0 : F6B4	Rated range
-150.1 : -210	-1501 : -2100	FA23 : F7CC	-238.1 : -346.0	-2381 : -3460	F6B3 : F27C	Under-range
< -210.0	-32768	8000	< -346.0	-32768	8000	Underflow[2]

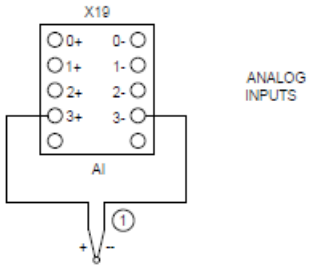
[1] A value change of 1 indicates a temperature change of +/- one-tenth degree.

[2] Faulty wiring (for example, polarity reversal, or open inputs) or sensor error in the negative range (for example, wrong type of thermocouple) can cause the thermocouple module to signal underflow.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1231 AI 4xTC



X19: Upper user wiring terminal (Light gray, No keying)

Signal	Pin #		Signal
AI 0+	1	2	AI 0-
AI 1+	3	4	AI 1-
AI 2+	5	6	AI 2-
AI 3+	7	8	AI 3-
	9	10	

① TC 0, 1, and 2 are not shown connected for clarity.

NOTE

Connect the positive input terminal to the negative input terminal on each unused TC input channel. You can deactivate unused thermocouple channels. Deactivated channels do not report errors.

A.10.10 SB 1231 AI 2xRTD

Table 1-316 General specifications

Technical data	SB 1231 AI 2xRTD
Article number	6ES7231-5PB50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	29 grams / 56 grams
Power dissipation	0.3 W
Current consumption (bus)	50 mA max. (5 V DC)
Current consumption (24 V DC)	None
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

Table 1-317 Analog inputs

Technical data	SB 1231 AI 2xRTD	
Number of inputs	2	
Sensor types	See Selection table for RTD sensors.	
Ranges	See Selection table for RTD sensors.	
Resolution	Temperature	0.1 °C / 0.1 °F
	Resistance	15 bits plus sign
Maximum withstand voltage	±35 V	
Noise rejection	85 dB for the selected noise reduction (10 Hz, 50 Hz, 60 Hz or 400 Hz)	
Common mode rejection	> 120 dB	
Impedance	>= 10 MΩ	
Isolation	Field side to logic	707 V DC (type test)
	Logic to 24 V DC	707 V DC (type test)
	Field side to 24 V DC	707 V DC (type test)
	Channel to channel	None
Accuracy	See Selection table for RTD sensors.[4]	
Repeatability	±0.05% of full scale	
Maximum sensor dissipation	0.2 mW	
Measuring principle	Integrating	
Board update time	See Noise reduction and update times for the RTD board.	
Wire resistance	20 Ω, 2.7 Ω for 10 Ω RTD max.	
Diagnostics	Overflow/underflow[1, 2]	
	Wire break[3]	
Cable length	100 m to sensor max.	
Cable size	0.2 mm^2 to 0.8 mm^2 (AWG 24 to 18)	
Ferrule size	0.25 mm^2 or 0.34 mm^2 (AWG 24 or 22)	

[1] The overflow and underflow diagnostic alarm information is reported in the analog data values, even if the alarms are disabled in the board configuration.

[2] For resistance ranges, underflow detection is never enabled.

[3] When wire break alarm is disabled and an open wire condition exists in the sensor wiring, the board can report random values.

[4] Accuracy can be affected when the signal board is subjected to radio frequency radiation between 480 MHz to 800 MHz or when the signal board's ambient temperature changes at a rate of 3 °C per minute or faster.

The SB 1231 AI 2xRTD measures the value of resistance connected to the signal board inputs. The measurement type can be selected as either "Resistor" or "Thermal resistor".

- "Resistor": The nominal range full scale value is decimal 27648.
- "Thermal resistor": The value is reported in degrees multiplied by ten. (For example, 25.3 degrees is reported as decimal 253.) The climatic range values are reported in degrees multiplied by one hundred. (For example, 25.34 degrees is reported as decimal 2534.)

The SB 1231 AI 2xRTD uses a current to measure the resistance of the sensor. For resistance ranges and the RTD ranges of 200 ohms or less the current is 0.25 mA. For the 500- and 1000-ohm RTD ranges the current is 0.20 mA. This current is pulsed depending on the number of active channels on the module. For two active channels, the duty cycle for one channel is 50%. If four channels are active, the duty cycle for one channel is 25%. The maximum output voltage for an open circuit condition on the sensor is 3.3 V DC (measured between the I+ and I- terminals).

The SB 1231 AI 2xRTD supports measurements with 2-wire, 3-wire, and 4-wire connections to the sensor resistor.

Selection table for RTD sensors

Table 1-318 Ranges and accuracy for the different sensors supported by the RTD board

Temperature coefficient	RTD type	Under range minimum[1]	Nominal range low limit	Nominal range high limit	Over range maximum[2]	Normal range accuracy @ 25 °C	Normal range accuracy -20 °C to 60 °C
Pt 0.003850 ITS90 DIN EN 60751	Pt 100 climatic	-145.00 °C	-120.00 °C	145.00 °C	155.00 °C	±0.20 °C	±0.40 °C
	Pt 10	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±1.0 °C	±2.0 °C
	Pt 50	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±0.5 °C	±1.0 °C
	Pt 100						
	Pt 200						
	Pt 500						
	Pt 1000						
Pt 0.003902 Pt 0.003916 Pt 0.003920	Pt 100	-243.0 °C	-200.0 °C	850.0 °C	1000.0 °C	±0.5 °C	±1.0 °C
	Pt 200						
	Pt 500						
	Pt 1000						
Pt 0.003910	Pt 10	-273.2 °C	-240.0 °C	1100.0 °C	1295.0 °C	±1.0 °C	±2.0 °C
	Pt 50	-273.2 °C	-240.0 °C	1100.0 °C	1295.0 °C	±0.8 °C	±1.6 °C
	Pt 100						
	Pt 500						
Ni 0.006720 Ni 0.006180	Ni 100	-105.0 °C	-60.0 °C	250.0 °C	295.0 °C	±0.5 °C	±1.0 °C
	Ni 120						
	Ni 200						
	Ni 500						
	Ni 1000						
LG-Ni 0.005000	LG-Ni 1000	-105.0 °C	-60.0 °C	250.0 °C	295.0 °C	±0.5 °C	±1.0 °C
Ni 0.006170	Ni 100	-105.0 °C	-60.0 °C	180.0 °C	212.4 °C	±0.5 °C	±1.0 °C
Cu 0.004270	Cu 10	-240.0 °C	-200.0 °C	260.0 °C	312.0 °C	±1.0 °C	±2.0 °C
Cu 0.004260	Cu 10	-60.0 °C	-50.0 °C	200.0 °C	240.0 °C	±1.0 °C	±2.0 °C
	Cu 50	-60.0 °C	-50.0 °C	200.0 °C	240.0 °C	±0.6 °C	±1.2 °C
	Cu 100						
Cu 0.004280	Cu 10	-240.0 °C	-200.0 °C	200.0 °C	240.0 °C	±1.0 °C	±2.0 °C
	Cu 50	-240.0 °C	-200.0 °C	200.0 °C	240.0 °C	±0.7 °C	±1.4 °C
	Cu 100						

[1] RTD values below the under-range minimum value are reported as -32768.

[2] RTD values above the over-range maximum value are reported as +32767.

Table 1-319 Resistance

Range	Under range minimum	Nominal range low limit	Nominal range high limit	Over range maximum[1]	Normal range accuracy @ 25 °C	Normal range accuracy -20 °C to 60 °C
150 Ω	n/a	0 (0 Ω)	27648 (150 Ω)	176.383 Ω	±0.05%	±0.1%
300 Ω	n/a	0 (0 Ω)	27648 (300 Ω)	352.767 Ω	±0.05%	±0.1%
600 Ω	n/a	0 (0 Ω)	27648 (600 Ω)	705.534 Ω	±0.05%	±0.1%

[1] Resistance values above the over-range maximum value are reported as +32767.

The board reports 32767 on any activated channel with no sensor connected. If open wire detection is also enabled, the board flashes the appropriate red LEDs.

When 500 Ω and 1000 Ω RTD ranges are used with other lower value resistors, the error can increase to two times the specified error.

Best accuracy is achieved for the 10 Ω RTD ranges if 4 wire connections are used.

The resistance of the connection wires in 2 wire mode causes an error in the sensor reading; therefore, accuracy is not guaranteed.

Table 1-320 Noise reduction and update times for the RTD board

Rejection frequency selection	Integration time	Board update time (seconds)
400 Hz (2.5 ms)	10 ms[1]	4- / 2-wire: 0.142 3-wire: 0.285
60 Hz (16.67 ms)	16.67 ms	4- / 2-wire: 0.222 3-wire: 0.445
50 Hz (20 ms)	20 ms	4- / 2-wire: 0.262 3-wire: 0.505
10 Hz (100 ms)	100 ms	4- / 2-wire: 1.222 3-wire: 2.445

[1] To maintain resolution and accuracy when the 400 Hz filter is selected, the integration time is 10 ms. This selection also rejects 100 Hz and 200 Hz noise.

Internal calibration

After power is applied, the board performs internal calibration for the analog-to-digital converter. During this time, the board reports a value of 32767 on each channel until the channel provides valid data. The STEP 7 program might need to allow for this initialization time. Because the initialization time varies based on the board's configuration, you must verify the behavior of the board in your system. If required, you can include logic in the STEP 7 program to accommodate the initialization time of the board.

You can implement this logic using a polling read in the "Startup OB" which blocks operation until the initialization is complete. You must implement the polling read with an immediate access. If the value of the RTD polling read is 32767, you must repeat the read until the value changes. For each board, use only the input channel with the greatest value for the RTD polling read. For example, if input channel number 0 is the highest used input channel, you should execute the RTD polling read on channel number 0. The board initializes the channels in order from 0 to 1.

Representation of analog values for RTDs

A representation of the digitized measured value for the RTD standard temperature range sensors is shown in the table below:

Table 1-321 Representation of analog values for resistance temperature detectors PT 100, 200, 500, 1000 and PT 10, 50, 100, 500 GOST (0.003850) standard

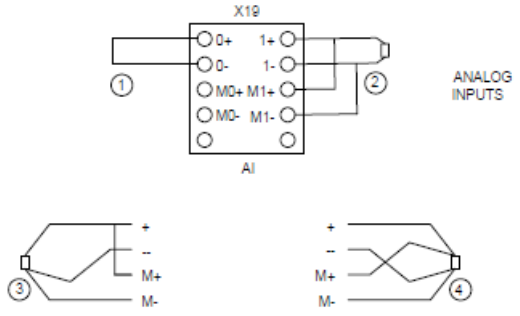
Pt x00 standard in °C[1]	Units		Pt x00 standard in °F[1]	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	Over-range
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	Rated range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	Under-range
< -243.0	-32768	8000	< -405.4	-32768	8000	Underflow

[1] A value change of 1 indicates a temperature change of +/- one-tenth degree.

Wiring diagram

The wiring diagram and pin connector locations are shown below:

SB 1231 AI 2xRTD



X19: Upper user wiring terminal (Light gray, No keying)

Signal	Pin #		Signal
AI I0+	1	2	AI I1+
AI I0-	3	4	AI I1-
AI M0+	5	6	AI M1+
AI M0-	7	8	AI M1-
	9	10	

① Loop back unused inputs.

② 2-wire RTD connection represented.

③ 3-wire RTD connection represented.

④ 4-wire RTD connection represented.

NOTE

You can deactivate unused RTD channels. Deactivated channels do not report errors.
To avoid extra stabilization time, which is automatically added to an active unused channel, make the current loop continuous. For consistency, connect a resistor like the 2-wire RTD connection to the RTD board.

A.11 Battery board (BB) 1297

The S7-1200 G2 Battery board (BB) 1297 provides long-term backup of the real-time clock. It is pluggable in the signal board slot(s) of the S7-1200 G2 CPU. You must add the battery board to the device configuration and download the hardware configuration to the CPU for the battery board to be functional. The battery is not included and must be purchased separately. When adding or replacing the battery, a UL certified CR2032 (Li/MnO_2) battery with a rating of 3 V, 225 mAh must be used.

⚠ WARNING

Risks when installing or connecting an unspecified battery in the BB 1297
Installing an unspecified battery in the battery board or otherwise connecting an unspecified battery to the circuit can result in fire or component damage and unpredictable operation of machinery. The battery must be installed in a non-hazardous environment.
Use only the specified battery for backup of the real-time clock.
Fire or unpredictable operation of machinery can result in death, severe personal injury, or property damage.

Table 1-322 General specifications

Technical data	**BB 1297**
Article number	6ES7297-4AX50-0XA0
Dimensions W x H x D (mm)	15 x 62 x 63 mm
Weight (product/shipping)	26 grams / 42 grams
Power dissapation	0.2 W
Current consumption (SM Bus)	35 mA max. (5 V DC)
Current consumption (24 V DC)	None
Operating environment	Horizontal mounting -20 °C to 40 °C[1] -20 °C to 60 °C[2]
	Vertical mounting -20 °C to 40 °C[1] -20 °C to 50 °C[2]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

[2] Operating temperature range using rated voltages, 50% of maximum specifications, and alternate I/O active

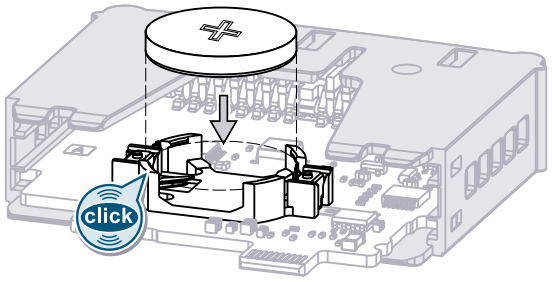
Battery (not included)	**BB 1297**
Hold up time	Approximately 1 year
Battery type	CR2032, temperature rating of ≥ 85 °C recommended
Nominal voltage	3 V
Nominal capacity	At least 200 mAH

Diagnostics	BB 1297
Critcal battery level	< 2.5 V[1]
Battery diagnostic	Low voltage indicator:[2] • Low battery voltage causes the CPU MAINT LED to illuminate with the yellow light continuously ON. • Diagnostic buffer event: 16#06:2700 "Maintenance demanded: At least one battery empty"
Battery status	You can use input bit Ic.0 in the STEP 7 program to monitor the battery status. 0 = Battery OK 1 = Battery low
Battery status update	Battery status updates at power up and then once per day while CPU is in RUN mode.

[1] If the battery charge is 2.5 V or less, it triggers the diagnostic buffer event 16#06:2700 and causes the yellow light of the CPU MAINT LED to be continuously lit. The CPU can maintain the real-time clock until the battery charge is 1.1 V or less. At this point, the real-time clock loads a default date and time (UTC Jan 1, 2012 00:00) because the value could be inaccurate.

[2] The battery only powers the real-time clock. The deterioration of the battery does not affect the retentive memory.

Table 1-323 Battery insertion diagram for the battery board

BB 1297 (6ES7297-4AX50-0XA0)	
	

A.12 Communication interfaces

A.12.1 CP 1243-1

Table 1-324 General specifications

Technical data	CP 1243-1
Article number	6GK7243-1BX50-0XE0
Dimensions W x H x D	30 x 134 x 100 mm
Weight (product/shipping)	180 grams / 230 grams
Power dissipation	1.7 W
Current consumption (bus)	0 mA (24 V DC external power supply)
Current consumption (24 V DC)	70 mA
Rated supply voltage	24 V DC
Supply voltage range	19.2 to 28.8 V DC
Reverse supply voltage protection	Yes

Technical data	CP 1243-1
Operating environment	Horizontal mounting -20 °C to 70 °C
	Vertical mounting -20 °C to 60 °C
	95% relative humidity at 25 °C during operation, without condensation, maximum

Table 1-325 Properties

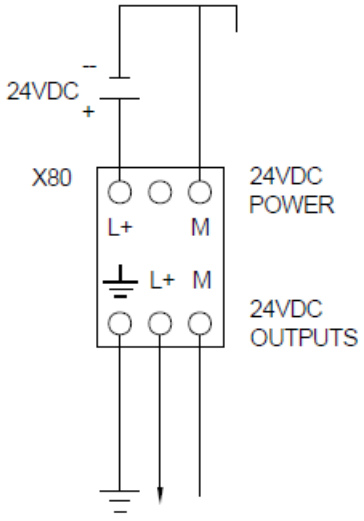
Technical data	CP 1243-1
Ethernet	Yes

For additional information, see CP 1243-1 (https://sieportal.siemens.com/su/blYx6).

Wiring diagram

The wiring diagram and pin connector locations are shown below:

CP 1243-1



X80: DC power wiring terminal (Gray, No keying)

DC power	L+		M
Pin #	1	3	5
Pin#	2	4	6
24 V DC output	GND	L+	M

A.12.2 CM 1241 RS232/422/485

Table 1-326 General specifications

Technical data	CM 1241 RS232/422/485
Article number	6ES7241-1EA50-0XB0
Dimensions W x H x D	30 x 125 x 100 mm
Weight (product/shipping)	178 grams / 215 grams
Power dissipation	0.9 W
Current consumption (bus)	170 mA max. (5 V DC)
Current consumption (24 V DC)	None
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

NOTE

The CM 1241 supports three configuration types: RS232, RS422, and RS485. You can only use one configuration type per CM; you cannot use these configuration types simultaneously on the same CM. However, you can configure each CM in the G2 system with a different type.

Table 1-327 Transmitter and receiver for CM 1241 RS232/422/485 when configured as RS232

Technical data	CM 1241 RS232/422/485	
Type	RS232 (full duplex)	
Parity	No parity (default), even, odd, Mark (parity bit always set to 1), Space (parity bit always set to 0)	
Number of stop bits	1 (default), 2	
Wait time	0 to 65535 ms	
Data transmission rate	300, 600, 1200, 2400, 4800, 9600 (default), 19200, 38400, 57600, 76800, 115200 bits/s	
Transmitter output voltage	±5 V min. at R_L = 3 kΩ	
Transmit output voltage	±15 V DC max.	
Receiver input impedance	3 kΩ min.	
Receiver threshold/sensitivity	0.8 V min. low, 2.4 max. high; 0.5 V typical hysteresis	
Isolation	RS232 signal to chassis ground	707 V DC (type test)
	RS232 signal to CPU logic common	707 V DC (type test)
Receiver input voltage	±25 V DC max.	
Flow control	Hardware, software	
Cable length	10 m shielded max.	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

Table 1-328 Transmitter and receiver for CM 1241 RS232/422/485 when configured as RS422/485

Technical data	CM 1241 RS232/422/485
Type	RS422 (full duplex) or RS485
Parity	No parity (default), even, odd, Mark (parity bit always set to 1), Space (parity bit always set to 0)

Technical data	CM 1241 RS232/422/485	
Number of stop bits	1 (default), 2	
Wait time	0 to 65535 ms	
Data transmission rate	300, 600, 1200, 2400, 4800, 9600 (default), 19200, 38400, 57600, 76800, 115200, 250000 bits/s	
Common mode voltage range	RS422: -7 V to +12 V, 1 second, 3 VRMS continuous	
Transmitter differential output voltage	2 V min. at R_L = 100 Ω 1.5 V min. at R_L = 54 Ω	
Termination and bias (Page 262)	Internal bias options provided, including none. Optional 300 Ω internal termination provided. No external termination required.	
Receiver input impedance	5.4 kΩ min. including termination	
Receiver threshold/sensitivity	±0.2 V min., 60 mV typical hysteresis	
Isolation	RS422/485 signal to chassis ground	707 V DC (type test)
	RS422/485 signal to CPU logic common	707 V DC (type test)
Flow control	RS422: XON/XOFF	
Cable length	1000 m shielded max. (data transmission rate dependent)	
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)	

Wiring diagram

The wiring diagram and pin connector locations are shown below:

CM 1241 RS232/422/485

X30: Upper user wiring terminal (Gray, No keying)

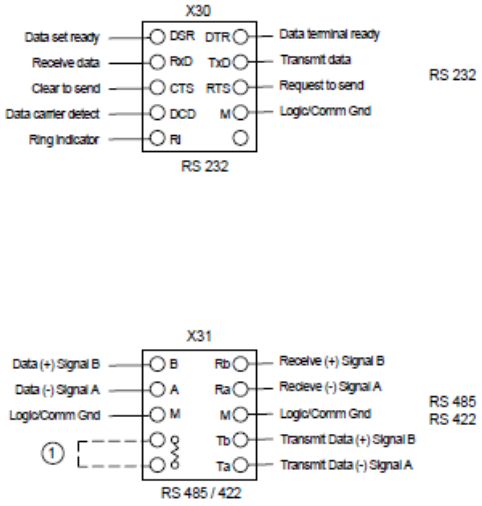
RS232 Signal	Pin #		RS232 Signal
DSR Data set ready	1	2	DTR Data terminal ready
RxD Receive data	3	4	TxD Transmit data
CTS Clear to send	5	6	RTS Request to send
DCD Data carrier detect	7	8	M Logic or comm ground
RI Ring indicator	9	10	

X31: Lower user wiring terminal (Gray, No keying)

RS485 Signal	Pin #		RS422 Signal
B Data (+) Signal B (RxD/TxD+)	1	2	Rb Receive Data (+) Signal B (RxD+)
A Data (-) Signal A (RxD/TxD-)	3	4	Ra Receive Data (-) Signal A (RxD-)
M Logic or comm ground	5	6	M Logic or comm ground

① 300 Ω termination can be made by connecting pin 7 to pin 9 on the X31 terminal block (recommended when cable length is greater than 50 m).

CM 1241 RS232/422/485



See ①	7	8	Tb Transmit Data (+) Signal B (TxD+)
See ①	9	10	Ta Transmit Data (-) Signal A (TxD-)

① 300 Ω termination can be made by connecting pin 7 to pin 9 on the X31 terminal block (recommended when cable length is greater than 50 m).

A.12.3 CB 1241 RS485

Table 1-329 General specifications

Technical data	CB 1241 RS485
Article number	6ES7241-1CA50-0XB0
Dimensions W x H x D	15 x 62 x 63 mm
Weight (product/shipping)	29 grams / 56 grams
Power dissipation	0.4 W
Current consumption (bus)	75 mA max. (5 V DC)
Current consumption (24 V DC)	None
Operating environment	Horizontal mounting -20 °C to 60 °C[1]
	Vertical mounting -20 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum

[1] Operating temperature range using maximum voltages and maximum specifications

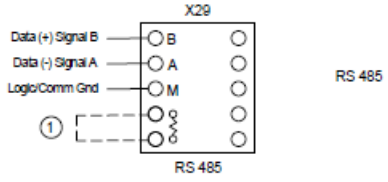
Table 1-330 Transmitter and receiver

Technical data	**CB 1241 RS485**	
Type	RS485	
Data transmission rate	300, 600, 1200, 2400, 4800, 9600 (default), 19200, 38400, 57600, 76800, 115200, 250000 bits/s	
Parity	No parity (default), even, odd, Mark (parity bit always set to 1), Space (parity bit always set to 0)	
Number of stop bits	1 (default), 2	
Wait time	0 to 65535 ms	
Common mode voltage range	-7 V to +12 V, 1 second, 3 VRMS continuous	
Transmitter differential output voltage	2 V min. at R_L = 100 Ω 1.5 V min. at R_L = 54 Ω	
Termination and bias	Internal bias options provided, including none. Optional 300 Ω internal termination provided. No external termination required.	
Receiver input impedance	5.4 kΩ min. including termination	
Receiver threshold/sensitivity	±0.2 V min., 60 mV typical hysteresis	
Isolation	RS485 signal to chassis ground	707 V DC (type test)
	RS485 signal to CPU logic common	707 V DC (type test)
Flow control	Not supported	
Cable length	1000 m shielded max. (data transmission rate dependent)	
Cable size	0.2 mm² to 0.8 mm² (AWG 24 to 18)	
Ferrule size	0.25 mm² or 0.34 mm² (AWG 24 or 22)	

Wiring diagram

The wiring diagram and pin connector locations are shown below:

CB 1241 RS485



X29: Upper user wiring terminal (Gray, No keying)

RS485 Signal	Pin #		
B Data (+) Signal B (RxD/TxD+)	1	2	
A Data (-) Signal A (RxD/TxD-)	3	4	
M Logic or comm ground	5	6	
See ①	7	8	
See ①	9	10	

① 300 Ω termination can be made by connecting pin 7 to pin 9 on the X29 terminal block (recommended when cable length is greater than 50 m).

A.13 Input simulators

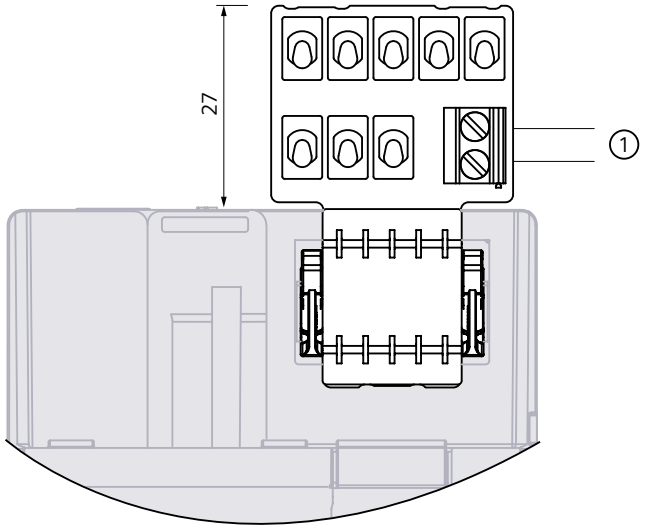
Table 1-331 General specifications

Technical data	8 Position Simulator	14 Position Simulator
Article number	6ES7274-1XF50-0XA0	6ES7274-1XH50-0XA0
Dimensions W x H x D (mm)	43 x 35 x 23	67 x 35 x 23
Weight	20 grams	30 grams
Points	8	14
Used with CPU	CPU 1212C, CPU 1212FC	CPU 1214C, CPU 1214FC

⚠ WARNING

Safe use of input simulators
Input simulators are not approved for use in Class I DIV 2 or Class I Zone 2 hazardous locations where they present a potential hazard.
Do not use in Class I DIV 2 or Class I Zone 2 hazardous locations.
Unapproved use can result in death or severe personal injury, and property damage.

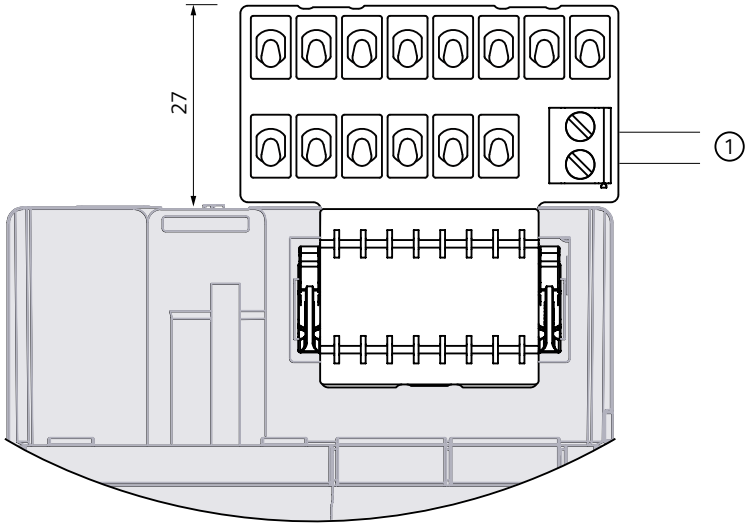
8 Position Simulator (6ES7274-1XF50-0XA0)



① 24 V DC simulator power input

All dimensions are in millimeters (mm).

14 Position Simulator (6ES7274-1XH50-0XA0)



① 24 V DC simulator power input

All dimensions are in millimeters (mm).

See also

Mounting dimensions (Page 65)

A.14 Companion products

A.14.1 Power module (PM) 1207

The PM 1207 is an optional external power supply for the SIMATIC S7-1200 G2 system.

Technical data	PM 1207
Article number	6EP3333-4SC00-3AX0 (with EX certification) 6EP3333-4SB00-3AX0 (without EX certification)
Dimensions W x H x D	70 x 125 x 100 mm
Weight (product/shipping)	450 grams / 600 grams
Design format	Matches the S7-1200 G2 shape and color
Input	120 to 240 V AC
Voltage range	85 to 264 V AC
Line frequency	47 to 63 Hz
Input current (full load)	1.1 A at 120 V AC 0.56 A at 240 V AC
Inrush current	43 A max. at 240 V AC
I^2t	1.8 A^2 s
Isolation (input AC to output DC)	3000 V AC
Hold up time (loss of power)	20 ms at 120 V AC 85 ms at 240 V AC
Internal fuse	3.15 A, slow blow, not user replaceable

[1] Operating temperature range using maximum voltages and maximum specifications

Technical data	PM 1207
External miniature circuit breaker recommended	16 A characteristic B or 10 A characteristic C
Output	24 V DC / 5A
UDI diagnostic interface	Yes
Power dissipation	13 W
Current consumption (bus)	Not connected to CPU bus
Operating environment	Horizontal mounting -25 °C to 60 °C[1]
	Vertical mounting -25 °C to 50 °C[1]
	95% relative humidity at 25 °C during operation, without condensation, maximum
Cable size	0.2 mm^2 to 1.5 mm^2 (AWG 24 to 16)

[1] Operating temperature range using maximum voltages and maximum specifications

You can find more information about this module on the product catalog (https://support.industry.siemens.com/cs/us/en/ps) web site.

Ordering information

B

B.1 CPUs

Table 1-332 CPUs

CPU models		Article number
CPU 1212C	CPU 1212C AC/DC/RLY	6ES7212-1BG50-0XB0
	CPU 1212C DC/DC/DC	6ES7212-1AG50-0XB0
	CPU 1212C DC/DC/RLY	6ES7212-1HG50-0XB0
CPU 1214C	CPU 1214C AC/DC/RLY	6ES7214-1BH50-0XB0
	CPU 1214C DC/DC/DC	6ES7214-1AH50-0XB0
	CPU 1214C DC/DC/RLY	6ES7214-1HH50-0XB0

Table 1-333 Fail-safe CPUs

Fail-safe CPU models		Article number
CPU 1212FC	CPU 1212FC DC/DC/DC	6ES7212-1AF50-0XB0
	CPU 1212FC DC/DC/RLY	6ES7212-1HF50-0XB0
CPU 1214FC	CPU 1214FC DC/DC/DC	6ES7214-1AF50-0XB0
	CPU 1214FC DC/DC/RLY	6ES7214-1HF50-0XB0

B.2 Signal modules (SMs)

Signal modules (SMs)		Article number
Digital input	SM 1221 DI 16x24VDC	6ES7221-1BH50-0XB0
Digital output	SM 1222 DQ 16x24VDC	6ES7222-5BH50-0XB0
	SM 1222 DQ 16xRLY	6ES7222-5HH50-0XB0
Digital input / output	SM 1223 DI 8x24VDC / DQ 8x24VDC	6ES7223-5BH50-0XB0
	SM 1223 DI 8x24VDC / DQ 8xRLY	6ES7223-5PH50-0XB0
	SM 1223 DI 16x24VDC / DQ 16x24VDC	6ES7223-5BL50-0XB0
	SM 1223 DI 16x24VDC / DQ 16x24VDC Sink	6ES7223-5BL50-1XB0
	SM 1223 DI 16x24VDC / DQ 16xRLY	6ES7223-5PL50-0XB0
Analog input	SM 1231 AI 8x14bit	6ES7231-4HF50-0XB0
Analog output	SM 1232 AQ 8x14bit	6ES7232-4HF50-0XB0
Analog input / output	SM 1233 AI 4x14bit / AQ 4x14bit	6ES7233-4HF50-0XB0
RTD and thermocouple	SM 1231 AI 8xTC	6ES7231-5QF50-0XB0
	SM 1231 AI 4xRTD	6ES7231-5PD50-0XB0

B.3 Signal boards (SBs)

Signal boards (SBs)		Article number
Digital input	SB 1221 DI 8x24VDC	6ES7221-3BF50-0XB0
Digital output	SB 1222 DQ 8x24VDC	6ES7222-5BF50-0XB0
Digital input / output	SB 1223 DI 4x24VDC / DQ 4x24VDC	6ES7223-7BF50-0XB0
	SB 1223 DI 4x5VDC / DQ 4x5VDC	6ES7223-7AF50-0XB0
Analog input	SB 1231 AI 4x14bit	6ES7231-4HD50-0XB0
Analog output	SB 1232 AQ 4x14bit	6ES7232-4HD50-0XB0
Analog input / output	SB 1233 AI 2x14bit / AQ 2x14bit	6ES7233-4HD50-0XB0
RTD and thermocouple	SB 1231 AI 4xTC	6ES7231-5QD50-0XB0
	SB 1231 AI 2xRTD	6ES7231-5PB50-0XB0

B.4 Battery board (BB)

Battery board (BB)		Article number
Battery	BB 1297 (battery type CR2032 not included)	6ES7297-4AX50-0XA0

B.5 Communication

Table 1-334 Communication processor (CP)

Communication processor (CP)		Article number
Ethernet interface	CP 1243-1	6GK7243-1BX50-0XE0

Table 1-335 Communication module (CM)

Communication module (CM)		Article number
Serial communication	CM 1241 RS232/422/485	6ES7241-1EA50-0XB0

Table 1-336 Communication board (CB)

Communication board (CB)		Article number
Serial communication	CB 1241 RS485	6ES7241-1CA50-0XB0

B.6 Memory cards

SIMATIC memory cards	Description	Article number
Siemens SIMATIC MC	32 GB	6ES7954-8LT0x-0AA0
	2 GB	6ES7954-8LP0x-0AA0
	256 MB	6ES7954-8LL0x-0AA0
	24 MB	6ES7954-8LF0x-0AA0
	12 MB	6ES7954-8LE0x-0AA0
	4 MB	6ES7954-8LC0x-0AA0

Standard memory cards[1]	Description	Vendor part number[2]
INDMEM	512 MB, Type SDHC	B0CVVRFCQ4
	1 GB, Type SDHC	B0CVVR1W9T
Transcend	4 GB, Type SDHC	TS4GSDHC4
	8 GB, Type SDHC	TS8GSDC300S
Verbatim	4 GB, Type SDHC	B000RLBWJK
	8 GB, Type SDHC	B000WJ725U
	16 GB, Type SDHC	B001L1RGUE
SanDisk	16 GB, Type SCHC	SDSDBNN-016G-AW6VN
	32 GB, Type SDHC	SDSQUA4-032G-AW6KA
Onn	32 GB, Type SCHC	100006056

[1] You can only use Standard (non-SIMATIC) memory cards for transferring the license conditions and copyrights Open Source Software (OSS) information to a memory card for viewing.

[2] These devices are not sold by Siemens. Other memory cards of type SDHC may also work.

B.7 Spare parts and other hardware

Table 1-337 Simulators, spare doors, DIN rails, and end retainer

Item		Article number
Input simulator	Input simulator, 8 position (CPU 1212C, CPU 1212FC)	6ES7274-1XF50-0XA0
	Input simulator, 14 position (CPU 1214C, CPU 1214FC)	6ES7274-1XH50-0XA0
Spare door kit (one pair per kit)	CPU 1212C, CPU 1212FC (70 mm)	6ES7291-1AA50-0XA0
	CPU 1214C, CPU 1214FC (80 mm)	6ES7291-1AB50-0XA0
	SM, CM (30 mm)	6ES7291-1BA50-0XA0
	SM (50 mm)	6ES7291-1BB50-0XA0
DIN rail	DIN rail 35 mm, length 483 mm	6ES5710-8MA11
	DIN rail 35 mm, length 530 mm	6ES5710-8MA21
	DIN rail 35 mm, length 830 mm	6ES5710-8MA31
	DIN rail 35 mm, length 2000 mm	6ES5710-8MA41
DIN rail end retainer	End retainer thermoplastic, 5.2 mm	8WH9150-0CA00

B.8 Terminal block spare kits

Replacing the terminal block connector

Refer to the tables below and your module specifications to determine the correct terminal block replacement.

NOTE

PLCs require correct wiring to ensure safety and proper operation.

When replacing the terminal block in your S7-1200 G2 CPU or module, it is important that you use the correct terminal block and correct wiring source for your module.

The G2 removable terminal block is designed to prevent you from accidentally placing a high voltage wired terminal block into a low voltage module, or from placing a special voltage wired terminal block into a normal voltage module.

Table 1-338 CPU - Terminal block spare kits

CPU (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
CPU 1212C DC/DC/DC (6ES7212-1AG50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	8 position, tin-plated, gray	6ES7292-2AH50-0XA0
	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
CPU 1212C DC/DC/RLY (6ES7212-1HG50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	8 position, tin-plated, orange	6ES7292-2AH50-0XA3
	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
CPU 1212C AC/DC/RLY (6ES7212-1BG50-0XB0)	6 position, tin-plated, orange	6ES7292-2AF50-0XA3
	8 position, tin-plated, orange	6ES7292-2AH50-0XA3
	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
CPU 1214C DC/DC/DC (6ES7214-1AH50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	12 position, tin-plated, gray	6ES7292-2AM50-0XA0
	16 position, tin-plated, gray	6ES7292-2AR50-0XA0
CPU 1214C DC/DC/RLY (6ES7214-1HH50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	12 position, tin-plated, orange	6ES7292-2AM50-0XA3
	16 position, tin-plated, gray	6ES7292-2AR50-0XA0
CPU 1214C AC/DC/RLY (6ES7214-1BH50-0XB0)	6 position, tin-plated, orange	6ES7292-2AF50-0XA3
	12 position, tin-plated, orange	6ES7292-2AM50-0XA3
	16 position, tin-plated, gray	6ES7292-2AR50-0XA0

Table 1-339 Fail-safe CPU - Terminal block spare kit

Fail-safe CPU (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
CPU 1212FC DC/DC/DC (6ES7212-1AF50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	8 position, tin-plated, gray	6ES7292-2AH50-0XA0
	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
CPU 1212FC DC/DC/RLY (6ES7212-1HF50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	8 position, tin-plated, orange	6ES7292-2AH50-0XA3
	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
CPU 1214FC DC/DC/DC (6ES7214-1AF50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	12 position, tin-plated, gray	6ES7292-2AM50-0XA0
	16 position, tin-plated, gray	6ES7292-2AR50-0XA0
CPU 1214FC DC/DC/RLY (6ES7214-1HF50-0XB0)	6 position, tin-plated, gray	6ES7292-2AF50 0XA0
	12 position, tin-plated, orange	6ES7292-2AM50-0XA3
	16 position, tin-plated, gray	6ES7292-2AR50-0XA0

Table 1-340 SM - Terminal block spare kits

SM (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
SM 1221 DI 16x24VDC (6ES7221-1BH50-0XB0)	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
SM 1222 DQ 16x24VDC (6ES7222-5BH50-0XB0)	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
SM 1222 DQ 16xRLY (6ES7222-5HH50-0XB0)	14 position, tin-plated, orange	6ES7292-2AP50-0XA3
SM 1223 DI 8x24VDC / DQ 8x24VDC (6ES7223-5BH50-0XB0)	10 position, tin-plated, gray	6ES7292-2AK50-0XA0

SM (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
SM 1223 DI 16x24VDC / DQ 16x24VDC (6ES7223-5BL50-0XB0)	10 position, tin-plated, gray	6ES7292-2AK50-0XA0
SM 1223 DI 16x24VDC / DQ 16x24VDC Sink (6ES7223-5BL50-1XB0)		
SM 1223 DI 8x24VDC / DQ 8xRLY (6ES7223-5PH50-0XB0)	10 position, tin-plated, gray 14 position, tin-plated, orange	6ES7292-2AK50-0XA0 6ES7292-2AP50-0XA3
SM 1223 DI 16x24VDC / DQ 16xRLY (6ES7223-5PL50-0XB0)		
SM 1231 AI 8x14bit (6ES7231-4HF50-0XB0)	10 position, gold-plated, light gray	6ES7292-2BK50-0XA4
SM 1232 AQ 8x14bit (6ES7232-4HF50-0XB0)		
SM 1233 AI 4x14bit / AQ 4x14bit (6ES7233-4HF50-0XB0)		
SM 1231 AI 8xTC (6ES7231-5QF50-0XB0)	10 position, gold-plated, light gray	6ES7292-2BK50-0XA4
SM 1231 AI 4xRTD (6ES7231-5PD50-0XB0)		

Table 1-341 CM - Terminal block spare kits

CM (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
CM 1241 RS232/422/485 (6ES7241-1EA50-0XB0)	10 position, tin-plated, gray	6ES7292-2AK50-0XA0

Table 1-342 SB - Terminal block spare kits

SB (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
SB 1221 DI 8x24VDC (6ES7221-3BF50-0XB0)	10 position, tin-plated, gray	6ES7292-4AK50-0XA0
SB 1222 DQ 8x24VDC (6ES7222-5BF50-0XB0)		
SB 1223 DI 4x24VDC / DQ 4x24VDC (6ES7223-7BF50-0XB0)		
SB 1223 DI 4x5VDC / DQ 4x5VDC (6ES7223-7AF50-0XB0)		
SB 1231 AI 4x14bit (6ES7231-4HD50-0XB0)	10 position, gold plated, light gray	6ES7292-4BK50-0XA4
SB 1232 AQ 4x14bit (6ES7232-4HD50-0XB0)		
SB 1233 AI 2x14bit / AQ 2x14bit (6ES7233-4HD50-0XB0)		
SB 1231 AI 4xTC (6ES7231-5QD50-0XB0)		
SB 1231 AI 2xRTD (6ES7231-5PB50-0XB0)		

Table 1-343 CB - Terminal block spare kits

CB (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	Terminal block article number
CB 1241 RS485 (6ES7241-1CA50-0XB0)	10 position, tin-plated, gray	6ES7292-4AK50-0XA0

Table 1-344 CP - Terminal block spare kits

CP (article number)	Use this terminal block spare kit (four per pack)	
	Terminal block description	**Terminal block article number**
CP 1243-1 (6GK7243-1BX50-0XE0)	6 position, tin-plated, gray	6ES7292-2AF50-0XA0

B.9 Programming software

Table 1-345 Programming software

SIMATIC software		Article number
Programming software	STEP 7 Basic V20	6ES7822-0AE24-0YA5
	STEP 7 Professional V20	6ES7822-1AE24-0YA5

Safety-relevant symbols

C

C.1 Devices without explosion protection

The following table explains the symbols located on your SIMATIC device, on its packaging, or in the accompanying documentation:

Symbol	Meaning
	General warning sign **Caution/Notice** Read the product documentation. The product documentation contains information about potential risks and enables you to recognize these risks and to implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by an electrically skilled person. IEC 60417 No. 6182
 CABLE SPEC.	Connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
 EMC	The device must be constructed and connected in accordance with EMC regulations.
 230V MODULES	A 230 V device can be exposed to electrical voltages, which can be dangerous. ANSI Z535.2
 24V MODULES	A device of Protection Class III can only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
 INDOOR USE ONLY INDUSTRIAL USE ONLY	The device is only approved for the industrial field and only for indoor use.
	An enclosure is required for installing the device. The following are considered to be enclosures: • Standing control cabinet • Modular control cabinet • Terminal boxes • Wall enclosure

C.2 Devices with explosion protection

The following table explains the symbols located on your SIMATIC device, on its packaging, or in the accompanying documentation:

Symbol	Meaning
	General warning sign **Caution/Notice** Read the product documentation. The product documentation contains information about potential risks and enables you to recognize these risks and to implement countermeasures.
	The assigned safety symbol applies to devices **with Ex approval**. Read the product documentation. The product documentation contains information about potential risks and enables you to recognize these risks and to implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by an electrically skilled person. IEC 60417 No. 6182
 F<2N DISPLAY F<4N HOUSING	Observe the mechanical rating of the device.
 CABLE SPEC.	Connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
 EMC	The device must be constructed and connected in accordance with EMC regulations.
 U = 0V	When the device is under voltage, it cannot be installed or removed, or plugged or pulled.
 230V MODULES	A 230 V device can be exposed to electrical voltages, which can be dangerous. ANSI Z535.2
 24V MODULES	A device of Protection Class III can only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
 INDOOR USE ONLY INDUSTRIAL USE ONLY	The device is only approved for the industrial field and only for indoor use.
 ZONE 2 INSIDE CABINET IP54	For Zone 2 potentially explosive atmospheres, the device can only be used when it is installed in an enclosure with a degree of protection ≥ IP54.
 ZONE 22 INSIDE CABINET IP6x	For Zone 22 potentially explosive atmospheres, the device can only be used when it is installed in an enclosure with a degree of protection ≥ IP6x.

Comparison to S7-1200

D

The following tables represent a comparison between S7-1200 and S7-1200 G2:

Major features	S7-1200	S7-1200 G2
Web API Support (Page 300)	Yes (subset)	Yes
Maximum number of concurrent Web API sessions	50	30
Mobile phone NFC Application (Page 299)	No	Yes
DHCP	No	Yes
DNS	No	Yes
OPC UA Server	Yes	Yes
Numerous Communication Modules:		
• PROFIBUS	Yes	No
• AS-I Master	Yes	No
• LTE (US and EU)	Yes	No
Configuration control (option handling)	Yes	No
S7 Routing	Yes	Yes

Features	S7-1200	S7-1200 G2
CPU Variants	1211C, 1212C, 1214C, 1215C, 1217C, 1212FC, 1214FC, 1215FC	1212C 1214C 1212FC 1214FC
Physical Dimensions, W x H x D (mm)	CPU 1211C/1212C: 90 x 100 x 75 CPU 1214C: 110 x 100 x 75 CPU 1215C: 130 x 100 x 75 CPU 1217C: 150 x 100 x 75 SM: 45 or 70 x 100 x 75 CM/CP: 30 x 100 x 75 SB/CB: 38 x 62 x 21	CPU 1212C/1212FC: 70 x 125 x 100 CPU 1214C/1214FC: 80 x 125 x 100 SM/CM: 30 or 50 x 125 x 100 SB/CB: 15 x 62 x 63
Built-in Analog	Yes	No, analog SMs (Page 405) and SBs (Page 436) available
Signal Boards Slots	1 for all CPU variants	CPU 1212C/1212FC: 1 CPU 1214C/1214FC: 2
SM/CM/CP	CPU 1211C: 3 CM/CP / 0 SM CPU 1212C: 3 CM/CP / 2 SM CPU 1214C/1215C/1217C: 3 CM/CP / 8 SM	CPU 1212C/1212FC: 6 total, 3 can be CMs or CPs CPU 1214C/1214FC: 10 total, 3 can be CMs or CPs
Module Placement	Left side (CM/CPs) Right side (SMs)	Right side only (CMs/CPs must be next to CPU)
Security (Page 158)	Standard Security Measures	Enhanced Security

Features	S7-1200	S7-1200 G2
Number of Ethernet Ports	CPU 1211C/1212C/1214C: 1 port (one interface) CPU 1215C/1217C: 2 switched ports (one interface)	All CPUs: 2 switched ports (one interface)
Load Memory Reporting (Online & diagnostics)	Load memory only reports program blocks	Reports the size of everything
IRT (Isochronous Real-Time PN) (Page 250)	No Support	HW Support
RT (Real-Time PN)	SW Support	HW Support
Motion Control (Page 302)	Yes	Yes (different)
Number of PROFINET Devices (Page 222)	16	31
Communication Priority	1 (will not interrupt 2 and above)	15 (will not interrupt 16 and above)
Memory Card Evaluation (what happens when you plug a memory card (Page 137))	Evaluates on transition to RUN, power up, and memory reset (MRES)	Evaluates on insertion, power up, and memory reset (MRES)
Work Memory Reporting	Work Memory (includes both code and data)	Code Work Memory / Data Work Memory
Cyclic OB (Page 102) (TIA cycle configuration)	milliseconds	microseconds
Synchronous Isochronous Interrupt OB 61	Cyclic only	Tied to Isochronous Scan
Programming Error OB 121 (Page 115) (synchronous)	No	Yes
I/O Access Error OB 122 (Page 116) (synchronous)	No	Yes
Number of User PIP(s) (Page 97)	4	32
Number of Diagnostics buffer (Page 126) Events		
• Visible in the buffer • Retentive	50 50	500 100
Reaction after serious firmware or hardware exception	Attempts defect-mode restart; LEDs show fatal error flash pattern	Attempts defect-mode restart (Page 319); attempts to load device configuration and program; LEDs (Page 315) show fatal error flash pattern;
Alarming configure, display, acknowledge		
• Program alarm wizard • PLC alarms editor • Alarm display • PLC alarm text lists • Central alarm management	No No No Yes No	Yes Yes Yes Yes Yes
Local output substitute values during startup	System automatically sets the output image	System automatically sets the output image
Distributed output substitute values during startup	User must use startup OB to set	User must use startup OB to set
Process image size	1 Kbyte inputs 1 Kbyte outputs	1 Kbyte inputs 1 Kbyte outputs
Bit memory size	8 Kbytes	8 Kbytes
Retentive Memory	14KB	20KB
TIA Languages	LAD, FBD, SCL, and CEM	LAD, FBD, SCL, and CEM

Features	S7-1200	S7-1200 G2
Media Redundancy Protocol (MRP) Support	Yes	Yes
Media Redundancy for Planned Duplication (MRPD) Support	No	Yes
TIA Portal Power Budget Calculation for local rack	No	Yes
Insertion or extraction of modules under power (hot swap)	No	No
EN 60068-2-6 Sinusoidal vibration	DIN rail / Panel mount: 1G/2G	DIN rail / Panel mount: 1G/1G
TOD (End of Month)	Follows START Date and only runs when TOD >= START Date	Ignores START Date and always runs at the end of Month
Enable Outputs in STOP	Allowed when only local IO is configured	Not supported
Backup and restore	Yes	Yes
CPU clears Temp memory on each OB call		
• Optimized block (OB, FC, or FB)	Yes	Yes
• Non-optimized block (FC or FB)	Yes	No
SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/ww/en/view/109750245)	No	Yes

Instruction set[1] (Page 170)	S7-1200	S7-1200 G2
Legacy instructions		
• FieldRead, FieldWrite	Yes	Superseded by variable array index and multi-dimensional arrays
• CTRL_HSC	Yes	Superseded by CTRL_HSC_EXT
• "Point-to-Point" instructions	Yes	Superseded by "PtP Communication" instructions
• "USS" instructions	Yes	Superseded by "USS communication" instructions
• "MODBUS" instructions	Yes	Superseded by "MODBUS (RTU)" instructions
• TM_MAIL	Yes	Superseded by TMAIL_C
Distributed I/O instructions		
• PROFIBUS[2]	Yes	No
• AS-i control[2]	Yes	No
Communication instructions		
• GPRSComm: CP1242-7	Yes	No
• OPC UA Server	Yes	Yes
• MODBUS TCP redundancy instructions	Yes	Yes
Safety instructions		
• RD_ARRAY_I	No	Yes

1 Instruction groups indicate folders in the TIA Portal instruction task card

2 These instructions are in the Extended instructions > Distributed I/O instructions

Instruction set[1] (Page 170)	**S7-1200**	**S7-1200 G2**
• RD_ARRAY_DI	No	Yes
• Range_16	No	Yes
Motion control instructions (Page 302)	Yes	Yes (different)
Alarming Instructions		
• Generate user message	Yes	Yes
• Generate program alarms	No	Yes
• Read status of program alarms	No	Yes
• Copy alarm to DB	No	Yes
• Acknowledge all alarms	No	Yes
• Read alarm resources	No	Yes
PID Instructions		
• Compact PID instructions	Yes	Yes
• Auxiliary functions instructions	Yes	Yes – adds instruction Filter_Universal
Instruction categories (folders in STEP 7 Instructions task card)		
• Process Image	No	Yes
• Module Parameterization	No	Yes
• Cryptography	No	Yes
• Time-based IO (requires IRT and special modules)	No	Yes
• OPC UA	Yes	Yes
• Teleservice	Yes	No
Miscellaneous instructions in existing categories		
• Move: Array_DB and Symbolic Move instructions	No	Yes
• Convert: REF	No	Yes
• Program Control: INIT_RD and WAIT	No	Yes
• Date and time-of-day: T_COMP and TIME_TCK	No	Yes
• String + Char: S_COMP, JOIN, SPLIT, and GetSymbolForReference	No	Yes

1 Instruction groups indicate folders in the TIA Portal instruction task card

2 These instructions are in the Extended instructions > Distributed I/O instructions

Instruction set[1] (Page 170)	S7-1200	S7-1200 G2
• PROFIEnergy: PE_START_END, PE_CMD, PE_DS3_Write_ET200-S, and PE_WOL	No	Yes
• Interrupts: MSK_FLT, DMSK_FLT, READ_ERR, DIS_IRT, and EN_IRT	No	Yes
• Diagnostics:GetClock-Status, and GEN_DIAG	No	Yes
Data consistency for MOVE_BLK and MOVE_BLK_VARIANT	64 bytes	Element size

1 Instruction groups indicate folders in the TIA Portal instruction task card

2 These instructions are in the Extended instructions > Distributed I/O instructions

Quantities and default values	S7-1200	S7-1200 G2
Minimum cycle time	Disabled	Enabled (1 ms)
Communication Load	20%	20% See SIMATIC S7-1500, S7-1500R/H, ET 200SP, ET 200pro Cycle and response times (https://support.industry.siemens.com/cs/us/en/view/59193558/-158758826123)
Size of Internal Load Memory	4MB	8 MB
HSC	6	8
PWM/PTO	4	8
Number of CPU connections	68	88
Number of active Trace jobs	2	4
Runtime meters	10	16
Hierarchical nesting depth of data type STRUCT	8	26 An array of STRUCT/UDT requires 3 hierarchical levels each. When using arrays of struct/UDT, the maximum nesting depth is reduced accordingly.

Legacy Scalance device support	S7-1200	S7-1200 G2
Scalance X005: 1P6GK50050BA001AA3	Yes	Not all
Scalance X31OFE: 1P6GK53100BA002AA3	Yes	No

SIMATIC S7-1200 G2 data

E

The EU Data Act, a key component of the European data strategy, went into effect on January 11, 2024.

The following information provides an overview of the data that is generated by the SIMATIC S7-1200 G2 automation system and accessible to you.

E.1 CPU data

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and program data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, system and security events, service data	Time formats, string formats, CSV, binary formats	Depending on application Several hundred bytes per event
Operating data (runtimes, cycle times, CPU utilization)	Numeric formats, time formats, JSON	Depending on application
Log data	Time formats, string formats, CSV	Depending on application

Continuous and real-time data generation

The SIMATIC S7-1200 G2 is able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The CPU operates with defined cycle times in which process data is acquired and processed.

Data storage and storage duration

Local data storage

The SIMATIC S7-1200 G2 stores data in integrated memory areas of the CPU and on the SIMATIC Memory Card.

Local data storage	Storage capacity	Storage duration
Load memory (with SIMATIC Memory Card)	Up to 32 Gbytes, depending upon SIMATIC Memory Card	Permanent
Program work memory	Up to 300 Kbytes, depending upon CPU	During operation of the CPU
Data work memory	Up to 750 Kbytes, depending upon CPU	During operation of the CPU
Retentive memory	20 Kbytes	Permanent
NFC tag memory	8 Kbytes	While NFC is enabled in the STEP 7 program

More information
You can find more information on memory areas, retentivity, and memory usage in the SIMATIC S7-1200 G2 Programmable Logic Controller system manual (https://support.industry.siemens.com/cs/us/en/view/109988293), "CPU memory" section.

Remote data storage
Data can be transmitted to external systems through various communication interfaces of the SIMATIC S7-1200 G2, such as PROFINET, Industrial Ethernet.

The SIMATIC S7-1200 G2 can send data to various remote systems, including SCADA systems, SQL databases, cloud platforms (e.g. Insights Hub), and file servers.

The SIMATIC S7-1200 G2 can send logging data to a SIEM system in the form of syslog messages.

The storage duration on external systems depends on the configuration of the respective system.

The SIMATIC S7-1200 G2 CPU can be integrated as a data source into the Siemens Industrial Edge concept.

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	TIA Portal Web server OPC UA HMI/SCADA systems CPU display	User management Authentication Certificates	Prioritization of control tasks over data access Data throughputs up to 1 Gbps via PROFINET Encrypted data transmission available (HTTPS, TLS)
Configuration and program data	TIA Portal Web server SIMATIC Memory Card	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Diagnostics data, system and security events, service data	TIA Portal SIMATIC Automation Tool Web server CPU display	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Operating data (runtimes, cycle times, CPU utilization)	TIA Portal Web server HMI/SCADA systems SIMATIC Controller Profiling	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Log data	TIA Portal Trace and logic analyzer function	User management Authentication	Encrypted data transmission available (HTTPS, TLS)

* "Quality of service" refers to the ability of the SIMATIC S7-1200 G2 to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from CPUs

To delete all data from the data memories of the CPU, the "Reset to factory settings" function is available.

A reset of the CPU to factory settings can be implemented using any of the following:

- Mode selector keys/switches of the CPU
- TIA Portal
- SIMATIC Automation Tool

More information
You can find more information on deleting data in the SIMATIC S7-1200 G2 Programmable Logic Controller system manual (https://support.industry.siemens.com/cs/us/en/view/109988293), "Securely removing data" section or in the TIA Portal Information System.

E.2 Data of the interface and I/O modules

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFIBUS, PROFINET, EtherNet/IP, Modbus TCP (only for interface modules as MultiFieldbus devices)

Continuous and real-time data generation

The interface and I/O modules are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the CPU.

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval by	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Through fieldbus without authentication With CPU (Page 480)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughputs up to 1 Gbps through PROFINET
Configuration and parameter data (upload to programming device/PC)	TIA Portal (through CPU) S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Through fieldbus without authentication With CPU (Page 480)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Through fieldbus without authentication With CPU (Page 480)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface, power supply, and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Type of data	Access/retrieval by	Terms of use	Quality of service*
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Through fieldbus without authentication With CPU (Page 480)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface, power supply, and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from interface and I/O modules

Interface modules

To delete all data from the data memories of the interface module, the "Reset to factory settings" function is available.

A reset of the IM to factory settings can be implemented using any of the following:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

I/O modules

The data of an IO-Link master can be deleted using S7-PCT by executing the "Reset to factory settings" function.

For all other I/O modules, no delete function is available.

More information

You can find more information on deleting data in the SIMATIC S7-1200 G2 Programmable Logic Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109988293), "Securely removing data" topic and in the TIA Portal Information System.

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S7-1200 G2 Firmware update V4.1.4
Product Information

Description

Firmware update V4.1.4 corrects an issue where, when the S7-1200 G2 CPU is operating as a PROFINET iDevice, repeated communication interruptions cause the S7-1200 G2 CPU and its controlled PROFINET devices to report persistent faults and trigger alarms.

Required user action

You can update the CPU firmware using one of the following methods:

- The Online & diagnostics functions of STEP 7
- The SIMATIC Automation Tool V5.0 SP4 or later
- A SIMATIC Memory Card that contains the firmware update file from the Siemens Industry Online Support site

The S7-1200 G2 System Manual and the SIMATIC Automation Tool User Guide document these methods.
After you apply the CPU firmware update, verify that your application operates as expected.

NOTE

The firmware update process discards any additional data appended to the firmware update file. Appending data to a firmware update file has no effect on the firmware update or the S7-1200 G2 CPU. You cannot append data, for example, to add components.

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://www.siemens.com/cert.

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ET 200SP
Distributed I/O system

System Manual

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ET 200SP
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Introduction

1

Purpose of the documentation

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

Basic knowledge required

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

Validity of the documentation

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

Definition

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

Conventions

Please pay particular attention to notes highlighted as follows:

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

ID link for the digital nameplate



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

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

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

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

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

Standards

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

Special information

WARNING

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

Proper use of hardware products

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

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

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

NOTE

Important note for maintaining operational safety of your plant

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

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

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

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

NOTE

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

1.1 Siemens Industry Online Support

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

- **Product support**
  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**
  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**
  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**
  For answers and solutions concerning automation technology.
- **mySupport**
  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

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

1.2 Industry Mall

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

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

1.3 ET 200SP Documentation Guide

1.3.1 Information classes ET 200SP



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

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

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

Basic information



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

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

Examples:

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

Device information



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

Examples:

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

General information



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

Examples:

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

Product Information

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

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

Manual Collection ET 200SP

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

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

Manual Collection fail-safe modules

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

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

1.3.2 Basic tools

Tools

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

TIA Selection Tool

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

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

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

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

SIMATIC Automation Tool

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

The SIMATIC Automation Tool offers a wide range of functions:

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

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

PRONETA

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

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

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

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

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

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

SINETPLAN

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

The advantages at a glance

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

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

1.3.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

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

Functional scope of the MFCT

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

System/installation requirements for MFCT

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

For MFCT you must also install the following software:

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

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

1.3.4 SIMATIC Technical Documentation

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

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

Overview of the SIMATIC Technical Documentation

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



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

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



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



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

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

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

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

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

Updating the documentation

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

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

mySupport

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

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

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

Application examples

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

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

Safety information

2

2.1 Warnings in this document

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

2.2 Safety-related symbols

2.2.1 Devices without explosion protection

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

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

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

2.2.2 Devices with explosion protection

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

Symbol	Meaning
	The assigned safety symbols apply to devices **with Ex approval**. You must read the product documentation. The product documentation contains information about the potential risks and enable you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by electrically skilled person. IEC 60417 No. 6182
	Observe the mechanical rating of the device.
	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
	Note that the device must be constructed and connected in accordance with EMC regulations.
	When the device is under voltage, note that it may not be installed or removed, or plugged or pulled.
	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2

Symbol	Meaning
	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
	Be aware that the device is only approved for the industrial field and only for indoor use.
	For Zone 2 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP54.
	For Zone 22 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP6x.

2.3 Intended use

The system is used to control machines and plants.

Intended use also includes observance of this documentation, in particular the safety instructions and conditions of use. See Technical specifications (Page 345) section.

2.4 Changes to the device and spare parts

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

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

2.5 Target group and personnel qualifications

All persons working with this device require the following knowledge:

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

The following activities are reserved for specially qualified personnel:

Working on electrical parts

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

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

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

2.6 Personal protective equipment

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

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

- ESD wrist strap
- ESD shoes

2.7 Safe working

2.7.1 Working on electrical parts

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

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

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

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

2.8 Residual risks

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

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

2.8.1 Live parts

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

Operation

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

Installation and connection

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

Maintenance

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

2.8.2 External power supply to modules

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

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

Maintenance

Ensure the following points before starting work:

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

2.8.3 Voltage dangerous to touch due to permissible electric potential difference

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

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

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

Maintenance

Ensure the following points before starting work:

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

2.8.4 Conductive pollution

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

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

2.8.5 Overheating

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

To avoid overheating:

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

Installation and connection

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

Maintenance

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

2.8.6 Uncontrolled movements

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

- Follow the safety instructions described in the function manuals.

2.8.7 Unsafe operating states

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

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

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

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

2.9 Behavior in case of emergency

- Force EMERGENCY OFF

When the safe operating state has been restored:

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

2.10 Material damage

2.10.1 Transport and storage

- Only pack, store, transport and ship electronic components, modules or devices in the original product packaging or in other suitable materials, e.g. conductive foam rubber or aluminum foil.
- Observe the limits during transport and storage. See Technical specifications (Page 345) section.

2.10.2 Installation and connection

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

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

- Read the section Removing and inserting I/O modules/motor starters (hot swapping) (Page 314).
- Observe the special conditions for hazardous areas in the section Marks and approvals (Page 346).

New properties/functions

3

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Backup and restore configuration of the ET 200SP CPU by a central user	As of FW version V4.1 of a ET 200SP CPU, a central user can also back up and restore the configuration. Read about the rules you need to follow when backing up and restoring.	Section Backing up and restoring the CPU configuration (Page 298)
	Integrated security		
	Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts for ET 200SP CPUs with FW version V4.1 or higher. The temporary account lockout provides protection against brute force attacks.	Section Temporary account lockout in case of brute force attacks (Page 232)
	SIMATIC S7 data	This appendix in the ET 200SP System Manual provides you with an overview of the data that the ET 200SP distributed I/O system generates and makes available to you.	Appendix SIMATIC ET 200SP data (Page 388)
	Communication of the CPU		
	New function for OPC UA	Enables cross-vendor communication.	Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
	Activating IP forwarding through a data record transfer	For ET 200SP CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU via data record transfer.	

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Information on the data integrity and the signed firmware update of I/O modules	Data integration and signed firmware updates offer protection against manipulation of the system and increase the system security.	Section Secure operation of I/O modules (Page 65)
	BaseCarrier	New, wire-free assembly technology offers a customer-specific PCB for reduced mounting times and avoiding faulty wiring. Use of "BaseCarriers" instead of conventional "BaseUnits".	Section Installing and uninstalling BaseCarrier (Page 130)

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Retentive memory area for syslog messages	ET 200SP CPUs FW version V4.0 or higher store syslog messages retentively. This means that events that require a restart of the CPU also remain in the syslog storage.	Section Industrial cybersecurity (Page 33)
	Central user management	System-wide, central management of users and user groups outside TIA Portal via UMC server. User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to a group, removed from a group, or their passwords can be changed. All without the CPU configuration having to be changed or loaded.	Section Central user management (Page 234)
	SIMATIC Controller Profiling	Using the new instruction "Profiling", you can start or stop the profiling of an ET 200 CPU with firmware version V4.0 or higher. When starting the profiling, specify the configuration with which the profiling data is to be recorded.	STEP 7 online help

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

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Syslog messages	As of TIA Portal version V19 and FW version V3.1, you can forward the syslog messages of an ET 200SP CPU to a syslog server.	Section Industrial cybersecurity (Page 33)
	Local user management	As of TIA Portal version V19 and FW version V3.1, ET 200SP CPUs have improved management of users, roles and CPU function rights (User Management & Access Control, UMAC). As of the above-mentioned version, you manage all project users along with their rights (e.g. access rights) for all CPUs in the project. You do this in the editor for users and roles in the TIA Portal.	Section Local user management (Page 222)
	SIMATIC Controller Profiling	With SIMATIC Controller Profiling you can analyze and evaluate the runtime behavior of your user program on an ET 200 CPU as of FW Version V3.1. All the relevant information can be displayed graphically and evaluated in a web browser.	Application example SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/us/en/view/109750245)

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Support of PROFINET system redundancy R1	The redundant ET 200SP R1 system ensures high availability through redundant PROFINET connections. In contrast to S2 devices, R1 devices are equipped with two interface modules. If one interface module fails, the R1 device can still be reached by the H-CPUs via the second interface module. Thus, R1 devices have a higher availability than S2 devices.	Starting with section System overview (Page 67)
	BaseUnit BU type M0		Starting with section System overview (Page 67)
	IM 155-6 PN R1 interface module		Starting with section System overview (Page 67)

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	New shield terminal for connecting cable shields	The new stacked shield terminal provides extended space for clamping thanks to two clamping positions. In addition, a supporting element absorbs torsional and bending forces.	Section Connecting cable shields for I/O modules (Page 166)

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Modules for hazardous area	The Ex BaseUnits and Ex I/O modules enable the connection of intrinsically safe devices from the hazardous area Zone 0 and Zone 1.	System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533-/en) Starting from section System overview (Page 67)

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

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseUnits BU30-MS7, BU30-MS8, BU30-MS9 and BU30-MS10 for fail-safe motor starters	A simple, wire-saving group shutdown for fail-safe motor starters. In contrast to the earlier solution (BU30-MS5 and BU30-MS6), the fail-safe signal only has to be wired to the first motor starter. The fail-safe signal is internally routed via the BaseUnits.	Section Selecting a motor starter with suitable BaseUnit (Page 91) Section Forming potential groups (Page 99) Section Wiring BaseUnits for motor starters (Page 169)

Industrial cybersecurity

4

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

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

NOTE

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

4.1 Cybersecurity information

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

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

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

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

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

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

4.2 Security update notification

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

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

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

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

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

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

4.3 Basic information on industrial cybersecurity

4.3.1 Definition of industrial cybersecurity

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

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

4.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Prevention of risks to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices without their own security functions

- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

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

4.4 Integrated security concept and security strategies

4.4.1 Comprehensive security concept "Defense in Depth"

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

Productivity and know-how are protected on 3 levels:

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

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

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

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

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

4.4.2 Security management

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

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

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

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

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

Responsibility in the digital supply chain

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

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

Employee awareness

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

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

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

Maintaining the security concept through updates

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

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

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

Recommendations:

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

Always keep technology and knowledge up to date.

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

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

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

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

Continuously monitoring the security situation

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

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and effectively resolve security vulnerabilities.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network

- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: e.g. network segmentation, firewalls, VPN, DMZ (demilitarized zones)

4.5 Operational application environment and security assumptions

4.5.1 Intended use

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

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

Operational reliability and intended use

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

Area of application

Observe the "Area of application" section in System overview (Page 67).

4.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

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

Threat and Risk Assessment

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

Network security concepts

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

Access control concepts

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

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

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

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

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

4.6 Security properties of the devices

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

4.7 Secure operation of the system

4.7.1 Introduction to secure operation of the system

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

4.7.2 Hardening measures

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

Measures for system hardening include, for example:

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

4.7.3 Secure configuration

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

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

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

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

4.7.4 Access control

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

- Use a restrictive user and rights management system, e.g. for accessing the CPUs and TIA Portal
- Observe the information regarding password management in the section Protection (Page 219) and in the STEP 7 online help (TIA Portal).

4.7.5 Handling of sensitive data

Data protection information

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

This means for the products in this system:

Products with user management save user names and passwords to manage access rights. User names are also saved in logging alarms. These logging alarms are provided with a time stamp and stored in the internal cache of the CPU. They can be forwarded to a central syslog server.
You can find more information in the section Syslog messages (Page 54).

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

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

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

Storage of security-related data

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

Observe also the section Data worth protecting (Page 51).

4.7.6 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

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

For more information, refer to:

- The section Firmware update (Page 322)
- The section Notification of security updates (Page 34)

4.7.7 Notifications about security vulnerabilities (Siemens Security Advisories)

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

Siemens ProductCERT

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

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

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

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

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

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

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

4.7.8 Data backup

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

4.7.9 Security checks

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

File Integrity Guidelines describe the prescribed procedure for integrity checks.

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

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

4.7.10 Secure decommissioning

4.7.10.1 Introduction

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

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

4.7.10.2 Securely removing data

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

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

Secure erasure of data from the CPU and SIMATIC Memory Card

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

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

1. Format the SIMATIC Memory Card.

   The formatting deletes all contents from the SIMATIC Memory Card.

   Formatting with STEP 7:

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

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

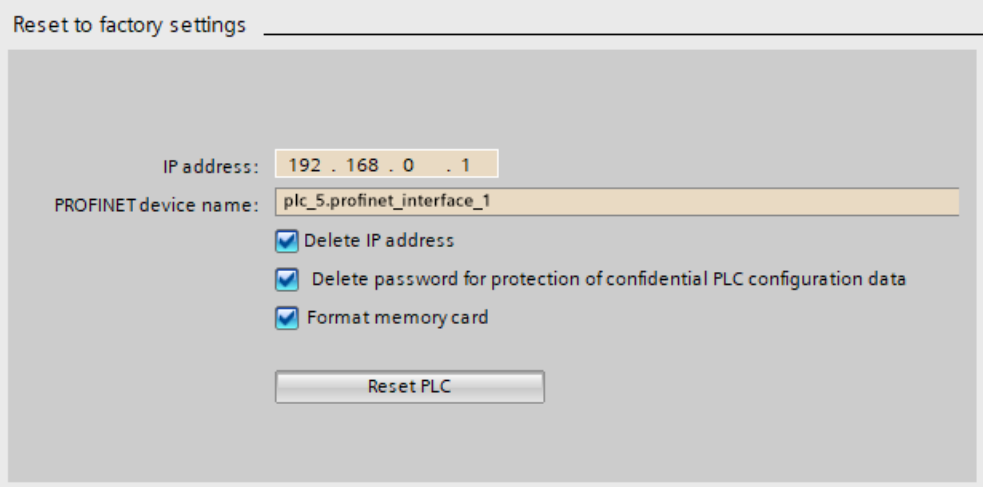


Figure 1-47 Resetting the CPU to factory settings

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

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

For more information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 328).

NOTE
If you no longer plan to use the SIMATIC Memory Card after formatting it, destroy it before disposing of it.
A secure destruction method is to shred the card to such a degree that it cannot be reconstructed. For this, you can also use a waste disposal service that specializes in data storage medium destruction.

Secure erasure of data from the interface module

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

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

Follow these steps in the order given:

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

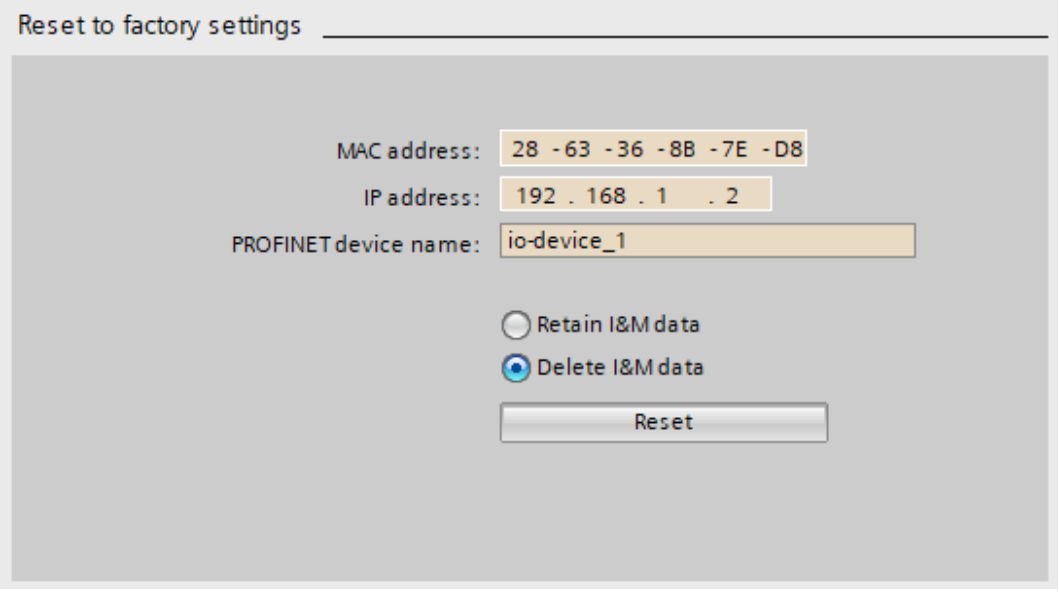


Figure 1-48 Resetting an interface module to factory settings

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

For more information on resetting the interface module to factory settings, refer to the section Resetting an interface module to factory settings (Page 332).

NOTE

STEP 7 ≥ V19

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

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

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

4.7.10.3 Recycling and disposal

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

NOTE

Recycler Guides

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

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

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

4.8 Secure operation of the engineering software

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

4.9 Secure operation of CPUs

4.9.1 Introduction to secure operation of CPUs

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

4.9.2 Secure configuration

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

4.9.3 User management and access control

4.9.3.1 Administration of user accounts

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

Take the following security measures:

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

You can find information on creating and managing user accounts in the Protection (Page 219) section under "User management" and in the online help for STEP 7 (TIA Portal).

4.9.3.2 Assigning secure passwords

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

- Therefore, always change the default passwords during commissioning and use different passwords for different users, functions and devices.
- When changing passwords, do not use passwords (or parts of passwords) that have been used in the past.
- Also, change passwords for functions you don't personally use to prevent misuse of such unused functions.
- Always keep your passwords confidential and ensure that only authorized individuals have access to the respective passwords.
- Exceed the required minimum password length and use a combination of lowercase letters, uppercase letters, numbers and special characters.

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

Overview of all components and functions with password protection

Components and functions with password protection	Comment
SIMATIC S7 app	See the SIMATIC S7 app (https://new.siemens.com/global/en/produkte/software/mobile-apps/simatic2go.html)
Syslog (with certificate protection)	See section Syslog messages (Page 54)
CPU	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
OPC UA	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section OPC UA Communication
SNMP Community-String (similar to a password)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section SNMP
Secure communication (with certificate protection)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
Web server	See the Web Server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560)

4.9.3.3 Password management

- You can find comprehensive recommendations for assigning secure passwords in the Industrial Security Configuration Manual (https://support.industry.siemens.com/cs/us/en/view/108862708).
- Set guidelines for assigning passwords and intervals for password changes.
- Settings for checking password policies when passwords are assigned or changed can be configured in the TIA Portal. You can find more information in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
- Changing and resetting the password for protection of confidential configuration data
  You can find information on the following topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925):
  - Description on how to change the password
  - Description on how to delete or reset the password
  - Description on how to assign the password via a SIMATIC Memory Card.
- For user management and access control, use the local/central user management.
- Using a password provider: A password provider can be set up in STEP 7, see the section Know-how protection (Page 246).
- In addition, you can use commercially available password management programs.

Setting password protection without engineering system

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

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

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

4.9.3.4 Setting protection levels

For detailed information about setting up protection levels for the CPU and assigning user authorizations, refer to the Configuring access protection for the CPU (Page 243) section and the STEP 7 online help (TIA Portal).

4.9.3.5 Certificate management

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

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

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

4.9.4 Protection functions

Integrated protection functions of the CPU protect against unauthorized access.

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

A description of the protection functions and their activation can be found in the section Protection (Page 219).

4.9.5 Signed firmware update for CPUs

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

Principle of the signed firmware updates for CPUs

Firmware updates for CPUs contain a digital signature.

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

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

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

The procedure for carrying out firmware updates for CPUs is described in the section Firmware update (Page 322).

Diagnostics alarms and remedy

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

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

In case of firmware update rejection, proceed as follows:

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

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

4.9.6 Secure Boot for CPUs

Secure Boot

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

Principle of "Secure Boot" for CPUs

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

The verification is carried out using standardized asymmetric cryptography methods.

In addition to the signed firmware update for CPUs (Page 49), Secure Boot prevents a manipulation of the firmware by a physical intervention into the CPU.

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

4.9.7 Web server

The CPUs have an integrated Web server.

It comes with built-in security features:

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

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

4.9.8 Secure Communication/OPC UA

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

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

4.9.9 Sensitive data

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

Sensitive data	Comment	Where can I find more information?
Confidential configuration data (private keys, passwords/access data)	Protection by using a strong password	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Protection of confidential configuration data
User management data	-	STEP 7 online help
Configuration of CPUs and interface modules	Protection through PROFINET Security Class 1	PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Blocks (data blocks, logic blocks)	Know-how protection, copy protection, write protection	Section Protection (Page 219)
Data deemed sensitive by the operator	Backups, other configuration data, analysis data	Section Backing up and restoring the CPU configuration (Page 298)

4.9.10 Backups and data backups

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

Backing up a STEP 7 project:

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

You can find more information in the section Backing up and restoring the CPU configuration (Page 298).

4.9.11 Additional measures for network security

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

- Deployment of CP 1543SP-1 with security functions

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

  The following measures additionally increase the protection against unauthorized access to functions and data of the CPU from external sources and via the network: You can find information on these topics in the section Further measures for protecting the CPU in Overview of the protective functions of the CPU (Page 219).
- You can find information on network security and network components for protection from unauthorized access in the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856), section Network security.

4.9.12 Remote access to CPU

4.9.12.1 Using a Web server

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

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

4.9.12.2 Remote access via Internet

Communication via SINEMA Remote Connect (SINEMA RC)

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

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

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

4.9.12.3 Remote access via TIA Portal

Communication via TIA Portal Cloud Connector

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

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

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

4.9.13 Recording Security events

Syslog storage

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

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

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

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

- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

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

You can find more information in the section Syslog messages (Page 54).

Connection to a SIEM system

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

4.9.14 Syslog messages

Using syslog messages

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

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

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

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

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

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

NOTE

Deleting the retentive syslog storage

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

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

Forwarding to a syslog server

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

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

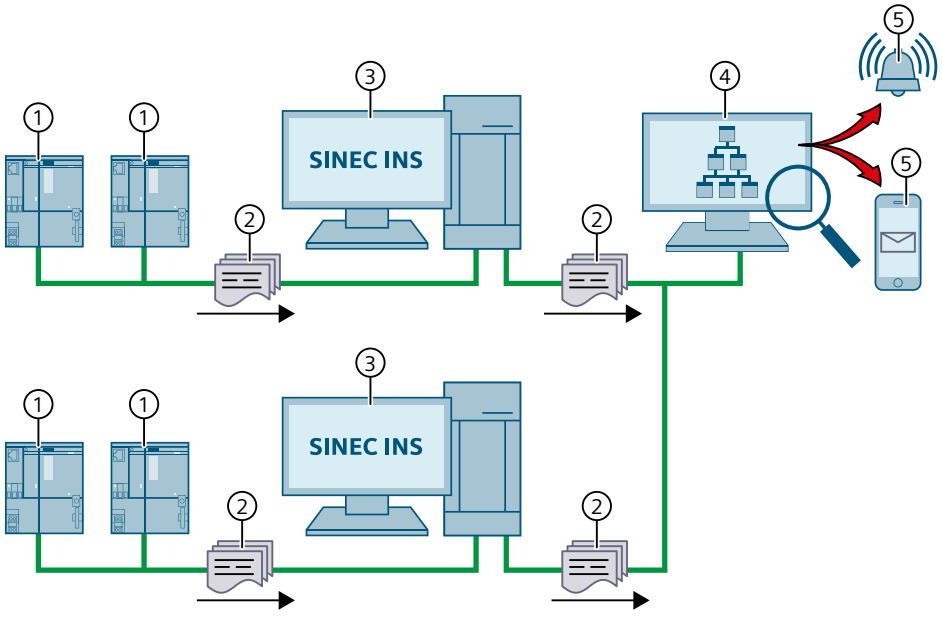
Use solely a TLS connection in productive operation. TLS ensures that all syslog messages from the CPU are securely transferred to the syslog server.

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

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

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

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



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

Figure 1-49 Forwarding and processing of syslog messages

More information

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

You can find information on the structure of syslog messages in the Structure of the Syslog messages (Page 59) section.

4.9.14.1 Transfer the syslog messages to a syslog server

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

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

Transmitting syslog messages via a TLS connection

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

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

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

Message in the diagnostic buffer of the CPU

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

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

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

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

Requirements

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

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

Procedure

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

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

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

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

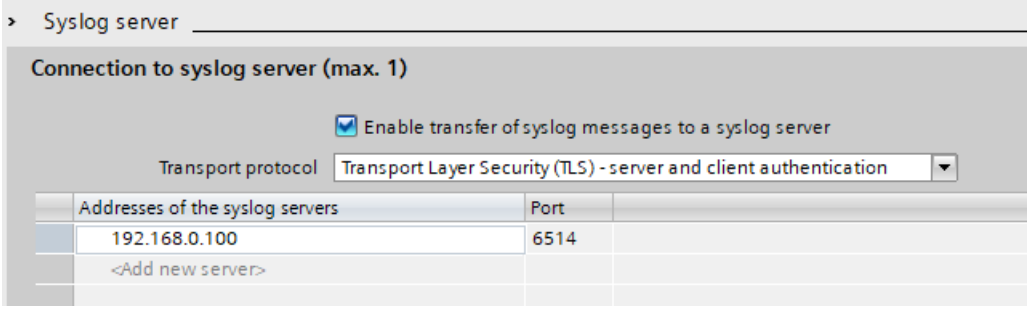


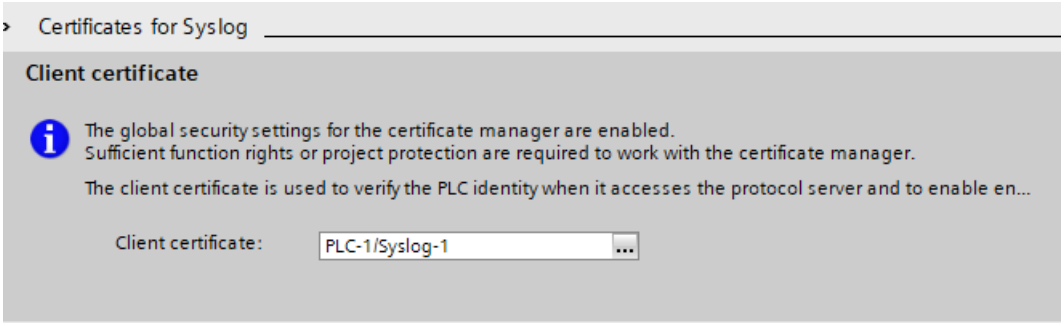
Figure 1-50 Transfer of syslog messages to a syslog server configured

Selecting the client certificate

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

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

3. Select the appropriate certificate in the "Client certificate" field.



Selecting the server authentication

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

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

NOTE

No authentication with automatically accepted server certificates

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

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

4.9.14.2 Structure of the Syslog messages

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

- HEADER
- STRUCTURED-DATA
- MSG (Message)

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

Structure of the HEADER element

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

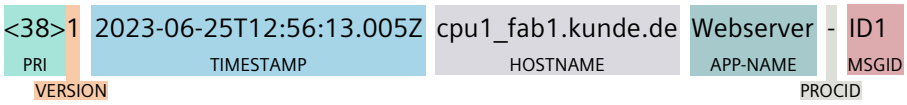


Figure 1-51 Example: HEADER of the syslog message of a CPU

The following table describes the parameters in the prescribed order.

Parameter	Description
PRI	PRI encodes the priority of the syslog message, divided into Severity (severity of the message) and Facility (origin of the message). The PRI value is formed as follows: • PRI = Facility x 8 + Severity Possible values: • Severity – 0 = Emergency: system is unusable – 1 = Alert: action must be taken immediately – 2 = Critical: critical conditions – 3 = Error: error conditions – 4 = Warning: warning conditions – 5 = Notice: normal but significant condition – 6 = Informational: informational messages – 7 = Debug: debug-level messages • Facility – 1 = User-level messages – 2 = Mail system – 3 = System daemons – 4 = Security/authorization messages – 5 = Messages generated internally by syslog – 6 = Line printer subsystem – 7 = Network news subsystem – 8 = UUCP subsystem – 9 = Clock daemon – 10 = Security/authorization messages – 11 = FTP daemon – 12 = NTP subsystem – 13 = Log audit – 14 = Log alert A CPU does not use all of the listed severity/facility values.
VERSION	Version number of the syslog specification.
TIMESTAMP	The device sends the time stamp in the format "2023-06-25T12:56:13.005Z" as UTC time without time zone and correction for daylight-saving/standard time.
HOSTNAME	Contains the name or the IP address (PROFINET interface X1) of the device or system from which the syslog message has been sent. IPv4 address according to RFC1035: Bytes in decimal representation: XXX.XXX.XXX.XXX IPv6 address according to RFC4291 Section 2.2 "-" is output if information is missing.
APP-NAME	Contains the component (device part or application) from which the message has been generated. "-" is output if information is missing.
PROCID	The process ID serves to clearly identify the individual processes, for example during analysis and troubleshooting. "-" is output if information is missing.
MSGID	ID to identify the message. "-" is output if information is missing.

Structure of the STRUCTURED-DATA element

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

- More information about the syslog message
- Application specific information

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

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

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

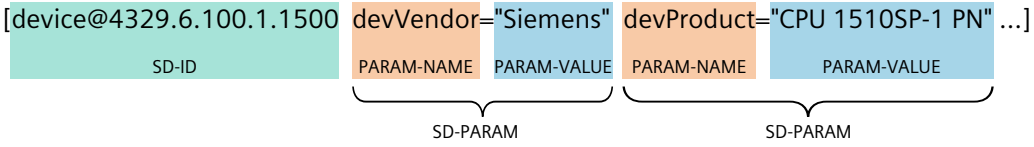


Figure 1-52 Example: SD ELEMENT of the syslog message of a CPU

Structure of the MSG element

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

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

More information

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

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

4.10 Secure operation of interface modules

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

4.10.1 Data integrity for interface modules

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

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

Data integrity for interface modules

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

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

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

Principle

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

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

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

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

I&M data

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

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

NOTE

Requirements for calculating the CRCs

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

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

Example:

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

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

The structure of the I&M data 0 to 4 is described in the section Record structure for I&M data (Page 308).

Spare parts scenario

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

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

4.10.2 Signed firmware update for interface modules

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

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

Principle of signed firmware updates for interface modules

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

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

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

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

You still have all the options for firmware updates, as described in the Firmware update (Page 322) section, when performing signed firmware updates for interface modules. If the firmware update was not successful, the module will continue to run with the previous firmware.

Diagnostics alarms and remedy

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

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

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

In case of firmware update rejection, proceed as follows:

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

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

4.11 Secure operation of I/O modules

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

4.11.1 Data integrity for I/O modules

Data integrity for I/O modules

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

Principle

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

You can find more information on the principle of data integrity and I&M4 data in the section Data integrity for interface modules (Page 62).

Spare parts scenario

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

- CHK_STATIC_SUBS
- CHK_OVERALL_SUBS
- CHK_OVERALL

You can find the structure of I&M data in the section Record structure for I&M data (Page 308).

4.11.2 Signed firmware update for I/O modules

Signed firmware update

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

It protects you against installing malicious firmware in case:

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

Signed firmware update for I/O modules

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

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

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 64) applies.

See also

Firmware update (Page 322)

4.12 Secure operation of the power supply modules

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

System overview

5

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

SIMATIC ET 200SP

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

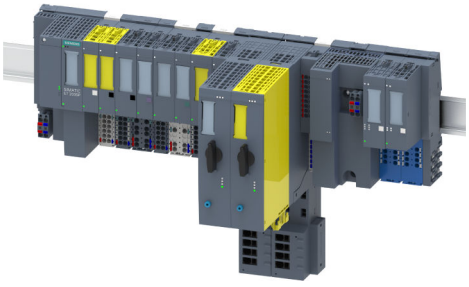
Customer benefits of the system

Compact design

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

Easy to use

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



Safety Integrated

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

Communication standards

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

High performance

- Isochronous PROFINET IO with the PROFIsafe and PROFIenergy profiles

Energy efficiency

- PROFIenergy as integrated function

CPU

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

Modules for hazardous area

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

Motor starter

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

Motion integrated

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

Powerful technology

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

Figure 1-53 SIMATIC ET 200SP distributed I/O system - Customer benefits

Area of application

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

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

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

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

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

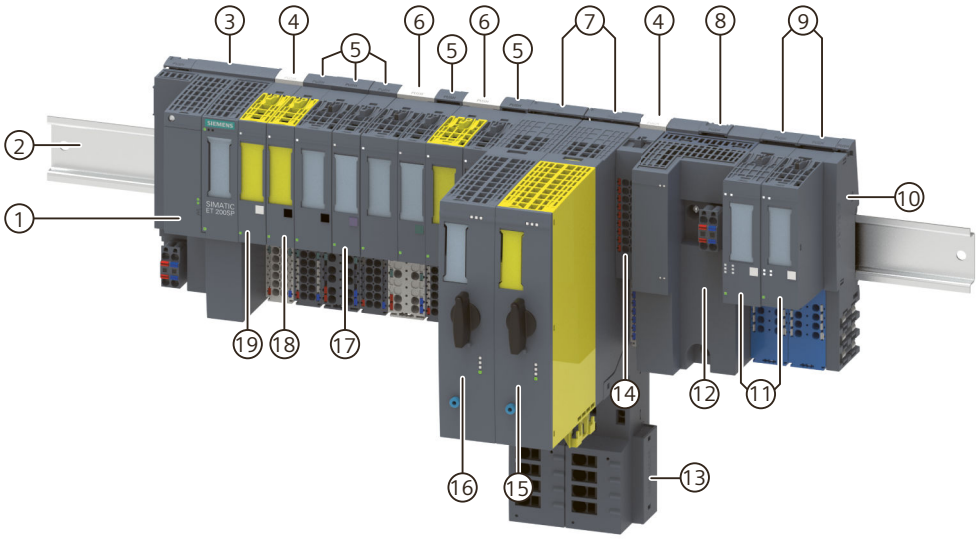
With use of an ET 200SP R1, you increase the availability of the system through redundant interface modules.

Configuration

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

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

Configuration example



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

Figure 1-54 Example configuration ET 200SP

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

Fail-safe automation systems

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

Safety Integrated

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

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

Fail-safe modules

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

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

Fail-safe motor starters

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

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

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

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

SIMATIC Safety F-system with ET 200SP

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

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

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

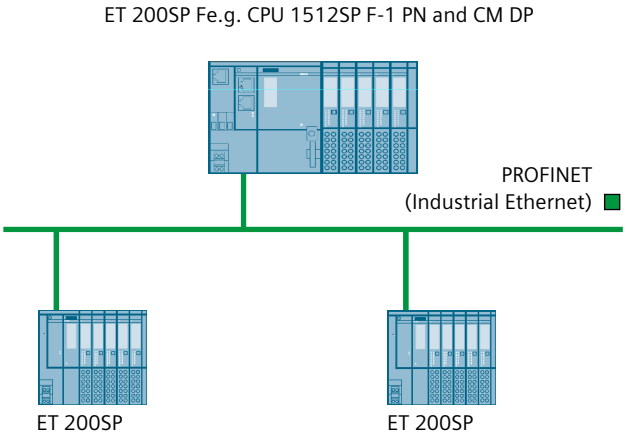


Figure 1-55 Fail-safe SIMATIC Safety automation system (sample configuration)

Fail-safe ET 200SP I/O modules

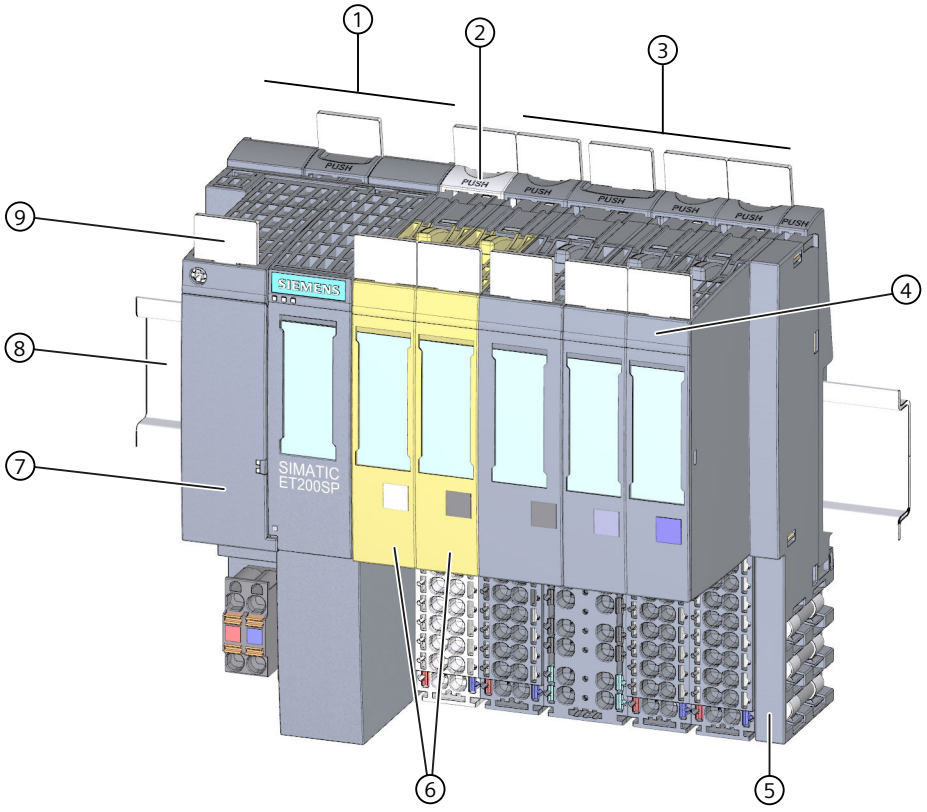
The following fail-safe I/O modules are available for the ET 200SP distributed I/O system:

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

ET 200SP fail-safe motor starters

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

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



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

Figure 1-56 Example of a configuration of the ET 200SP with fail-safe I/O modules

Hardware and software requirements

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

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

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

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

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

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

NOTE

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

Use in safety mode only

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

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

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

Achievable safety classes

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

You can achieve the safety classes of the table below:

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

Table 1-346 Safety classes that can be achieved with ET 200SP in safety mode

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

More information

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

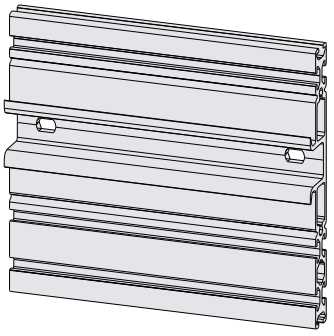
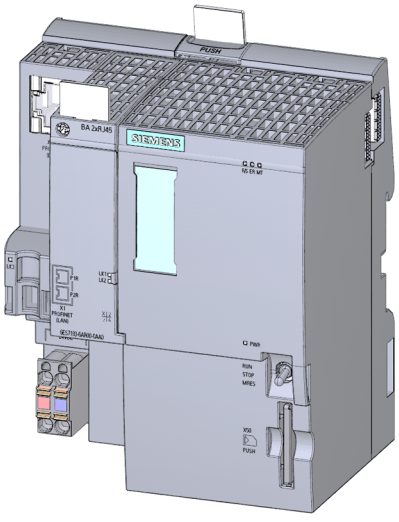
5.4 Components

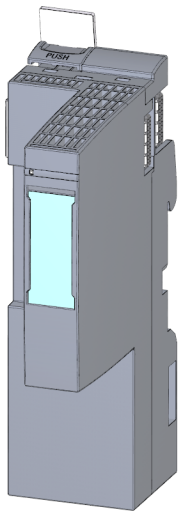
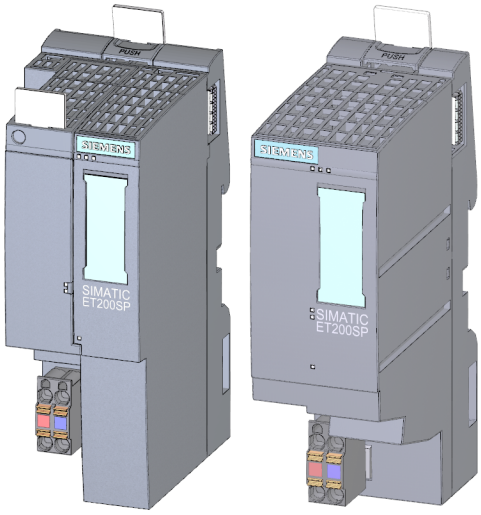
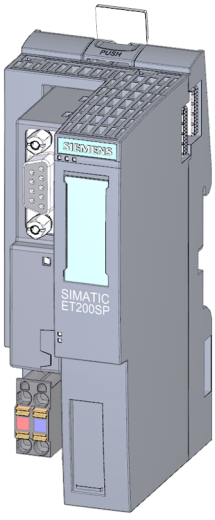
Overview of ET 200SP modules and accessories

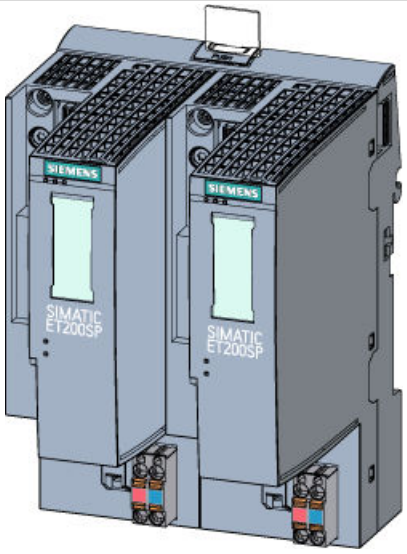
NOTE
A complete overview of the ET 200SP modules and accessories is available in the Product information on documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/de/de/view/73021864/en).

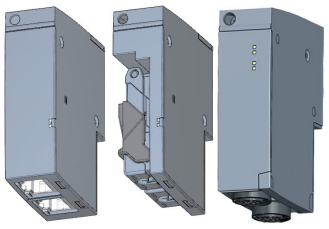
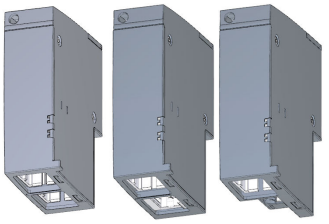
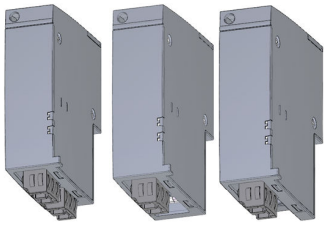
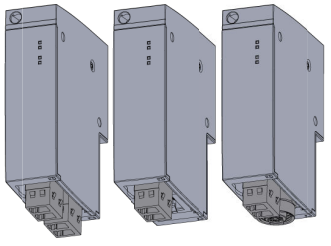
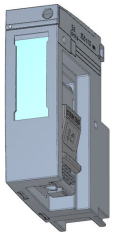
Basic components of the ET 200SP distributed I/O system

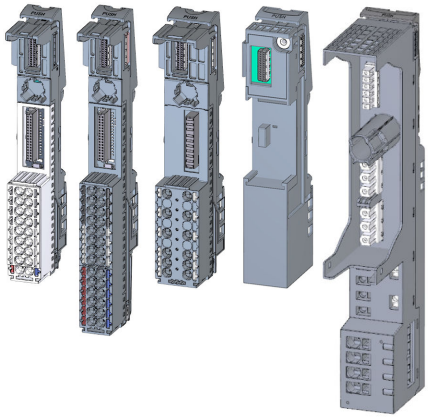
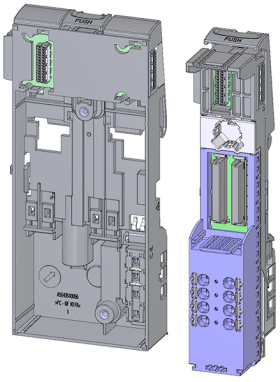
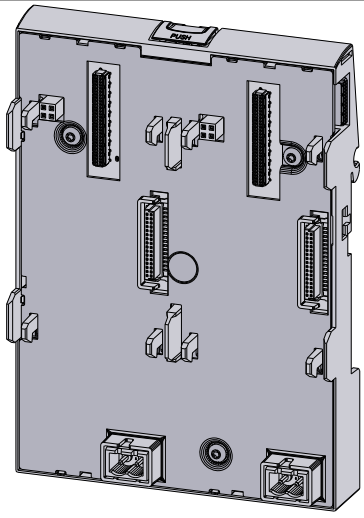
Table 1-347 Basic components of the ET 200SP

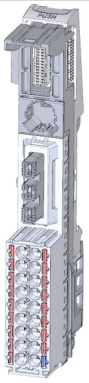
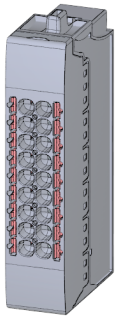
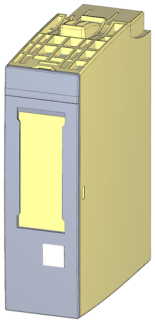
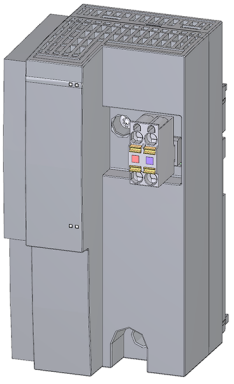
Basic component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the rack of the ET 200SP distributed I/O system. You install the ET 200SP system on the mounting rail. The mounting rail is 35 mm high.	
SIMATIC system rail	The system rail is the mounting rack of the ET 200SP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

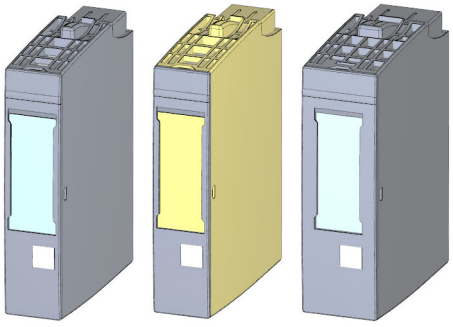
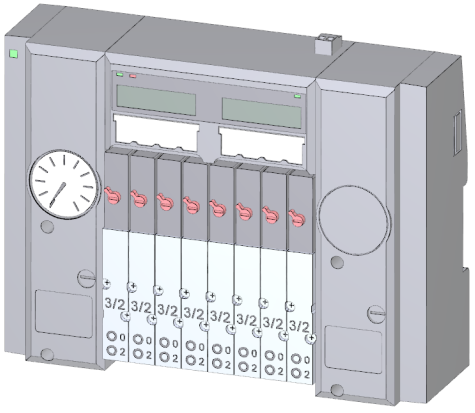
Basic component	Function	Figure
Communication module CM DP	The communication module CM DP • Connects the CPU with PROFIBUS DP • The bus connection is an RS485 interface.	
Interface module for PROFINET IO	The interface module: • Can be used as IO device on PROFINET IO • Links the ET 200SP with the IO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

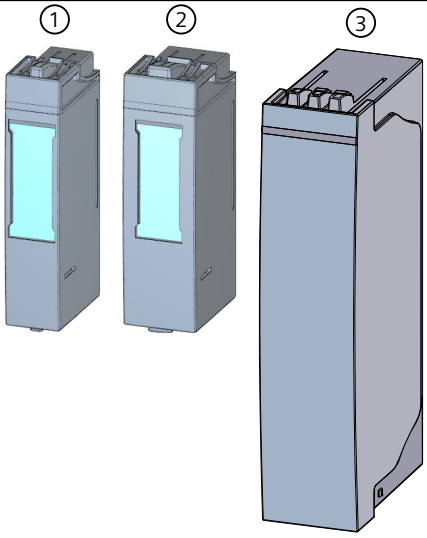
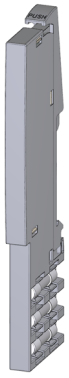
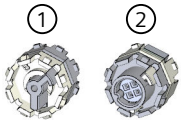
Basic component	Function	Figure
Interface modules and BaseUnit BU type M0 for redundant connection	The ET 200SP R1 system: • Use as redundant IO device on PROFINET IO • Connects the ET 200SP to the IO controller • Exchanges data with the I/O modules via the backplane bus.	

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

Basic component	Function	Figure
BaseUnit	The BaseUnits provide the electrical and mechanical connection of the ET 200SP modules. Place the I/O modules or the motor starter onto the BaseUnits. Respectively suitable BaseUnits are available for the different requirements. You can find additional information in section Selecting the BaseUnit for I/O modules (Page 89).	
Ex BaseUnit	You need the following BaseUnits for an Ex module group: • Ex BaseUnit for Ex power module • Ex BaseUnit for Ex I/O module	
BaseUnit ET 200SP R1	Connects the IM 155-6 PN R1 redundant interface modules to the backplane bus. It enables data exchange with the I/O modules. Note: Interface modules cannot be plugged in if the associated supply voltage connector is plugged in. Only use BusAdapters of the same type.	

Basic component	Function	Figure
PotDis-BaseUnit potential distribution module	You use the potential distribution module to distribute a variety of potentials (P1, P2). This allows you to implement a multi-cable connection without external terminals with 16-channel digital modules. The assembly has two parts: • If you need additional potential terminals, plug a PotDis-TerminalBlock in the PotDis-BaseUnit. • Alternatively, plug a BU cover (15 mm) on the PotDis-BaseUnit. With potential distribution modules, you may only connect to the PotDis-TB versions BR-W and n.c.-G potential, which exceed the voltage level of SELV/PELV. Other SELV/PELV potential groups should be separated with light-colored PotDis BUs. Suitable PotDis-BaseUnits are available in each case for the different requirements. You can find additional information in section Selecting a PotDis-BaseUnit (Page 95).	
PotDis-TerminalBlock	If you need additional potential terminals for a PotDis-BaseUnit, plug a PotDis-TerminalBlock in the PotDis-BaseUnit. Voltages greater than SELV/PELV are only permitted for the PO PotDis-TBs BR (bridged) and NC (not connected). The same applies to PE. Voltages at the terminals of the PotDis modules connected to the P1/P2 rails must not be greater than SELV/PELV. Suitable PotDis-TerminalBlocks are available in each case for the different requirements. You can find additional information in section Selecting a PotDis-TerminalBlock (Page 96).	
Fail-safe power module	The fail-safe power module allows the safety-related shutdown of digital output modules / fail-safe digital output modules.	
Ex power module	The Ex power module supplies the downstream Ex I/O modules via the power bus on the Ex BaseUnit of the Ex power module. An Ex BaseUnit is required for installing the Ex power module.	

Basic component	Function	Figure
I/O module / Fail-safe I/O module / Ex I/O module	The I/O module determines the function at the terminals. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are divided into the following module types: • Digital input (DI, F-DI, Ex-DI) • Digital output (DQ, F-DQ PM, F-DQ PP, F-RQ, Ex-DQ) • Analog input (AI, F-AI, Ex-AI) • Analog output (AQ, Ex-AQ) • Technology module (TM, F-TM-C) • Communication module (CM) • Power module (F-PM-E)	
Motor starter/fail-safe motor starter	The motor starter is a switching and protection device for 1-phase and 3-phase loads. The motor starter is available as a direct-on-line and reversing starter.	
Vale terminal AirLINE SP type 8647 (Bürkert GmbH & Co. KG) [1) 2)]	Basic component: Valve terminal AirLINE SP type 8647 (Bürkert). For more information on the AirLINE SP, type 8647 (e.g. data sheet and operating instructions), please contact Bürkert (https://www.burkert.co.uk/en/type/8647) directly. Function: Valve terminals are common in industrial automation and are used as pilot valves for controlling pneumatic actuators, for example in areas of the food, pharmaceutical and water treatment industries. The ET 200SP in combination with the AirLINE SP, type 8647 from Bürkert provides a universal interface between process and plant control that enables the flexible, modular configuration of pilot valves and I/O modules. The valve terminal can also be fitted to the base of the control cabinet with the help of the AirLINE Quick Adapter. This further reduces the space required in the control cabinet and considerably simplifies installation of the pneumatic system. [1) 2)]	

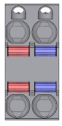
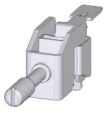
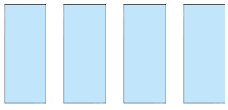
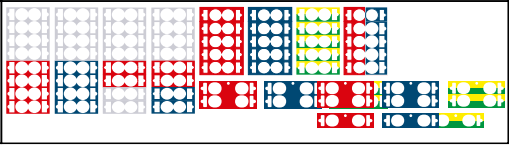
Basic component	Function	Figure
BU cover	Insert the BU cover on the BaseUnits: • Whose slots are not equipped with I/O modules/ motor starters//PotDis-TerminalBlocks • Whose slots have been reserved for future expansion (as empty slots). You can keep a reference identification label for the planned I/O module inside the BU cover. There are three versions: • For BaseUnits with a width of 15 mm ① • For BaseUnits/Ex BaseUnits with a width of 20 mm ② • For BaseUnits of motor starters with a width of 30 mm ③	
Server module	The server module completes the configuration of the ET 200SP. The server module includes holders for 3 spare fuses (5 × 20 mm). The server module ships with the CPU/interface module and is available as spare part.	
Coding element	The coding element codes the I/O module with the BaseUnit. There are two versions: • Mechanical coding element ①: Ensures the coding • Electronic coding element ②: This version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for the IO link master).	

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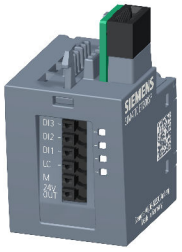
Accessories of the ET 200SP distributed I/O system

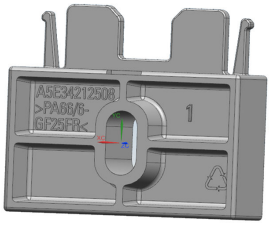
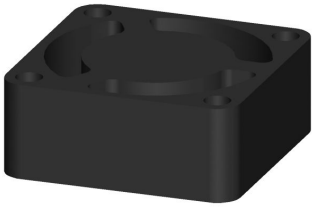
Table 1-348 Accessories of the ET 200SP

Accessories	Function	Figure
24 V DC connector	Application of the 24 V DC supply to the connector, and connection, e.g. to the CPU/interface module/Ex power module. The 24 V DC connector is available as a spare part.	
Shield connection	The shield connection allows the low-impedance contacting of cable shields with minimum installation times.	
Labeling strips	Attach the labeling strips to the modules for system-specific labeling of the ET 200SP distributed I/O system. The labeling strips can be printed. The labeling strips can be ordered as accessories (Page 370) on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.	
Reference identification labels	The labels enable the reference identification labeling of the ET 200SP components. The labels can be ordered on a mat for thermal transfer and inkjet printers as accessories (Page 370).	
Color identification labels	The color identification labels are module-specific and can be ordered for the process terminals, AUX terminals and additional terminals as accessories (Page 370).	

Accessories of the SIMATIC ET 200SP motor starters

Table 1-349 SIMATIC ET 200SP motor starter accessories

Accessories	Function	Figure
3DI/LC module	The optional 3DI/LC module has three digital inputs and one LC input. For reasons of operational safety, input LC is permanently set to manual local mode. By parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode. The functions of the 3DI/LC module are not relevant to functional safety.	

Accessories	Function	Figure
	Detailed information on the functions when using a 3DI/LC module can be found in the Manual (https://support.industry.siemens.com/cs/ww/en/view/109479973).	
Mechanical bracket for BaseUnit	Use the mechanical bracket for additional fixing of the motor starter. You can use the mechanical bracket on 7.5 mm and 15 mm mounting rails.	
Infeed bus cover	For finger-safe termination of the infeed bus, use the cover.	
Fan	You can use the motor starter at higher ambient temperatures if a fan is installed.	

Application planning

6

Overview

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

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

The BU type onto which you can plug the respective I/O module is printed on the I/O modules. You can therefore read which BU type you need straight from the I/O module (see Factory labels (Page 186) (page 122)).
Example: On the output module DQ 16x24VDC/0.5A ST with article number 6ES7132-6BH01-0B**A0** the information "BU: A0" is printed. This means you can plug this I/O module into a BaseUnit of BU type "A0", which means any BaseUnit whose article number ends in "A0". I/O modules that are suitable for two BU types are labeled accordingly, for example "BU: A0, A1".

NOTE

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

NOTE

Use of Ex modules

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

Table 1-350 Selecting a suitable BaseUnit for interface modules

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

Table 1-351 Selecting a suitable BaseUnit for I/O modules

Select BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **A0** See Digital, fail-safe, communication, technology or analog modules without temperature measurement (Page 89)	Digital, fail-safe, technology or communication module • 6ES7...**A0** • 24 V DC • 15 mm wide	DI 16×24VDC ST (6ES7131-6BH00-0B**A0**)	BU15-P16+A0+2D (6ES7193-6BP00-0D**A0**)
BU type **A1** See Analog modules with temperature measurement (Page 90)	Analog module **with** temperature measurement* • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4×RTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0C**A1**)	BU15-P16+A0+2D/T (6ES7193-6BP00-0D**A1**)
	Analog module **without** temperature measurement** • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4xU/I 2-wire ST (6ES7134-6HD00-0B**A1**)	
BU type **B0** (BU..B, dark-colored BaseUnit)	Digital output module with relay • 6ES7...**B0** • Up to 230 V AC • 20 mm wide	RQ 4×120VDC-230VAC/5A NO ST (6ES7132-6HD00-0B**B0**)	BU20-P12+A4+0B (6ES7193-6BP20-0B**B0**)
BU type **B1** (BU..B, dark-colored BaseUnit)	Digital modules • 6ES7...**B1** • Up to 230 V AC • 20 mm wide	DI 4×120..230VAC ST (6ES7131-6FD00-0B**B1**)	BU20-P12+A0+4B (6ES7193-6BP20-0B**B1**)
BU type **C0** (BU..D, light-colored BaseUnit)	Fail-safe power module • 6ES7...**C0** • 24 V DC • 20 mm wide CM AS-i Master ST/F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	CM AS-i Master ST (3RK7137-6SA00-0B**C1**)	BU20-P6+A2+4D (6ES7193-6BP20-0D**C0**)
BU type **C1** (BU..B, dark-colored BaseUnit)	F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	F-CM AS-i Safety ST (3RK7136-6SC00-0B**C1**)	BU20-P6+A2+4B (6ES7193-6BP20-0B**C1**)
BU type **D0**	AI Energy Meter • 6ES7...**D0** • Up to 400 V AC/ 480 V AC • 20 mm wide	AI Energy Meter 480VAC ST (6ES7134-6PA20-0B**D0**)	BU20-P12+A0+0B (6ES7193-6BP00-0B**D0**)

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

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

Select BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **F0**	F-RQ 1×24VDC/24..230VAC/5A • 6ES7...**F0** • Up to 230 V AC • 20 mm wide	F-RQ 1×24VDC/24..230VAC/5A (6ES7136-6RA00-0B**F0**)	BU20-P8+A4+0B (6ES7193-6BP20-0B**F0**)
BU type **U0**	DQ 4×24...230VAC/2A HF • 6ES7...**U0** • Up to 400 V AC/480 V AC • 20 mm wide	DQ 4×24...230VAC/2A HF (6ES7132-6FD00-0C**U0**)	BU20-P16+A0+2D (6ES7193-6BP00-0B**U0**)

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

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

Table 1-352 BaseUnit for motor starters

		Selecting the BaseUnit									
		BU-30--MS1	**BU-30--MS2**	**BU-30--MS3**	**BU-30--MS4**	**BU-30--MS5**	**BU-30--MS6**	**BU-30--MS7**	**BU-30--MS8**	**BU-30--MS9**	**BU-30--MS10**
24 V infeed		**x**		**x**							
500 V infeed		**x**	**x**			**x**		**x**	**x**		
F-DI terminals (no routing of the F-DI signal possible)						**x**	**x**				
F-DI infeed								**x**			**x**
F-DI routing									**x**	**x**	
Motor starters											
DS 0.1 - 0.4 A HF	3RK1308-0A-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.3 - 1A HF	3RK1308-0A-B00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.9 - 3A HF	3RK1308-0A-C00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 2.8 - 9A HF	3RK1308-0A-D00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 4.0 - 12A HF	3RK1308-0AE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.1 - 0.4 A HF	3RK1308-0B-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.3 - 1A HF	3RK1308-0BB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.9 - 3A HF	3RK1308-0BC-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*

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

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

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

Additional information

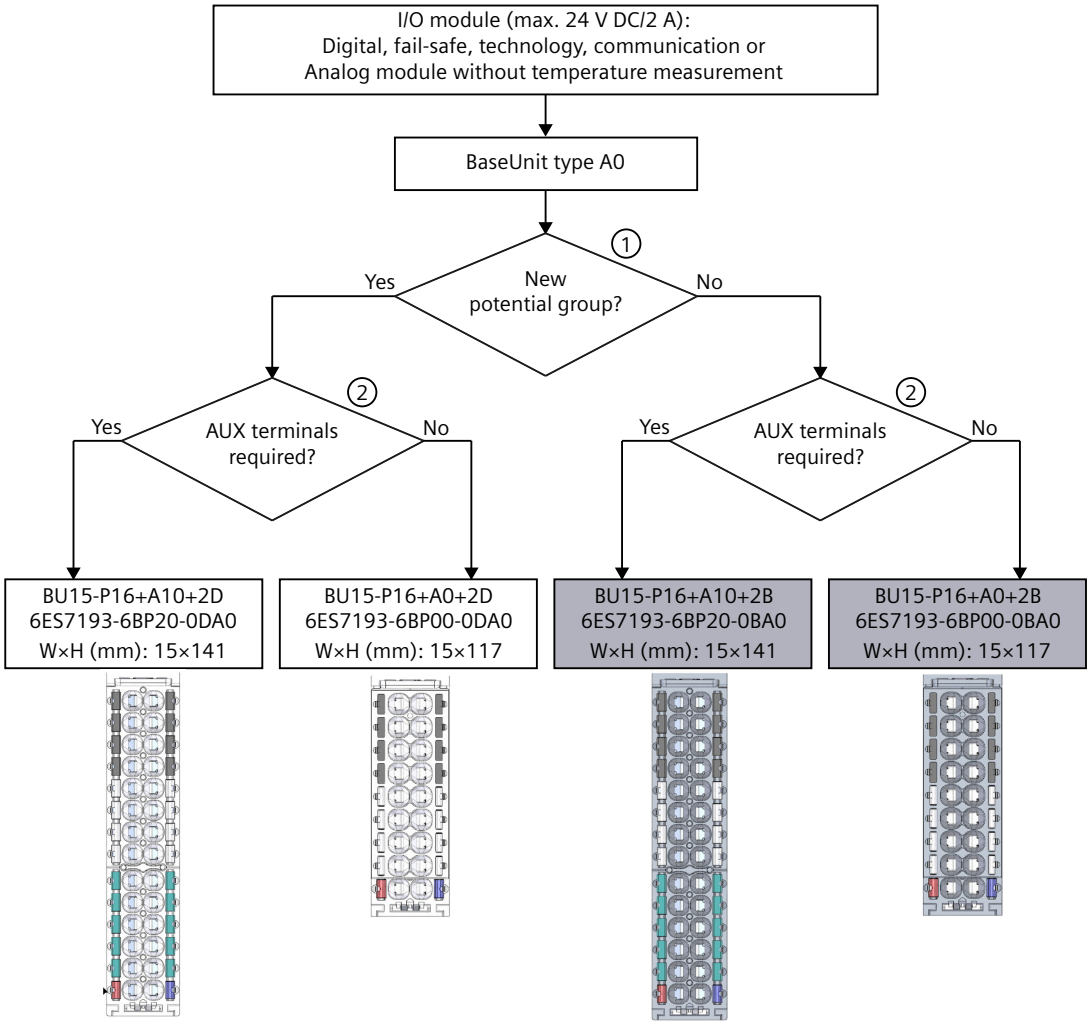
Additional information on the functional assignment of the terminals and on the associated BaseUnits can be found in one of the following manuals:

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

6.1 Selecting the BaseUnit for I/O modules

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

Selection of a suitable BaseUnit



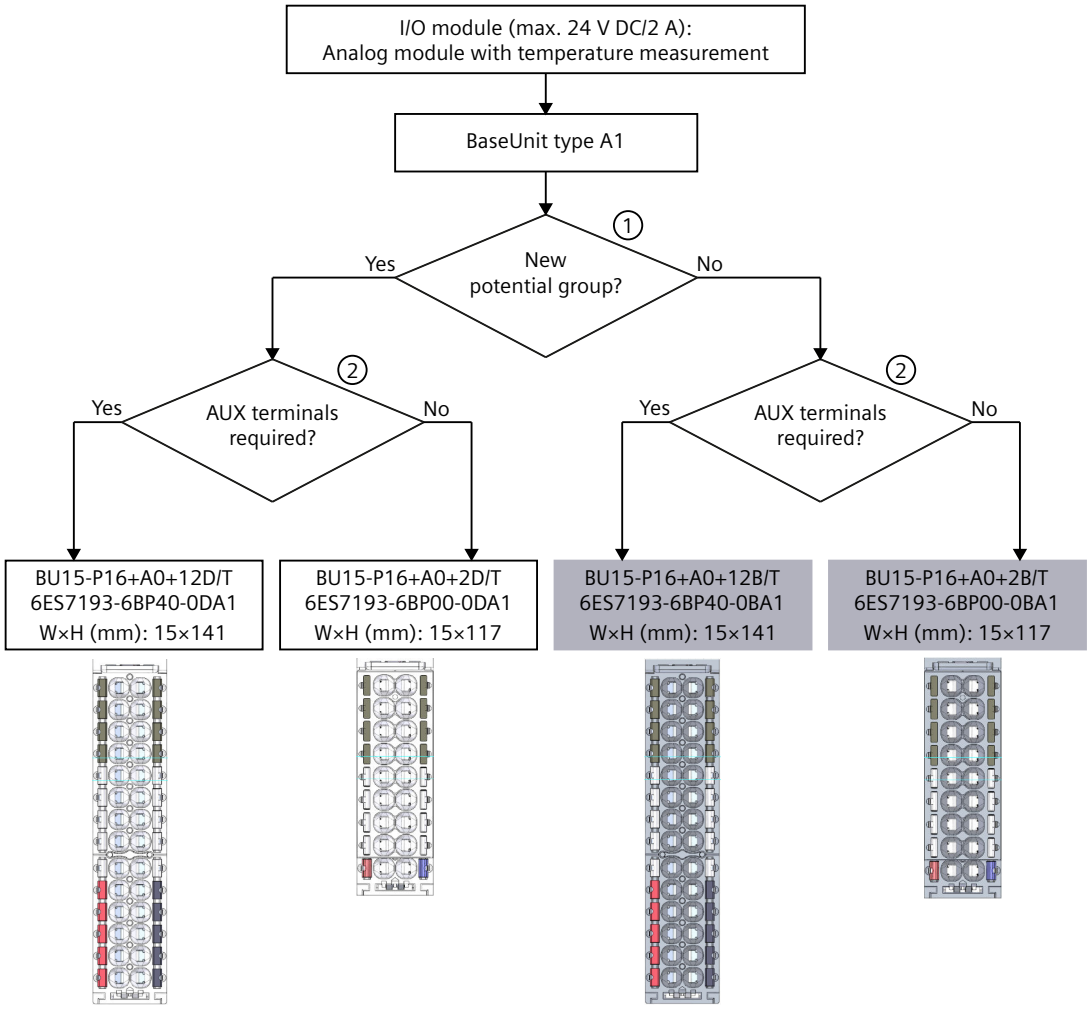
① Light-colored BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light-colored BaseUnit for the incoming supply voltage L+. A potential group opened with a light-colored BU type U0 must not contain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

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

Figure 1-57 Digital, fail-safe, communication, technology or analog modules without temperature measurement

6.1.2 Analog modules with temperature measurement

Selection of a suitable BaseUnit



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

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

Figure 1-58 Analog modules with temperature measurement

6.2 Selecting a motor starter with suitable BaseUnit

6.2.1 Selecting a BaseUnit for motor starters

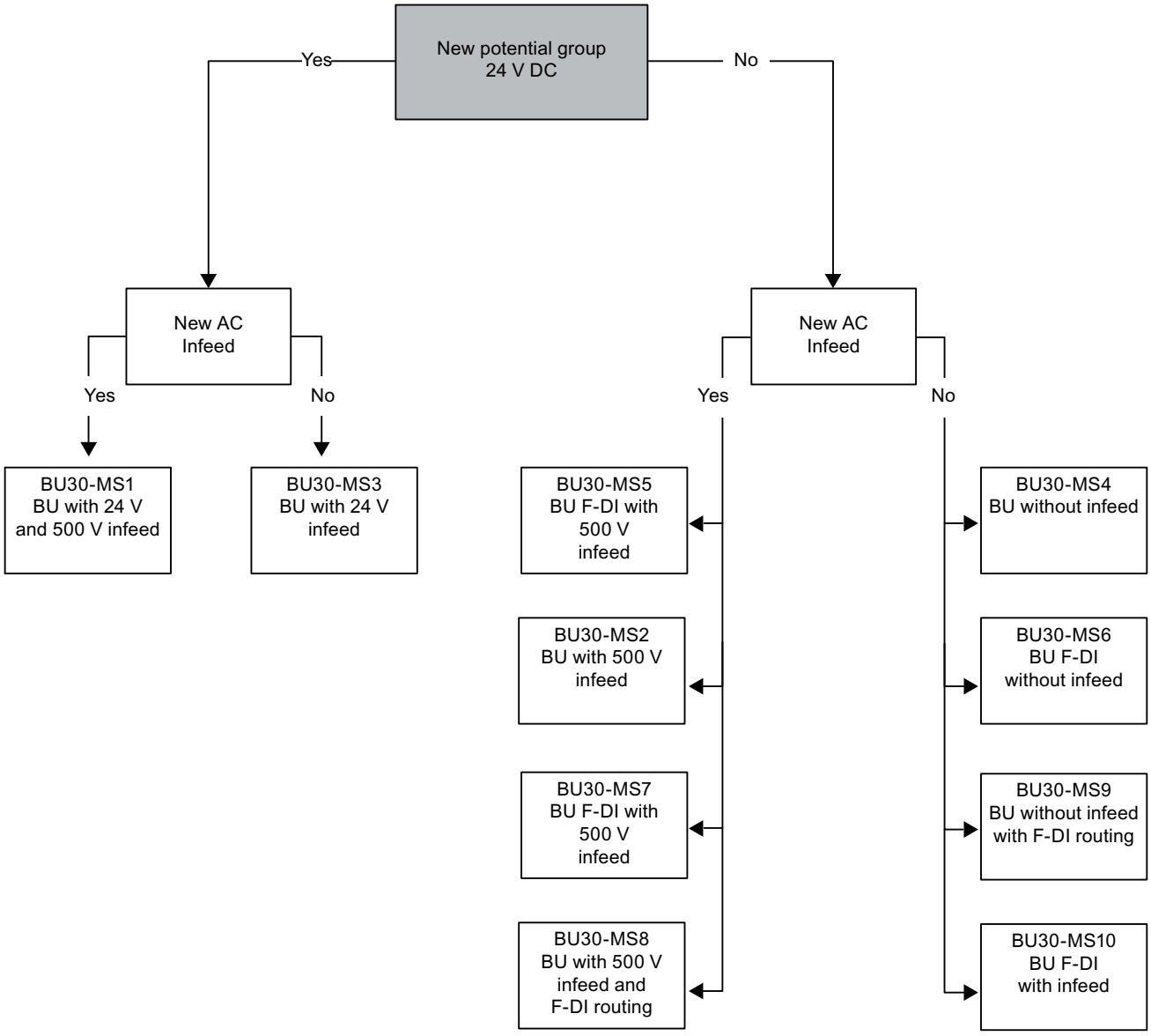
The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3" and "BU30-MS4" are compatible with all non-fail-safe motor starters. The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3", "BU30-MS4", "BU30-MS5", "BU30-MS6", "BU30-MS7", "BU30-MS8", "BU30-MS9" and "BU30-MS10" are compatible with all fail-safe motor starters. You will find an overview of available BaseUnits for motor starters here (Page 85). With the different BaseUnits, you can form different potential groups for the 24 V DC electronics supply (L+/M) and for the AC infeed.

Voltage range

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

Selection criteria for the BaseUnit

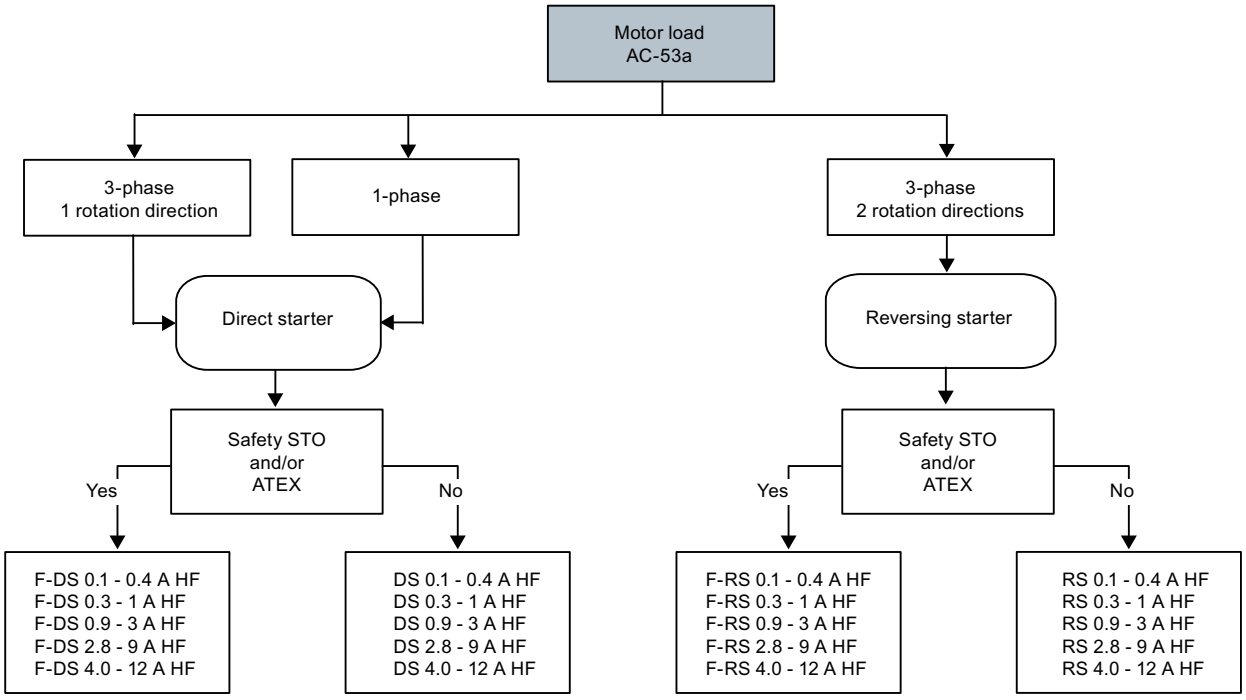
The figure below shows the criteria you use to select the appropriate BaseUnit:

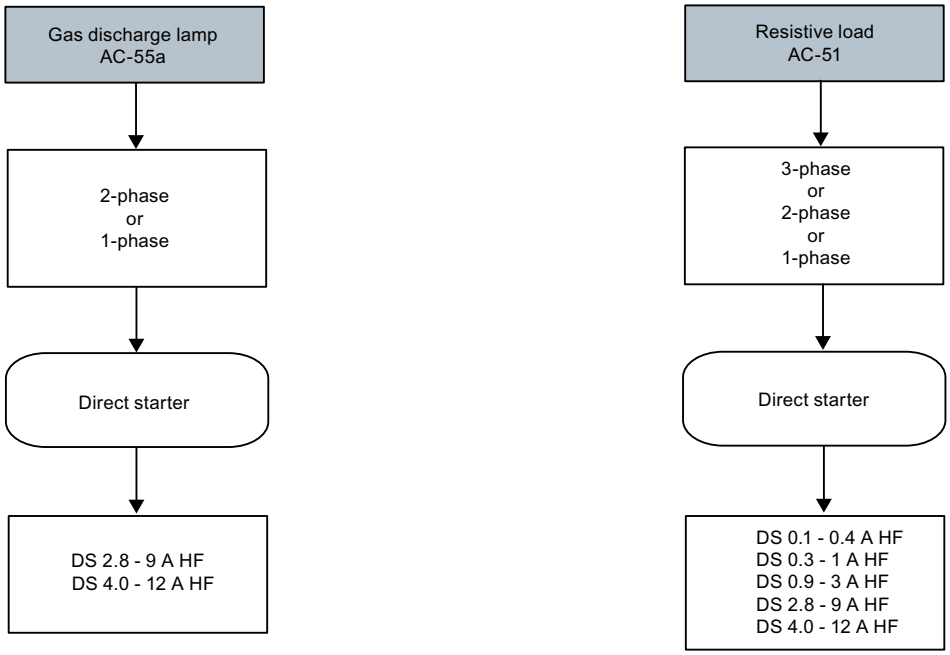


Form separate potential groups on the infeed bus for single-phase (L, N, PE) and three-phase (L1, L2, L3, PE) operation.

6.2.2 Selecting the motor starter

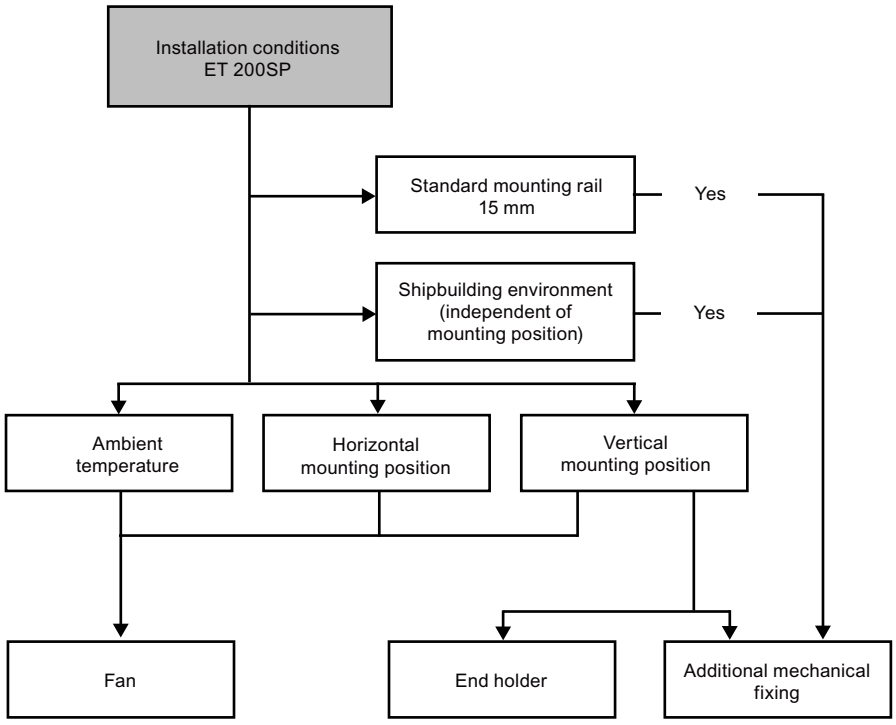
You select the suitable motor starter using the load type according to the following scheme:





6.2.3 Selecting accessories for motor starters

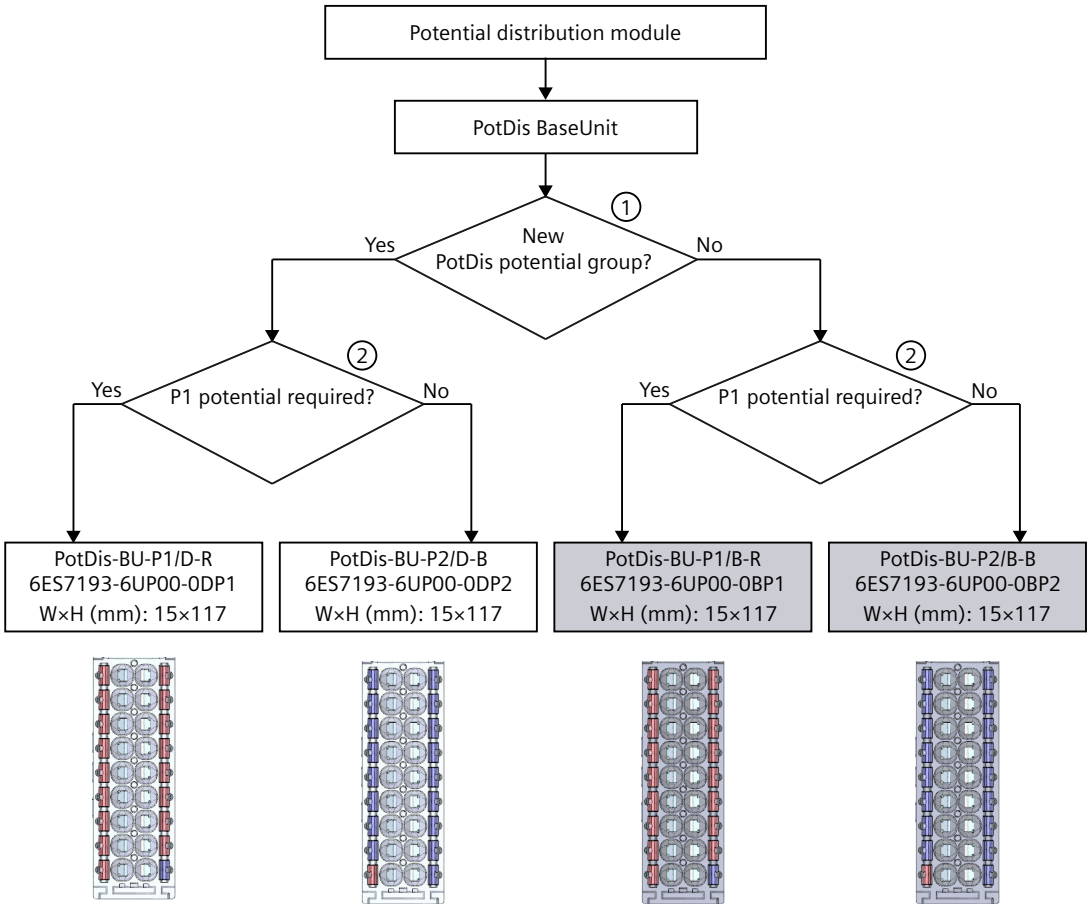
Observe the installation conditions of the station with ET 200SP motor starters. The figure below shows the criteria the station must meet:



6.3 Selecting potential distributor modules

6.3.1 Selecting a PotDis-BaseUnit

Selection of a suitable PotDis-BaseUnit potential distributor module



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

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

Figure 1-59 PotDis-BaseUnits

Please note:

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

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

Additional information

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

6.3.2 Selecting a PotDis-TerminalBlock

Selection of a suitable PotDis-TerminalBlock

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

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

The following PotDis-TerminalBlocks are available:

Table 1-353 Selection of TerminalBlock PotDis-TB

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

Additional information

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

6.4 Hardware configuration

Maximum mechanical configuration

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

Table 1-354 Maximum mechanical configuration

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

Electrical maximum configuration for I/O modules

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Address space

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

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

6.5 Forming potential groups

6.5.1 Basics

Introduction

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

Requirements

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

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

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

NOTE

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

Placement and grouping of I/O modules

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

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

NOTE

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

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

Placing and connecting potential distribution modules

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

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

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

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

NOTE

Identical voltages with potential distribution modules

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

Placement and grouping of I/O modules and motor starters

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

- An unassembled BaseUnit (BaseUnit with BU cover) must be inserted between the CPU, an interface module or an I/O module and the motor starter. This is not necessary between the motor starters.
- The empty slot can take on the potential (24 V DC) of the potential group on the left of it (L+, M), i.e. I/O modules and motor starters can be operated in the same potential group.

- If you would like to insert an I/O module on the right of a motor starter, then use only one BaseUnit of the BU...D Typ A0 type (light terminal box).
- The BaseUnits BU30-MS2, BU30-MS4, BU30-MS5, BU30-MS6, BU30-MS7, BU30-MS8, BU30-MS9 and BU30-MS10 can continue the potential group of other BaseUnit types. However, note the following exceptions:
  - Only a BaseUnit of type BU30-MS1 or BU30-MS3 may follow an AS-i module (AS-i potential group).
  - Only BaseUnits with fail-safe motor starters can be connected together in the same potential group of an F-PM-E.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Hazardous electrical voltage can cause electric shock, burns and property damage.
Disconnect your system and devices from the power supply before starting any assembly tasks.

AUX bus (AUX(iliary) bus)

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

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

The AUX bus can be used individually:

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

NOTICE

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

The AUX bus is designed as follows:

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

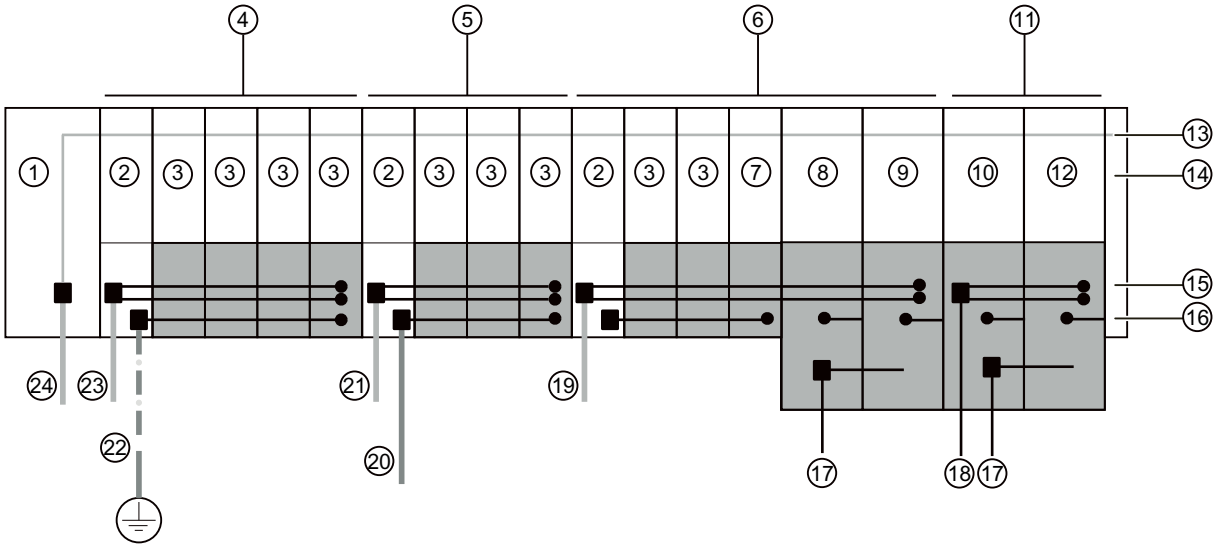
NOTE
The AUX potential must always be identical to the potential group of the supply voltage if it is not being used as PE.

Self-assembling voltage buses

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

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

Operating principle



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

Figure 1-60 Placing the BaseUnits

Connecting different potentials to the power or AUX bus

NOTE

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

6.5.2 Forming potential groups with BaseUnit type B1

Introduction

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

Requirements

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

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

Operating principle

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

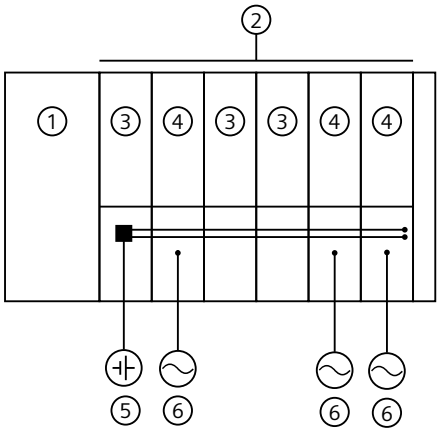
NOTE

Placing the BaseUnits for AC I/O modules

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

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

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



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

Figure 1-61 Placing the BaseUnits for the AC I/O modules

6.5.3 Forming potential groups with fail-safe modules

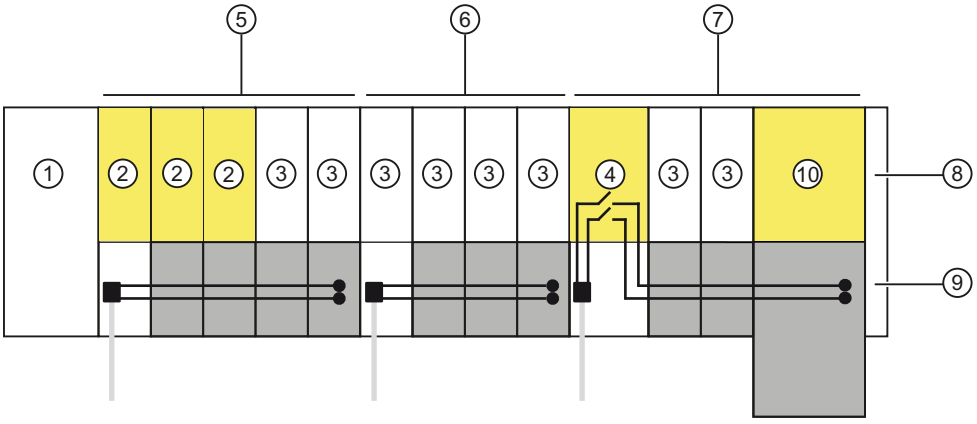
Introduction

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

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

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

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



① IM 155-6 PN HF interface module
② F-module
③ Non-fail-safe module
④ Power module F-PM-E 24VDC/8A PPM ST
⑤ Mixed fail-safe and non-fail-safe potential group with BaseUnits BU15..D and BU15..B. You achieve SIL3/Cat. 4/PLe for the fail-safe modules. No safety category can be achieved with the non-fail-safe motor starter.
⑥ Non-fail-safe potential group with BaseUnits BU15..D and BU15..B
⑦ Fail-safe potential group with BaseUnits BU20..D, BU15..B and BU30-MSx. Up to SIL2/Cat. 3/PLd is possible if you disconnect the self-assembling voltage bus and thus the non-failsafe modules.
⑧ Server module
⑨ Self-assembling voltage buses P1/P2
⑩ Fail-safe motor starter F-DS HF

Figure 1-62 ET 200SP - example of a configuration with fail-safe modules

6.5.4 Forming potential groups with Ex modules

Ex module group

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

NOTE

Thermal decoupling required

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

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

6.5.5 Forming potential groups with motor starters

Overview of the functions of the BaseUnits

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

✓ Function available

-- Function not available

Properties of the 500 V AC infeed bus

The infeed bus has the following properties:

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

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

Self-assembling voltage buses have the following properties:

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

Pay attention to the derating values depending on the configuration.

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

⚠ WARNING

Electric shock when operating the infeed bus without touch protection cover
There is a risk of electric shock when touching the infeed bus if you have not fitted a touch protection cover on the infeed bus on the right.
Always fit a touch protection cover on the infeed bus on the right (article number: 3RK1908-1DA00-2BP0).

⚠ WARNING

Electric shock when operating a BaseUnit without an inserted motor starter
If you fit a BaseUnit for motor starters without cover (e.g. option handling), there is a risk of an electric shock when touching the BaseUnit.
Always fit a cover on the BaseUnit (article number: 3RK1908-1CA00-0BP0).

Requirements

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

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

Operating principle

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

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

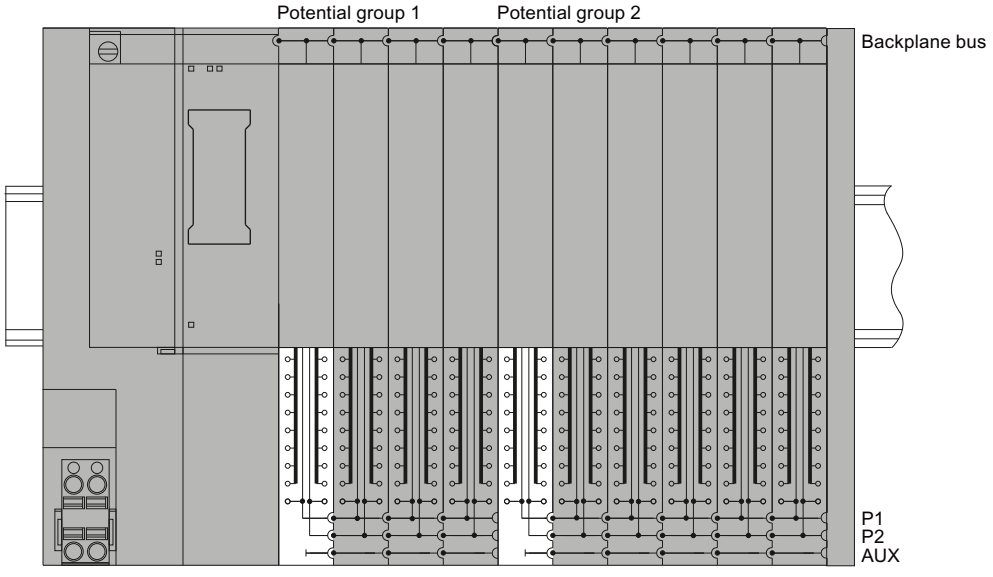
NOTE

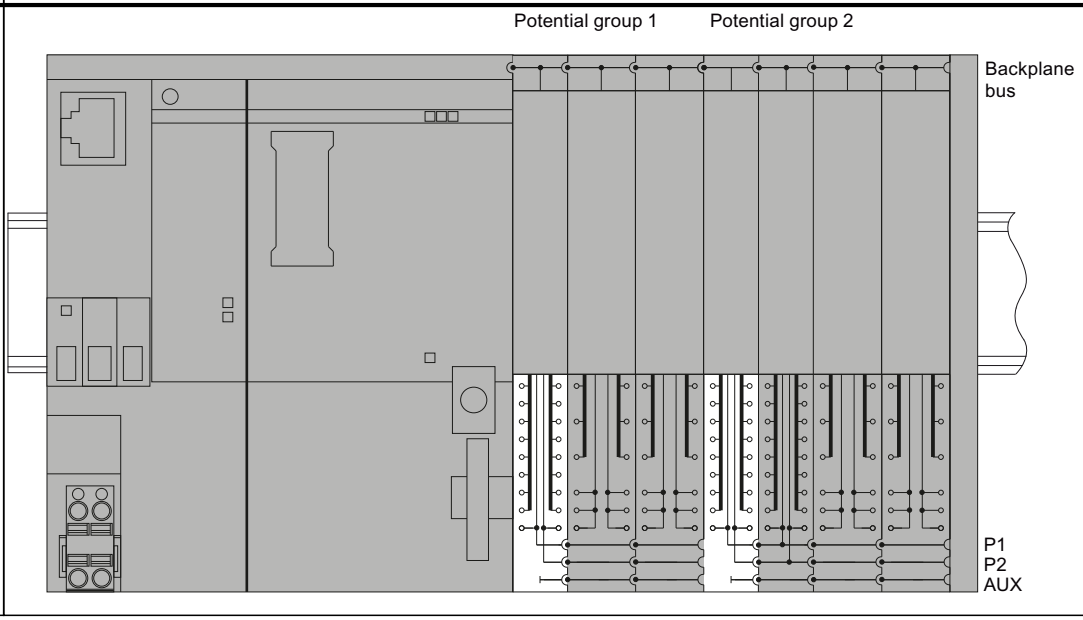
The motor starters' AC power supply is not connected to the AC power supply for the AC I/O modules (see Chapter "Forming potential groups with BaseUnit type B1 (Page 104)").

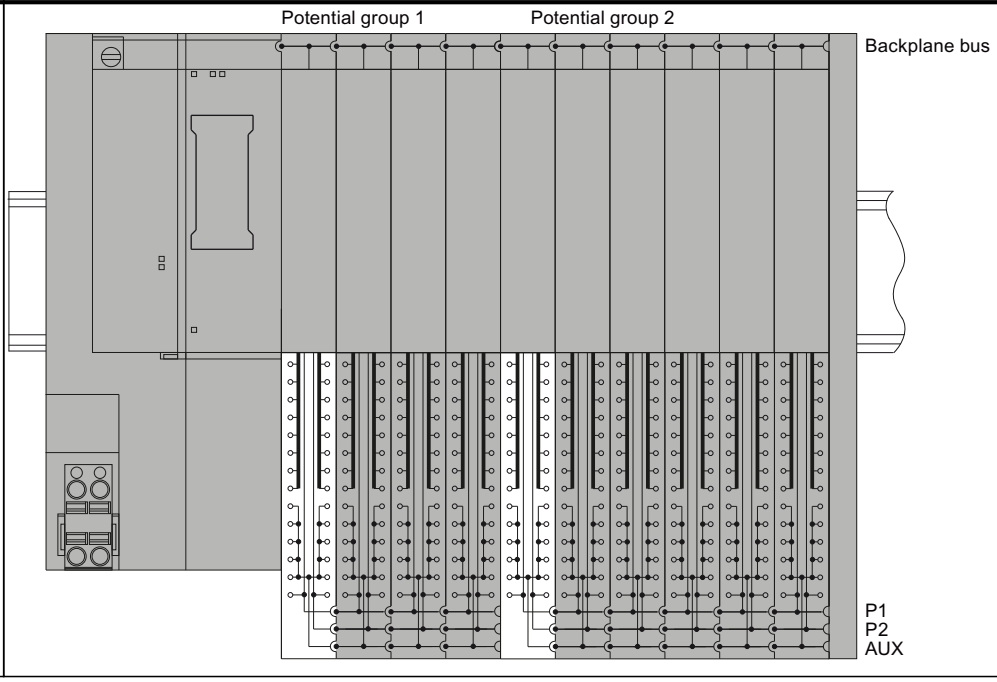
6.6 Configuration examples for potential groups

6.6.1 Configuration examples with BaseUnits

Table 1-355 Configuration examples with BaseUnits

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

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

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

6.6.2 Configuration examples with potential distributor modules

3-wire connection

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

NOTE

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

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

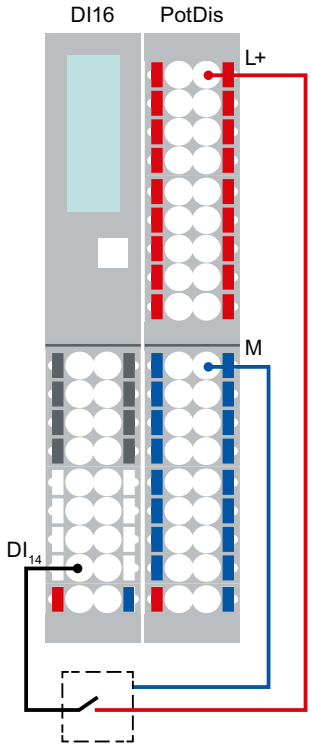


Figure 1-63 **Example: 3-wire connection**

Supply of external components

Another application of the potential distributor modules is the supply of potentials for external components. Potential distributor modules enable simple, compact, integrated and clear design.

Observe the current carrying capacity of each terminal: max. 10 A.

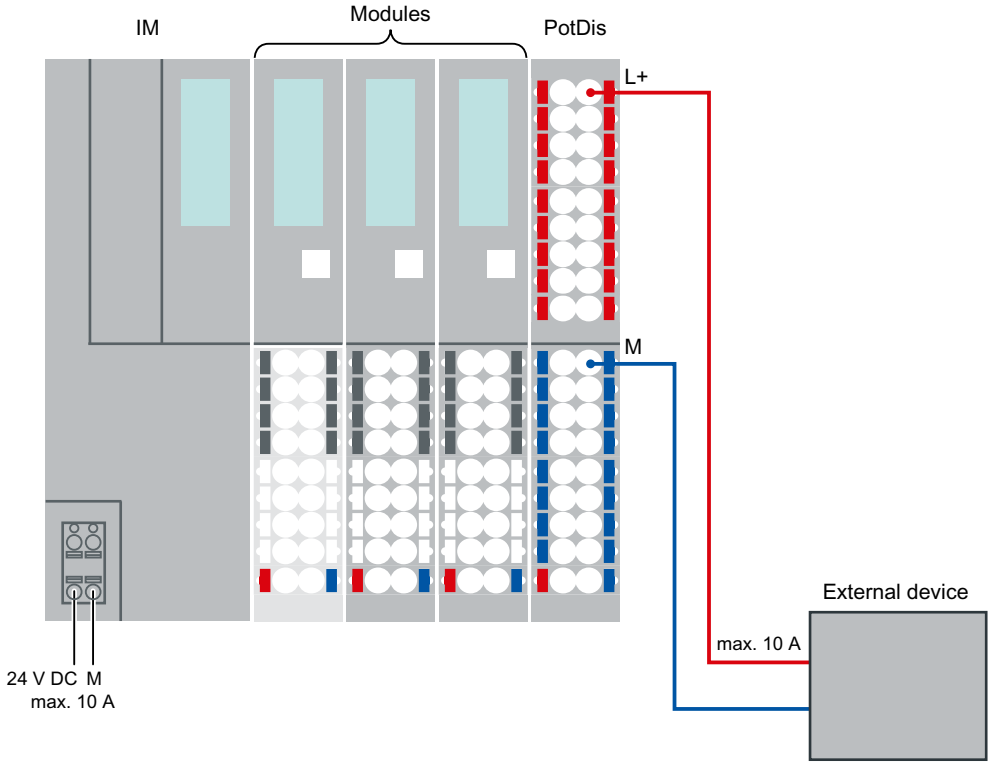


Figure 1-64 **Example: Supply of external components**

6.7 System redundancy R1

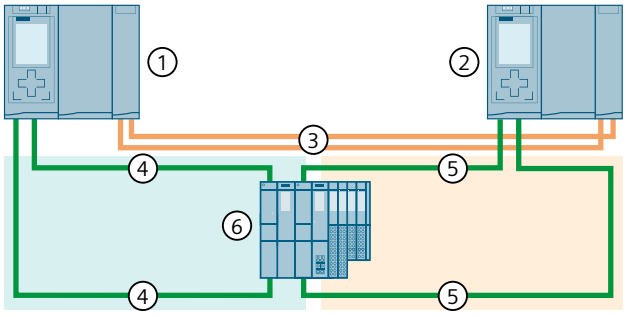
6.7.1 General notes on operating an ET 200SP R1 system

6.7.1.1 Example configuration of a system with ET 200SP R1

You need at least the following components for configuration of an ET 200SP R1 station:

- SIMATIC system rail (1 unit)
- BaseUnit BU type M0 (1 unit)
- Interface module IM 155-6 PN R1 (2 units)
- SIMATIC BusAdapter (2 units, e.g. BA 2×M12)
- BaseUnits and electronic modules (see section Configuration examples for potential groups (Page 109))
- Server module (1 unit)

- To operate a station with R1 system redundancy, you also need a set of R1-compatible S7-1500 CPUs (e.g. CPU 1517H-3 PN or CPU 1518HF-4 PN, 2 units).



① CPU 1
② CPU 2
③ Two fiber-optic cables (redundancy connections)
④ PROFINET cable (PROFINET ring 1)
⑤ PROFINET cable (PROFINET ring 2)
⑥ ET 200SP I/O device (with system redundancy R1)

Figure 1-65 Configuration of S7-1500H with R1 devices in the PROFINET ring

You can find additional configuration examples in the SIMATIC S7-1500 S7-1500R/H Redundant System (https://support.industry.siemens.com/cs/ww/de/view/109754833) System Manual.

6.7.1.2 Commissioning an R1 station

After you configure an ET 200SP R1 station, you perform a commissioning maintenance cycle before the deployment in productive operation. This ensures that both redundant interface modules have been correctly contacted and can operate the electronic modules. The following is checked at the same time:

- Test for hardware integrity. Especially for hardware units that are not used while the device is passive and has no access to the SP bus. To ensure that the hardware is fully intact, perform at least a temporary takeover of the SP bus.
- After the maintenance cycle, the redundancy group must return to its pre-maintenance state.

To perform a commissioning maintenance cycle, proceed as follows:

The initial state is: The S7-1500H redundant system is in the RUN-Redundant system state. The ACT LED of one of the two interface modules (IM 1: regardless whether slot 0 or slot 1) is continuously lit.

1. Test step: Disconnect the interface module with the continuously lit ACT LED (IM 1) from the operating voltage by removing the connector from the 24 V connection. The station must assume the following state:
   - The LEDs of interface module 1 all go out.
   - The ACT LED of interface module 2 starts to flash.
   - In the CPU user program, an OB 70 (loss of redundancy) is reported on the station.
   - In the CPU user program, no OB 86 (station failure) is reported on the station.
2. Test step: Check the inputs and outputs via interface module 2. Use the engineering or configuration tool (e.g. user program or tag table).

3. Test step: Restore the operating voltage of interface module 1. The station must assume the following state after restart of interface module 1:
   – The ACT LED of interface module 2 lights up continuously.
   – In the CPU user program, an OB 70 (redundancy return) is reported.
   – The S7-1500H redundant system is again in the RUN-Redundant system state.
4. Test step: Disconnect the interface module with the permanently lit LED ACT (IM 2) from the operating voltage by pulling the plug out of the 24 V connection. The station must assume the following state:
   – The LEDs of interface module 2 all go out.
   – The ACT LED of the interface module 1 starts to flash.
   – In the CPU user program, an OB 70 (loss of redundancy) is reported on the station.
   – In the CPU user program, no OB 86 (station failure) is reported on the station.
5. Test step: Check the inputs and outputs via interface module 1. Use the engineering or configuration tool (e.g. user program or tag table).
6. Test step: Restore the operating voltage of interface module 2. The station must assume the following state after restart from interface module 2:
   – The ACT of interface module 1 is lit continuously.
   – In the CPU user program, an OB 70 (redundancy return) is reported.
   – The S7-1500H redundant system is again in the RUN-Redundant system state.
   – The system is again in the same state as before test step 1. The commissioning maintenance cycle has been successfully completed.

6.7.1.3 Increased availability

Compared to other ET 200SP interface modules, the system availability has been increased through use of PROFINET R1 redundancy. Even if one interface module fails, the function of the station is maintained.

The module automatically restarts to quickly return to the redundant state if one of the two redundant interface modules of a station fails (e.g. due to a critical error). This eliminates repair time.

Critical failures are stored in the device for later evaluation. You make this information available to Customer Support by reading the service data. You can find information on reading out the service data in the Interface Module IM 155-6 PN R1 Equipment Manual.

6.7.2 Improving the switchover time of the ET 200SP R1 system

Definition

The switchover time of the ET 200SP R1 station is the time that elapses after failure of the primary connection until the back-up IM has established the primary connection and takes control of the process. The response time is extended once during a redundancy switchover.

Composition of the cycle time and response time

You can find information and notes on the configuration of the CPU, the general composition of the cycle time and response time and how you can improve these times in the Cycle and Response Times (https://support.industry.siemens.com/cs/ww/en/view/59193558) Function Manual.

Improving the switchover time through configuration of the ET 200SP R1 station

To improve response times for an R1 system, we recommend that you follow the instructions below when configuring the ET 200SP R1 station:

- The shorter the PROFINET update time of an IO device, the shorter the response time of the R1 system tends to be.
- The fewer the number of I/O modules plugged into an R1 station, the shorter the response time of the R1 system tends to be.
- The smaller the input and output data range of the I/O modules, the shorter the response time of the R1 system tends to be.
- Certain module types increase the switchover time. Therefore, configure the stations in such a way that these module types are configured in a separate ET 200SP R1 station. This ensures that the switchover time of the ET 200SP R1 station that does not contain these module types is shorter.

  The following table provides you an overview of the modules that belong to these module types.

Name	MLFB
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480VAC/CT HF for 1 A or 5 A current transformer, with network analysis functions	6ES7134-6PA00-0CU0 (no longer available)
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter CT ST, for 1 A or 5 A current transformer	6ES7134-6PA01-0BU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter CT HF, for 1 A or 5 A current transformer, with network analysis functions	6ES7134-6PA01-0CU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480V AC ST	6ES7134-6PA20-0BD0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480V AC/RC HF for Rogowski coils, current/voltage transformer 333 mV, with network analysis functions	6ES7134-6PA20-0CU0 (no longer available)
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter RC HF, for Rogowski coils or current/voltage transformer 333 mV, with network analysis functions	6ES7134-6PA21-0CU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter RC ST, for Rogowski coils or current/voltage transformer 333 mV	6ES7134-6PA21-0BU0
SIMATIC ET 200SP, CM 4xIO-Link ST Communication module IO-Link Master V1.1	6ES7137-6BD00-0BA0
Technology Module SITRANS FST070 Ultrasonic Flow Transmitter	7ME3448-6AA00-0BB1
Technology Module SITRANS FCT070 Coriolis Flow Transmitter	7ME4138-6AA00-0BB1

NOTE

You can find additional information on switchover times from SIEMENS Customer Support.

Installation 7

7.1 Basics

Introduction

All modules of the ET 200SP distributed I/O system are open equipment. This means you may only install the ET 200SP distributed I/O system in housings, cabinets or electrical operating rooms and in a dry indoor environment (degree of protection IP20). The housings, cabinets and electrical operating rooms must guarantee protection against electric shock and spread of fire. The requirements regarding mechanical strength must also be met. The housings, cabinets, and electrical operating rooms must not be accessible without a key or tool. Personnel with access must have been trained or authorized.

Installation location

Install the ET 200SP distributed I/O system in a suitable enclosure/control cabinet with sufficient mechanical strength and fire protection. Take into account the environmental conditions for operating the devices.

Mounting position

You can mount the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall.

The ambient temperature may be restricted in certain installation positions. You will find more information in section Mechanical and climatic environmental conditions (Page 360).

Pay attention to chapter "Installation conditions for motor starters (Page 120)" when using motor starters.

Mounting rail

Install the ET 200SP distributed I/O system on a mounting rail in accordance with ISO 60715 (35 × 7.5 mm or 35 × 15 mm) or on a SIMATIC system rail.

The ET 200SP R1 system must be mounted on the SIMATIC system rail only.

You need to ground the mounting rail separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

NOTE

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP distributed I/O system from shifting to the side.

NOTE

If the ET 200SP, distributed IO system is exposed to increased vibrations and shock, fasten the mounting rail to the mounting surface at intervals of approx. 200 mm.
For increased vibration and shock loads, you can mount the ET 200SP system on the SIMATIC system rail.

The following are suitable surfaces for the mounting rails:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend these in conjunction with the mounting rails in the section Accessories/spare parts (Page 370).

NOTE

If you use mounting rails from other manufacturers, make sure that they have the required properties for your ambient climatic conditions.

Minimum clearances

The figure below shows the minimum clearances you must observe when installing or dismantling the ET 200SP distributed I/O system.

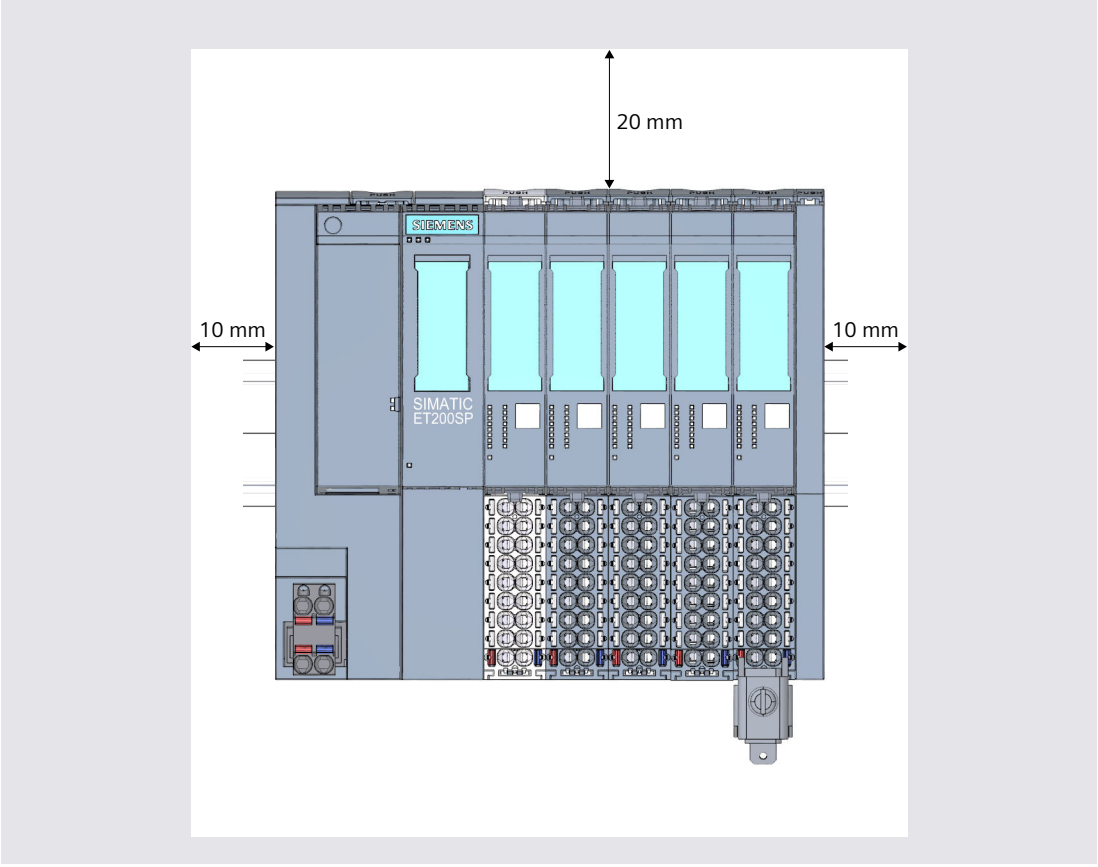


Figure 1-66 Minimum clearances

NOTE

Ex module group

When you are using an Ex module group in your configuration, you must observe other minimum clearances.

Additional information on minimum clearances and installing/removing Ex modules is available in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

General rules for installation

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Hazardous electrical voltage can cause electric shock, burns and property damage.
Disconnect your system and devices from the power supply before starting any assembly tasks.

Observe the following rules:

- Installation starts on the left-hand side with the CPU/interface module.
- A light-colored BaseUnit BU..D0, BU30-MS1 or BU30-MS3 with infeed of supply voltage L+ follows the CPU/interface module or is placed at the start of each potential group.
  If you use a CPU or IM 155-6 (V3.0 or higher), the first BaseUnit in the installation of the ET 200SP may also be a dark-colored BaseUnit of type B1 or D0.
- This is followed by BaseUnits BU..B, BU30-MS2 or BU30-MS4 (with a dark-colored terminal box).
- The matching I/O modules / motor starters can be plugged onto the BaseUnits. You will find matching combinations of BaseUnits and I/O modules / motor starters in Application planning (Page 85).
- The server module completes the configuration of the ET 200SP distributed I/O system.

NOTE
Mount the ET 200SP distributed I/O system only with disconnected supply voltage.

⚠ WARNING

Protection from conductive contamination
Taking into account the environmental conditions, the devices must be protected from conductive contamination.
This can be achieved, for example, by installing the devices in a control cabinet with the appropriate degree of protection.

Mounting rules for reducing the thermal load

The following rules reduce the thermal load of the ET 200SP distributed I/O system in the control cabinet:

- Separate 2 modules with high power dissipation with a module of low power dissipation or by an empty space.
- Mix modules with higher power dissipation and modules with less power dissipation. For example, modules with 16 outputs have a higher power dissipation than modules with 8 outputs.
- You should give preference to the horizontal mounting position.
- For vertical mounting position, plug modules with high power dissipation at the top, the interface module/CPU at the bottom.

- Mount an ET 200SP station with modules with high power dissipation in the lower area of the control cabinet.
- For a multi-tier configuration, plug modules with high power dissipation on the sides so that the waste heat can rise to the top unhindered.
- Avoid air movements at the terminals when using TC measurement with internal compensation.

7.2 Installation conditions for motor starters

Observe the following installation conditions when using an ET 200SP motor starter:

- Mounting position

  You can fit the motor starter vertically or horizontally. The mounting position refers to the alignment of the mounting rail The maximum permissible ambient temperature range depends on the mounting position:

  – Up to 60° C: Horizontal mounting position
  – Up to 50° C: Vertical installation position

  You also need to consider the current carrying capacity of the ET 200SP components.

  In the case of a vertical mounting position, use end retainers "8WA1808" at both ends of the ET 200SP station:
- Mounting rail

  Use one of the following mounting rails:

  – 35x15 mm DIN rail in accordance with DIN EN 60715
  – 35x7.5 mm DIN rail in accordance with DIN EN 60715
  – SIMATIC S7 mounting rail
- Current carrying capacity of the ET 200SP station
  Current carrying capacity refers to the current load via the power bus and the infeed bus of the ET 200SP station.

Depending on the ambient conditions and mounting position, you have to take account of the fan unit or additional mechanical fixings.

Mechanical brackets

Use the mechanical brackets in the following situations:

- When using a 15 mm mounting rail with a single motor starter installation, i.e. no motor starter mounted directly next to it in the system
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

Designing interference-free motor starters

For interference-free operation of the ET 200SP station in accordance with standard IEC 60947-4-2, use a dummy module before the first motor starter. No dummy module is required to the right of the motor starter.

Note the following mounting rules:

Use the following dummy module on the standard mounting rail between the previous module and the SIMATIC ET 200SP motor starter:

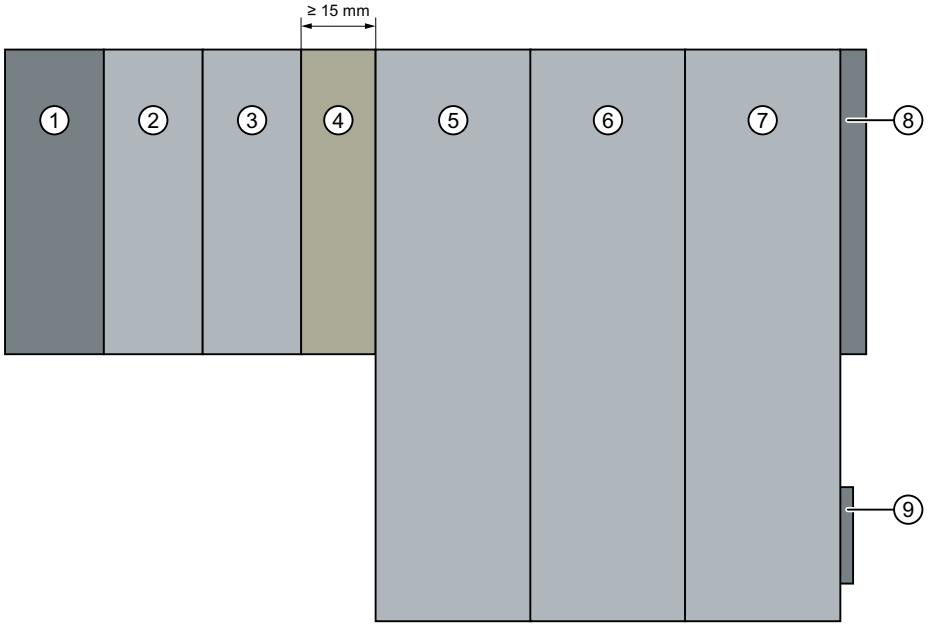
BU cover 15 mm: 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0

For operation of the ET 200SP station with an unused BaseUnit, a cover must be provided for the open BaseUnit plug contacts (power connector, power bus connector, and backplane bus connector).

The cover protects the plug contacts against dirt. The BU cover can be ordered as an accessory.

Mount the dummy module

The figure below provides a schematic representation of how to implement measures for improving interference immunity.



①	Interface module	⑥	Motor starter
②	Digital input module	⑦	Motor starter
③	Digital output module	⑧	Server module
④	Dummy module	⑨	Infeed bus cover
⑤	Motor starter		

NOTICE

Ensure interference immunity
You must not plug any other module into the BaseUnit of the dummy module, otherwise interference immunity is no longer ensured.

7.3 Mounting the CPU/interface module

Introduction

The CPU/the interface module connects the ET 200SP distributed I/O system to the fieldbus and exchanges the data between the higher-level control system and the I/O modules / motor starters.

Requirement

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for mounting and removing the BusAdapter)

Mounting the CPU/interface module

Watch the video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To install a CPU/interface module, follow these steps:

1. Install the CPU/interface module on the mounting rail.
2. Swivel the CPU/interface module towards the back until you hear the mounting rail release button click into place.

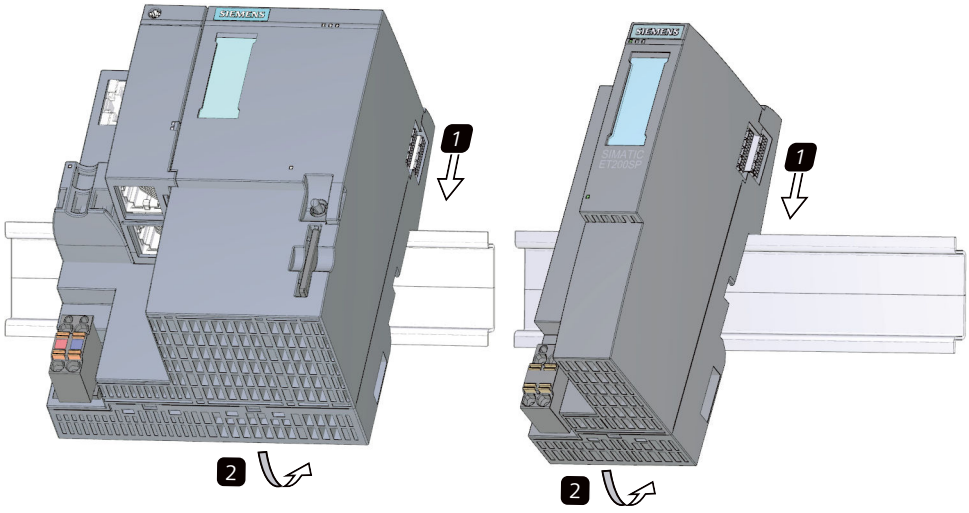


Figure 1-67 Mounting the CPU/interface module

Dismantling the CPU/interface module

The CPU/interface module is wired and BaseUnits are located to its right.

To remove the CPU/interface module, follow these steps:

1. Switch off the supply voltage for the CPU/interface module. Remove the 24 V DC connector from the CPU/interface module.
2. Confirm the mounting rail release on the first BaseUnit. At the same time, shift the CPU/interface module parallel to the left until it detaches from the rest of the module group.

   Note: The mounting rail release button is located above the CPU/interface module or BaseUnit.
3. While pressing the mounting rail release button on the CPU/interface module, swivel the CPU/interface module off of the mounting rail.

NOTE

It is not necessary to remove the BusAdapter from the CPU/interface module.

7.4 Installing ET 200SP R1

Introduction

The ET 200SP R1 system connects the ET 200SP distributed I/O system to the fieldbus and exchanges the data between the higher-level controller and the I/O modules / motor starters.

Requirement

The SIMATIC system rail is installed.

Tools required

3 to 3.5 mm screwdriver (only for mounting and removing the BusAdapter)

Mounting the ET 200SP R1 system

To mount the ET 200SP R1 system, proceed as follows:

1. Hang the BaseUnit BU type M0 onto the SIMATIC system rail.
2. Swivel the BaseUnit BU type M0 backwards until the system rail release audibly engages.
3. Plug the IM 155-6 PN R1 interface modules onto the BaseUnit BU type M0 until the lock audibly engages.
4. Plug the 24 V DC connectors into both interface modules.
5. Connect a BusAdapter to each interface module. Screw the BusAdapter to the interface module.

Removing the ET 200SP R1 system

To remove the ET 200SP R1 system, proceed as follows:

1. Switch off the supply voltage for the ET 200SP R1 system. Unplug the 24 V DC connectors from both interface modules.
2. Press the interface module release on the BaseUnit BU type M0. Detach the interface modules from the BaseUnit BU type M0.
3. Press the system rail release on the BaseUnit. Move the BaseUnit BU type M0 parallel to the left until it detaches from the rest of the module group.

   Note: The system rail release is located above the BaseUnit BU type M0.
4. With the system rail release pressed on the BaseUnit, swivel the BaseUnit BU type M0 off of the system rail.

NOTE

It is not necessary to remove the BusAdapter from the IM 155-6 PN R1 interface modules.

7.5 Installing the CM DP communication module

Introduction

You need the CM DP communication module to use the CPU with a DP master or DP slave.

Requirements

- The mounting rail is fitted.
- The CPU is installed.

Installing CM DP

To install the CM DP communication module, follow these steps:

1. Install the CM DP to the right of the CPU.
2. Swivel the CM DP towards the back until you hear the mounting rail release button click into place.

3. Slide the CM DP to the left until you hear it click into the CPU.

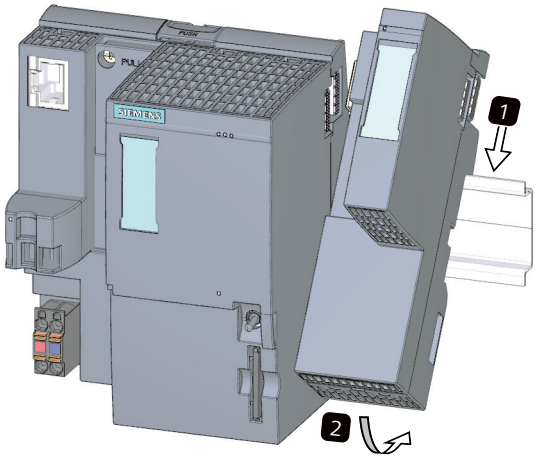


Figure 1-68 Installing CM DP

Removing a CM DP

The CPU and the CM DP are wired and BaseUnits are located to its right.

To remove the CM DP communication module, follow these steps:

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU and the CM DP parallel to the left until they detach from the rest of the module group (clearance about 16 mm).
3. Press the mounting rail release button on the CM DP and move it to the right until it detaches from the CPU (clearance about 8 mm).
4. While pressing the mounting rail release button on the CM DP, swivel the CM DP off of the mounting rail.

NOTE

It is not necessary to remove the bus connector from the CM DP unless you have to replace the CM DP.

7.6 Mounting BaseUnits for I/O modules

Introduction

The BaseUnits are used for electromechanical connection between the individual ET 200SP components. They also provide terminals for connecting external sensors, actuators and other devices.

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for dismantling the terminal box and the encoding element)

Installing a BaseUnit

Watch "Install configuration" video sequence
(https://support.automation.siemens.com/WW/view/en/95886218)

To install a BaseUnit, follow these steps:

1. Hook the BaseUnit onto the mounting rail.
2. Swivel the BaseUnit backwards until you hear it click into place on the mounting rail.
3. Slide the BaseUnit parallel to the left until you hear it latch onto the preceding CPU/interface module or BaseUnit.

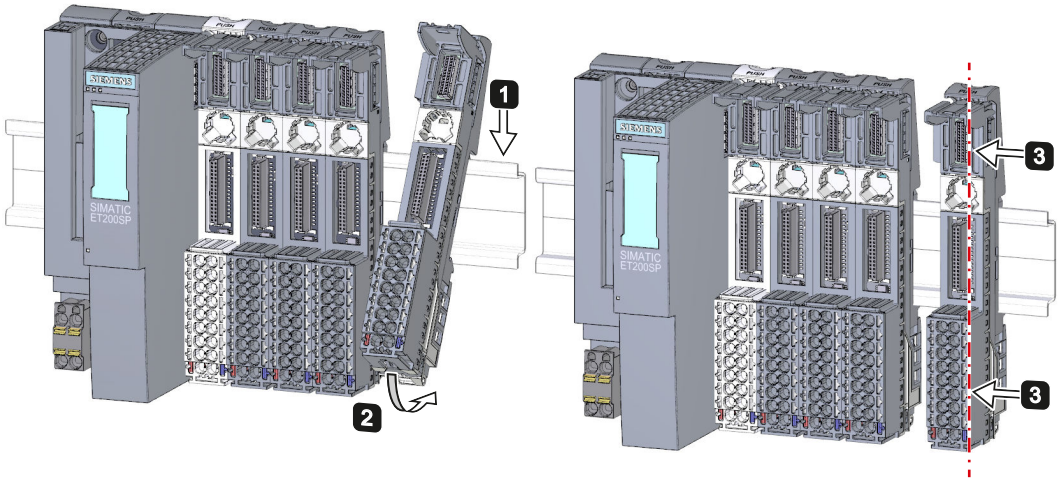


Figure 1-69 Installing a BaseUnit

Removing a BaseUnit

⚠ WARNING

Hazardous Voltage
Hazardous electrical voltage can cause electric shock, burns and property damage.
Disconnect your system and devices from the power supply before starting any assembly tasks.

To remove a BaseUnit, follow these steps:

The BaseUnit is wired and there are other BaseUnits to its right and left.

To remove a specific BaseUnit, move the adjacent modules. As soon as you have created a clearance of about 8 mm from the adjacent BaseUnits, you can remove the BaseUnit.

NOTE
You can replace the terminal box without removing the BaseUnit. Refer to section Replacing the terminal box on the BaseUnit (Page 320).

To remove a BaseUnit, follow these steps:

1. Switch off all supply voltages on the ET 200SP distributed I/O system.
2. Loosen the wiring on the BaseUnit (with a 3 to 3.5 mm screwdriver).
3. **Removing (from the right):**
   Press the mounting rail release on the relevant BaseUnit. Move the BaseUnit parallel to the right and swivel the BaseUnit off of the mounting rail while pressing the mounting rail release.
   Removing (from the left):
   Press the mounting rail release on the relevant BaseUnit and the BaseUnit located to its right. Move the BaseUnit parallel to the left and swivel the BaseUnit off of the mounting rail while pressing the mounting rail release.
   Note: The mounting rail release is located above the BaseUnit

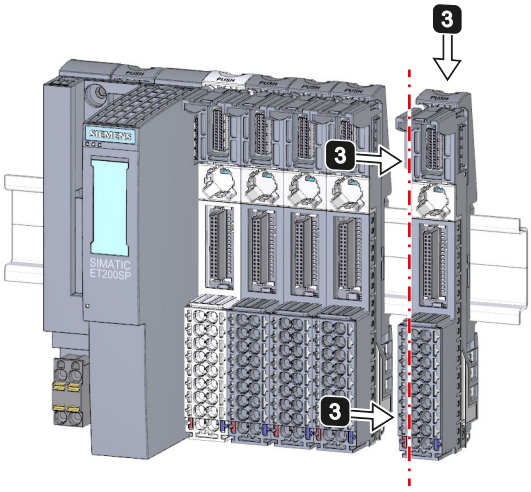


Figure 1-70 Removing the BaseUnit (removing from the right)

7.7 Mounting and dismantling BaseUnits for motor starters

Requirements

- The mounting rail is fitted.
- When using a 15 mm mounting rail, you must install the additional mechanical mounting (3RK1908-1EA00-1BP0).

NOTE

Mechanical bracket for BaseUnit
You will find out how to mount the mechanical bracket for the BaseUnit in chapter "Mounting the mechanical bracket for the BaseUnit (Page 144)".

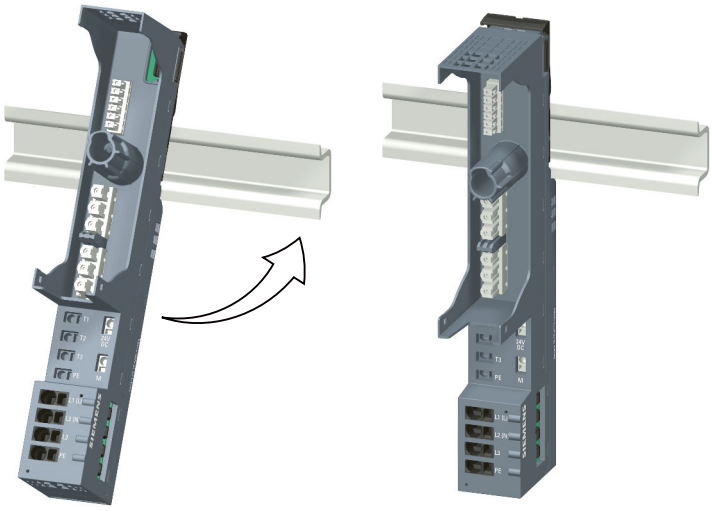
⚠ CAUTION

Protection against electrostatic charge
When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

Mounting a BaseUnit

Proceed as follows to mount a BaseUnit for motor starters:

1. Hook the BaseUnit into the DIN rail from above.
2. Swing the BaseUnit to the rear until the BaseUnit audibly engages.



3. Slide the individual BaseUnits to the left to the previous BaseUnit until they audibly engage.

   Assemble the BaseUnits only on the DIN rail.

NOTE

The BaseUnits for motor starters can be plugged together with the BaseUnits for I/O modules.

Disassembling the BaseUnit

⚠ WARNING

Hazardous Voltage

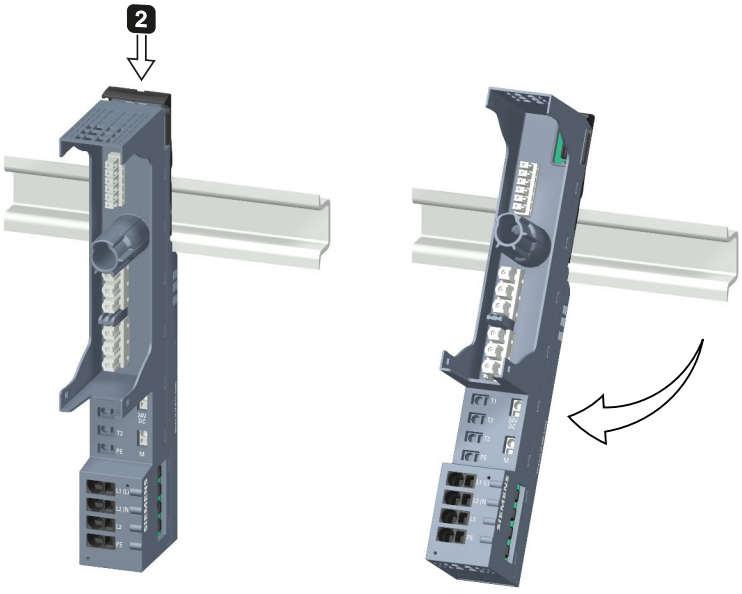
Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

To disassemble the BaseUnit, proceed as follows:

1. Disconnect the main power supply and the control current supply of the SIMATIC ET 200SP motor starter.
2. Actuate the DIN rail release on the BaseUnit of the motor starter.
3. Move the BaseUnit to the left. As soon as there is a clearance of approximately 8 mm to the neighboring BaseUnits, you can disassemble the BaseUnit of the motor starter.

4. Swing the BaseUnit away from the DIN rail while pressing the DIN rail release.



7.8 Installing and uninstalling BaseCarrier

7.8.1 Installing BaseCarrier

Requirements

- The printed circuit board with all the holes and connectors required is available to you. You can find more information in PCB Design Guide (http://support.automation.siemens.com/WW/view/en/109988377)

  Please note the following guidelines for obtaining possible approvals:

  – ATEX/IECEX/UKEX:

    For use of the BaseCarrier system in Zone 2, the customized printed circuit board must meet the applicable requirements according to the current version of EN IEC 60079-0, EN 60079-7, IEC 60079-0 and IEC 60079-7.

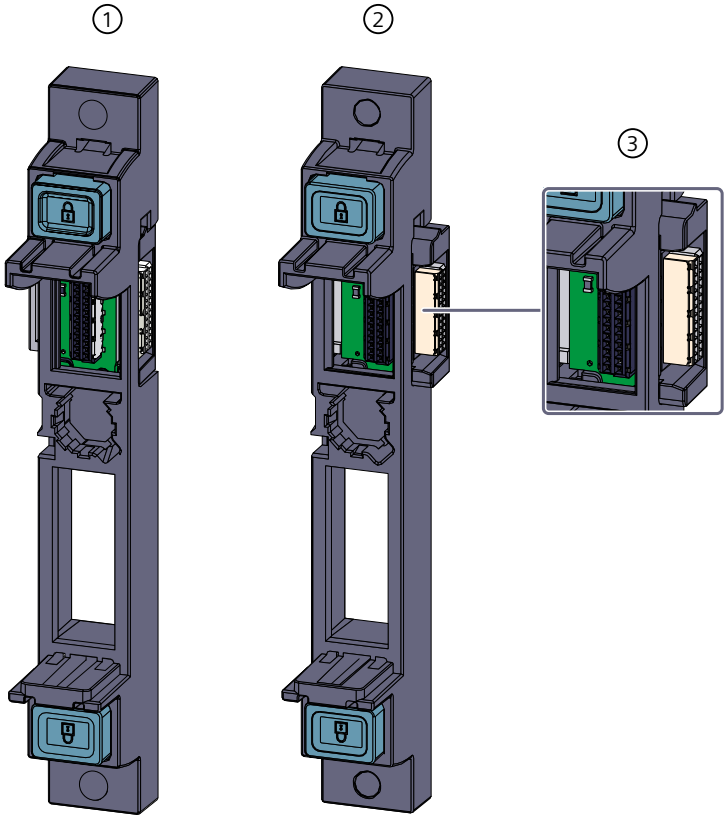
  – FM:

    In order to use the customized printed circuit board with the BaseCarrier as an FM Approved device, the printed circuit board must be FM Approved with the Base Carrier.

  – UL:

    The customized PCB must be UL rated according to ZPMV2 min 130°C, V-0.

- The bus housing with the bus PCB of the BaseCarrier is in position B.



① Bus PCB in position A
② Bus PCB in position B
③ Detail of the bus circuit board

Figure 1-71 Positions of the bus PCB

Installing system with BaseCarrier

To install the BaseCarrier, follow these steps:

1. Screw the DIN rail to the printed circuit board. To do this, use the supplied hexagon socket-head screw adapters with a width A/F of 2.5 mm.

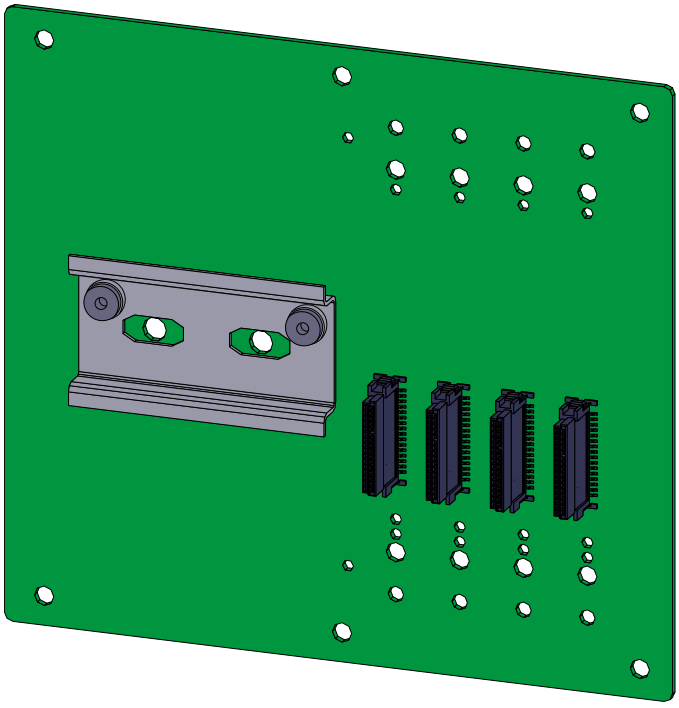
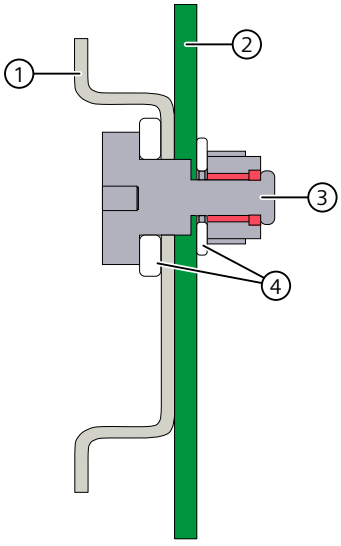


Figure 1-72 Mounted DIN rail on the printed circuit board.



① DIN rail
② Printed circuit board
③ Screw adapter
④ Washer (not included in the scope of delivery)

Figure 1-73 Example of a mounted DIN rail on a thin printed circuit board with washes

2. Insert the I/O adapter in the first BaseCarrier.

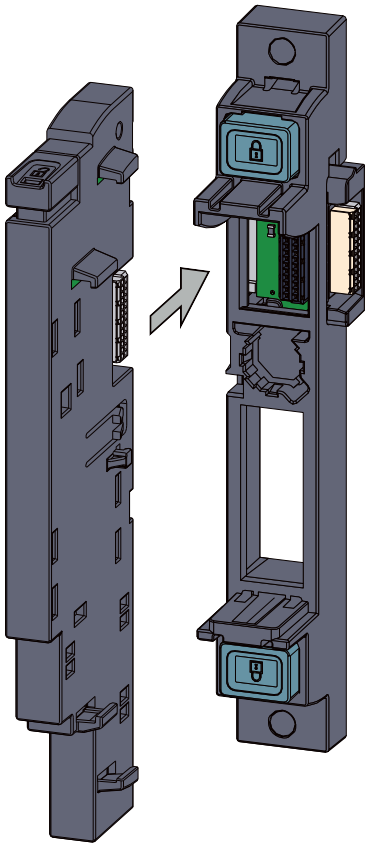


Figure 1-74 Inserting I/O adapter in the BaseCarrier

3. Position the first BaseCarrier using the centering pins and press the “Push-Lock” elements down. Ensure that both elements engage audibly.

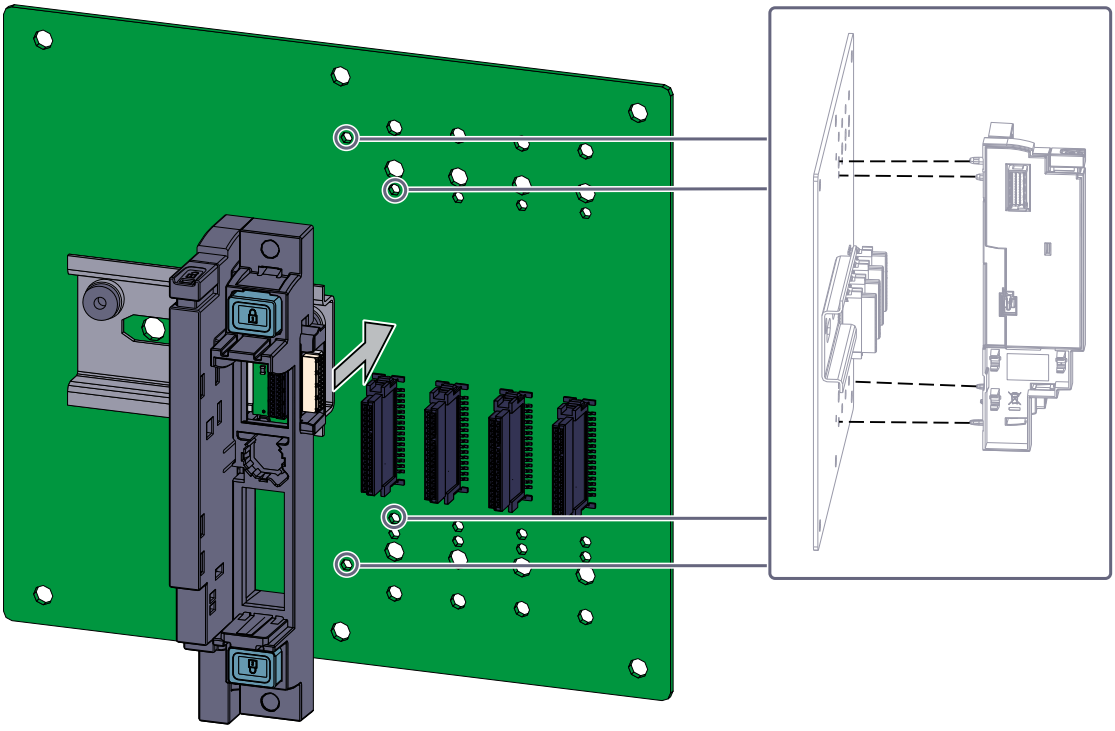


Figure 1-75 Holes on the printed circuit board

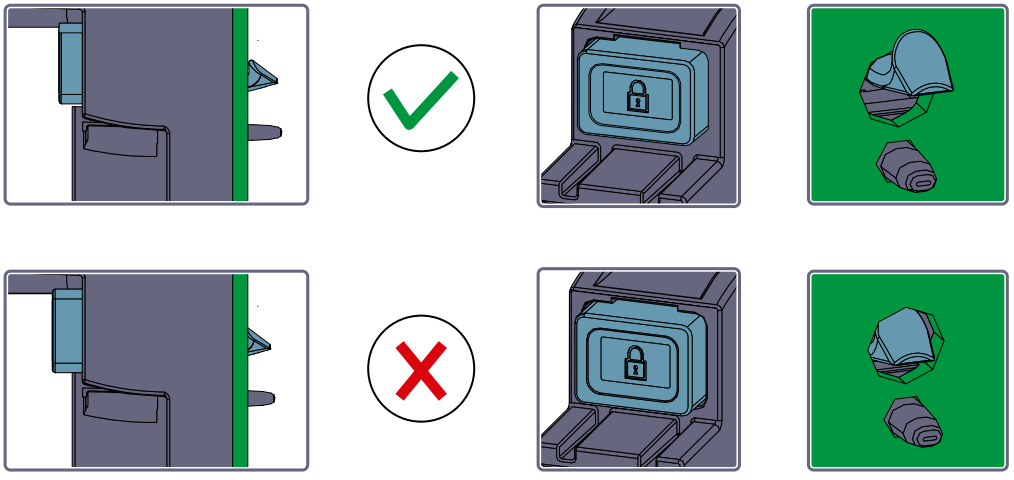


Figure 1-76 Visual control of the hooks

4. Connect the SP bus by sliding the bus housing with the bus PCB to the left in position A.

5. Insert the other BaseCarriers on the printed circuit board.
   Complete the setup with a BaseCarrier for the server module.

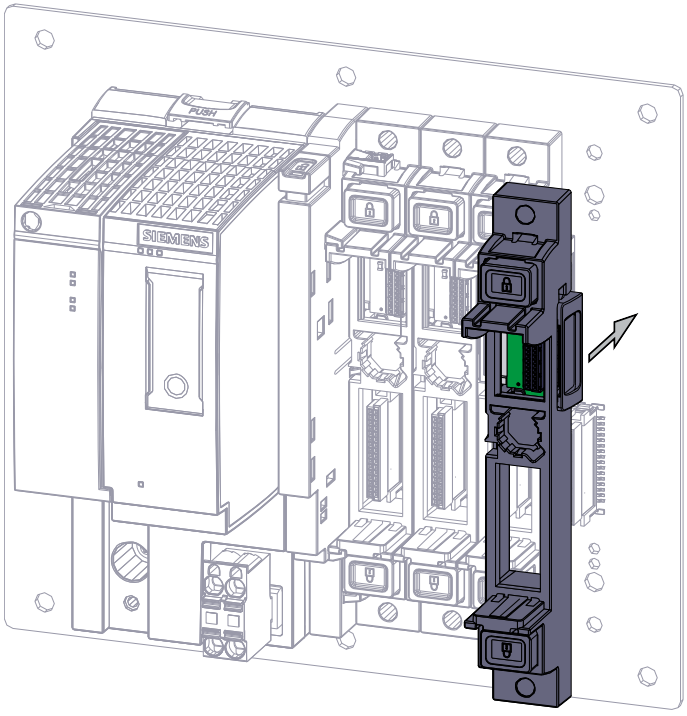


Figure 1-77 Mounting the last BaseCarrier

NOTE

Different position of the centering pins and corresponding holes

To ensure that you insert the right BaseCarrier type in the correct position, the centering pins and the corresponding holes on the printed circuit board for the BaseCarrier types are encoded differently.

6. To install the interface module, hang the interface module into the DIN rail ① and swing the interface module backwards ② until the DIN rail lock clicks into place. Slide the interface module to the right until it clicks into place on the I/O adapter ③.

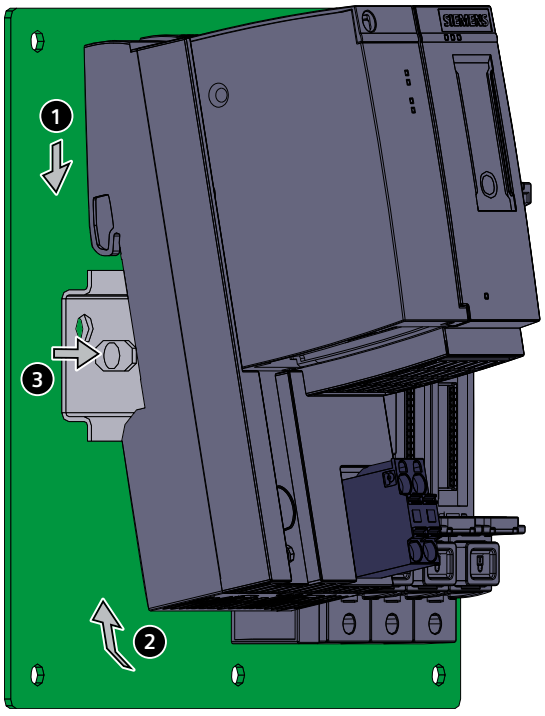


Figure 1-78 Installing the interface module

7. Place the end clamp on the DIN rail in front of the interface module and fix the end clamp by tightening the screw.

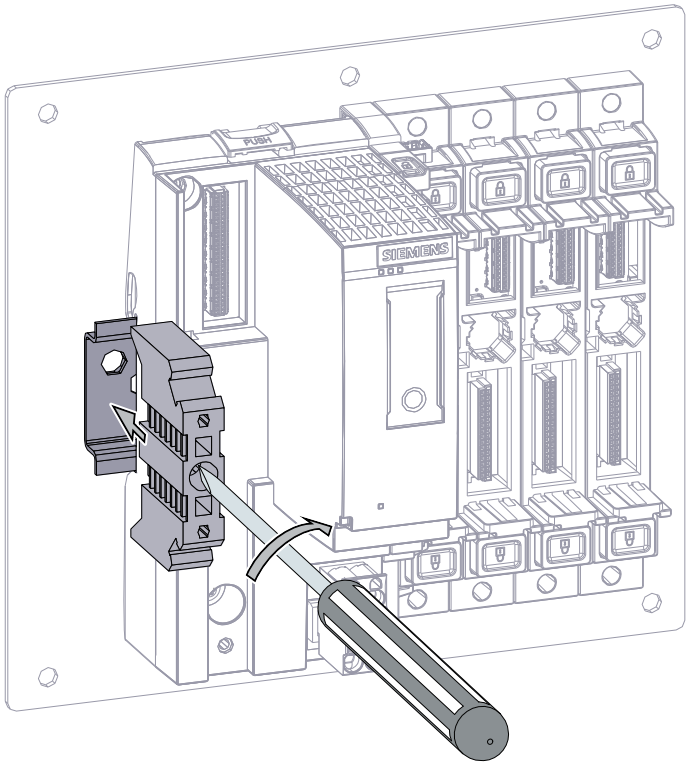


Figure 1-79 Attaching the end clamp

8. Insert the ET 200SP I/O modules and the server module into the BaseCarrier.

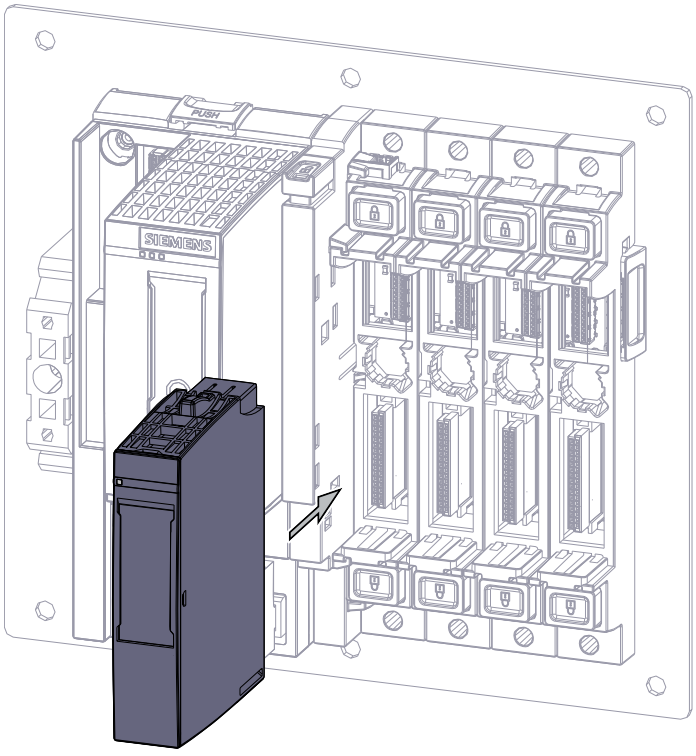


Figure 1-80 Setting up I/O modules

9. Put the SIMATIC bus adapter onto the interface module.

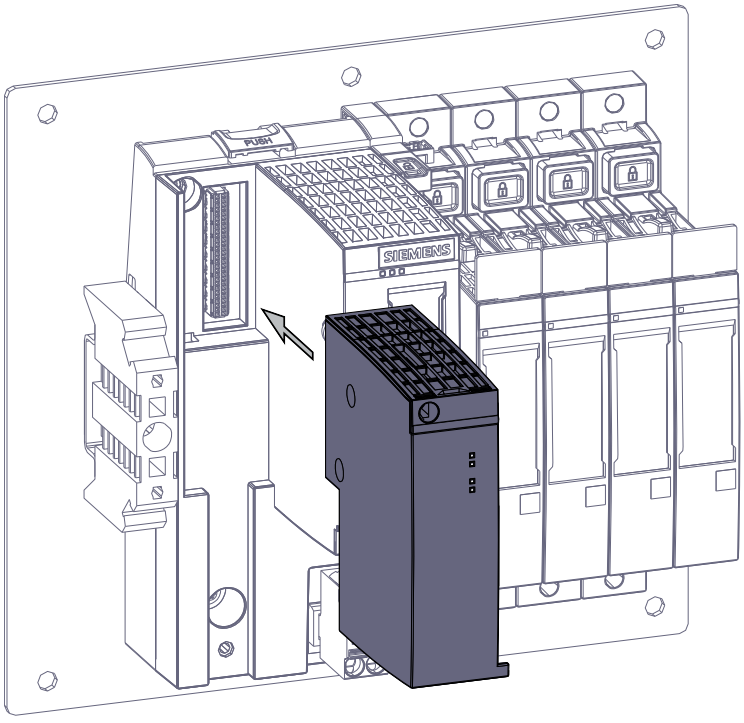


Figure 1-81 Inserting SIMATIC bus adapter to the interface module

7.8.2 Dismantling BaseCarrier

Dismantling ET 200SP system

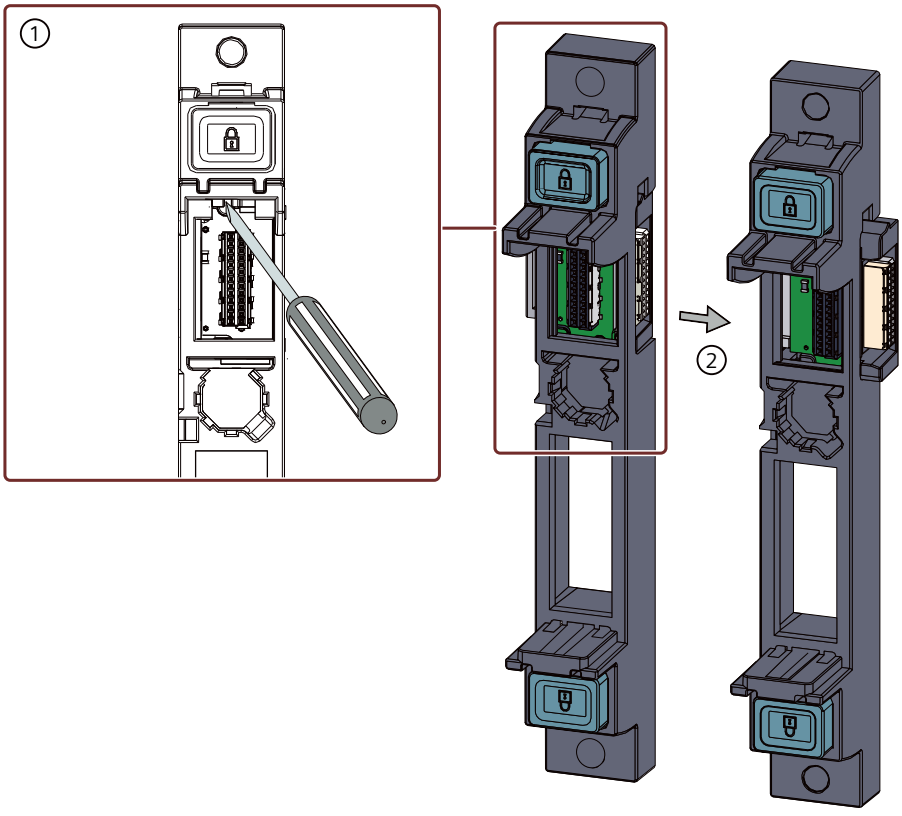
To dismantle the system, proceed as follows:

1. Remove the BusAdapter and the I/O modules.
2. Loosen the screw of the end clamp and remove the end clamp.
3. To decouple the interface module from the I/O adapter, press the "Push lock" element on the I/O adapter and slide the interface module to the left.

Dismantling BaseCarrier

To dismantle the BaseCarrier, proceed as follows from right to left:

1. To detach the SP bus, slide the bus housing to the right in position B.
   Use a slotted screw as in the following image.



① Detailed view bus housing with attachment point for the screwdriver
② Bus housing from position A to position B

Figure 1-82 Detaching the bus PCB

2. To detach the BaseCarrier from the printed circuit board, press the slotted screw into the recesses on the "Push lock" elements.

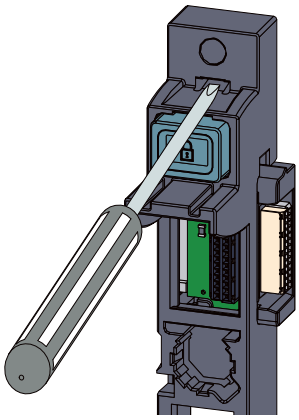


Figure 1-83 Detaching the BaseCarrier from the printed circuit board

The hooks come loose and you can pull the BaseCarrier off the printed circuit board.

3. To detach the I/O adapter from the BaseCarrier, press the slotted screw into the recesses on the I/O adapter ① and pull the I/O adapter from the BaseCarrier. Ensure that the bus housing is in position B.

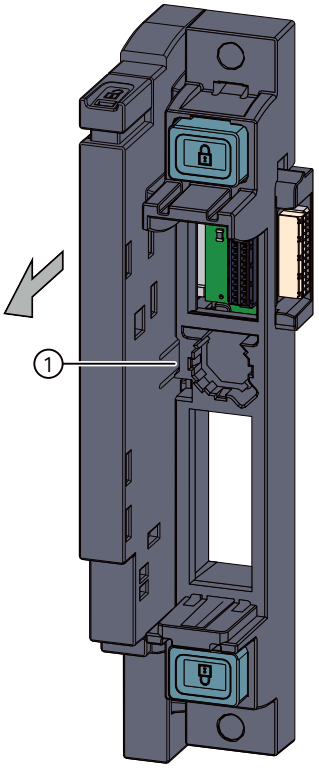


Figure 1-84 Detaching the I/O adapter from the BaseCarrier

7.9 Installing potential distributor modules

Introduction

You use the potential distributor module to distribute a variety of potentials (P1, P2).

Requirements

The mounting rail is installed.

Installing and uninstalling PotDis-BaseUnit

You install/uninstall PotDis-BaseUnits as you would the BaseUnits for I/O modules. You can find additional information in section Mounting BaseUnits for I/O modules (Page 125).

Installing and uninstalling PotDis-TerminalBlock

Installing
Plug the PotDis-TerminalBlock in die PotDis-BaseUnit. Proceed exactly as described in Section Inserting I/O modules / motor starters and BU covers (Page 178).

Uninstalling
To remove a PotDis-TerminalBlock, follow these steps:

1. Switch off all supply voltages on the ET 200SP distributed I/O system.
2. Simultaneously press the top and bottom release buttons of the PotDis-TerminalBlock.
3. Remove the PotDis-TerminalBlock from the front of the PotDis-BaseUnit.

7.10 Installing the server module

Introduction

The server module on the far right of the assembly/line completes the ET 200SP distributed I/O system.

Requirement

The last BaseUnit is mounted.

Installing the server module

Watch "Install configuration" video sequence
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a server module:

1. Hook the server module onto the mounting rail to the right of the last BaseUnit.
2. Swivel the server module backwards on the mounting rail.
3. Move the server module parallel to the left until you hear it latch onto the last BaseUnit that precedes it.

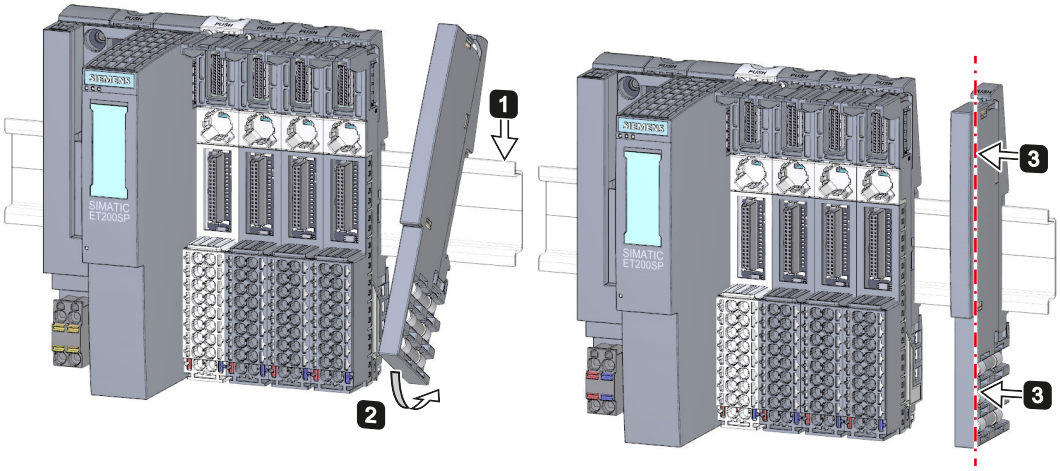


Figure 1-85 Installing the server module

Removing the server module

Proceed as follows to remove a server module:

1. Press the mounting rail release button on the server module.
2. Move the server module parallel to the right.
3. While pressing the mounting rail release button, swivel the server module off the mounting rail.

7.11 Mounting further accessories for motor starters

7.11.1 Mounting the cover for the 500 V AC infeed bus

Introduction

The 500 V infeed bus connects all SIMATIC ET 200SP motor starters. For finger-safe termination of the infeed bus, you must use the cover.

⚠ DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Hazardous electrical voltage causes electric shock, burns and property damage.
Disconnect your system and devices from the power supply before starting any assembly tasks.

⚠ DANGER

Infeed bus - electric shock
You must provide the infeed bus with a touch protection cover on the right (Article No.: 3RK1308-1DA00-2BP0).
Failure to do so will result in the danger of electric shock.

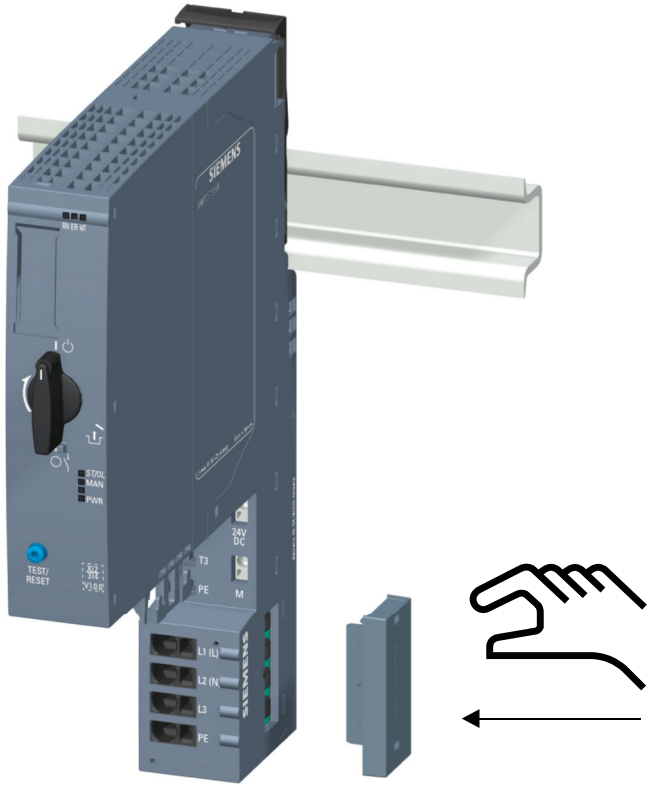
⚠ WARNING

Personal injury may occur
On the last plugged-in BaseUnit of a motor starter, place a cover on the opening of the contacts of the infeed bus.

Procedure

Proceed as follows to mount the infeed bus cover on a SIMATIC ET 200SP motor starter:

1. Press the cover onto the opening of the BaseUnit on the right until it audibly engages.

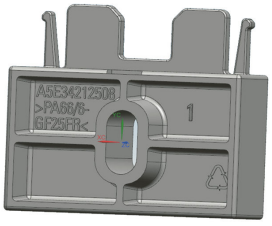


The cover can be removed again using 2 fingers and without tools.

7.11.2 Mounting the mechanical bracket for the BaseUnit

Introduction

To achieve higher stability, you can use a mechanical bracket on 7.5 mm and 15 mm mounting rails.



You must use the mechanical bracket in the following situations:

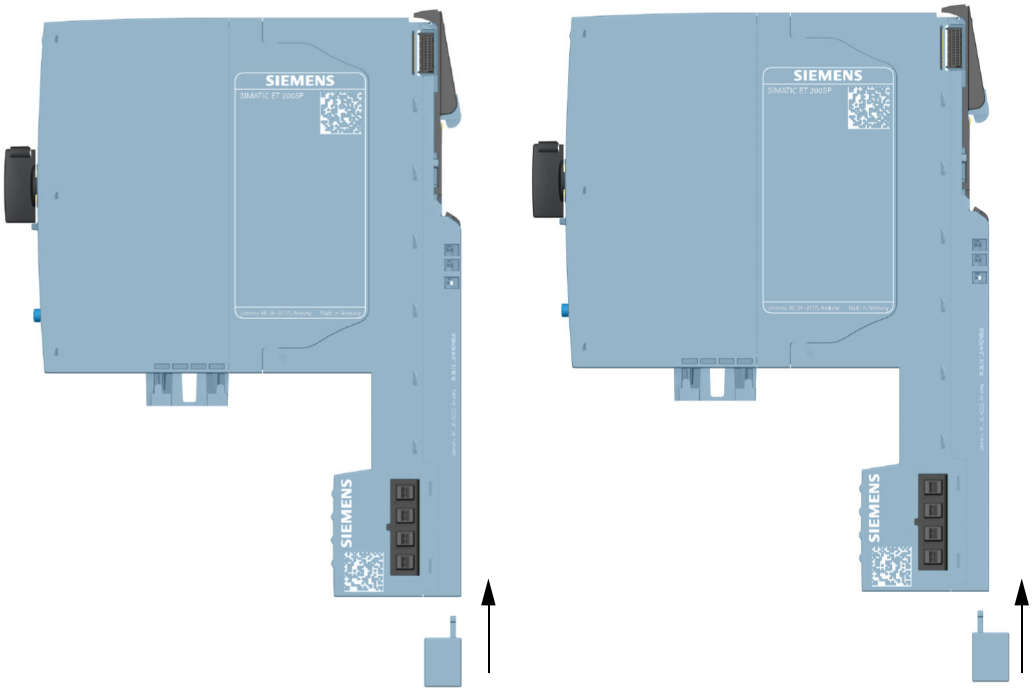
- When using a 15 mm mounting rail
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

You can find further information on the mechanical bracket in chapter "Installation conditions for motor starters (Page 120)".

Procedure

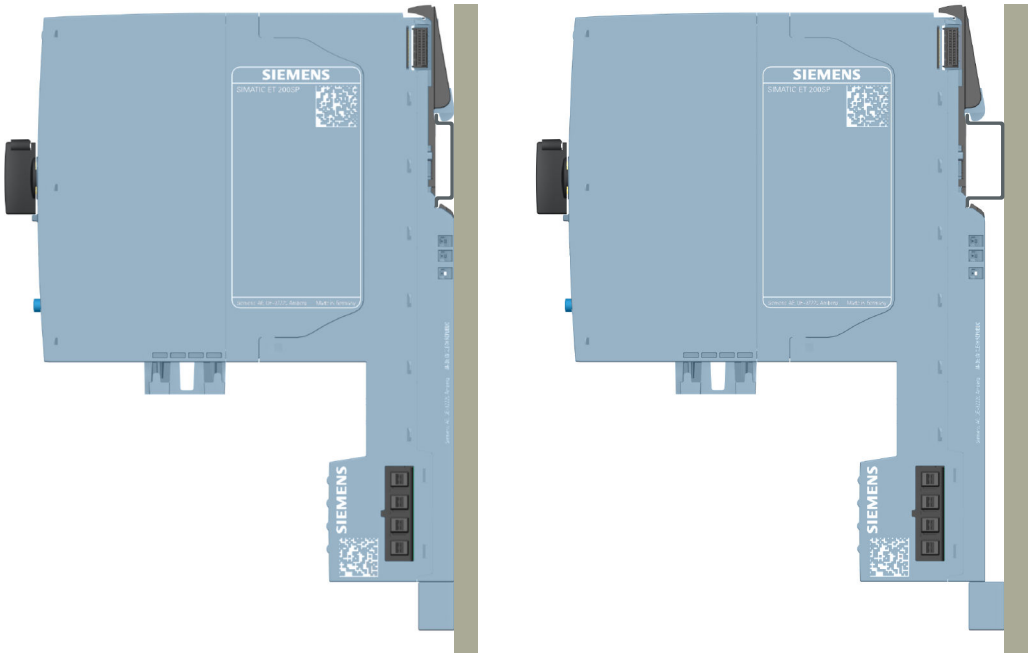
To mount the mechanical bracket, proceed as follows:

1. Insert the mechanical bracket into the opening at the bottom of the BaseUnit.
   You use the same mechanical bracket for both mounting rails, rotated through 180° respectively.



2. Hook the BaseUnit into the mounting rail.
3. Insert the mechanical bracket into the BaseUnit.
4. Screw the mechanical bracket securely onto the mounting panel. Use an M4 screw and a suitable washer.

The figures below show the mechanical bracket after installation on a 7.5 mm or 15 mm mounting rail.



7.11.3 Mounting the BU cover

Introduction

BU covers are plugged onto BaseUnits whose slots have been reserved for future expansion (as empty slots). The BU covers for motor starters serve as touch protection covers for unoccupied slots.

⚠ DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Hazardous electrical voltage causes electric shock, burns and property damage.
Disconnect your system and devices from the power supply before starting any assembly tasks.

⚠ DANGER

BaseUnit without motor starter - electric shock
If you install a BaseUnit without motor starter in the ET 200SP system (e.g. options handling), you must provide the BaseUnit with a BU cover (Article No: 3RK1908-1CA00-0BP0).
Failure to do so will result in the danger of electric shock.

Procedure

To mount the BU cover onto a SIMATIC ET 200SP motor starter, insert the BU cover in the BaseUnit in parallel until both interlocks audibly engage.

Wiring

8

8.1 Rules and regulations for operation

Introduction

When installing the ET 200SP distributed I/O system as part of a plant or system, special rules and regulations need to be adhered to depending on the area of application.

This section provides an overview of the most important rules that must be observed for the integration of the ET 200SP distributed I/O system in a plant or system.

Specific application

Adhere to the safety and accident prevention regulations applying to specific applications, for example machine protection guidelines.

EMERGENCY STOP devices

EMERGENCY STOP devices in accordance with IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

External fuses/switches

Install the external fuses/switches in the proximity of the ET 200SP distributed I/O system.

Excluding hazardous plant states

Hazardous operating states must not occur when

- the plant restarts after a voltage dip or power failure.
- Bus communication is reestablished following a fault.

If necessary, EMERGENCY STOP must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY STOP is unlocked.

Line voltage

Below, everything you need to consider in terms of line voltage is described (refer to section Insulation, protection class, degree of protection and rated voltage (Page 364)):

- For fixed plants or systems without an all-pole mains disconnection switch, a mains disconnection device (all-pole) must be available in the building installation.
- For load power supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200SP distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 V DC supply

Below you will find a description of what you need to pay attention to with 24 V DC supply:

- In the event of danger through overload, you must provide lightning protection measures:
  - For external lightning protection
  - For internal lightning protection: Only if greater values (phase - ground) or (phase - phase) are required for the power surge than those specified in the section Electromagnetic compatibility (Page 364).
- For 24 V DC supply: Ensure protection by electrical separation and separate cable routing or increased insulation of circuits with dangerous potentials from extra low voltage (SELV/PELV) in accordance with IEC 61131-2 / IEC 61010-2-201.

Requirements for power supplies in the event of voltage interruption

NOTE

To ensure adherence to IEC 61131-2, only use power packs/power supply units (e.g. 230/400 V AC → 24 V DC) with a mains buffering time of at least 10 ms. Observe the relevant requirements in your application (e.g. product standard for "burners" 30 ms according to EN 298 or 20 ms according to NAMUR recommendation NE 21) with respect to possible voltage interruptions. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).
Of course, these requirements also apply to power packs/power supply units not constructed using ET 200SP or S7-1500/S7-300-/S7-400 design.

Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- Make sure that the system for discharging electromagnetic interference is connected to a functional earth or to protective conductor with a sufficient cross-section for all plants with an ET 200SP distributed I/O system.
- For supply, signal and bus lines, you must ensure that the laying of the lines and the installation is correct.
- For signal and bus lines, you must ensure that a wire/cable break or a cross-circuit does not lead to undefined states of the plant or system.

Reference

You can find more information in the Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.

8.2 Additional rules and regulations for the operation of the ET 200SP with fail-safe modules

8.2.1 Safety extra-low voltage (SELV, PELV) for failsafe modules and failsafe motor starters

⚠ WARNING

The failsafe modules must be operated with safety extra-low voltage (SELV, PELV).
You can find more information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.
The fail-safe modules operate with the 24 V DC rated voltage. The tolerance range is 19.2 V DC to 28.8 V DC.
The fail-safe motor starters operate with the 24 V DC rated voltage. The tolerance range is 20.4 V DC to 28.8 V DC.
Within the overvoltage range from 32 V DC to 36 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 36 V DC, the F-modules are permanently de-energized.
Use a power supply unit that does not exceed U_m = 36 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.
All system components that can supply electrical energy in any form whatsoever must fulfill this condition.
Each additional circuit (24 V DC) used in the system must have a safety extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.
Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module may not exceed a fault voltage U_m in the event of a fault.

⚠ WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.
An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage U_m to be exceeded.

8.2.2 Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

⚠ WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have proof-test intervals of 20 years as defined in IEC 61508:2010 without considerable loss of safety.
The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".
To achieve the required safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PLe, it is sufficient that a sensor has a single-channel connection. However, to achieve SIL3/Cat. 3/PLe with a single-channel connected sensor, the sensor itself must be SIL3/Cat. 3/PLe-capable. Otherwise, this safety level can only be achieved through two-channel connection of sensors.

To achieve SIL3/Cat. 4/PLe, sensors must be connected by two channels.

⚠ WARNING

In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.
Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Additional requirements for sensors for fail-safe motor starters

Only single-channel sensors that fulfill the required safety category themselves may be connected to the fail-safe motor starter's F-DI. Fail-safe laying must be observed in accordance with the required safety category.

⚠ WARNING

Safety-related shutdown using the F-DI

Depending on the I/O used, the shutdown takes place via one or two output channels (terminals):

- PM-switching: The shutdown takes place via two output channels.
- PP-switching: The shutdown takes place via one output channel.

Shutdown via only one output channel (PP-switching) achieves SIL 3 according to ISO 62061 and PLe/Cat.4 according to EN ISO 13849-1, if it is ensured that the cabling is installed in a cross-circuit-proof/P-short-circuit-proof manner.

Duration requirements for sensor signals

⚠ WARNING

Observe the following requirements for sensor signals:

- To ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in the section "Response times" of the relevant F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

If the actuators switch voltages greater than 24 V DC (e.g. 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).
This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

8.2.3 Crosstalk of digital input/output signals

When fail-safe digital output and input signals are in a single cable, F-DQ modules and F-PM-E modules may experience readback errors.

Cause: capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. A cross circuit/short-circuit is detected, which leads to safety-related tripping.

Remedy:

- Separate cables for F-DI modules, F-DQ modules, and F-PM-E modules or non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels for the F-PM-E module
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it.

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

Remedy:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

8.3 Additional rules and regulations for operation of an Ex module group

Ex module group

You can find the rules and regulations for operation of an Ex module group in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en)

8.4 Additional rules and instructions for operation with motor starters

8.4.1 Protection against short circuit

The motor starter complies with type of coordination 1. Secure the feeder cable for the infeed bus according to current, country-specific rules for conductor protection.

⚠ WARNING

Hazardous Voltage at the Motor
Can Cause Death, Serious Injury, or Property Damage.
Following a short-circuit, the SIMATIC ET 200SP motor starter is defective. Replace the motor starter following a short-circuit.

8.5 Operating the ET 200SP on grounded incoming supply

Introduction

Below you will find information on the overall configuration of an ET 200SP distributed I/O system on a grounded incoming supply (e.g. TN-S network). The specific subjects discussed are:

- Disconnecting devices and short-circuit and overload protection according to IEC 60364 (corresponds to DIN VDE 0100) and IEC 60204 (corresponds to DIN VDE 0113)
- Load power supplies and load circuits.

Grounded incoming supply

In the case of grounded incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example, a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical separation (SELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with 24 V DC output voltage require safe electrical separation and voltage limiting (extra low voltage). Load power supplies/power supply modules with 24 V DC output voltage are not connected to the protective conductor. According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as SELV (Safety Extra Low Voltage).

The wiring of SELV circuits must be safely separated from the wiring of other circuits that are not SELV, or the insulation of all conductors must be dimensioned for the higher voltage.

Grounded extra-low voltage (PELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with grounded 24 V DC output voltage require safe connection to the protective conductor and voltage limiting (extra low voltage).

According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as PELV (Protective Extra Low Voltage).

The wiring of PELV circuits must be safely separated from the wiring of other circuits that are not PELV, or the insulation of all conductors must be dimensioned for the higher voltage.

Configuration of ET 200SP with ungrounded reference potential

To conduct interference currents, the reference potential of the CPU/interface module and the BaseUnits BU15...D is connected internally via an RC combination (IM/CPU: R = 10 MΩ / C = 100 nF, BU15...D: R = 10 MΩ / C = 4 nF) with the mounting rail (functional grounding).

- This configuration conducts high-frequency interference currents and prevents static charges.
- It is always possible to configure an ungrounded setup of the ET 200SP distributed I/O system as the ET 200SP distributed I/O system has no fixed ground connection. The power pack/power supply module for 24 V DC must also be ungrounded and electrically isolated.

If you want to configure the ET 200SP distributed I/O system with grounded reference potential, connect the 1M connection of the CPU/interface module electrically with the protective conductor.

Short-circuit / overload protection

Various measures as protection against short-circuits and overloads are required for setting up a full installation. The type of components and the binding protective measures depend on which IEC (DIN VDE) regulation applies to your system configuration. The table refers to the figure below and compares the IEC (DIN VDE) regulations.

Table 1-356 Components and protective measures

	Refer to figure	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Disconnecting device for controller, sensors, and actuators	①	Main switch	Disconnector
Short-circuit / overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	With grounded secondary circuit: **single-pole** protection otherwise: **all-pole** protection
Load current supply for AC load circuits with more than five items of electromagnetic equipment	②	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

Cable temperature measurement threshold

NOTE

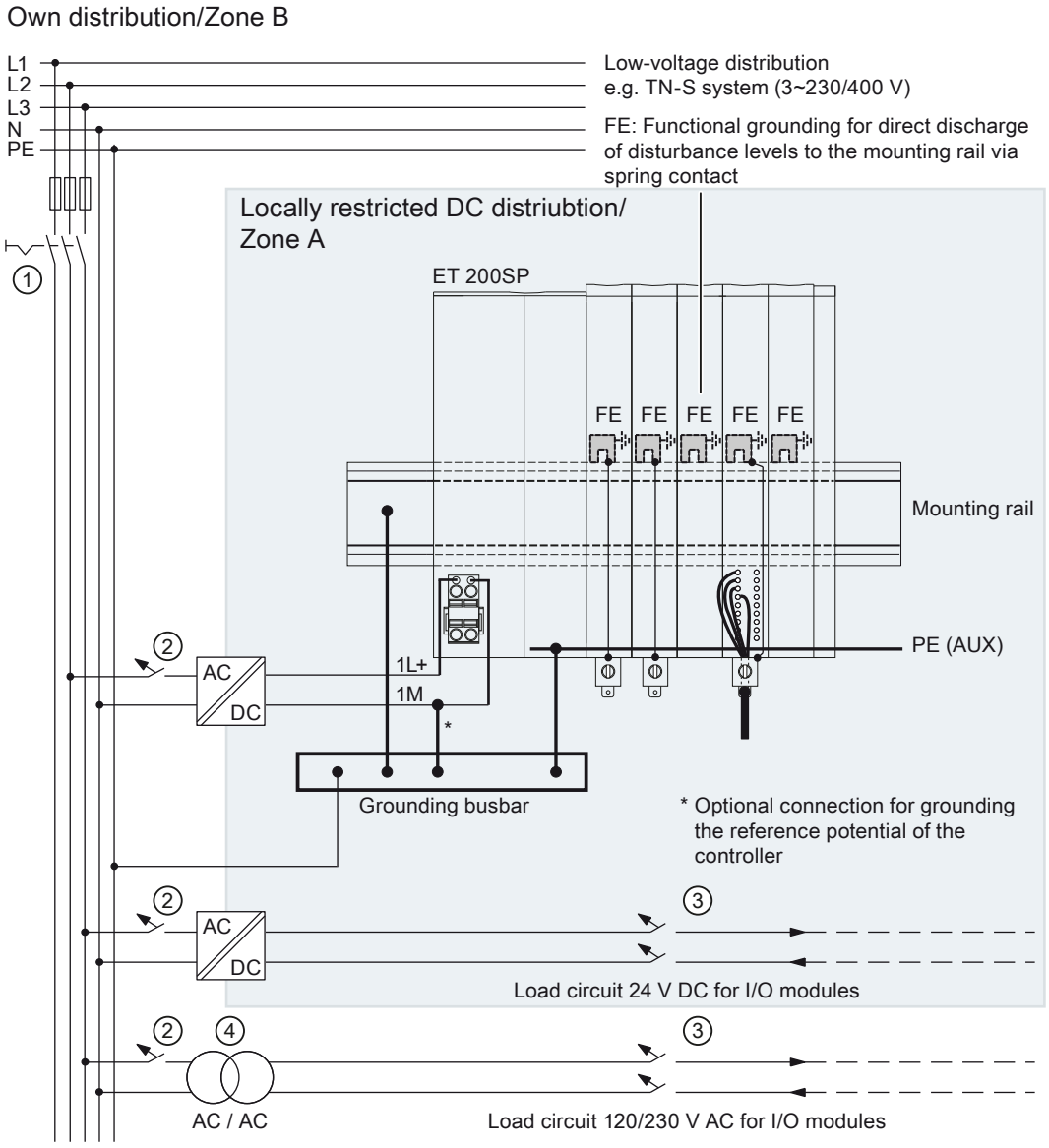
Cable temperature measurement threshold

When choosing a cable, remember that the cable temperature in operation can be up to 30 °C higher than the ambient temperature of the ET200SP system (example: at an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

ET 200SP in the overall configuration

The figure below shows the overall configuration of the ET 200SP distributed I/O system (load current supply and grounding concept) with supply from a TN-S network.



① Main switch
② Short-circuit / overload protection
③ Load current supply
④ Optional for galvanic isolation

Figure 1-86 ET 200SP in the total configuration

NOTE
In general, you need to connect the DC I/O modules of the ET 200SP distributed I/O system to your own distribution (or batteries) via an upstream, local power supply unit.
If you connect the DC I/O modules directly to your own distribution, you need to provide additional protective measures against overvoltages.

8.6 Electrical configuration of the ET 200SP

Electrical isolation

Electrical relationships

With the ET 200SP distributed I/O system, there is electrical isolation between:

- The load circuits/process and all other circuit components of the ET 200SP distributed I/O system.
- The communication interfaces of the CPU (PROFINET) or of the interface module (PROFINET/PROFIBUS) and all other circuit components.

The figures below show the electrical relationships of the ET 200SP distributed I/O system with the CPU and the interface module. Only the most important components are represented in the figures.

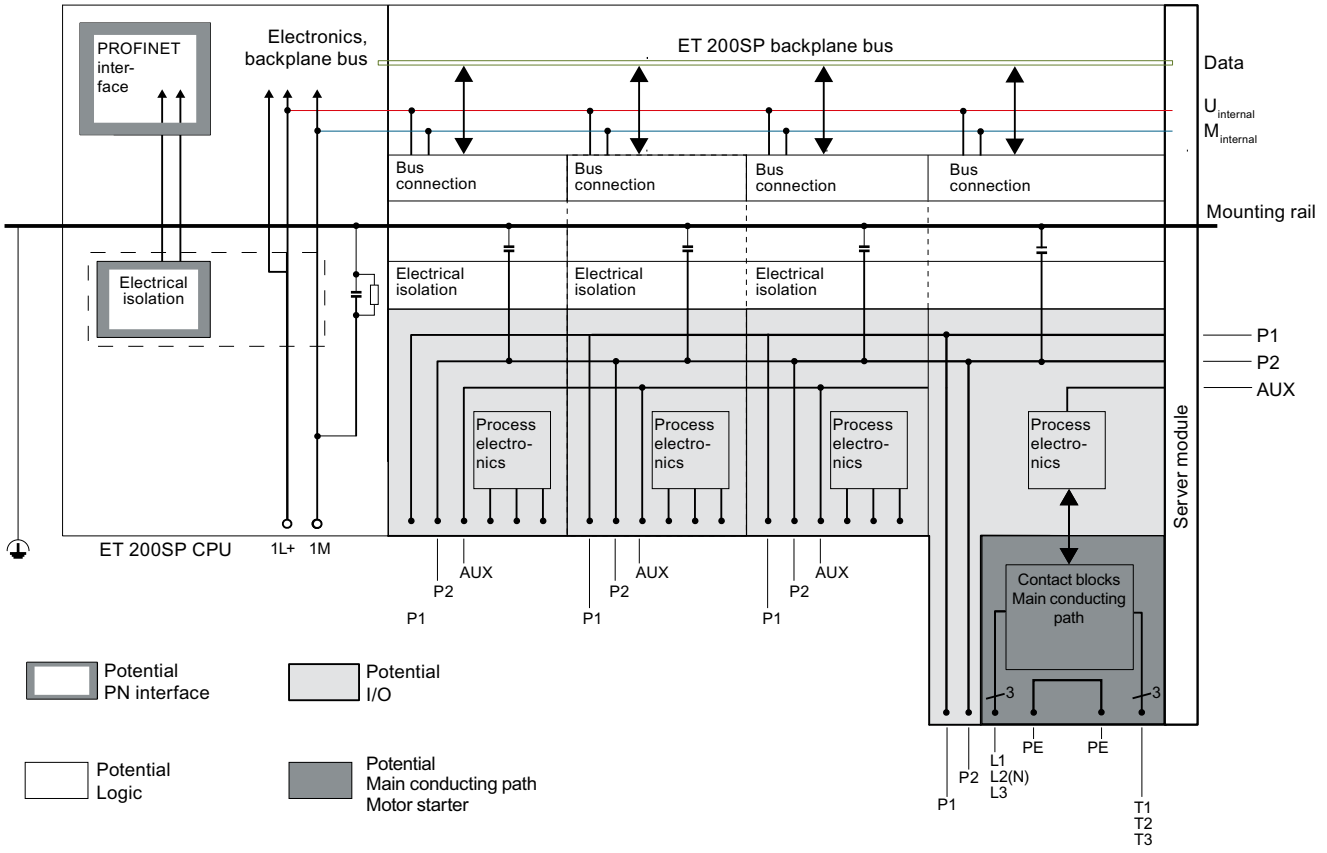


Figure 1-87 Electrical relationships for ET 200SP with CPU

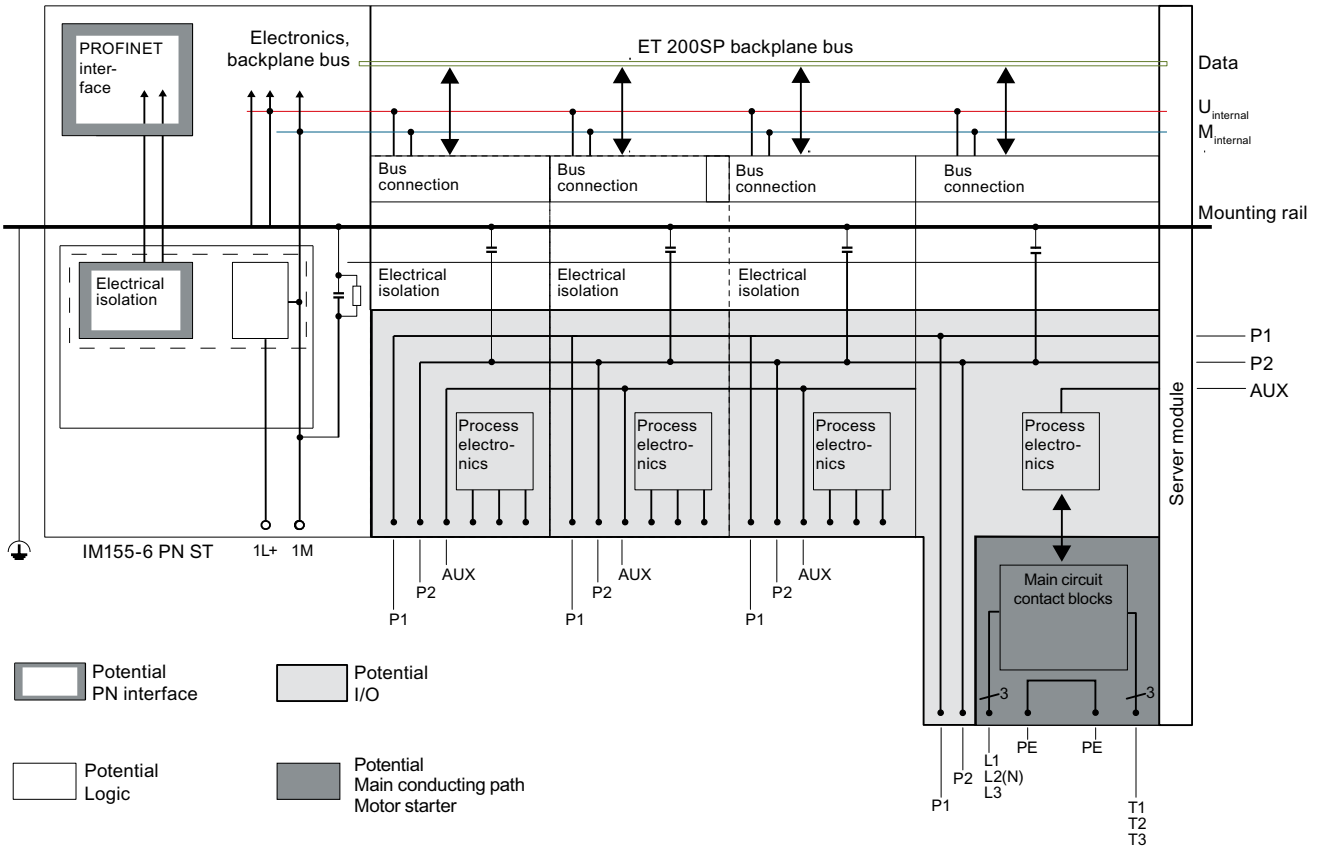


Figure 1-88 Electrical relationships for ET 200SP with interface module (using IM 155-6 PN ST as an example)

8.7 Wiring rules

Introduction

Use suitable cables to connect the ET 200SP distributed I/O system. Also select the cable insulation corresponding to the applied voltage. The tables below set out the wiring rules for CPU/interface module, BaseUnits and motor starter.

⚠ CAUTION

Use copper cables on connectors with terminal connections
Use solely copper cables (Cu) for all signal and supply lines that are connected to the device via terminals, e.g. 24 V DC power supply cable to the 24 V DC power supply connections.

Wiring rules for the CPU/interface module and BaseUnits for I/O modules

Wiring rules for ...		CPU/interface module (supply voltage)	BaseUnits (push-in terminal)
Permitted cable cross-sections of solid cables (Cu)		0.2 to 2.5 mm^2	
		AWG*: 24 to 13	
Connectable cable cross-sections for flexible cables (Cu)	Without wire end ferrule	0.2 to 2.5 mm^2	
		AWG*: 24 to 13	AWG*: 24 to 14
	With end sleeve (with plastic sleeve)***	0.25 to 1.5 mm^{2**}	0.14 to 1.5 mm^2
		AWG*: 24 to 16	AWG*: 26 to 16
	With TWIN end sleeve***	0.5 to 1 mm^2	0.5 to 0.75 mm^2 (see below)
		AWG*: 20 to 17	AWG*: 20 to 18
Stripping length of the cables		8 to 10 mm	
Wire-end ferrules in accordance with DIN 46228 with plastic sleeve***		8 and 10 mm long	
TWIN end sleeves		12 mm long	

* AWG: American Wire Gauge

** Wire end ferrules without plastic sleeve: 0.25 to 2.5 mm^2/AWG: 24 to 13

*** See note on wire-end ferrules

Note the following for BaseUnits with function version < FS10:

NOTE

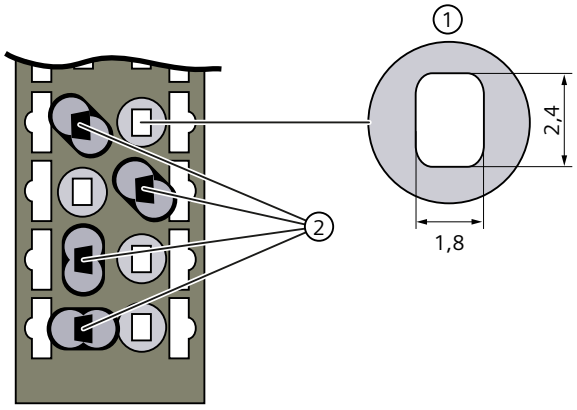
Wire-end ferrules

Optimum results with respect to a high-quality and permanent electrical connection with maximum conductor pull forces at the same time can be achieved by using crimping dies, preferably with smooth surfaces, which are provided, for example, with rectangular and trapezoidal crimp cross-sections.

Crimping dies with a pronounced wave profile are unsuitable.

TWIN end sleeves for the cables of the I/O modules' push-in terminals

Due to the space required by TWIN end sleeves with 0.75 mm² cross-section, you must ensure a correct angle for the cable arrangement when crimping the TWIN end sleeve so that the cables are optimally arranged.



① Cross-section of the terminal compartment
② Crimping TWIN end sleeves at the correct angle

Figure 1-89 TWIN end sleeves

Wiring rules for motor starters

Wiring rules for ...		L1(L), L2(N), L3, PE	T1, T2, T3, PE, 24 V DC, F-DI, M	DI1 ... DI3, LC, M, 24 V OUT
Permitted cable cross-sections of solid cables (Cu)		1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
Connectable cable cross-sections for flexible cables (Cu)	Without wire end ferrule	1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve	1 to 6 mm²	0.5 to 2.5 mm²	0.25 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve (with plastic sleeve)	1 to 4 mm²	0.5 to 1.5 mm²	0.25 to 0.75 mm²
		AWG: 18 to 11	AWG: 20 to 16	AWG: 24 to 18
Stripping length of the cables		15 mm	10 mm	8 mm
End sleeves according to DIN 46228 with plastic sleeve		15 mm long	10 mm long	8 mm long

Safety standards for fail-safe motor starters

Fail-safe motor starters fulfill the following standards under certain conditions:

- PLe/Cat.4 according to EN ISO 13849-1
- Safety Integrity Level SIL 3 according to IEC 62061

To fulfill both standards, lay cross-circuit proof and P-cross-circuit proof control cables from the safe output of a sensor or F-DQ to the safe input of the motor starter, e.g. as a separately sheathed cable or in a separate cable duct.

Line protection

The line protection of the SIMATIC ET 200SP motor starter is provided for the motor outgoing feeder cable when the following condition is met:

The cross-section of the motor outgoing feeder cable must be dimensioned for the load ratios of the motor and for the cable-laying method.

Comply with national regulations. The user is responsible for the correct selection and dimensioning of the motor connection cable to DIN VDE 0100 and DIN VDE 0298-4 and/or UL 508.

The conductor protection for the incoming feeders must be ensured by the owner of the installation depending on the cross-section.

Cable temperature measurement threshold

NOTE

Cable temperature measurement threshold

When choosing a cable, remember that the cable temperature in operation can be up to 30 °C higher than the ambient temperature of the ET200SP system (example: At an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

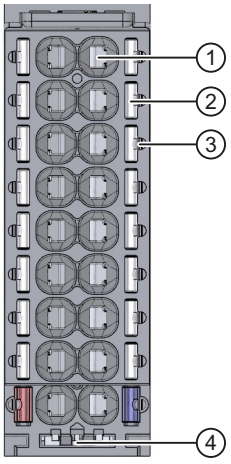
8.8 Wiring BaseUnits for I/O modules

Introduction

The BaseUnits connect the ET 200SP distributed I/O system to the process. The following versions of the BaseUnits can be used:

- BaseUnits (with light-colored terminal box) for opening a potential group: BU..D
- BaseUnits (with dark-colored terminal box) for extending the potential group: BU..B
- BaseUnits with additional AUX terminals or additional terminals: BU..+10..
- BaseUnits with integrated thermal resistor for compensation of the reference junction temperature when connecting thermocouples: BU..T
- PotDis-BaseUnits (with light-colored terminal box) for opening a PotDis potential group: PotDis-BU..D

- PotDis-BaseUnits (with dark-colored terminal box) for extending the potential group: PotDis-BU..B



① Push-in terminal
② Spring release
③ Measuring probe (suitable probes: 1 mm diameter, length ≥ 10 mm while observing the permitted voltage category)
④ Holder for shield connection

Figure 1-90 View of the BaseUnit

NOTE

The pin assignment of the BaseUnit depends on the connected I/O module. Information on the BaseUnits and I/O modules can be found in the associated manuals.
Replacement of the terminal box on the BaseUnit is described in the section Replacing the terminal box on the BaseUnit (Page 320).

NOTE

Special terminal designations in the wiring and block diagrams of the I/O modules/BaseUnits

- **RES**: Reserve, these terminals must remain unconnected so that they can be used for future expansions
- **n.c.**: Not connected, these terminals have no function. However, they can be connected to potentials specifically defined for a module, for example, for the laying unused wires.

Requirements

- The supply voltages are turned off.
- Follow the wiring rules.
- Color identification labels (Page 189) (optional) have been applied.

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without wire end ferrule, multi-wire (stranded) with wire end ferrule or ultrasonically sealed

Watch the video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only in the case of stranded conductors (except for 2.5 mm^2 cross-section):
   Seal or crimp the wire with wire end ferrules.
3. Insert the wire into the push-in terminal as far as it will go.

Connection of cables: multi-wire (stranded), without wire end ferrule, unprocessed

To connect a wire without a wire end ferrule, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Push with the screwdriver into the spring release.
3. Insert the wire into the push-in terminal as far as it will go.
4. Pull the screwdriver out of the spring release.

Removing wires

Using the screwdriver, press the spring release of the terminal as far as it will go and pull out the wire.

NOTE

When you press the spring release, you should not pull on the wire/cable at the same time. This prevents you from damaging the terminal.

8.9 Connecting cable shields for I/O modules

Introduction

- You need the shield connector to contact cable shields (e.g. for analog modules). The shield connector conducts interference currents on cable shields to ground via the mounting rail. It is not necessary to contact the shield at where the cable enters the cabinet.
- Fasten the shield connector to the BaseUnit.
- The shield connection consists of a shield support, a shield terminal and a supporting element.
- The shield connector is automatically connected to the functional ground (FG) of the mounting rail after installation.

Requirements

- BaseUnit must be one of the following types:
  - A0, A1
  - B0
  - C0, C1
  - F0
  - U0
- The shield terminal is suitable for cables with max. ∅ 7 mm each.

Required tools

- Stripping tool
- Slotted screwdriver with a 3.5 mm blade or Torx T10

Procedure

Watch the "Wiring BaseUnits" video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

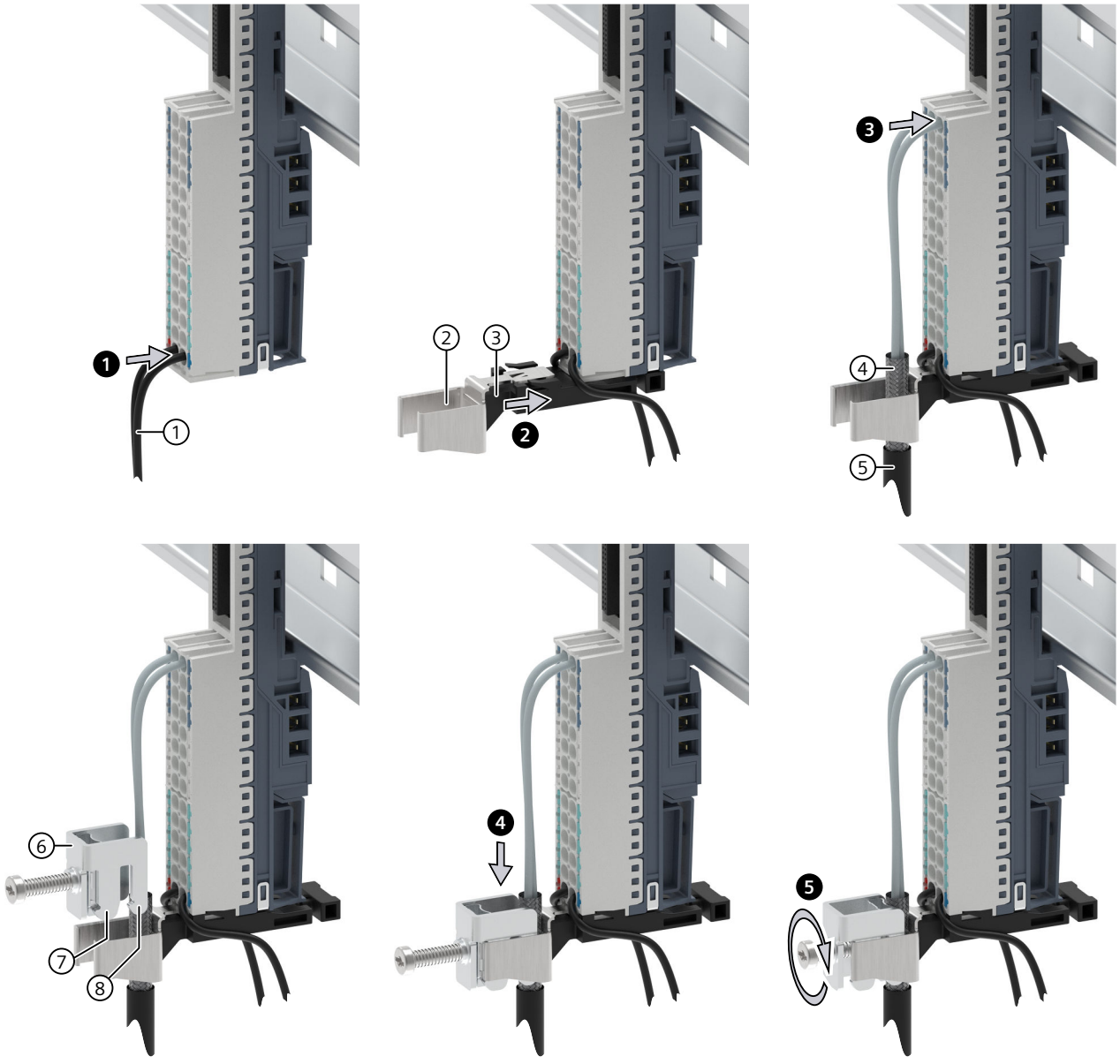
To connect the cable shield, follow these steps:

1. If required, connect the supply voltage L+ and ground to the BaseUnit.
2. Push the supporting element with the shield support into the guideway till the supporting element clicks into place.

   If you use a 7.5 mm mounting rail, you must first shorten the supporting element. To do so, unscrew the spacer of the support element.
3. Remove the cable insulation material around the shield terminal.

   Connect the cable to the BaseUnit and place the cable in the shield contact.
4. Insert the shield terminal into the corresponding clamping position of the shield support.
   - Clamping space height 1: 1.9 mm to 15.5 mm
   - Clamping space height 2: 10.9 mm to 23.5 mm

5. Tighten the shield terminal with approximately 0.5 Nm.
   When doing this, ensure that the terminal is completely in contact with the exposed protective braided shield.



①	Supply voltage L+, M	⑤	Cable to the encoder
②	Shield support	⑥	Shield terminal
③	Supporting element	⑦	Suspension for clamping position 1
④	Insulation material removed (approx. 20 mm)	⑧	Suspension for clamping position 2

Figure 1-91 Mounting the shield contact

NOTE

Shield terminal does not have a null terminal.

Fix the shield terminal only when there is at least one inserted cable.

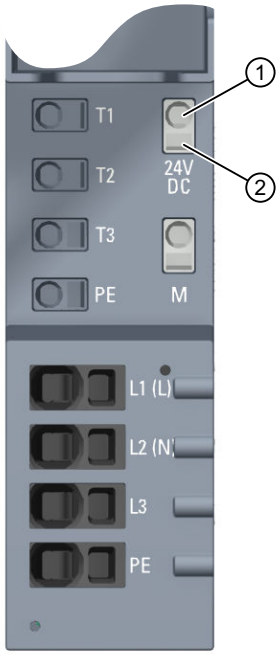
8.10 Wiring BaseUnits for motor starters

Introduction

The following versions of BaseUnits can be used:

- BU30-MS1 (with 24 V DC and 500 V AC infeed)
- BU30-MS2 (with 500 V AC infeed)
- BU30-MS3 (with 24 V DC infeed)
- BU30-MS4 (without infeed)
- BU30-MS5 (with 500 V AC infeed and single F-DI)
- BU30-MS6 (without infeed and with single F-DI)
- BU30-MS7 (with F-DI and 500 V AC infeed)
- BU30-MS8 (with 500 V AC infeed and F-DI routing)
- BU30-MS9 (with F-DI routing)
- BU30-MS10 (with F-DI infeed)

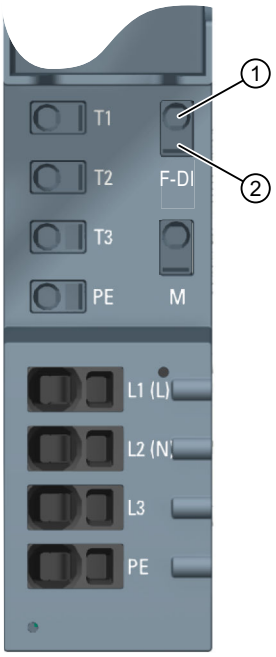
The following figure shows an example of a BaseUnit BU30-MS1 (with the maximum number of terminals):



① Push-in terminal
② Spring release

Figure 1-92 Terminals on a BaseUnit BU30-MS1

The following figure shows an example of a BaseUnit BU30-MS5 (with the maximum number of terminals):



① Push-in terminal
② Spring release

Figure 1-93 Terminals on a BaseUnit BU30-MS5

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Hazardous electrical voltage can cause electric shock, burns and property damage.
Turn off and lock out all power supplying this device before working on this device.

For wiring finely-stranded or stranded conductors without end sleeves on push-in connections, a screwdriver is required.

Requirements

- The supply voltages are switched off
- Observe the wiring rules

NOTICE

Interconnection of the F-DI input of BaseUnits BU-30-MS5, BU-30-MS6, BU-30-MS7 and BU-30-MS10 with surge filters
If your system requires overvoltage protection, you must interconnect the F-DI input of the BaseUnits BU-30-MS5, BU-30-MS6, BU-30-MS7 and BU-30-MS10 with surge filters.
Please see "Electromagnetic Compatibility" in the technical specifications.

Required tools

Use the screwdriver "SZF 1-0.6x3.5" (for finely-stranded cables only).

Connecting conductors: Solid without end sleeve, stranded (stranded wire) with end sleeve

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Electromagnetic compatibility of fail-safe modules (Page 357)".
2. Only in the case of stranded conductors:
   Crimp the cable with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Pull on the cable to ensure it is tight.

Connecting conductors: multi-wire (stranded), without end sleeve, unfinished

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Wiring rules (Page 161)".
2. Press the screwdriver into the spring release.
3. Insert the conductor into the push-in terminal until it engages.
4. Pull the screwdriver out of the spring release.
5. Check whether or not the conductor is firmly connected by pulling on the cable.

Video sequence

At the following Internet link, you can see a video about connecting conductors: Wire BaseUnits (http://support.automation.siemens.com/WW/view/en/95886218)

Releasing conductors

To release a conductor, proceed as follows:

1. Press the screwdriver into the spring release of the terminal until it engages.
2. Pull the conductor out.

NOTE

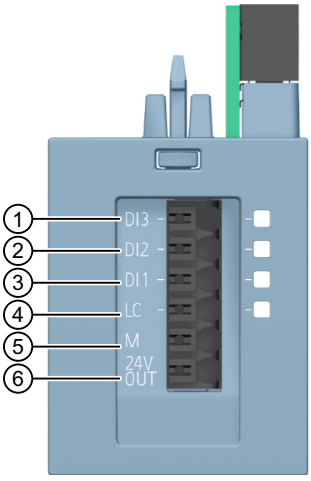
When pressing the spring release, you must not pull on the wire/cable at the same time. In this way, you avoid damaging the terminal.

8.11 Connecting the 3DI/LC module for the motor starter

You will find further information on the 3DI/LC module in the ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

Procedure

The figure below shows the connections of the 3DI/LC module.



① Digital input 3
② Digital input 2
③ Digital input 1
④ Local control (manual local)
⑤ Ground
⑥ 24 V DC/ 100 mA output

NOTE

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6).
Connect only cables of a width not exceeding 30 m to the 3DI/LC module.
The supply (5 and 6) is protected against short-circuits.

Terminal sketch of the 3DI/LC module

The following diagram shows a terminal sketch of the 3DI/LC module:

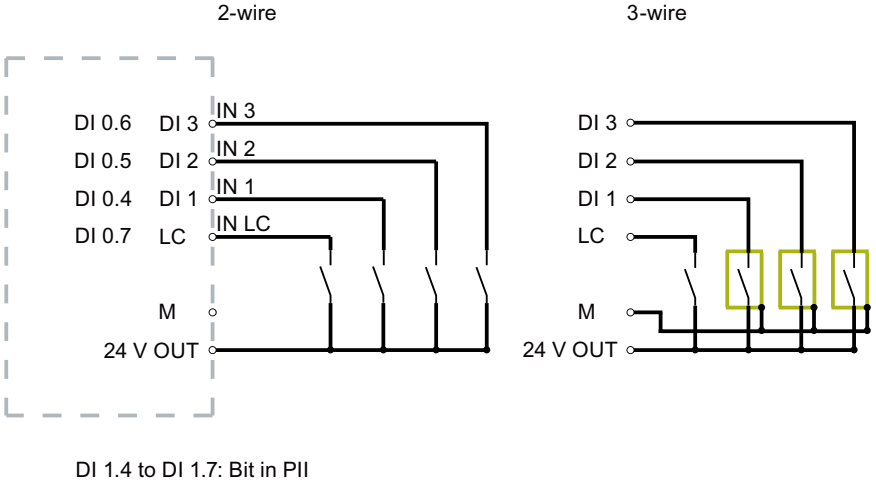


Figure 1-94 Connection example of inputs

8.12 Connecting the supply voltage to the CPU/interface module

Introduction

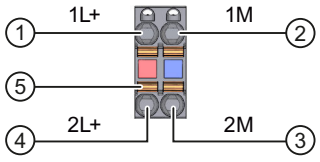
The supply voltage of the CPU/interface module is supplied by means of a 4-pin connector plug located on the front of the CPU/interface module.

Power supply unit

Only use power supply units of type SELV/PELV with safe electrically isolated functional extra low voltage (≤ 28.8 V DC).

Connection for supply voltage (X80)

The connections of the 4-pole connector have the following meaning:



① +24 V DC of the supply voltage (current limited to 10 A)
② Ground of the supply voltage (current limited to 10 A)
③ Ground of the supply voltage for loop-through
④ +24 V DC of the supply voltage for loop-through
⑤ Spring opener (one spring opener per terminal)

1L+ and 2L+ and 1M and 2M are internally jumpered

Figure 1-95 Supply voltage connection

A strain relief is not present. The cable connector offers you the option of looping the supply voltage uninterrupted, even when it is unplugged.

For the maximum wire cross-sections, observe the information in the tables of the wiring rules (Page 161).

Requirements

- Only wire up the connector plug when the supply voltage is turned off.
- Follow the wiring rules (Page 161).

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without end sleeve, multi-wire (stranded) with end sleeve or ultrasonically sealed

Watch video sequence: "Connect BusAdapter to the interface module" (https://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only in the case of stranded conductors:
   Seal or crimp the wire with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Push the wired connector plug into the plug socket of the interface module.

Connection of cables: multi-wire (stranded), without end sleeve, unfinished

To connect a wire without an end sleeve, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.
3. Pull the screwdriver out of the spring release.
4. Push the wired connector plug into the socket in the interface module.

Removing a wire

Using the screwdriver, press the spring release as far as it will go and pull out the wire.

8.13 Connecting interfaces for communication

Connect the communication interfaces of the ET 200SP distributed I/O system using the standardized connector or directly. If you want to prepare communication cables yourself, the interface assignment is specified in the manuals of the corresponding modules. Observe the mounting instructions for the connectors.

Detailed information on the available BusAdapters and the procedure for connecting PROFINET IO to the CPU/interface module is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

8.13.1 Connecting PROFINET IO (RJ45 port) to the CPU

Introduction

You use the RJ45 bus connector to connect PROFINET IO (RJ45 port) directly to the CPU.

Required accessories

- Cable ties with standard width of 2.5 mm or 3.6 mm for strain relief
- Please observe the specifications in the PROFINET Installation Guide (https://www.profibus.com).

Mounting the bus connector

Mount the PROFINET connector in accordance with the instructions in the PROFINET Installation Guide (https://www.profibus.com).

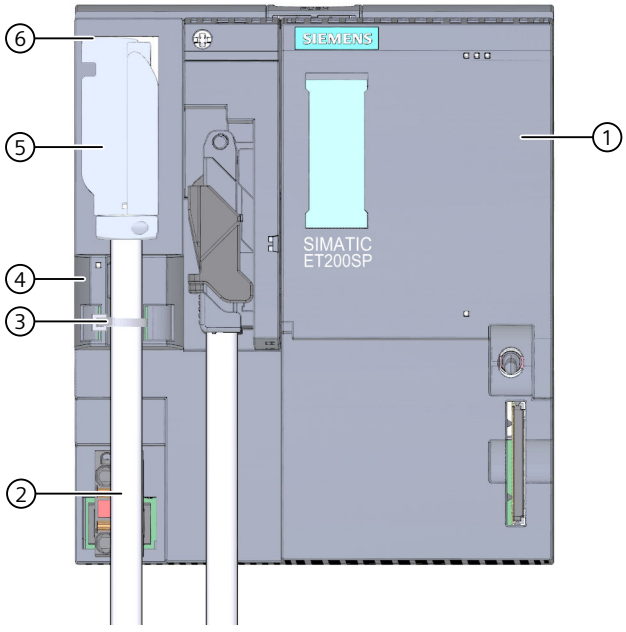
Procedure

Insert the RJ45 bus connector into the PROFINET port (RJ45 port) on the CPU.

NOTE

Cable support and strain relief

If you are using a FastConnect RJ45 bus connector with 90° cable outlet (6GK1901-1BB20-2AA0), we recommend you provide strain relief for the PROFINET connecting cable. For this you need a cable tie with a standard width of 2.5 mm or 3.6 mm. Use it to fasten the PROFINET connecting cable directly after it exits the bus connector to the provided cable support on the CPU (on the front directly below the PROFINET interface X1P3).



① CPU
② PROFINET connecting cable
③ Strain relief (cable tie)
④ Cable support
⑤ FastConnect RJ45 bus connector with 90° cable outlet
⑥ PROFINET connector (RJ45 port)

Figure 1-96 Connecting PROFINET IO (RJ45 port) to the CPU

8.13.2 Connecting the PROFIBUS DP interface to the interface module/communications module CM DP

Introduction

Using the bus connector (RS485), connect the PROFIBUS DP to the interface module/communications module CM DP.

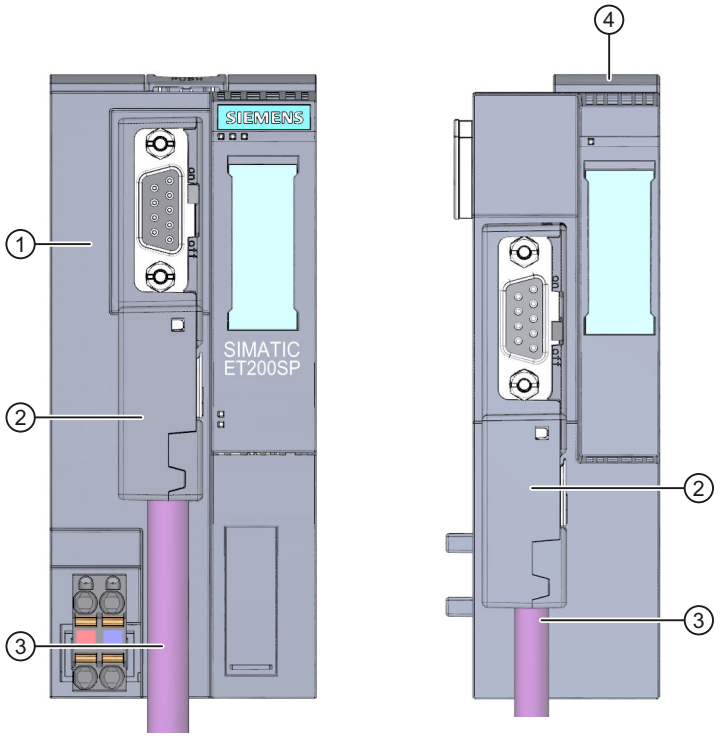
Required tools

3 to 3.5 mm screwdriver

Procedure

To connect the PROFIBUS DP interface to the interface module / DP communication module CM DP, follow these steps:

1. Connect the PROFIBUS cable to the bus connector.
2. Plug the bus connector into the PROFIBUS DP connector.
3. Securely tighten the fixing screws of the bus connector (0.3 Nm).



① Interface module
② PROFIBUS FastConnect bus connector
③ PROFIBUS connecting cable
④ Communications module CM DP

Figure 1-97 Connect PROFIBUS DP to the interface module/communications module CM DP

Reference

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109793857/en).

8.14 Inserting I/O modules / motor starters and BU covers

Introduction

- You insert the I/O modules on the BaseUnits. The I/O modules are self-coding and type-coded.
- You insert the PotDis-TerminalBlocks on the PotDis-BaseUnits.
- You insert the BU covers on BaseUnits whose slots are not equipped with I/O modules/PotDis-TerminalBlocks.
- You insert the BU covers on BaseUnits whose slots have been reserved for future expansion (as empty slots).
- The BU covers for motor starters serve as touch protection covers for unoccupied slots.
  The BU covers have a holder for the reference identification label on the inside. For future expansion of the ET 200SP, remove the reference identification label from the holder and insert it into the final I/O module.
  It is not possible to attach a reference identification label to the BU cover itself.
  There are three versions:
  - BU cover with a width of 15 mm
  - BU cover with a width of 20 mm
  - BU cover with a width of 30 mm (for motor starters)

Requirement

Refer to chapter "Application planning (Page 85)".

Plugging in I/O modules and BU covers

Watch video sequence: "Insert I/O modules"
(https://support.automation.siemens.com/WW/view/en/95886218)

Insert the I/O module or BU cover parallel into the BaseUnit until you hear both latches click into place.

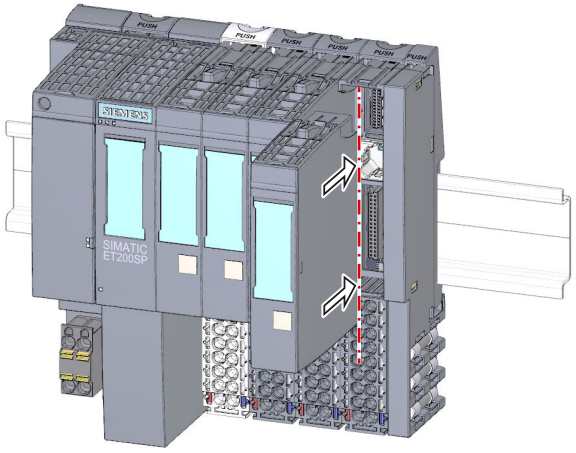


Figure 1-98 Plugging in I/O modules or BU covers (using an I/O module as example)

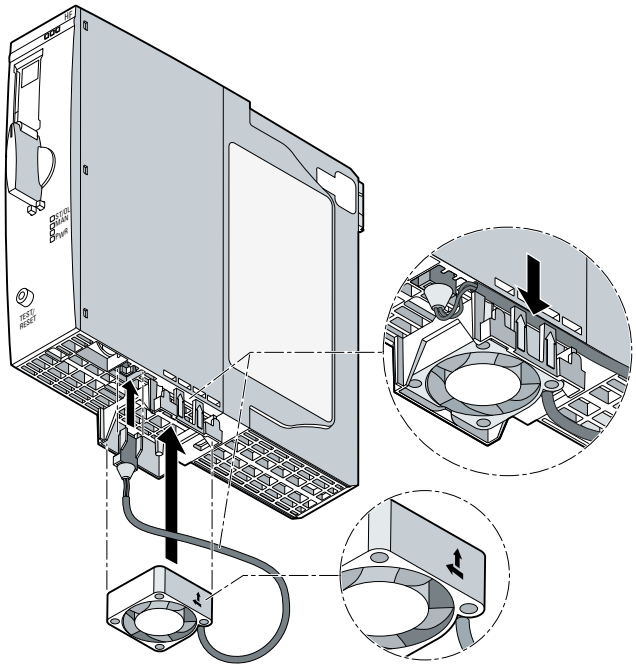
8.15 Mounting/disassembly of motor starters

8.15.1 Mounting the fan

Procedure

Proceed as follows to mount a fan on a SIMATIC ET 200SP motor starter:

1. Slide the fan onto the motor starter until you can hear the fan engage.
   Observe the blowing direction of the fan when mounting. The air stream must be directed to the inside of the motor starter. The correct blowing direction is indicated by arrows on the bottom of the fan.
2. Insert the connection plug into the opening above the fan.



3. Secure the fan cable to the fixing eyes on the right-hand side of the fan cover.

NOTE

Specified ambient temperatures are not reached if the fan is incorrectly installed
If you do not observe the blowing direction of the fan when mounting, the specified ambient temperatures will not be reached. The device shuts down prematurely due to excessively high temperature.

8.15.2 Mounting/disassembly of motor starters

Procedure

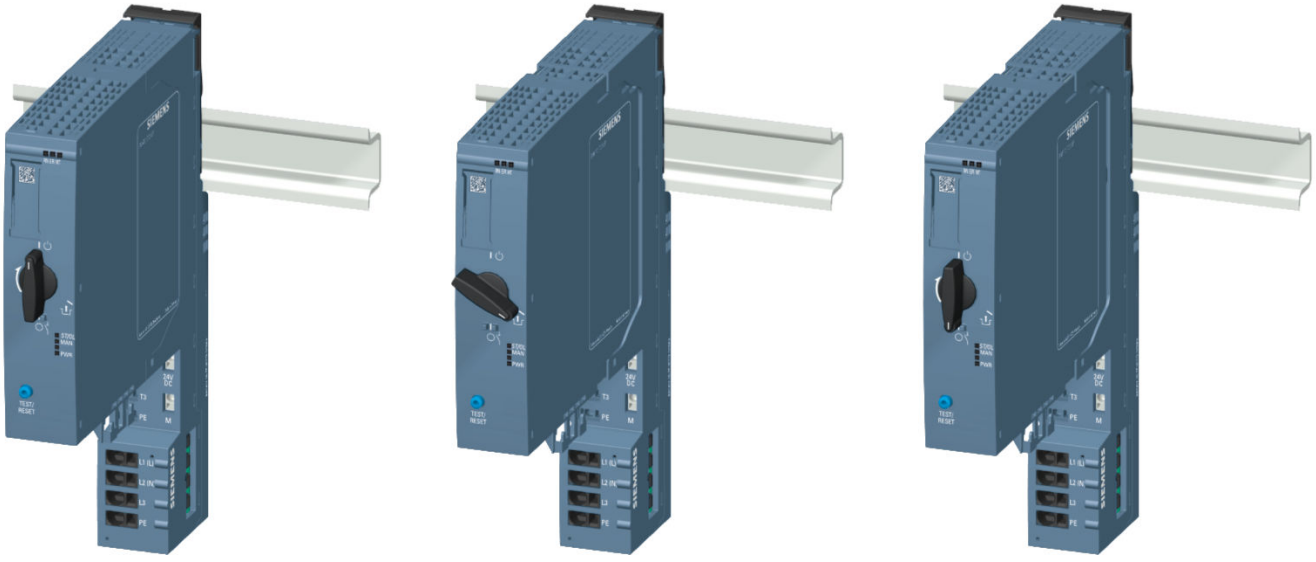
⚠ CAUTION

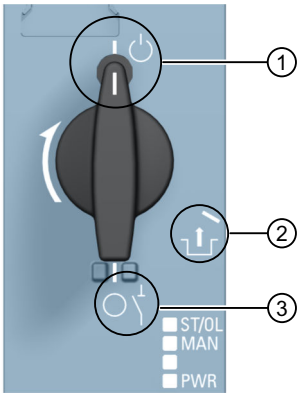
Protection against electrostatic charge
When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

To assemble a SIMATIC ET 200SP motor starter, proceed as follows:

- Position the mechanical interlock of the SIMATIC ET 200SP motor starter in the assembly/disassembly position ②
- Place the SIMATIC ET 200SP motor starter onto the BaseUnit.
- Turn the mechanical interlock clockwise to the parking position ③
- Turn the mechanical interlock counterclockwise to the operating position (= end position) ①

① ② ③





① Operating position/READY
The motor starter is firmly locked in the BaseUnit, and all electrical contacts are connected.

② Assembly/disassembly position
All electrical contacts are open, and you can use the SIMATIC ET 200SP motor starter in the BaseUnit, or you can remove it from the BaseUnit.

③ Parking position/OFF
In this position, you cannot remove the SIMATIC ET 200SP motor starter from the BaseUnit, but all electrical contacts are open. In addition, you can open the locking lever on the mechanical rotary interlock in this position, and fix the position with a padlock (shackle diameter 3 mm). This ensures the isolating function in accordance with IEC 60947-1.
In the parking position, the motor starter counts as a disconnected element for the head module. During operation, the parking position is therefore a hot swapping state. See also Removing and inserting I/O modules/motor starters (hot swapping) (Page 314)



NOTE

Parking position/OFF

This position is only permissible for maintenance purposes and not for continuous operation. In this position, dust protection and mechanical durability are not ensured.
If you do not use the motor starter for an extended period, remove it and attach the BU cover (3RK1908-1CA00-0BP0).

Mount the touch protection cover for the infeed bus on the last BaseUnit.

NOTE

Touch protection cover for the infeed bus

You will find out how to mount the touch protection cover of the infeed bus on a SIMATIC ET 200SP motor starter in chapter "Mounting the cover for the 500 V AC infeed bus (Page 143)".

To connect the assembly, mount the server module after the last BaseUnit.

NOTE

Server module

You can find out how to assemble/disassemble the server module in chapter "Installing the server module (Page 141)".

NOTE

Removing the motor starter

You will find out how to remove the motor starter in chapter "Replacing a motor starter (Page 320)".

8.15.3 3DI/LC module

Introduction

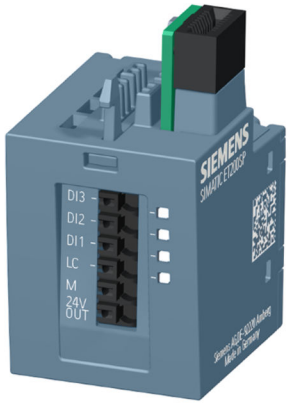
The optional 3DI/LC module with three inputs and one further LC input can be connected to the motor starter. The status of the inputs of the 3DI/LC module can be seen via the process image input (PII) of the motor starter.

NOTE

The 3DI/LC module can be used for the motor starter and the fail-safe motor starter.

The input actions can be parameterized. For reasons of operational safety, the LC input is permanently set to manual local mode. For example, by parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode.

The figure below shows the 3DI/LC module.



Assembly

⚠ WARNING

Risk of injury from automatic restart
When you mount the the 3DI/LC module, the motor starter can switch on autonomously if an ON command (DI1 to DI3) is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.
Revoke the ON commands at DI1 to DI3 before mounting the 3DI/LC module.

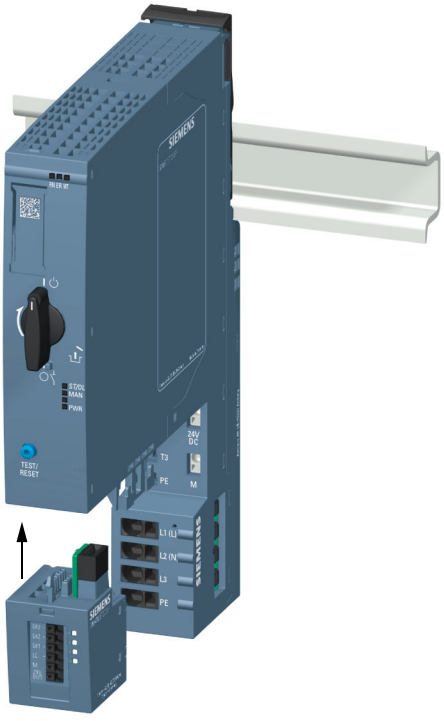
Proceed as follows to mount a 3DI/LC module onto a motor starter:

1. Wire the 3DI/LC module according to the connection diagram.

NOTE

Connecting the 3DI/LC module
You will find out how to connect the 3DI/LC module in chapter "Connecting the 3DI/LC module for the motor starter (Page 172)".

2. Slide the 3DI/LC module into the motor starter until the 3DI/LC module engages.



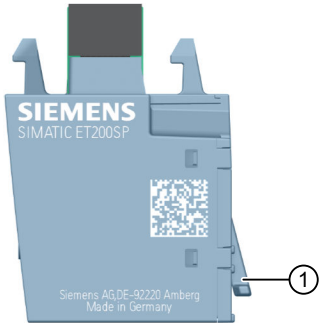
The figure below shows a motor starter with a mounted 3DI/LC module.



Disassembly

Proceed as follows to remove a 3DI/LC module from a motor starter:

1. Push the release lever on the rear of the 3DI/LC module.



① Release lever

2. Remove the 3DI/LC module from the motor starter while pressing the release lever.

8.16 Labeling ET 200SP

8.16.1 Factory markings

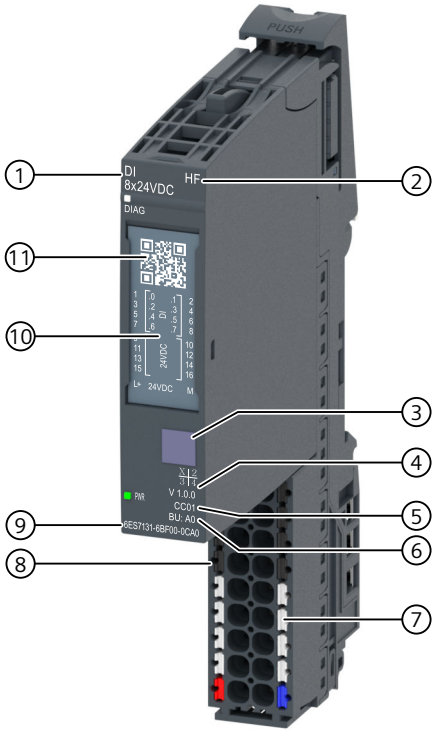
Introduction

For better orientation, the ET 200SP is equipped with various markings ex factory, which help in the configuration and connection of the modules.

Factory markings

- Module labeling
- Color coding of module type
  - Digital input modules: white
  - Digital output modules: black
  - Analog input modules: light blue
  - Analog output modules: dark blue
  - Technology module: turquoise
  - Communication module: light gray
  - Special module: mint green
- Module information
  - Functional version of the module, e.g. "X/2/3/4" (= functional version 1)
  - Functional status in plain text
  - Firmware version of the module at delivery, e.g. "V1.0.0"
  - Information on the ID link
  - Color code for usable color identification label, e.g. "CC0"
  - Usable BaseUnit type, e.g. "BU: A0"
- Color coding of the potential group
  - Opening the potential group: Light-colored terminal box and light-colored mounting rail release button
  - Further conduction of the potential group: Dark-colored terminal box and dark-colored mounting rail release button
- Color coding of the spring releases
  - Process terminals: gray, white
  - AUX terminals: turquoise
  - Additional terminals: red, blue

– Terminals for self-assembling voltage buses P1, P2: red, blue



① Module type and name
② Function class
③ Color coding of module type
④ Function and firmware version
⑤ Color code for selection of the color coding labels
⑥ BU type
⑦ Color coding of the spring releases (by group)
⑧ Color coding of the potential group
⑨ Article number
⑩ Wiring diagram
⑪ 2D matrix code/ID link

Figure 1-99 Factory markings

8.16.2 Optional markings

Introduction

In addition to the factory markings, there are also other options for labeling and/or marking terminals, BaseUnits and I/O modules for the ET 200SP distributed I/O system.

Optional markings

Color identification labels
The color identification labels are module-specific labels for color coding the potentials of the I/O modules. A color code (e.g. 01) is printed on each color identification label and I/O module. The color code allows you to read which color identification label is required for the terminals of the associated BaseUnit directly from the I/O module.

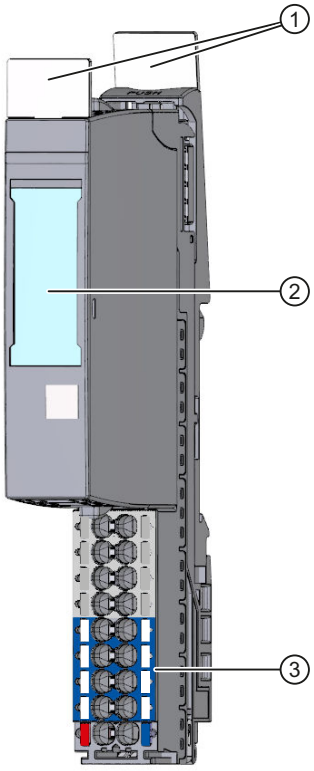
The following versions of color coded labels are available:

- Module-specific color combinations for the process terminals (see the device manuals I/O modules (https://support.automation.siemens.com/WW/view/en/55679691/133300)). The different colors have the following meaning: Gray = input or output signal, red = potential +, blue = ground.
- For the AUX terminals in the colors yellow-green, blue or red
- For the add-on terminals in the colors blue-red
- For the potential distributor modules (see manual BaseUnits (https://support.automation.siemens.com/WW/view/en/59753521)):
  - For PotDis-BaseUnit PotDis-BU-P1/x-R: red
    For PotDis-BaseUnit PotDis-BU-P2/x-B: blue
  - For PotDis-TB-P1-R: red or gray
    For PotDis-TB-P2-B: blue or gray
    For PotDis-TB-BR-W: depending on application, yellow/green, blue, red or gray
    For PotDis-TB-n.c.-G: gray

Reference identification labels
The reference identification labels (in accordance with EN 81346) can be inserted onto each CPU/interface module, BusAdapter, BaseUnit, I/O module and PotDis-TerminalBlock. This makes it possible to create a fixed assignment between the reference identification label of the BaseUnit and the I/O module/PotDis-TerminalBlock.

With the standard plotter setting, the reference identification label is suitable for automatic labeling with E-CAD systems.

Labeling strips
The labeling strips can be inserted in the CPU/interface module, I/O module and BU cover and allow identification of the ET 200SP distributed I/O system. The labeling strips can be ordered on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.



① Reference identification labels
② Labeling strips
③ Color identification labels

Figure 1-100 Optional markings

8.16.3 Applying color identification labels

Requirements

The BaseUnits must not be wired when you apply the color identification labels.

Required tools

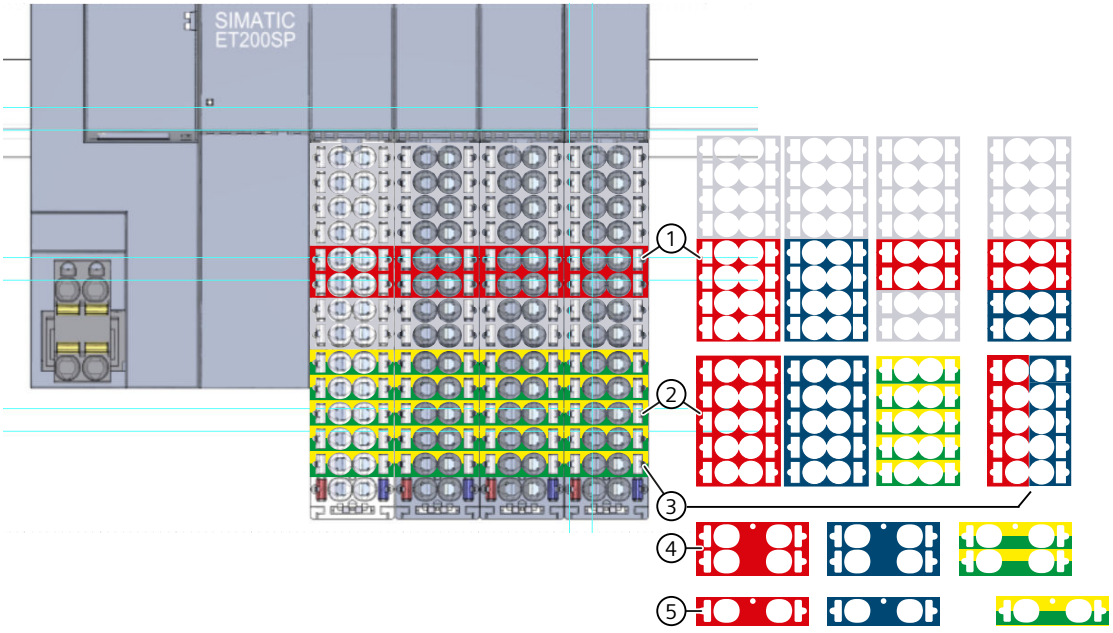
3 mm screwdriver (only for removing the color identification labels)

Applying color identification labels

Press the color-coded labels into the terminal box of the BaseUnit.

NOTE

To remove the color-coded labels, you must first disconnect the wiring on the BaseUnit and then carefully lever the color-coded labels out of the holder using a screwdriver.



① Module-specific color identification labels (15 mm) for the process terminals. You can find additional information in the I/O Module (https://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
② Color identification labels (15 mm) for the 10 AUX terminals
③ Color identification label (15 mm) for the 10 add-on terminals
④ Color identification labels (20 mm) for the 4 AUX terminals
⑤ Color identification labels (20 mm) for the 2 AUX terminals

Figure 1-101 Applying color identification labels (example)

NOTICE

AUX bus as PE bar
If you use an AUX bus as a protective conductor (PE), attach the yellow-green color identification labels to the AUX terminals.
If you stop using the AUX terminals as a protective conductor bar, remove the yellow-green color identification labels and make sure that the system is still protected.

NOTICE

Supply of incorrect potential possible
Check that the color-coded labels/wiring is correct before commissioning the plant.

8.16.4 Applying labeling strips

Procedure

Watch video sequence: "Labeling"
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a labeling strip:

1. Label the strips.
2. Insert the labeling strip into the interface module or I/O module.

8.16.5 Applying reference identification labels

Procedure

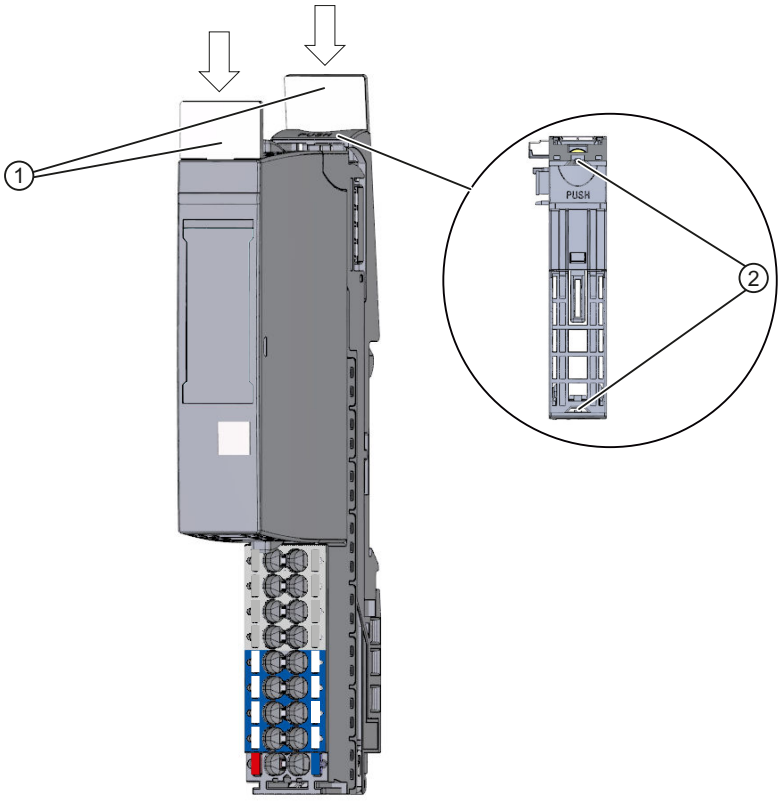
Watch video sequence: "Labeling"
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a reference identification label:

1. Break off the reference identification labels from the sheet.
2. Insert the reference identification labels into the opening on the CPU/interface module, BusAdapter, BaseUnit, I/O module and PotDis-TerminalBlock. The insertion opening is located on top of the BaseUnit or the I/O module/PotDis-TerminalBlock.

NOTE

Reference identification label
The printable side of the reference identification label must be facing forward.



① Reference identification labels
② Opening for label

Figure 1-102 Applying reference identification labels

Configuring

9

9.1 Configuring ET 200SP

Introduction

The ET 200SP distributed I/O system is configured and assigned parameters with STEP 7 (CPU/interface module, I/O modules, motor starter and server module) or using configuration software of a third-party manufacturer (interface module, I/O modules, motor starter and server module).

"**Configuring**" is understood to mean the arranging, setup and networking of devices and modules within the device view or network view. STEP 7 graphically represents modules and racks. Just like "real" module racks, the device view allows the insertion of a defined number of modules.

When the modules are inserted, STEP 7 automatically assigns the addresses and a unique hardware identifier (HW identifier). You can change the addresses later. The hardware identifiers cannot be changed.

When the automation system is started, the CPU/interface module compares the configured planned configuration with the system's actual configuration. You can make parameter settings to control the response of the CPU/interface module to errors in the hardware configuration.

"**Parameterizing**" the components used signifies setting their properties. During parameter assignment, the hardware parameters are set and the settings for data exchange are made:

- Properties of the modules to which parameters can be assigned
- Settings for data exchange between components

STEP 7 compiles the hardware configuration (result of "configuring" and "assigning parameters") and downloads it to the CPU/interface module. The CPU/interface module then connects to the configured components and transfers their configuration and parameters. Modules can be replaced very easily because STEP 7 transfers the configuration and parameters when a new module is inserted.

Requirements for configuration of the CPU

Table 1-357 Requirement for installing the CPU

Configuration software	Requirements	Installation information
CPU 151xSP-1 PN: STEP 7 (TIA Portal) as of V13 Update 3	• PROFINET IO • PROFIBUS DP (optional): With the communication module CM DP	STEP 7 online help
CPU 151xSP F-1 PN: STEP 7 (TIA Portal) as of V13 SP1		
CPU 151xSP-1PN (as of FW version V1.8), CPU 151xSP F-1 PN (as of FW version V1.8): STEP 7 (TIA Portal) as of V13 SP1 Update 4		

Configuring a motor starter

You configure SIMATIC ET 200SP motor starters in exactly the same way as the I/O modules of the ET 200SP distributed I/O system. The GSD files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

Configuring ET 200SP

See the STEP 7 online help or the documentation of the configuration software manufacturer.

NOTE

For I/O modules that are installed on a BaseUnit BU..D (light-colored BaseUnit), you always have to set the parameter "Potential group" to "Enable new potential group". If you do not set this parameter correctly, the CPU/interface module goes to STOP and generates a parameter error.

NOTE

For PROFIBUS with configuration via GSD file

In the configuration software, you must set for the BU covers whether these are on a light-colored or dark-colored BaseUnit.

Configuring F-modules with a GSD file

If you want to configure F-modules with a GSD file, you need S7-FCT in order to calculate the F_iPar_CRC and assign the PROFIsafe addresses. Additional information can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833).

You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

See also

GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)

9.2 Configuring the CPU

9.2.1 Reading out the configuration

Introduction

When a connection to a CPU present in the configuration exists, you use the "Hardware detection" function to read out the configuration of this CPU, including centrally configured modules, and apply it to your project. You do not need to manually configure the CPU and the centrally present modules, as the physical configuration is read out automatically.

If you have already configured a CPU and the centrally present modules and you want to load the current configuration and parameters in a new project, it is advisable to use the "Upload device as new station" function. For additional information about this function, refer to section Backing up and restoring the CPU configuration (Page 298).

Procedure for reading out an existing configuration

1. Create a new project and configure an "Unspecified CPU".

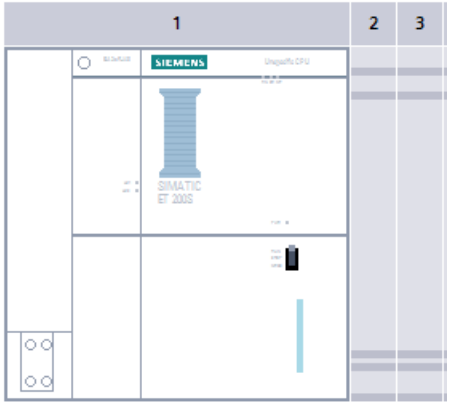


Figure 1-103 Unspecified CPU in the device view

2. In the device view (or in the network view), select the "Hardware detection" command in the "Online" menu.

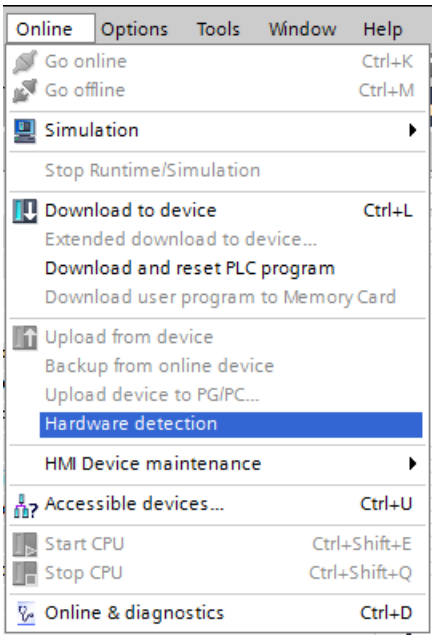


Figure 1-104 Hardware detection in the Online menu

You can also double-click the CPU and click "Detect" in the message.

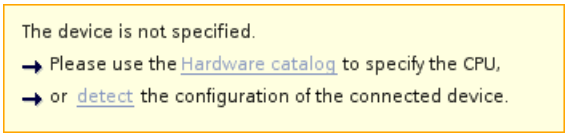


Figure 1-105 Hardware detection message in the device view

3. In the "Hardware detection for PLC_x" dialog box, click "Refresh". Then, select the CPU and the PG/PC interface and click "Detect".
STEP 7 downloads the hardware configuration including the modules from the CPU to your project.

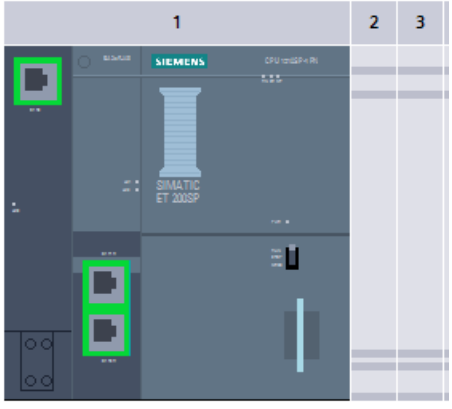


Figure 1-106 Result of the hardware detection in the device view

STEP 7 assigns a valid default parameter assignment for all modules. You can change the parameter assignment subsequently.

NOTE
If you want to go online after the hardware detection, you have to first download the detected configuration to the CPU; otherwise, an error may occur due to inconsistent configurations.

Properties of central modules

The properties of the CPUs have special significance for system behavior. You can set the following for a CPU using STEP 7:

- Startup behavior
- Parameter assignment of the interface(s), for example, IP address, subnet mask
- Web server, e.g. activation, user administration, and languages
- OPC UA server
- Global Security Certificate Manager
- Cycle times, e.g. maximum cycle time
- System and clock memory
- Protection level for access protection with assigned password parameter
- Time and day settings (daylight saving/standard)

The properties that can be set and the corresponding value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the online help and in the manuals of the relevant CPUs.

9.2.2 Addressing

Introduction

In order to address the automation components or I/O modules, they have to have unique addresses. The following section explains the various address areas.

I/O address

I/O addresses (input/output addresses) are required in the user program to read inputs and set outputs.

STEP 7 automatically assigns input and output addresses when you connect the modules. Each module uses a continuous area in the input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q addr...	Type	Order no.	Firmware
PLC_1	0	1			CPU 1510SP-1 PN	6ES7 510-1DJ00-0AB0	V1.6
PROFINET-Schnittstelle_1	0	1 X1			PROFINET interface		
Port_1	0	1 X1 P1			Port		
Port_2	0	1 X1 P2			Port		
Port_3	0	1 X1 P3			Port		
	0	1 X2					
DI 4x120..230VAC ST_1	0	2	0		DI 4x120..230VAC ST	6ES7 131-6FD00-0BB1	V1.0
DQ 8x24VDC/0.5A ST_1	0	3		0	DQ 8x24VDC/0.5A ST	6ES7 132-6BF00-0BA0	V1.1
AI 8xRTD/TC 2-wire HF_1	0	4	1...16		AI 8xRTD/TC 2-wire ...	6ES7 134-6JF00-0CA1	V2.0
AQ 2xU/I HF_1	0	5		1...4	AQ 2xU/I HF	6ES7 135-6HB00-0CA1	V1.0

Figure 1-107 Example with input / output addresses from STEP 7

STEP 7 assigns the address areas of the modules by default to the process image partition 0 ("Automatic updating"). This process image partition is updated in the main cycle of the CPU.

Device address (e.g. Ethernet address)

Device addresses are addresses of programmable modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required to address the various devices on a subnet, for example, to download a user program.

Hardware identifier

STEP 7 automatically assigns a hardware identifier to identify and address modules and submodules. You use the hardware identifier in the case of diagnostic messages or operations, for example, to identify a defective module or the module addressed.

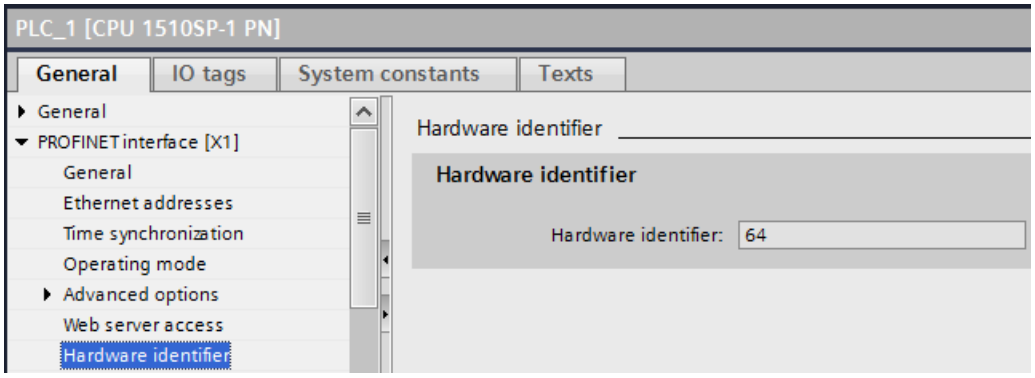


Figure 1-108 Example of a hardware identifier from STEP 7

In the "System constants" tab, you will find all hardware identifiers and their symbolic names (of the hardware identifier) for the selected module.

You can also find the hardware identifiers and names for all modules of a device in the default tag table of the "System constants" tab.

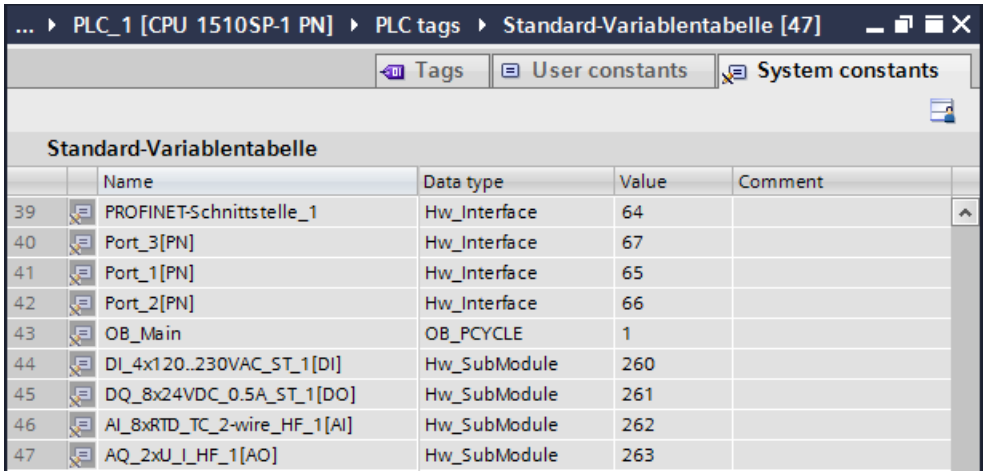


Figure 1-109 Example of an excerpt from a default tag table in STEP 7

9.2.3 Process images and process image partitions

9.2.3.1 Process image - overview

Process image of the inputs and outputs

The process image input and output is an image of the signal states. The CPU transfers the values from the input and output modules to the process image input and output. At the start of the cyclic program, the CPU transfers the process image output as a signal state to the output modules. Afterwards the CPU transfers the signal states of the input modules to the process image input.

Advantages of the process image

The process image accesses a consistent image of the process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The CPU does not update the process image until the next cycle.

You can only assign the addresses of a module to a single process image partition.

32 process image partitions

By means of process image partitions, the CPU synchronizes the updated inputs/outputs of particular modules with defined user program sections.

The overall process image is subdivided into up to 32 process image partitions (PIP).

The CPU updates PIP 0 in each program cycle (automatic update) and assigns it to OB 1.

You can assign the process image partitions PIP 1 to PIP 31 to the other OBs during configuration of the input/output modules in STEP 7.

After the OB has been started, the CPU updates the assigned process image partition for inputs and reads in the process signals. At the end of the OB the CPU writes the outputs of the assigned process image partition directly to the peripheral outputs without having to wait for the completion of the cyclic program processing.

9.2.3.2 Automatically updating process image partitions

You can assign one process image partition to each organization block. In this case, the user program automatically updates the process image partition. The exceptions are PIP 0 and isochronous OBs.

Updating the process image partition

The process image partition is divided into two parts:

- Process image partition of the inputs (PIPI)
- Process image partition of the outputs (PIPQ)

The CPU always updates/reads the process image partition of the inputs (PIPI) before processing of the associated OB. The CPU outputs the process image of the outputs (PIPQ) at the end of the OB.

The figure below illustrates the updating of the process image partitions.

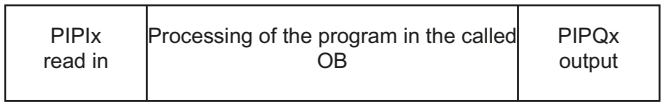


Figure 1-110 Updating process image partitions

9.2.3.3 Update process image partitions in the user program

Requirements

Alternatively, you can also use the following instructions for the process image update:

- "UPDAT_PI" instruction
- "UPDAT_PO" instruction

You will find the instructions in STEP 7 in the "Instructions" task card under "Extended instructions". The instructions can be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

- The process image partitions must not be assigned to any OB. This means the process image partitions are not automatically updated.

NOTE

Update of PPI 0

PIP 0 (automatic update) cannot be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: updates the process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: updates the process image partition of the outputs

With this instruction you transfer the process image partition of the outputs to the output modules.

Synchronous cycle interrupt OB

In the synchronous cycle interrupt OBs, you use the "SYNC_PI" and "SYNC_PO" operations to update the process image partitions of the operations. For additional information on the synchronous cycle interrupt OBs, refer to the STEP 7 Online Help.

Direct I/O access to the inputs and outputs of the module

As an alternative to access via the process image, you can directly access the I/O (write and read access) if this is necessary for program-related reasons. Direct (write) access to I/O also writes to the process image. This prevents a subsequent output of the process image from again overwriting the value written by direct access.

Reference

Additional information on process image partitions is available in the function manual, Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

9.3 Configuring the interface module

Configuring

Read the STEP 7 online help and/or the documentation of the configuration software manufacturer when configuring the interface module.

The F-destination address is saved permanently on the coding element of the ET 200SP fail-safe modules. Fail-safe motor starters do not need an F-destination address or a coding element.

NOTE
The supply voltage L+ must be applied to the F-module when the F-destination address is assigned.

NOTE
Note the following in conjunction with configuration control:
Before you can use configuration control together with F-modules, you must assign the F-destination address to the F-modules at the designated slots. For this, each F-module must be inserted in the slot configured for it. The actual configuration can then differ from the specified configuration.

For additional information on assigning the F-destination address, refer to the SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) Programming and Operating Manual and to the online help for the *S7 Configuration Pack*.

9.4 Module-to-Module Communication (MtM)

Introduction

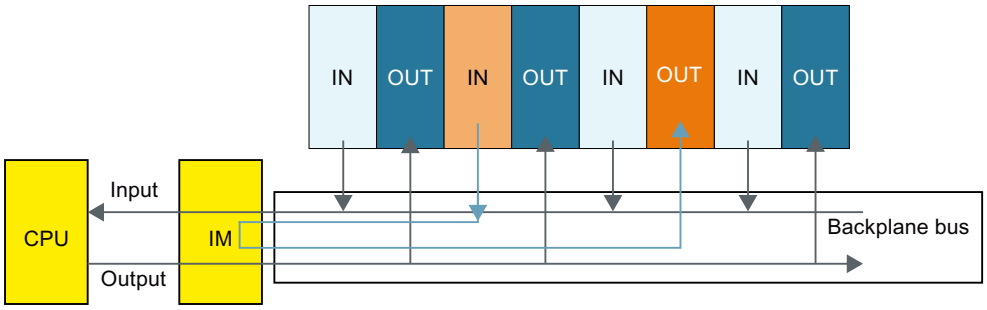
Module-to-Module Communication (MtM) offers the following advantages:

- Improved performance during transmission of data by bypassing the IO controller.
- Deterministic cycle times
- Cost-effective, high-performance solutions for applications where the performance of a specific technology module is not required.

Module-to-Module Communication (MtM)

Module-to-Module Communication (MtM) enables direct exchange of data between specific IO modules within a station via the interface module. This enables you to move small and/or time-critical tasks to the IO module. You achieve better performance while reducing the load on the CPU.

With Module-to-Module Communication (MtM), the interface module copies the input data of an IO module directly to a different IO module via the ET 200SP backplane bus. The IO module (data sink) carries out application-specific processing of the data.



You configure the data source and data sink for Module-to-Module Communication (MtM) in the hardware configuration of the respective output module. Programming of the user program is **not** required in the variant for Module-to-Module Communication (MtM).

NOTE

The preparation of the input data in the output module (mapping) and the output of the data to the outputs are application- and technology-specific.
Example: The DQ 4x24VDC/2A HS digital output module supports

- the application cam control with Module-to-Module Communication (MtM) under the designation DQ 4x24VDC/2A HS **MCC MtM**

Additional information can be found in the manuals of the corresponding IO modules. An overview of which I/O modules support module-to-module communication (MtM) can be found in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/73021864)Product Information. Information on which interface module supports module-to-module communication (MtM) can be found in the Equipment Manuals of the interface modules.

See also

FAQ "How do you parameterize module-to-module communication?" (https://support.industry.siemens.com/cs/ww/en/view/109767618)

9.5 Value status

Introduction

Value status (QI, quality information) refers to status information of I/O channels that is made available to the user program via the process image input (PII). However, since the value status is partly derived from the diagnostics, there may be a time delay between the occurrence of the error and the message depending on the diagnostics.

Each bit of the value status is assigned to a channel and provides information about the validity of the process value of the respective channel (1 = no errors on the channel of the I/O module, 0 = value is bad).

The assignment of the value status bytes in the process image input depends on the module used. Detailed information can be found in the manual for the relevant I/O module.

Summary: Possible cause for value status = 0:

- A channel has an error (overflow/underflow, wire break, short-circuit, etc.)
- The supply voltage L+ is missing at the terminals or is not sufficient
- A channel has been deactivated
- PROFIenergy pause is activated

  If you set the "Continue working" mode, the value status remains = 1.
- Outputs are inactive (value status = 0: Module not plugged in. Value status is generated via interface module in distributed mode)

If, for example, there is a wire break at an input but the wire break diagnostics is disabled, the value status of the channel is set to "0" but no diagnostics is triggered. Diagnostics is only also triggered if the wire break diagnostics is enabled.

With module-by-module channel diagnostics of the I/O modules, these also map the value status module-by-module. The channels are mapped here module-by-module to value status = 0 or value status = 1.

Which interface modules support the value status?

The following interface modules support the value status:

- IM 155-6 PN ST
- IM 155-6 PN HS
- IM 155-6 PN/2 HF
- IM 155-6 PN/3 HF
- IM 155-6 PN R1
- IM 155-6 MF HF
- IM 155-6 DP HF

Which I/O modules support the value status?

The I/O modules of the function classes Standard, High Feature and High Speed support the value status.

Activating value status

Table 1-358 Value status depending on the respective configuration variant

	STEP 7 TIA (integrated I/O module; PROFINET and PROFIBUS)	**STEP 7 HSP (PROFINET and PROFIBUS)**	**GSD PROFINET (can be integrated in STEP 7 TIA and STEP 7)**	**GSD PROFIBUS (can be integrated in STEP 7 TIA and STEP 7)**
Select the I/O module from the hardware catalog and activate the value status	There is only **one** entry in the hardware catalog for each I/O module. In the configuration dialog, you can set whether the I/O module is to be operated with or without value status.		There are **multiple** entries in the hardware catalog for each I/O module. On selection in the hardware catalog, it must be determined whether the I/O module is to be operated with or without value status. The value status can be recognized by the suffix "QI".	
Input substitute value behavior	The "Input values with module failure" parameter (input substitute value behavior) is available for CPUs 1500 from FW version V2.0. If the I/O module is configured with value status, the parameter is fixed at "Input value 0". Input substitute value behavior can only be configured if no value status has been configured.	The "Input values with module failure" parameter is not available.	The "Input values with module failure" parameter (input substitute value behavior) is available for CPUs 1500 from FW version V2.0. The same restrictions apply as for I/O modules integrated in STEP 7 TIA. Due to the limited capabilities of the GSD, however, these are not locked in the GSD interface.	The "Input values with module failure" parameter is not available.

Special features for modules with MSI/MSO

The meaning of the value status of the basic submodule is described above. The value status of the MSI/MSO submodules are copies of the base submodule. The value status of the MSI/MSO submodules remains set to "0" as long as the base submodule has not been configured.

9.6 Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is executed by the IO controller for each IO module.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Deactivating the IO device
- Station stop, for example, due to:
  - Missing server module
  - At least one I/O module is installed on an incorrect BaseUnit
  - With the ET 200SP R1, the pulling of the server module during ongoing operation does not lead to a station stop

The "current-free/voltage-free" behavior takes effect in the following cases:

- IO module firmware update
- Reset to factory settings
- With enabled configuration control without presence of a valid control data record (DS196)
- Incorrectly configured module
- Module with incorrect parameter assignment

NOTE

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

Basics of program execution

10

10.1 Events and OBs

Start events

The table below gives an overview of the possible event sources for start events and their OBs.

Table 1-359 Start events

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
Starting [2]	1	100, ≥ 123	Ignore	0 to 100
Cyclic program [2]	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt [2]	2 to 24 (2)	10 to 17, ≥ 123	Not applicable	0 to 20
Time-delay interrupt [2]	2 to 24 (3)	20 to 23, ≥ 123	Not applicable	0 to 20
Cyclic interrupt [2]	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	Not applicable	0 to 20
Hardware interrupt [2]	2 to 26 (18)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Synchronous cycle interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error [3]	22	80	Ignore	0 or 1
Cycle monitoring time exceeded once			STOP	
Diagnostics interrupt	2 to 26 (5)	82	Ignore	0 or 1
Pull/plug interrupt for modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1
MC-servo [4]	17 to 26 (25)	91	Not applicable	0 or 1
MC-PreServo [4]	17 to 26 (25)	67	Not applicable	0 or 1
MC-PostServo [4]	17 to 26 (25)	95	Not applicable	0 or 1

1) If you have not configured the OB.

2) In the case of these event sources, besides the permanently assigned OB numbers (see column: Possible OB numbers) in STEP 7 you can assign OB numbers from the range ≥ 123.

3) If the maximum cycle time has been exceeded twice within one cycle, the CPU always assumes the STOP state, regardless of whether you have configured OB 80.

4) You will find more information on these event sources and the starting behavior in the S7-1500 Motion Control function manual.

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
MC-Interpolator [4]	16 to 26 (24)	92	Not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

1) If you have not configured the OB.

2) In the case of these event sources, besides the permanently assigned OB numbers (see column: Possible OB numbers) in STEP 7 you can assign OB numbers from the range ≥ 123.

3) If the maximum cycle time has been exceeded twice within one cycle, the CPU always assumes the STOP state, regardless of whether you have configured OB 80.

4) You will find more information on these event sources and the starting behavior in the S7-1500 Motion Control function manual.

Response to triggers

The occurrence of a start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. The event enters the queue according to its priority.
- If the event comes from an event source to which you have not assigned an OB, the CPU executes the default system reaction.

NOTE

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

Assignment between event source and OBs

The type of OB determines where you make the assignment between OB and event source:

- With hardware interrupts and isochronous mode interrupts, the assignment is made during the configuration of the hardware or when the OB is created.
- In the case of the MC-Servo, MC-PreServo, MC-PostServo and MC-Interpolator, STEP 7 automatically assigns the OBs 91/92 as soon as you add a technology object.
- For all other types of OB, the assignment is made when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment changes, and not the configured assignment. The configured assignment takes effect after loading, and at startup.

The CPU ignores hardware interrupts to which you did not assign an OB in your configuration or which occur after the DETACH instruction. The CPU does not check whether an OB is assigned to this event when an event arrives, but only prior to the actual processing of the hardware interrupt.

OB priority and runtime behavior

If you have assigned an OB to the event, the OB has the priority of the event. The CPU supports the priority classes 1 (lowest priority) to 26 (highest priority). The following items are essential to the processing of an event:

- Calling and processing of the assigned OB
- The update of the process image partition of the assigned OB

The user program processes the OBs exclusively on a priority basis. This means the program processes the OB with the highest priority first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. The user program processes events of the same priority in order of occurrence.

NOTE

Communication

Communication (e.g. test functions with the PG) always works permanently with the priority 15. So as not to unnecessarily prolong program runtime in the case of time-critical applications, these OBs should not be interrupted by communication. Assign a priority >15 for these OBs.

Programming guideline and programming style guide

The programming guideline gives you many recommendations and tips for optimal programming of the S7-1500 automation system.

The programming guidelines described in the programming style guide help you to create a uniform program code. You can better maintain and reuse the uniform program code. This allows you to detect or avoid errors early on, for example, through compilers.

You can find the programming guideline and programming style guide on the Internet (https://support.industry.siemens.com/cs/us/en/view/81318674).

Reference

You can find more information on organization blocks in the STEP 7 online help.

10.2 Asynchronous instructions

Introduction

In program processing, a differentiation is made between synchronous and asynchronous instructions.

The "synchronous" and "asynchronous" properties relate to the temporal relationship between the call and execution of the instruction.

The following applies to synchronous instructions: When the call of a synchronous instruction is ended, the execution is also ended.

This is different in the case of asynchronous instructions: When the call of an asynchronous instruction is ended, the execution of the asynchronous instruction is not necessarily ended

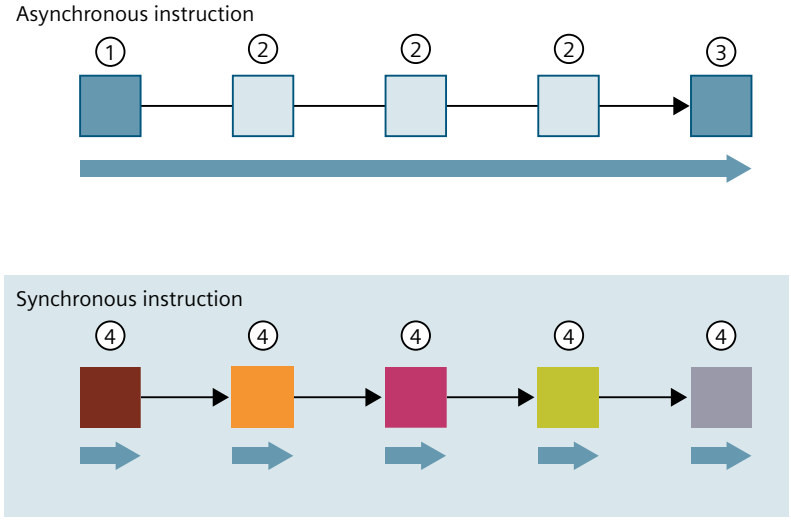
yet. This means the execution of an asynchronous instruction can extend over multiple calls. The CPU processes asynchronous instructions in parallel with the cyclic user program. Asynchronous instructions generate jobs in the CPU for their processing.

Asynchronous instructions are usually instructions for transferring data (data records for modules, communication data, diagnostics data).

Difference between synchronous/asynchronous instructions

The figure below shows the difference between processing an asynchronous instruction and processing a synchronous instruction. In this figure the asynchronous instruction is called five times before the execution is completed, for example, a data record is completely transferred.

With a synchronous instruction, the instruction is fully executed in each call.



① First call of the asynchronous instruction, start of processing
② Intermediate call of asynchronous instruction, continuation of processing
③ Last call of the asynchronous instruction, termination of processing
④ The synchronous instruction is completely processed at each call
➡ Duration of the complete processing

Figure 1-111 Difference between synchronous and asynchronous instructions

Parallel processing of asynchronous instruction jobs

A CPU can process several asynchronous instruction jobs in parallel. The CPU processes the jobs in parallel under the following conditions:

- Several asynchronous instruction jobs are called at the same time.
- The maximum number of concurrently running jobs for the instruction is not exceeded.

The figure below shows the parallel processing of two jobs of the instruction WRREC. The two instructions are processed in parallel for a specific period here.

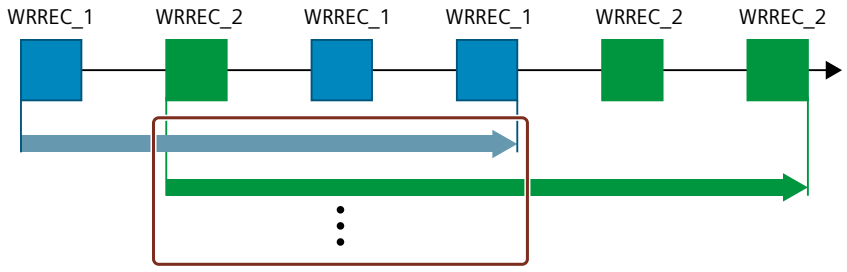


Figure 1-112 Parallel processing of the asynchronous instruction WRREC

NOTE

Dependencies between asynchronous instructions

The call sequence in the user program may differ from the processing sequence of the asynchronous instructions. This can lead to problems with dependencies between asynchronous instructions.

Solution: To ensure correct timing of processing, use the status outputs of the asynchronous instructions in a sequencer. If an asynchronous instruction is finished and this is acknowledged via the parameter DONE, then only the next asynchronous instruction should start.

Example: For the RecipeImport and RecipeExport recipe functions, you need a CSV file for the recipe data. If you use the same CSV file for import and export, then the two asynchronous statements are dependent on each other. Link the status of the DONE parameter of the RecipeImport instruction in a sequencer to the next step where the RecipeExport is executed. The link thus ensures correct processing.

Assignment of call to job of the instruction

To execute an instruction over multiple calls, the CPU must be able to uniquely assign a subsequent call to a running job of the instruction.

To assign a call to a job, the CPU uses one of the following two mechanisms, depending on the type of the instruction:

- Via the instance data block of the instruction (in the case of the "SFB" type)
- The input parameters of the instruction identifying the job. These input parameters must match in each call during processing of the asynchronous instruction.
  Example: A "Create_DB" instruction job is identified by the input parameters LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB and SRCBLK.

  The following table shows which instruction you can identify with which input parameters.

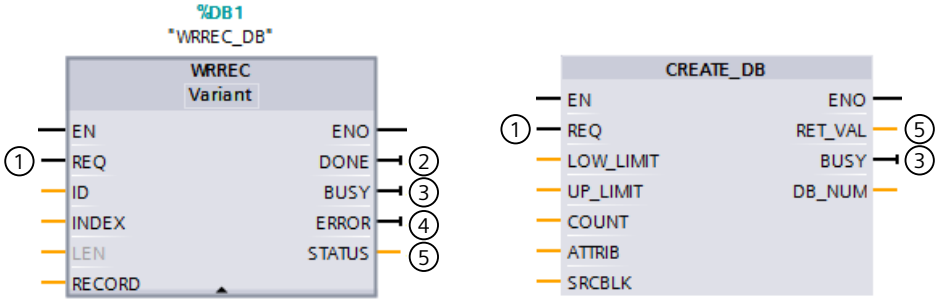
Instruction	Job is identified by
DPSYC_FR	LADDR, GROUP, MODE
D_ACT_DP	LADDR
DPNRM_DG	LADDR
WR_DPARM	LADDR, RECNUM
WR_REC	LADDR, RECNUM

Instruction	Job is identified by
RD_REC	LADDR, RECNUM
CREATE_DB	LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB, SRCBLK
READ_DBL	SRCBLK, DSTBLK
WRIT_DBL	SRCBLK, DSTBLK
RD_DPARA	LADDR, RECNUM
DP_TOPOL	DP_ID

Status of an asynchronous instruction

An asynchronous instruction shows its status via the block parameters STATUS/RET_VAL and BUSY. Many asynchronous instructions also use the block parameters DONE and ERROR.

The figure below shows the two asynchronous instructions WRREC and CREATE_DB.



① The input parameter REQ starts the job to execute the asynchronous instruction.

② The output parameter DONE indicates that the job was completed without error.

③ The output parameter BUSY indicates whether the job is currently being processed. When BUSY =1, a resource is assigned for the asynchronous instruction. If BUSY = 0, then the resource is free.

④ The output parameter ERROR indicates that an error has occurred.

⑤ The output parameter STATUS/RET_VAL provides information on the status of the job execution. The output parameter STATUS/RET_VAL receives the error information after the occurrence of an error.

Figure 1-113 Block parameters of asynchronous instructions using the instructions WRREC and CREATE_DB as examples.

Summary

The table below provides you with an overview of the relationships described above. It shows in particular the possible values of the output parameters if processing is not completed after a call.

NOTE

Following every call, you must evaluate the relevant output parameters in your program.

Relationship between REQ, STATUS/RET_VAL, BUSY and DONE during a "running" job.

Seq. no. of the call	Type of call	REQ	STATUS/RET_VAL	BUSY	DONE	ERROR
1	First call	1	W#16#7001	1	0	0
			Error code (for example, W#16#80C3 for lack of resources)	0	0	1
2 to (n - 1)	Intermediate call	Not relevant	W#16#7002	1	0	0
n	Last call	Not relevant	W#16#0000, if no errors have occurred.	0	1	0
			Error code, if errors have occurred	0	0	1

Consumption of resources

Asynchronous instructions occupy resources in the CPU while they are being processed. The resources are limited depending on the type of CPU and instruction; the CPU can only process a maximum number of asynchronous instruction jobs simultaneously. The resources are available again after a job has been successfully completed or processed with an error.

Example: For the RDREC instruction, a 1512SP-1 PN CPU can process up to 20 jobs in parallel.

If the maximum number of concurrent jobs for an instruction is exceeded, the following occurs:

- The instruction returns error code 80C3 (lack of resources) in the block parameter STATUS.
- The CPU does not execute the job until a resource becomes free again.

NOTE

Lower-level asynchronous instructions

Several asynchronous instructions use one or more lower-level asynchronous instructions for their processing. This dependence is shown in the tables below.

Please note that, if there are several lower-level instructions, typically only one lower-level instruction is occupied at one time.

Extended instructions: maximum number of concurrently running jobs

Table 1-360 Maximum number of concurrently running jobs for asynchronous extended instructions and lower-level instructions used

Extended instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
Distributed I/O		
RDREC	20	
RD_REC	10	

Extended instructions	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
WRREC	20	
WR_REC	10	
D_ACT_DP	8	
ReconfigIOSystem	uses RDREC, WRREC, D_ACT_DP,	
DPSYC_FR	2	
DPNRM_DG	8	
DP_TOPOL	1	
ASI_CTRL	uses RDREC, WRREC	
PROFIenergy		
PE_START_END	uses RDREC, WRREC	
PE_CMD	uses RDREC, WRREC	
PE_DS3_Write_ET200S	uses RDREC, WRREC	
PE_WOL	uses RDREC, WRREC, TUSEND, TURCV, TCON, TDISCON	
Module parameter assignment		
RD_DPAR	10	
RD_DPARA	10	
RD_DPARM	10	
WR_DPARM	10	
Diagnostics		
Get_IM_Data	10	
GetStationInfo	10	
Recipes and data logging		
RecipeExport	10	
RecipeImport	10	
DataLogCreate	10	
DataLogOpen	10	
DataLogWrite	10	
DataLogClear	10	
DataLogClose	10	
DataLogDelete	10	
DataLogNewFile	10	
Data block functions		
CREATE_DB	10	
READ_DBL	10	
WRIT_DBL	10	
DELETE_DB	10	
File handling		
FileReadC	10	
FileWriteC	10	

Extended instructions	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
Reference information		
ResolveSymbols	10	
GetSymbolForReference	10	

Basic instructions: maximum number of concurrently running jobs

Table 1-361 Lower-level instructions used for asynchronous basic instructions

Basic instructions	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
Array DB		
ReadFromArrayDBL	uses READ_DBL (see Extended instructions)	
WriteToArrayDBL	uses READ_DBL, WRIT_DBL (see Extended instructions)	

Communication: maximum number of concurrently running jobs

Table 1-362 Maximum number of concurrently running jobs for asynchronous instructions and lower-level instructions used for Open User Communication

Open User Communication	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
TSEND TUSEND	64	88
TRCV TURCV	64	88
TCON	64	88
TDISCON	64	88
T_RESET	64	88
T_DIAG	64	88
T_CONFIG	1	
TSEND_C	uses TSEND, TUSEND, TRCV, TCON, TDISCON	
TRCV_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
TMAIL_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

Table 1-363 Lower-level instructions used for asynchronous instructions for MODBUS TCP

MODBUS TCP	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
MB_CLIENT	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
MB_SERVER	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

Table 1-364 Maximum number of concurrently running jobs for asynchronous instructions for S7 communication. The S7 communication instructions use a common pool of resources.

S7 communication	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
PUT GET USEND URCV BSEND BRCV	192	264

Table 1-365 Lower-level instructions used for asynchronous instructions for communications processors

Communications processors	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
PtP communication		
Port_Config	uses RDDEC, WRREC	
Send_Config	uses RDDEC, WRREC	
Receive_Config	uses RDDEC, WRREC	
Send_P2P	uses RDDEC, WRREC	
Receive_P2P	uses RDDEC, WRREC	
Receive_Reset	uses RDDEC, WRREC	
Signal_Get	uses RDDEC, WRREC	
Signal_Set	uses RDDEC, WRREC	
Get_Features	uses RDDEC, WRREC	
Set_Features	uses RDDEC, WRREC	
USS communication		
USS_Port_Scan	uses RDDEC, WRREC	
USS_Port_Scan_31	uses RDDEC, WRREC	
MODBUS (RTU)		
Modbus_Comm_Load	uses RDDEC, WRREC	
Modbus_Master	uses RDDEC, WRREC	
Modbus_Slave	uses RDDEC, WRREC	
ET 200S serial interface		
S_USSI	uses CREATE_DB	
SIMATIC NET		
FTP_CMD	uses TSEND, TRCV, TCON, TDISCON	

Table 1-366 Maximum number of concurrently running jobs for asynchronous instructions for OPC UA

OPC_UA	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
OPC_UA_Connect	10	
OPC_UA_Disconnect	10	
OPC_UA_NamespaceGetIndexList	10	
OPC_UA_NodeGetHandleList	10	
OPC_UA_NodeReleaseHandleList	10	
OPC_UA_TranslatePathList	10	
OPC_UA_ReadList	10	
OPC_UA_WriteList	10	
OPC_UA_MethodGetHandleList	10	
OPC_UA_MethodReleaseHandleList	10	
OPC_UA_MethodCall	10	
OPC_UA_ServerMethodPre	10	
OPC_UA_ServerMethodPost	10	
OPC_UA_ConnectionGetStatus	10	

Technology: maximum number of concurrently running jobs

Table 1-367 Maximum number of concurrently running jobs for asynchronous instructions for technology. The instructions for technology use a common pool of resources.

Technology	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1512SP-1 PN CPU 1512SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**
Motion Control	
MC_Power MC_Reset MC_Home MC_Halt MC_MoveAbsolute MC_MoveRelative MC_MoveVelocity MC_MoveJog MC_MoveSuperimposed MC_Stop MC_WriteParameter MC_SetAxisSTW MC_MeasuringInput MC_MeasuringInputCyclic MC_AbortMeasuringInput MC_OutputCam MC_CamTrack	300

Technology	**CPU 1510SP-1 PN** **CPU 1510SP F-1 PN** **CPU 1512SP-1 PN** **CPU 1512SP F-1 PN** **CPU 1514SP-2 PN** **CPU 1514SP F-2 PN** **CPU 1514SP T-2 PN** **CPU 1514SP TF-2 PN**
MC_GearIn MC_TorqueLimiting MC_TorqueAdditive MC_TorqueRange	

More information

You can find additional information on block parameter assignment in the STEP 7 online help.

11 Protection

11.1 Overview of the protection functions

Advantages and customer benefits of protection functions

The protection functions listed protect your investments from unauthorized access and manipulation, helping to secure plant availability.

Protection functions

To set up secure networks, the SIMATIC S7-1500 automation system offers an integrated security concept:

Table 1-368 Overview of protection functions

Protection function	Description
Integrity protection	The CPUs come with an integrity protection function as standard. This helps detect any manipulations: • In the engineering data on the SIMATIC Memory Card; see also information on the integrity protection of the SIMATIC Memory Card as of CPU FW version V3.1 in the next section • At the engineering data during data transfer between TIA Portal and CPU • At the engineering data during data transfer between HMI system and CPU • At the encrypted firmware
Protection of confidential configuration data	Protection of confidential CPU configuration data
Central user administration (as of firmware version 4.0)	Connection of a central server (UMC server) that is responsible for the administration and authentication of users. The central user management (User Management Component) allows the management of user groups and users independent of TIA Portal for comprehensive automation solutions.
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for project users and roles in the TIA Portal.
Access protection (up to FW version V3.0)	Protection against unauthorized configuration changes using authorization levels
Know-how protection	Protection against unauthorized access and modifications to algorithms with password protection
Copy protection	Protection against duplication of programs by linking individual blocks to the serial number of the original memory card on the SIMATIC Memory Card
Protection by locking the CPU/interface module	Protection against unauthorized access by locking the front cover with a seal or a lock

You can find more information about security mechanisms of the SIMATIC automation systems in the Security with SIMATIC S7 controllers (https://support.industry.siemens.com/cs/ww/en/view/77431846) document and in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual.

Integrity protection of the SIMATIC Memory Card, as of CPU FW version V3.1 or higher

With CPUs as of FW version V3.1, the integrity protection of the SIMATIC Memory Card depends on the password for protecting confidential configuration data that you assigned during the configuration of the CPU. This results in the following changes when using SIMATIC Memory Cards:

- To transfer a CPU to a card reader/USB memory device via drag and drop:
  For CPUs as of FW version V3.1, you need to enter the password of the CPU you want to use with the SIMATIC Memory Card. If you enter an incorrect password, the CPU will not start up after power on and will report the contents of the SIMATIC Memory Card as faulty.
- To insert a CPU from a card reader/USB memory device:
  In order to be able to verify the integrity of the included configuration in STEP 7, you must enter the password of the CPU from which the project was loaded. In this case, STEP 7 checks the data on the SIMATIC Memory Card and reports potential damage.
  Entering the password is optional. If you do not want to use the integrity check, you do not need to enter the password (restore project).

For CPUs with FW version V4.1 or higher, you can select whether you also want to protect the entire configuration of the CPU in addition to protecting the configuration data. The data is stored encrypted in the SIMATIC.S7S folder on the SIMATIC Memory Card and can only be decrypted with the password for protection of confidential configuration data.
If you revoke or add the setting for protection of all data, the contents of the SIMATIC.S7S folder on the SIMATIC Memory Card will be deleted at the next download to the CPU. Other files, such as recipes or backup files on the SIMATIC Memory Card, are not deleted. After the deletion, the CPU performs a restart.

You can find information on the folder structure on the SIMATIC Memory Card in the Structure and Use of the CPU Memory
(https://support.industry.siemens.com/cs/ww/en/view/59193101) Function Manual.

Secure communication

There is an increasing need to transfer data to external computers in encrypted form via Intranet or public networks.

SIMATIC S7-1500 CPUs and ET 200 CPUs with firmware version 2.0 and higher support the Internet PKI (RFC 5280) with STEP 7 as of V14. This makes the configuration and the operation of Secure Communication possible, for example:

- Hypertext Transfer Protocol Secure (HTTPS)
- Secure Open User Communication
- Secure Communication with OPC UA

A public key infrastructure (PKI) can issue, distribute and check digital certificates. For S7-1500 CPUs, you create certificates for various applications in the CPU properties in STEP 7, for example: TLS certificates for Secure Open User Communication, web server certificates, OPC UA certificates.

With STEP 7 and WinCC as of version V17, SIMATIC S7-1500 CPUs and ET 200 CPUs as of firmware version 2.9 support innovated and standardized secure PG/PC and HMI communication – referred to as Secure PG/HMI communication for short.

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the ET 200SP CPU from external sources and via the network:

- Deactivation of the Web server
- Deactivation of the OPC UA server (you can find additional information on the security mechanisms for OPC UA server in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual)
- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication
- Deactivation of SNMP

When you use the Web server, protect your S7-1500 automation system against unauthorized access:

- By setting password-protected access rights for specific users in the user administration.
- By using the pre-set option "Permit access only via HTTPS".
  The option allows access to the web server only with the secure hypertext transmission protocol HTTPS.

When you use the OPC UA server, protect your S7-1500 automation system against unauthorized access:

- By not setting up OPC UA server access for the "Anonymous" user.
- By disabling the "Automatically accept client certificates during runtime" option.

Security functions in communications processors

Communications processors support security functions, such as access protection using a firewall, protection against data manipulation using VPN, FTPS, HTTPS, SNMPv3, and secure NTP.

More information

You can find more information on the protection functions described in the STEP 7 online help.

Siemens products and solutions are only one element of a comprehensive industrial security concept. Observe the additional information on Industrial Security (http://www.siemens.com/industrialsecurity).

11.2 Protection of confidential configuration data

As of STEP 7 V17, you have the option of assigning a password for protecting confidential configuration data of the respective CPU. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols.

You can find detailed information on protecting confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

NOTE

Replacement part scenario
Replacing the CPU in a replacement part scenario has an impact on the password for protection of confidential configuration data. When you replace the CPU, observe the rules for the replacement part scenario in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

11.3 Local user management

11.3.1 Useful information on local user management and access control

As of TIA Portal version V19 and CPU firmware version V3.1, ET 200SP CPUs have an improved way to manage users, roles and CPU function rights (User Management & Access Control, UMAC).

For HMI devices, authentication is not possible via either local or central users (TIA Portal V19/V20).

Starting from the above-named versions, you manage all project users along with their rights (e.g. access rights) for CPUs in the project in the editor for users and roles of the project in TIA Portal:

- To manage users along with their rights, for example, to control access rights, navigate to the "Security Settings > Users and roles" area in the project tree.

TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs.

The user management becomes effective in the respective CPUs after the configuration is loaded. Each CPU then "knows" who may access which service and execute specific functions.

This new approach is also referred to hereinafter as "local user management and access control".

NOTE

Support of central users and groups for CPU function rights
UMC (User Management Component) can also be used to manage users centrally in TIA Portal. With this component, you manage central users and groups on connected UMC servers, e.g. by connecting an MS Active Directory. The authentication is then implemented using UMC. The central user management for CPU-specific function rights via UMC is currently supported as of TIA Portal V20 and CPU FW version V4.0 (see Useful information on central user management and access control (Page 234)).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - but only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example the security concept "Defense in Depth", in particular the remarks on plant security and hardening measures.

Detailed information is available in the section Industrial cybersecurity (Page 33).

Users, roles and function rights

Users and roles were also managed in the predecessor versions of TIA Portal under "Security settings > Users and roles". In addition to the existing user management options, e.g. for HMI devices, you can also manage all CPU function rights in this editor starting from TIA Portal Version V19.

The CPU function rights are effective in runtime, which is why you will find these rights on the "Runtime rights" tab in the editor for users and roles. For each CPU in the project, there is a section with all CPU function rights to choose from - separated according to CPU services such as PG/HMI communication (engineering access, access levels), web server and OPC UA.

Besides the user management for projects, additional user management possibilities were available for the web server and OPC UA server in the CPU properties (static user management for CPUs up to FW version V3.0):

- Users for the OPC UA server (authentication)
- Users for the web server (authentication and access control)

These additional user management possibilities have been integrated in the local user management in the project tree as of TIA Portal V19 and CPU FW version V3.1.

Introduction to local user management and access control

For CPUs up to firmware version V3.0, users were managed under the respective CPU properties for the individual services "Web server", "OPC UA", etc. Web server users were managed in the "Web server" area, OPC UA users in the "OPC UA" area.

To restrict access by the PG/HMI to the CPU using access levels, you assigned passwords for the respective levels. With this approach, for example, HMI accesses could be permitted without restriction, but write accesses could be made dependent on the knowledge of a password. You assigned the passwords for the different access levels in the "Protection & Security" area of the CPU properties. As a result, the access protection always applied to groups having the corresponding passwords and not to individual users.

With the introduction of local user management and access control in TIA Portal version V19, you use the "Security settings > Users and roles" area in the project tree in TIA Portal to manage all users, together with their roles and function rights, of a CPU. This same holds for the access protection for engineering/HMI accesses, which as of TIA Portal version V19 no longer relies on access levels with password protection by default but instead on the user management.

You can find more information on the new access protection here (Page 228).

As already introduced, e.g. for engineering rights, you use role assignments for combining individual function rights. In a further step, you assign the roles to individual users. The "Assigned rights" tab lists all function rights that were assigned to a user via roles and that the user can exercise for the corresponding CPU.

The following figure shows an example of the available and activated function rights of a CPU. At least one user must have full access to the CPU. Otherwise, the configuration cannot be compiled. A role with full access to the CPU must be created for this.

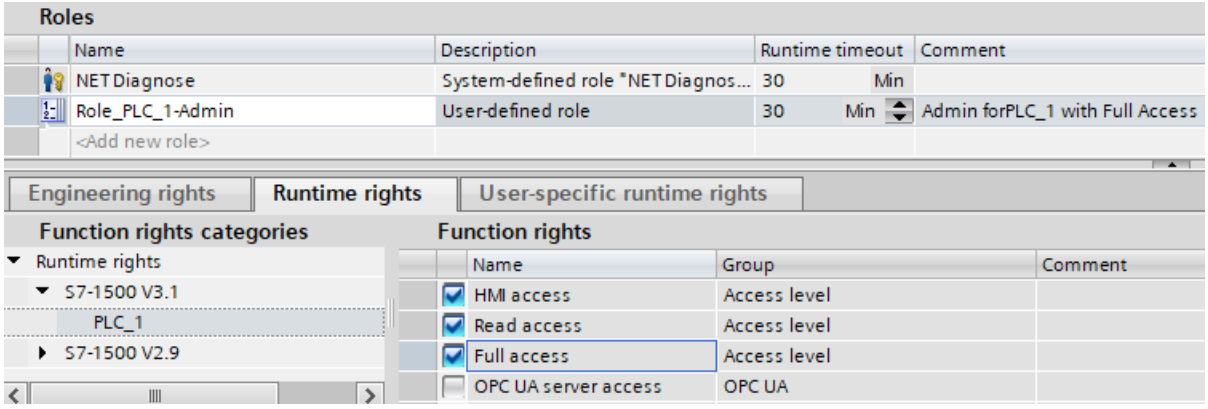


Figure 1-114 Assigning function rights of a CPU to a role

The following figure shows the assignment of the role with full access to a user ("Admin").

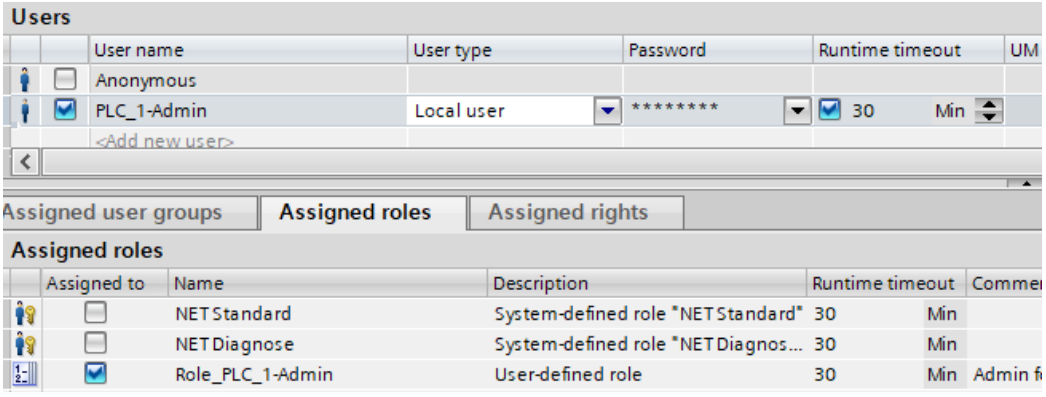


Figure 1-115 Assigning a role to a user

Requirement

CPU parameter assignment: To make use of users, roles and function rights for a CPU, the "Enable access control" option must be selected in the "Protection & Security > Access control" area.

In the "Configuration of user management" area, the "Local user management" option is preset, whereby the users are loaded to the CPU.

If you select the option "Central user management", you have to add additional parameters such as the UMC server address and server ID (see Useful information on central user management and access control (Page 234)).

No project protection is required for the user management.

Default characteristics

The "Enable access control" option is selected by default for the access control. Users can be configured with their assigned passwords and their roles and function rights.

Loading to device

If you want to download changes to the user configuration in RUN mode, the hardware configuration in the CPU and in the STEP 7 project must be unchanged. Otherwise, a transition to STOP is required to download the user configuration together with the changed hardware configuration.

Save your STEP 7 project and then configure only the desired changes in the user configuration. Load your project into the CPU.

Changes to the access rights for the "Anonymous" user can only be loaded in STOP mode.

A fail-safe ET 200SP CPU may only load a user to whom the runtime right "Full access including fail-safe" is assigned. Otherwise, STEP 7 displays an error message when loading the configuration.

Explanations of the options for the user management download (Load preview):

- If you select the option "Keep online user management data", the local user management is not downloaded to the CPU.
- If you select the option "Download all user management data (reset to project)", all passwords changed online via WebAPI are deleted. After the download, the configured local user data is valid.
- If you select the option "Update user management data, but keep online passwords" and have not changed existing user names, the passwords changed online via WebAPI are retained. Only changes to function rights and/or roles take effect. Newly configured users are downloaded with their settings and deleted users are no longer available after the download to the CPU.
  If you have changed a user name in the project and assigned a password to this user in the project, this setting takes effect after the download. The previously valid user name with the password changed online is deleted during the download.

Runtime timeout

You can set a runtime timeout for both the role and the user in "Security settings > Users and roles".

For an ET 200SP CPU, these settings are taken into account by the various services as follows:

- By means of the Web API you can, for example, create a web page or application that takes the settings for the runtime timeout into account. Standard web pages do not take the settings for the runtime timeout into account and use the default value.
- The other services (PG/HMI communication and OPC UA server) do not use the runtime timeout; the logged-in user is not logged out after the set time.

11.3.2 Advantages of local user management and access control

The advantages of the new local user management for CPUs and the changes associated with it are described in the following.

Quick activation/deactivation of local user management

The options for user management can be found in the "Protection & Security > Access control" area:

- Access control disabled: Every user has full access to all functions with the exception of the GDS Push function for the online transfer of certificates.

  ⚠ WARNING

  Disabled access control carries the risk of unauthorized access and thus the risk of personal injury and property damage.
  Only use this setting in a protected environment, such as during commissioning.

- Access control enabled: The configured users with their assigned roles and associated function rights become effective after the configuration is loaded.

Access protection for PG/HMI accesses, now with user authentication

While it was possible to assign passwords for access levels for CPUs with firmware versions <V3.1, you can configure users with corresponding function rights for the current CPUs. This means that PG/HMI accesses can be authenticated in the same way as OPC UA and web server accesses.

Everything in one place

Irrespective of the service for which you configure users, roles and rights for a CPU: you manage the data at the same place.

All users, no matter if you're managing their engineering rights for the project or their local runtime rights for individual CPUs in the project, can be found in the editor for users and roles in the project tree.

Powerful password functions

- Support for compliance with complexity rules for password creation:
  Already at the password creation stage, you can have the TIA Portal check for compliance with complexity rules, such as rules on password length, uppercase/lowercase letters (project tree, "Security settings > Settings" area).
  The complexity rules are also saved in the CPU when the user management is loaded. When the password is changed online, the CPU identifies and applies these rules. This prevents a user from overriding the complexity rules set by the configuration engineer and assigning an insecure password.

- The period of validity of passwords can be set:
  To ensure that a user does not have access to the CPU with a compromised password for an unlimited time, you can assign a period of validity. The time remaining until the validity expires is then displayed on login so that each user can change his password in time.

Loading the user management during operation

As of firmware version V3.1, certain security-relevant configuration data can be loaded in both STOP and RUN system state. This means that loading the hardware configuration does not necessarily lead to a CPU STOP.

You can load the following changes in both STOP and RUN system state (Download to device > Hardware configuration):

- Local user management extended/changed
- TIA Portal-configured certificates modified
- Syslog configuration changed

If you made additional changes to the hardware configuration (for example, modules added, parameters changed, etc.), then the CPU automatically requests the STOP state before loading the configuration.

Therefore, when loading just one user with modified roles/function rights to the CPU, for example, this process does not require the CPU to be in STOP state.

The load preview dialog contains a security area where you can define how the CPU is to handle user data changed since the last load operation (not when loading for the first time). This allows changes to user data (e.g. password changes during runtime) to be retained.

Loading the device as a new station - with user data

If you load a previously configured CPU into a new project, for example, because you do not have the original project, the user data is also loaded into the project and is available for further editing of the CPU settings.

Changing passwords during operation

You can use the web server API to write an application that any user can use to change his password at runtime, provided that the original password was entered correctly and the new password complies with the configured password policy.

Requirement: You have enabled access control for the CPU.

A use can change his own password at any time, even if the password has expired. If the password has expired, the user must change his password. Login is not possible with an expired password.

API methods used:

- Api.ChangePassword
- Api.GetPasswordPolicy

You can find more information about the API methods in the Web server Function Manual (https://support.industry.siemens.com/cs/us/en/view/59193560).

NOTE

Passwords changed at runtime take precedence over loaded passwords
If you changed your password during operation and subsequently load your project, the password assigned during runtime takes precedence over the password set in the project (default setting).
If you want to overwrite the passwords changed during runtime by loading the project, you must select the option "Load all user management data (reset to project data)". In this case, **all** passwords changed during runtime will be lost.

11.3.3 From access level to user function rights

The implementation of access protection for CPUs with the new local user management is described in the following.

Access levels as function rights

While access could only be controlled using passwords for ET 200SP CPUs up to FW version V3.0, you create corresponding users and roles with the necessary function rights for access control for CPUs as of FW version V3.1. The assignment between access level and the associated function right results from the already known access levels:

- Users who are to have full access must have a role with the function right "Full access".
  A CPU configuration can only be compiled and loaded if at least one user has the function right "Full access" or "Full access incl. fail-safe".
- Users who are to have read access must have a role with the function right "Read access".
- Users who are to have HMI access must have a role with the function right "HMI access".

If a user has none of these function rights, that user also has no access to the CPU.

The hierarchical organization of the access levels also remains the same for the corresponding function rights:

- A user with full access also has the function rights "Read access" and "HMI access".
- A user with read access also has the function right "HMI access".

NOTE

Compatibility of the "ENDIS_PW" instruction
The "ENDIS_PW" instruction can be used only to disable or enable passwords for protection levels. The "ENDIS_PW" instruction has no effect on assigned rights for users or roles.

Continued use of access levels

Even though the new local user management replaces the familiar access protection using corresponding function rights of individual users, the option exists to continue using this familiar access protection. This is required, for example, for HMI devices that only support access levels and are unable to make use of the new user management.

If you need configuration of an access level, for example, to grant access to an HMI device without user and password assignment, select the "Use legacy access control via access levels" option in the CPU properties.

NOTE

Users for OPC UA and web server

Independent of the access protection, you always have to configure the users for the web server and OPC UA server in the project tree ("Security settings > Users and roles" area).

Restrictions on continued use of the access levels

When using the "Legacy access control" option, you cannot select the access level directly in the table for setting the access levels. This selection can only be made for the new local user management in one way: using the access protection function rights of the "Anonymous" user.

The system creates the local "Anonymous" user in a project by default. With the help of this user, you define the behavior of the CPUs in the project for anyone who logs in without a user name and password. For security reasons, the anonymous user is deactivated and must be activated before use.

A link in the area where you set the access levels takes you to the editor for the required settings for the "Anonymous" user.

Examples:

- If the "Anonymous" user is deactivated or if the "Anonymous" user is activated and no function rights have been assigned to that user, then nobody can log in without a user name and password (corresponds to the access level "No access (complete protection")).
- If the "Anonymous" user is activated and the "Full access" function right for a CPU is assigned to that user via a corresponding role, the result of this setting is "No protection". You achieve the same effect with regard to access protection by setting "No access protection" in the "Protection & Security" area of the CPU properties.

Procedure

To activate the "Legacy access control" and set the required access level, follow these steps:

1. In the CPU properties, go to "Protection & Security > Access control".
2. Select the option "Enable access control" and, in addition, select the "Use legacy access control via access levels" check box.

   The access level selection cannot be used in this setting. You set the access level using the "Anonymous" user of the CPU.

   The "Anonymous" user is deactivated by default. This means that the resulting access level for users without a password is "No access (complete protection)" (default setting).
3. Go to "Security Settings > Users and roles" in the project tree.

4. Activate the "Anonymous" user, if you want to set a different access level than "No access (complete protection)". You can assign a role with function rights that grants access to the CPU without password input only to the activated "Anonymous" user.
5. You cannot assign function rights for a CPU directly to a user. You must first create a role: Therefore switch to the "Roles" tab and add a new role. Assign a meaningful name, e.g. "PLC1-Read-Access-Role". If you assign this role to a user, this user is to have read access to PLC1 during operation.
6. Assign the required function right for accessing the CPU named "PLC1" – in this case "Read access" – to the role "PLC1-Read-Access-Role".
7. Switch to the "Users" tab and assign the "PLC1-Read-Access-Role" role to the activated "Anonymous" user.

   Result: The "Anonymous" user has read access for PLC1. This means that the access level tables of the CPU "PLC1" in the project are preset to "Read access" (cannot be changed) and users who are not logged in only have read access.

   For full access, or full access including fail-safe, you must configure a password for the full access in the table for the access protection. Anyone performing an action at runtime requiring full access to the CPU, e.g. a project is to be loaded to the CPU, must legitimize themselves for this action with this password.

Tip

To make the user rights transparent, use meaningful names for the respective roles. You create users and roles for the entire project; you must select the function rights of a role individually for each CPU in the project. A descriptive name allows you to recognize immediately the CPUs for which read access is granted and the CPUs for which no access is granted (complete protection).

11.3.4 Information regarding compatibility

In the following sections, you will find information on the behavior of the CPUs with local user administration when, for example, modules are exchanged in STEP 7 and on further use of projects and programs without local user administration.

Replacement part scenario

If you replace a CPU with firmware version <V3.1 with a CPU with firmware version V3.1 or higher, the program stored on the memory card runs the same as on the original CPU. The behavior with regard to the configured access levels and the users for the OPC UA server and web server corresponds to the behavior of the predecessor CPU.

In this case, the "Change password function" via the web server API is not accepted by the CPU because the CPU has been configured for firmware version < V3.1 and has no local user management.

Exchanging the CPU (upgrade)

If you exchange a CPU (FW <V3.1) in the TIA Portal for a current CPU (FW V3.1 or higher), the configured user data is affected as follows:

- The user data of the OPC UA server and web server is transferred to the "Users and roles" editor in the project tree.

NOTICE
Passwords are lost when the CPU is exchanged Make sure that the passwords are available before exchanging the CPU. They must be entered again in the "Users and roles" editor. Otherwise, you have to assign new passwords and inform the users.

- A corresponding role is created for each web server user in the "Users and roles" editor; the name of the role contains the CPU name, the string "Web" and the already configured web server user name. In this way, you can easily restore the original rights for each CPU by assigning these roles in the "Users and roles" editor.
- The "OPC UA server access" role is created for each OPC UA server user.
- OPC UA guest access and the web server user "Everybody" are migrated to the "Anonymous" user.
- Each OPC UA user and each web server user is listed in the "User" column in the "Users and roles" editor. If there is a web server user and a OPC UA user with the same name, only one user is created.
- For a protected project, you can select which action the CPU performs:
  - Migrate users (requirement: you are logged in as a user with the right to manage users and roles and the right to edit the project/configuration)
  - Remove users
  - Cancel
- The "Legacy access control via access levels" option is set for access protection.

Exchanging the CPU (downgrade)

If you exchange a CPU (FW V3.1 or higher) in the TIA Portal for a predecessor CPU (< FW V3.1), the configured user data is affected as follows:

- The local user management is no longer available.
- Users with function rights for the web server are not transferred.
- Users of the OPC UA server remain with their user rights in the "Users and roles" editor. No users are moved to the "OPC UA" area of the CPU parameters.
- It is no longer possible for users to change passwords during runtime (via web server API).

11.4 Temporary account lock in case of brute force attacks

Useful information about brute force attacks

In a brute force attack, combinations of credentials (for example, user name and password) are systematically tried out with the aim of gaining access to a user account. Trying all options requires a lot of computing effort and time until a correct combination of user name and password is found.

Brute force attacks are particularly effective with weak or simple passwords.

Protecting a CPU from brute force attacks

As of STEP 7 V19, you can define password policies in the project tree under "Security settings" and thus ensure that strong passwords are assigned.

As of STEP 7 V21, there is the additional option of setting up a temporary account lock for CPUs as of FW version V4.1. You can only configure the temporary account lock for local user accounts. For central user accounts, protection against brute force attacks is configured directly on the UMC server.

You specify a maximum number of failed login attempts per time unit (monitoring time). If the specified number of failed login attempts is reached within the monitoring time, the period of the account lock (lockout duration) begins. During this time period, every login attempt is unsuccessful, regardless of whether the login data is correct or incorrect.

The indicator for hits ("correct password") is masked. The attacker does not receive any feedback about the temporary lock.

Configuring the locking of the local user account in STEP 7

To configure the locking of the local user account, follow these steps:

1. Place the required ET 200SP CPU from the hardware catalog in the network view.
2. Select the ET 200SP CPU in the network view of STEP 7.
3. In the Inspector window, navigate to "Properties > General > Protection & Security > Lockout of user account at runtime".
4. Select the "Lockout of the user account after failed login attempts" check box.
   The fields below become editable.
5. Edit the other fields according to the following options:
   - Max. failed login attempts:
     Define the number of failed login attempts that will be accepted by the ET 200SP CPU for a user account. If this number is reached within the monitoring time, the affected user account will be locked.
     Default: 5 failed login attempts
   - Monitoring time:
     Determine the time period between failed login attempts for a user account. The time period starts again after each failed login. If a valid login attempt is made within the time period, the time is reset.
     Default: 2 minutes

– Lockout duration:
  Determine the time period for which the user account should be locked. The time period starts when the set number of failed login attempts for a user account is reached within the monitoring time. The ET 200SP CPU refuses all login attempts during the lockout duration. If an unsuccessful login attempt is made during the lockout duration, the set lockout duration starts again.
  Default: 2 minutes

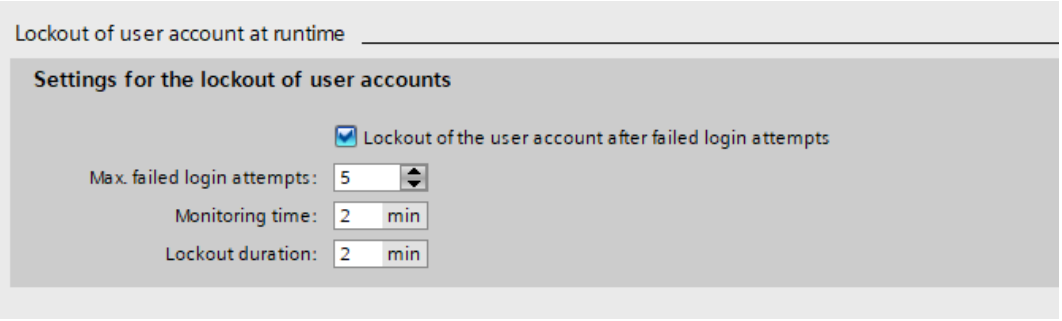


Figure 1-116 Configure the locking of the user account during runtime

6. Download the configuration to the ET 200SP CPU.

Result: You have configured the settings for lockout of user accounts and downloaded them to the ET 200SP CPU.

The following figure shows an example of the procedure for locking a user account. A maximum number of 4 incorrect login attempts was set here.

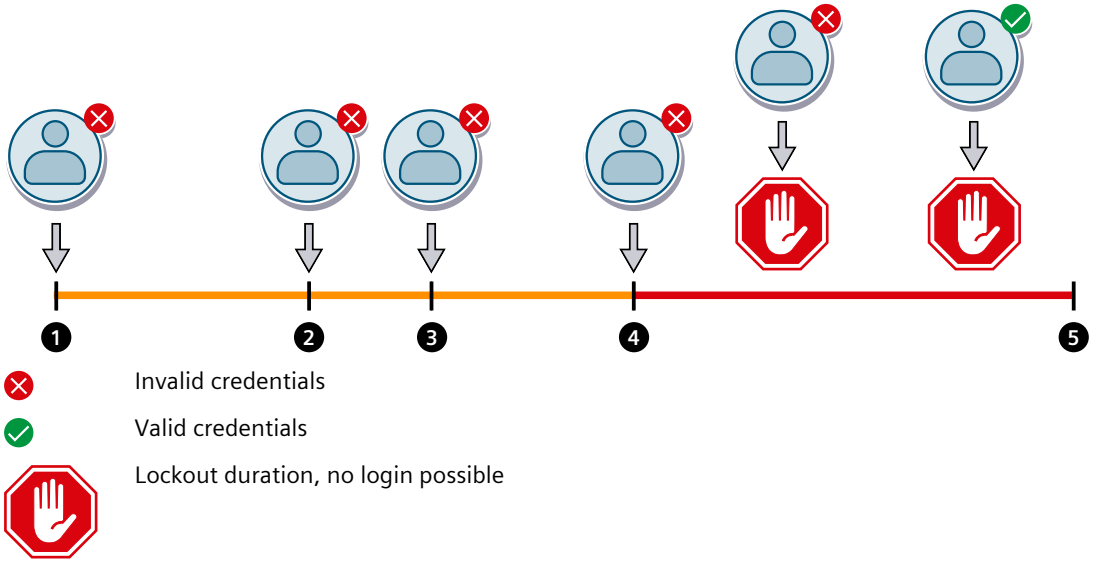


Figure 1-117 Sequence in the event of failed login attempts on an ET 200SP CPU

1. Failed login attempt no. 1:
   The set monitoring time ▬ starts. The counter for the number of failed login attempts is set to 1.
2. Failed login attempt no. 2 within the monitoring time:
   The set monitoring time ▬ starts again. The counter for the number of failed login attempts is incremented by 1.

3. Failed login attempt no. 3 within the monitoring time:
   The set monitoring time starts again. The counter for the number of failed login attempts is incremented by 1.
4. Failed login attempt no. 4 within the monitoring time:
   The set number of failed login attempts within the monitoring time has been reached. The set lockout duration starts.
   As long as the lockout duration is running, the CPU responds to each login as if it were an incorrect login attempt (no login possible). A login attempt with incorrect credentials during the lockout duration leads to a restart of the lockout duration.
5. After lockout duration elapses:
   Login attempts are again accepted by the CPU. The counter for the number of failed login attempts is reset to 0.

Influence of events on the temporary account lock

The following states and events belong to the temporary account lock:

- Incorrect login attempt detected
- Ongoing monitoring time
- Current lockout duration

The following events reset all states of the temporary account lock for all local users:

- Transition from POWER-ON to POWER-OFF
- Download to CPU

Password changes by local users during operation via the Web API have **no** effect on the temporary account lockout.

11.5 Central user management

11.5.1 Useful information on central user management and access control

As of TIA Portal version V20 and CPU firmware version V4.0, ET 200SP CPUs have the possibility to leave the authentication of users to a central UMC server.

As of the versions specified above, you manage users centrally and combine multiple users with the same roles/function rights into one group.

The central authentication service is performed in this case by the UMC (User Management Component).

You set up linking between user/group and assigned roles and function rights in the editor "Users and roles" in TIA Portal - as with the local user management.

For HMI devices, the authentication is not possible via either local or central users (TIA Portal V19/V20).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - but only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example the security concept "Defense in Depth", in particular the remarks on plant security and hardening measures.

Detailed information is available in the section Industrial cybersecurity (Page 33).

Advantages of central user management

Central user management allows management of users and user groups independently of TIA Portal. This enables the user management to be scaled from a few users and CPUs in a single project (local user management) up to extensive automation solutions with multiple projects, users and user groups (central user management) – without increased workload.

If you use the central user management (UMC), you can, for example, configure user groups on the UMC server set up for this purpose. The users of a group then have the same roles and function rights on the CPU.

During operation, users can be added to or removed from a group or passwords can be changed on the UMC server. The CPU configurations do not need to be changed and reloaded.

⚠ WARNING

Decoupling the user management from the CPU involves risks

When central user management is used, the CPU or TIA Project has no way of checking the central user administration. UMC administrators must carefully check the effect of their changes with regard to modified roles and function rights.

Changes to central users at the time of the change do not affect the existing connection to the CPU at this time. These include, for example, the following changes:

- Delete a user on the UMC Server
- Users are moved to other groups on the UMC server and thus get other roles and rights.

The changed user configuration will only take effect when you log in again.

Requirements

The configuration in the editor for users and roles (TIA Portal) provides you with a wide scope of usage scenarios in connection with UMC:

- Programming device with TIA Portal is connected to a UMC domain. In this case, the users and groups can be synchronized in the editor for users and roles.
- Programming device with TIA Portal is not connected to a UMC domain but the names of the user groups/central users used in operation are known and can be added without contact to the UMC server.

  The names of the user groups/central users can also be entered without connection to the UMC domain and synchronized with the UMC domain later.

  The synchronization is not necessary for authentication of CPU users via a UMC server. The group names or user names only have to match to make use of the authentication service.

A CPU which needs to authenticate the querying users (e.g. via web, PG/HMI communication or OPC UA) for diverse online functions requires the following information for access to the authentication service:

- The UMC server address
  Example: https://central.umc.testnet:443/ra
  (443 = port for https, ra = remote authentication)
- A server ID (fingerprint of the server certificate).
  You can determine the fingerprint of a certificate through Windows (open the certificate, "Details" tab, "Fingerprint" field).

As an alternative to the server ID, you can configure a list of CA certificates. These certificates are used by the CPU to verify the certificate returned by the UMC server when a connection is established. In order for the verification to be successful, the entire certificate chain down to the root certificate must have been loaded. The verification does not work for end-entity certificates or for intermediate certificates without a certificate chain to the root certificate.

Further requirements for operation (Runtime):

- User groups and users have been set up on the UMC server.
- A connection can be established between the CPU and UMC server via the configured UMC server address.
- CPU time is current. As with local user management, central users are informed about the remaining validity of their password. CPU and UMC server must have the same date and time settings.

NOTE

No logon possible if the UMC server is not available or the CPU time is reset

- If you use only UMC users and UMC user groups to access the CPU during operation and the UMC server becomes unreachable, e.g. due to connection abort, then no one can log on anymore.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/function rights.
- If you use UMC user groups or UMC users to access the CPU during operation, the CPU time must be up-to-ate.
  If the CPU time has been reset, e.g. by restoring the factory settings, and no NTP time synchronization has been configured, it is also not possible to log on via the central user management. Authentication of the UMC server using certificates requires an up-to-date CPU time.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/functional rights to set the time (e.g. from the "Web server - Maintenance" group).
  - Alternatively, you can synchronize the CPU time using NTP servers (for information on configuration, see section Time synchronization (Page 302)).

Basic procedure for using the User Management Component (UMC)

The following basic steps are required to use the User Management Component (UMC):

1. Installation of UMC on one or more computers in the system.
2. Assigning a corresponding UMC version as a UMC ring server or UMC server. This creates a UMC system consisting of one or multiple UMC computers.
3. Creating users and user groups in UMC. These can exist only in UMC or can be imported from a Microsoft Active Directory.
4. Connection of the UMC agent that is installed on the computer with the TIA Portal installation. The connection can be established with the TIA Administrator or with the Windows command line.
5. Usage of UMC users and UMC user groups, for example, in the context of the TIA Portal project creation.
6. Authentication of UMC users after logging on via UMC.

NOTE

Enabled "Anonymous" user is always loaded
An enabled "Anonymous" user with its configured roles/function rights is loaded even if you only enabled the central user management. Local user management does not have to be additionally enabled for the "Anonymous" user to take effect.

Additional information on the UMC server

More information on setting up (installing, configuring) a UMC server as well as creating central users and groups can be found here (https://support.industry.siemens.com/cs/us/en/view/109780337).

11.5.2 Configuring central user management in the editor for users and roles

The procedure for the configuration of the central user management in the TIA Portal version V20 with an ET 200SP CPU is described below (firmware version as of V4.0).

We distinguish between the following use cases:

- The project is configured in the environment that has access to the UMC server.
- The project is created in an environment that has no access to the UMC server.
  This is, for example, the case for a machine that is configured independently of the later place of installation and environment. The parameters for the user management must still be modified at the installation location.

Requirements - TIA Portal has access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is an online connection to the UMC server.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click the "Add new UMC user group" button.



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the user groups, select the user groups to be imported into the editor.
6. Assign the desired roles to the groups.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User" tab.
3. Click "Add user".



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the central users, select the users to be imported into the editor.
6. Assign the desired roles to the users.

Requirements - TIA Portal has no access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is no online connection to the UMC server at the time in which user management is configured.

NOTE

Case sensitivity of user name

Although the UMC server does not differentiate between upper and lower case of the user name/group name when logging on, deviations in case prevent the user from logging on for users/groups who are configured offline or unsynchronized in the TIA Portal.

Recommendation:

- Before login, synchronize users and user groups in the TIA Portal and download this configuration to the CPU. In this case, the case of the user name is not relevant during logon.
- If possible, import users/groups as described above.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click in the <Add new user group> field in the "Name" column.
   The TIA Portal enters a default name.
4. Modify the default name - this name will be used in the target environment of UMC.
   The name can also be modified in the target environment during commissioning.

Result: The groups are set up but not synchronized, i.e. no UM domain ID is assigned.

When a connection to the UMC server exists in the target environment, the following process takes place when a central user logs on:

- The CPU forwards the authentication request to the UMC server.
- After a successful check, the UMC server returns a list of groups to which the logged-on user belongs.
- The CPU determines the assigned roles and function rights for the user based on the group names.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Click in the <Add new user> field in the "User name" column.
   The user type "Local user" is preset.
3. Modify the default user name - this name will be used in the target environment of UMC.
4. In the column "User type" change the entry to "Central user".

Result: The central user has been set up but not yet synchronized, meaning that no UM domain ID is assigned.

In the target environment with a connection to a UMC server, you can still adjust the provisional group and central user names using the TIA Portal.

Changing the user type - Effects

- When you change the user type (central user > local user), the data for the connection to the UMC server is lost (UM domains ID).
- When the user type is changed from local user to a central user, the configured password and the comment are lost.

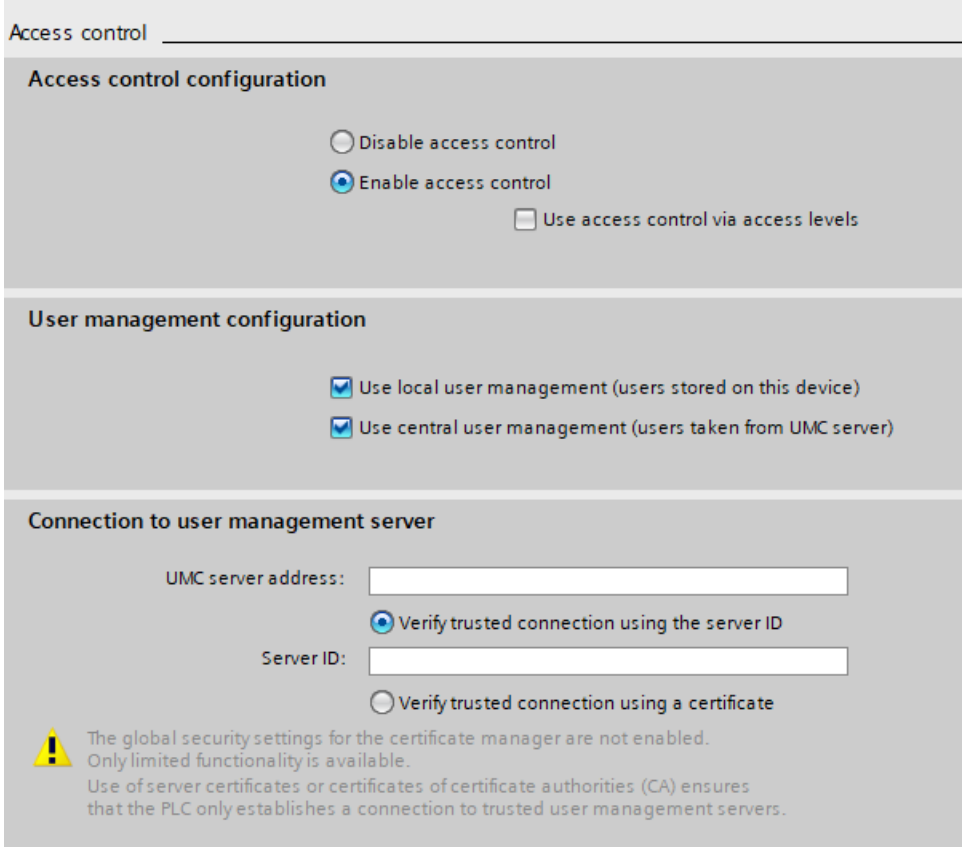
11.5.3 Configuring central user management for an ET 200SP CPU

The procedure for configuration of the ET 200SP CPU is described below (firmware version as of V4.0).

Procedure - CPU configuration for central user management

To configure the central user management for an ET 200SP CPU, follow these steps:

1. Place the CPU and navigate to the area "Protection & Security > Access control".
2. Ensure that access control has been enabled (access control via protection levels may be enabled or disabled).
3. Select the option "Use central user management (users taken from UMC server)".
   In addition, the local user management can also be activated in order to still be able to access the CPU if the connection to the UMC server fails, for example.
4. Add the specifications to the UMC server address and server ID for authentication of the UMC server.
   As an alternative to the server ID, you can also add the CA certificate or intermediate certificate for authentication. The CPU must have the entire certificate chain for verification of the server certificate including root certificate.



Changing the connection data for the UMC server

A user with a role that grants full access to the CPU can download modified connection data (UMC server address and server ID) in both STOP and RUN modes of the CPU.

11.5.4 Logon of central users

The processes for the logon of central users are described below from the perspective of different applications.

Requirements

- A UMC server is connected to the CPU (firmware version V4.0 or higher) and is accessible.
- The required central users and groups have been set up for the UMC server.
- The CPUs are configured accordingly for the central user management (roles and function rights) and the configuration is loaded.

Logging onto a protected CPU

If you access a CPU online and the operation requires function rights from users, a dialog appears, as with the local user management, which queries the user type. As of TIA Portal version V20, you can log on as central user.

Causes of a failed logon of a central user

Besides known causes, such as a wrong user name (not configured) or wrong password, the logon may, for example, fail due to network problems (UMC server not reachable) or an oversized response frame.

Tip

To handle such cases, set up a local user who can read the diagnostic buffer in the event of a failed logon and determine the exact cause.

In the diagnostic buffer, the causes are represented by an error code that you can interpret using the following table.

Each entry in the diagnostic buffer also leads to a corresponding syslog message so that connected evaluation systems can record the processes.

Table 1-369 Error codes for failed login

Error code	Meaning
#8000 0001	Missing configuration. The UMC server endpoint is not specified.
#8000 1000	Unspecified UMC system error.
#8000 1001	No DNS address configured.
#8000 1002	The DNS server is not reachable, e.g. because it was shut down as the remote port cannot be reached due to firewall settings.
#8000 1003	During data exchange with the UMC server: The interface is currently receiving new parameters.

Error code	Meaning
#8000 1004	The UMC server cannot be reached. The UMC server does not respond to the ARP telegram or there are problems with the TCP handshake to establish a connection.
#8000 1005	The IP address of the UMC server cannot be reached due to missing routing information.
#8000 1006	The UMC server refuses to establish the connection. Connection was closed unexpectedly.
#8000 2xxx	Internal, unrecoverable TLS error.
#8000 3001	Validation of the UMC server certificate failed. Possible causes: Verification against the chain of trust not possible. Certificate not valid or expired. Verification of Identity failed (subject alternative name, FQDN, IPv4 check). Server ID verification failed (fingerprint).
#8000 4001	UMC server does not respond (timeout).
#8000 4002	HTTP response telegram too long (system limit exceeded).
#8000 4003	Invalid HTTP response.
#8000 5xxx	Encoded HTTP status code of the HTTP request. Example of an encoding of Status Code 500 (#1F4) = Internal Server Error: Coding: #8000 5000 + #1F4 (=500) = #8000 51F4
#8000 6001	Syntax error in JSON response telegram from UMC server.
#8000 6002	JSON response telegram from the UMC server too long (system limit exceeded).
#8000 6003	Unexpected JSON format. The message has a valid JSON format, but it is not a valid UMC authentication response from the UMC server.
#8000 7xxx	Login failed (unknown error).

Logging on as an OPC UA client or as a web client

The user name and password are transferred via the UserNameIdentityToken during logon of an OPC UA client to the OPC UA server of the ET 200SP CPU.

The user name and password are also queried for web clients if you want to use the full functionality of the web server of the ET 200SP CPU. See also the Web server function manual, section "Authentication". The following process applies to OPC UA clients and web clients:

- For central users, the CPU forwards the authentication query to the UMC server.
- If the authentication is successful, the UMC server returns the assigned groups to which the user belongs.
- The CPU generates the corresponding session context and grants the authorizations (function rights from the determined roles).
- The client can then execute the access in the context of the session in accordance with the granted function rights.

How does the CPU (OPC UA server or the website of the web server) recognize whether the user is a local or a central user?

You have the freedom to configure a user both as a local user and as a central user. This results in an ambiguity about which service is responsible for the authentication and which user ultimately gains access. Since access permission for the user depends solely on the password in this case, you should use strong passwords, e.g. created by a password generator.

The following rules apply to ensure unambiguousness for the responsible authentication service (local or central user management):

- For logon of a local user, add the prefix "L:" (uppercase or lowercase) in front of the user name.
  Example: L:username

  If you do not use a prefix for the user names, central user management is automatically responsible (when central and local user management are used at the same time). If you use only one type of user management, access is unambiguous even without a prefix.
- A user name must not begin with the string "L:" (uppercase or lowercase).

11.6 Configuring access protection for the CPU

Introduction

The following section describes how to use the individual access levels of the CPUs. The description applies to ET 200SP CPUs up to firmware version V3.0. In later firmware versions, you use the local user management (Page 222) in the "Users and roles" editor in the project tree. The access levels are represented there by function rights of the same name, which you assign to individual users via roles.

The CPU offers four access levels to limit access to specific functions.

By setting up the access levels and the passwords for a CPU, you limit the functions and memory areas that are accessible without entering a password. You specify the individual access levels as well as the entry of their associated passwords in the object properties of the CPU.

Rules for passwords

Ensure that passwords are sufficiently secure. Passwords must not follow a machine-recognizable pattern. Follow the rules below:

- Assign a password that is at least 8 characters long.
- Use different cases and characters: uppercase/lowercase, numbers and special characters.

Access levels of the CPU

Table 1-370 Access levels and access restrictions

Access levels	Access restrictions
Full access (no protection)	Any user can read and change the hardware configuration and the blocks.
Read access	With this access level, read-only access to the hardware configuration and the blocks is possible without entering a password, which means you can download the hardware configuration and blocks to the programming device. In addition, HMI access and access to diagnostics data is possible. Without entering the password, you cannot load any blocks or hardware configuration into the CPU. Additionally, the following are **not** possible without the password: • Writing test functions • Firmware update (online)
HMI access	With this access level only HMI access and access to diagnostics data are possible without entering the password. Without entering the password, you can neither load blocks nor the hardware configuration into the CPU, nor load blocks and hardware configuration from the CPU into the programming device. Additionally, the following are **not** possible without the password: • Writing test functions • Changing the mode (RUN/STOP) • Firmware update (online) • Display of the online/offline comparison status
No access (complete protection)	When the CPU has complete protection, no read or write access to the hardware configuration and the blocks is possible (without access authorization in the form of a password). HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

An enumeration of which functions are available in the different protection levels is available in the "Setting options for the protection" entry in the STEP 7 online help.

Properties of the access levels

Each access level allows unrestricted access to certain functions without entering a password, for example, identification using the "Accessible devices" function.

The default setting of the CPUs is "No access (complete protection)". In the default access level, the user is not allowed to read or modify the hardware configuration or the blocks. To obtain access to the CPUs, assign parameters alternatively in the properties of the CPU:

- A password for the protection level "No access (complete protection)"
- Another protection level, e.g. "Full access (no protection)".

Communication between the CPUs (via the communication functions in the blocks) is not restricted by the access level of the CPU, unless PUT/GET communication is deactivated in the "No access" (complete protection) access level.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

NOTE

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes to the CPU by restricting the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC memory card are not write- or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC memory card.

Behavior of functions with different access levels

The STEP 7 online help includes a table which lists the online functions that are available in the different access levels.

Selecting the access levels

To configure the access levels of a CPU, follow these steps:

1. Open the properties of the CPU in the Inspector window.
2. Open the "Protection" entry in the area navigation.
   A table with the possible access levels is available in the Inspector window.

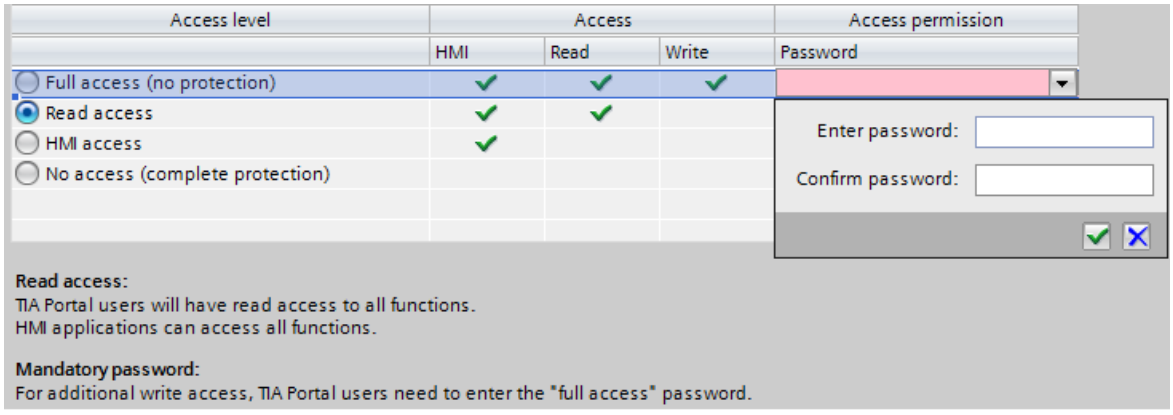


Figure 1-118 Possible access levels

3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the access level show you which operations are still available without entering the password. In the example (see above), read access and HMI access are still possible without a password.
4. In the "Enter password" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to guard against incorrect entries.
5. Assign additional passwords as required for other access levels.
6. Download the hardware configuration for the access level to take effect.

The CPU logs the following actions with an entry in the diagnostic buffer:

- Input of the correct or incorrect password, as the case may be
- Changes in the configuration of access levels

Behavior of a password-protected CPU during operation

The CPU protection takes effect after you have downloaded the settings to the CPU.

Before an online function is executed, the CPU checks the necessary permission and, if necessary, prompts the user to enter a password. You can only execute password-protected functions from one programming device/PC at any time. Another programming device/PC cannot log on.

Access authorization to the protected data is in effect for the duration of the online connection or until you rescind the access authorization manually with "Online > Delete access rights".

Access levels for F-CPUs

For the fail-safe CPUs, there is an additional access level in addition to the four described access levels. For additional information on this access level, refer to the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

11.7 Using the user program to set additional access protection

Access protection via user program

You can also restrict access to a password-protected CPU in STEP 7 via the ENDIS_PW operation. You can find a description of this block in the online help under the keyword "ENDIS_PW: Limit and enable password legitimation".

11.8 Know-how protection

Application

You can use know-how protection to protect one or more OB, FB or FC blocks as well as global data blocks in your program from unauthorized access. Enter a password to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block.

Password provider

As an alternative to manual entry of password, you can connect a password provider to STEP 7. When using a password provider, you select a password from a list of available passwords. When a protected block is opened, STEP 7 connects to the password provider and retrieves the corresponding password.

To connect a password provider you have to install and activate it. A settings file in which you define the use of a password provider is also required.

A password provider offers the following advantages:

- The password provider defines and manages the passwords. When know-how protected blocks are opened, you work with symbolic names for passwords. A password is marked, for example, with the symbolic name "Machine_1" n the password provider. The actual password behind "Machine1" remains hidden from you.
  A password provider therefore offers you optimum block protection as the users do not know the password themselves.
- STEP 7 automatically opens know-how protected blocks without the direct entry of a password. This saves you time.

You will find more information on connecting a password provider in the STEP 7 online help.

Readable data

If a block is know-how protected, only the following data is readable without the correct password:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling in a program
- Online/offline comparison
- Load

Global data blocks and array data blocks

You protect global data blocks (global DBs) from unauthorized access with know-how protection. If you do not have the valid password, you can read the global data block but not change it.

Know-how protection is not available for array data blocks (array DBs).

Setting up block know-how protection

To set up block know-how protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".

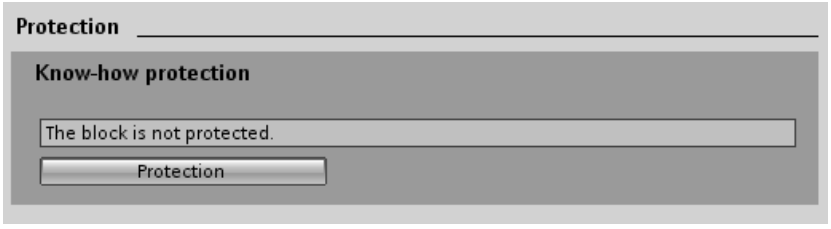


Figure 1-119 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Know-how protection" dialog.



Figure 1-120 Setting up block know-how protection (2)

4. Click the "Define" button to open the "Define Password" dialog.

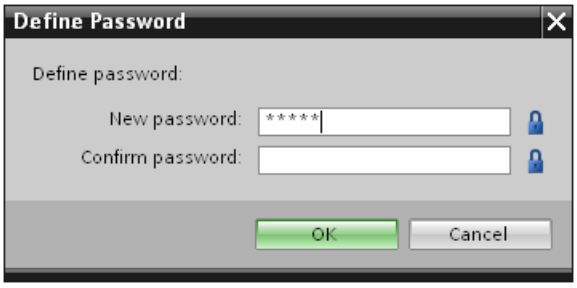


Figure 1-121 Setting up block know-how protection (3)

5. Enter the new password in the "New password" box. Enter the same password in the "Confirm password" box.
6. Click "OK" to confirm your entry.
7. Close the "Know-how protection" dialog by clicking "OK".

Result: The selected blocks are now know-how protected. Know-how protected blocks are marked with a lock in the project tree. The password entered applies to all blocks selected.

NOTE

Password provider
Alternatively, you can set up know-how protection for blocks with a password provider.

Opening know-how protected blocks

To open a know-how protected block, follow these steps:

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected block is open.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. You must enter the password again the next time you open the block. If you close the "Access protection" dialog with "Cancel", you will be able to open the block but you cannot display the block code or edit the block.

If you copy the block or add it to a library, for example, this does not cancel the know-how protection of the block. The copies will also be know-how-protected.

Removing block know-how protection

To remove block know-how protection, follow these steps:

1. Select the block from which you want to remove know-how protection. The protected block must not be open in the program editor.
2. In the "Edit" menu, select the "Know-how protection" command to open the "Know-how protection" dialog.
3. Clear the "Hide code (Know-how protection)" check box.



Figure 1-122 Removing block know-how protection (1)

4. Enter the password.



Figure 1-123 Removing block know-how protection (2)

5. Click "OK" to confirm your entry.

Result: Know-how protection is removed from the selected block.

See also

Copy protection (Page 250)

11.9 Copy protection

Application

The copy protection allows you to protect your program against unauthorized duplication. With copy protection you associate the blocks with a specific SIMATIC memory card or CPU. Through the linking of the serial number of a SIMATIC memory card or of a CPU the use of this program or of this block is only possible in conjunction with a specific SIMATIC memory card or CPU.

Copy and know-how protection

Recommendation: to prevent unauthorized reset of copy protection, additionally apply know-how protection to a copy-protected block. To do this, first set up copy protection and then apply know-how protection for the block. You can find further information on setting up know-how protection in section Know-how protection (Page 246)

Setting up copy protection

To set up copy protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".



Figure 1-124 Setting up copy protection (1)

3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.

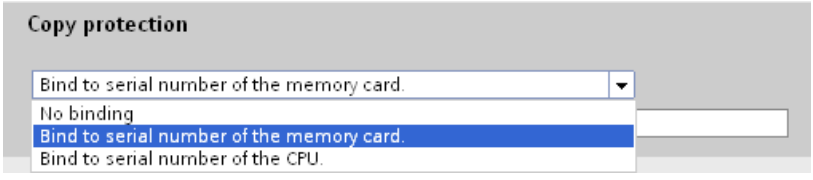


Figure 1-125 Setting up copy protection (2)

4. Activate the option "Serial number is inserted when downloading to a device or a memory card" if the serial number is to be inserted automatically during the uploading process (dynamic binding). Assign a password using the "Define password" button to link the use of a block additionally to the input of a password.
   Activate the option "Enter serial number" if you want to manually bind the serial number of the CPU or the SIMATIC memory card to a block (static binding).

5. You can now set up the know-how protection for the block in the "Know-how protection" area.

NOTE
If you download a copy-protected block to a device that does not match the specified serial number, the entire download operation will be rejected. This means that blocks without copy protection will also not be downloaded.

Removing copy protection

To remove copy protection, follow these steps:

1. Remove any existing know-how protection.
2. Open the properties of the block in question.
3. Select the "Protection" option under "General".
4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.

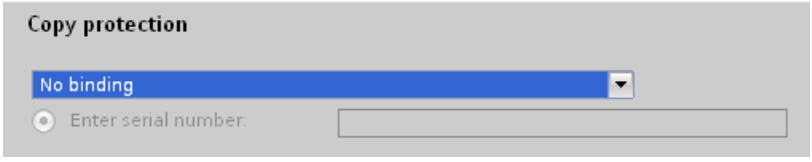


Figure 1-126 Removing copy protection

Configuration control (option handling) 12

Introduction

Configuration control (option handling) is used to operate various standard machine configuration levels in one project without changing the configuration or the user program.

Operating principle of configuration control

You can use configuration control to operate different standard machine configurations with a single configuration of the ET 200SP distributed I/O system.

- A station master is configured in a project (maximum configuration). The station master comprises all modules needed for all possible plant parts of a modular standard machine.
- The project's user program provides for several station options for various standard machine configuration levels as well as selection of a station option. A station option uses, for example, only some of the configured modules of the station master and these modules are inserted in the slots in a different order.
- The standard machine manufacturer selects a station option for a configuration of the standard machine. To do this, the project need not be modified, and it is not necessary to load a modified configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. The configuration control does not have an impact on the parameter assignment of the modules.

Configuration control allows you to flexibly vary the centralized/distributed configuration. This is only possible if the station option can be derived from the station master.

The following figure shows three configurations of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

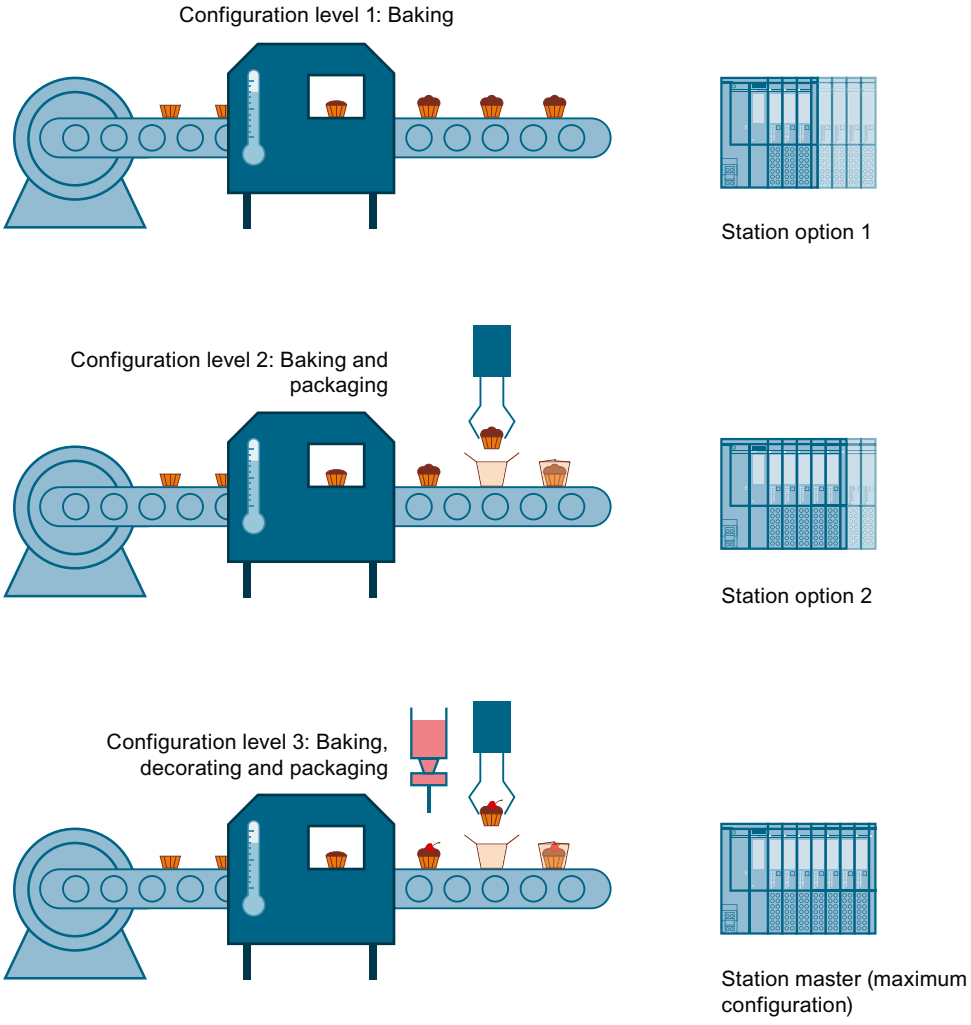


Figure 1-127 Various configuration levels of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

Advantages

- Simple project management and commissioning by using a single STEP 7 project for all station options.
- Simple handling for maintenance, versioning and upgrade:
- Hardware savings: Only those I/O modules are installed that are required for the machine's current station option.
- Savings potential in the creation, commissioning and the documentation for standard machines.
- Simple station expansion by using pre-wired empty slots. To expand, you simply exchange the BU cover for the new model. You can find further information on this in section Examples of configuration control (Page 271).

Procedure

To set up the configuration control, follow these steps:

Step	Procedure	See...
1	Enable configuration control in STEP 7	Section Configuring (Page 254)
2	Create control data record	Section Creating the control data record (Page 256)
3	Transfer control data record	Section Transferring the control data record in the startup program of the CPU (Page 266)

Library for configuration control

A library for configuration control is available on the Internet for download (https://support.industry.siemens.com/cs/#document/29430270?lc=en-WW). The library contains data types with the structure of the control data records for the ET 200SP distributed I/O system. You can implement your flexible automation solution inexpensively with the help of these data types.

NOTE

Configuration control in the case of motor starters
"Manual local" mode is possible in the case of motor starters when configuration control is active. The motor starter works with the last valid parameters. Do not change the parameterization while "manual local" mode is active.

12.1 Configuring

Requirements

Configuration control is supported by the ET 200SP distributed I/O system with both an ET 200SP CPU and with interface modules via PROFINET IO and PROFIBUS DP.

Centrally for ET 200SP CPU:

- STEP 7 Professional V13 Update 3 or higher
- CPU
  - CPU 1510SP-1 PN
  - CPU 1512SP-1 PN
  - CPU 1514SP-2 PN
  - CPU 1515SP PC2
- Firmware version V1.6 or higher

- All modules of the CPU must be able to start up even with different configurations.
  - The startup parameter "Comparison preset to actual configuration" of the CPU is set to "Startup CPU even if mismatch" (default setting) and the module parameter "Comparison preset to actual module" of the module is set to "From CPU" (default setting).
    or
  - The module parameter "Comparison preset to actual module" for the module is set to "Startup CPU even if mismatch".

Distributed via PROFINET IO:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 PN BA/ST/HF/HS, IM 155-6 MF HF
- You have assigned the interface module to an IO controller.

Distributed via PROFIBUS DP:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 DP HF
- You have assigned the interface module to a DP master.
- The startup parameter is set to "Operate if preset configuration does not match actual configuration"

Modules with submodules distributed across different ARs/fieldbuses may not be a part of the AR for the active configuration control.

Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the CPU/interface module in STEP 7 (TIA Portal).

- The "Allow to reconfigure the device via the user program" parameter is located in the "Configuration control" area for an ET 200SP CPU.
- The "Allow to reconfigure the device via the user program" parameter is located in the "Module parameter" area under "General" for an IM 155-6 PN or IM 155-6 MF HF interface module.

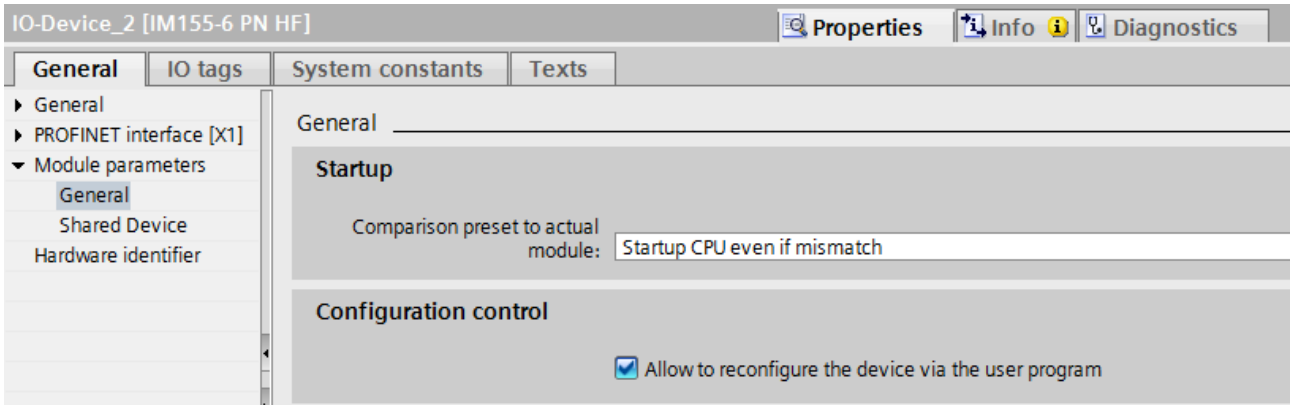


Figure 1-128 Enabling configuration control using an IM 155-6 PN HF as an example

12.2 Creating the control data record

12.2.1 Introduction

Required steps

To create a control data record for the configuration control, follow these steps:

1. Create a PLC data type that contains the structure of the control data record.
   The following figure shows a PLC data type "CTR_REC", which contains the structure of the control data record for an ET 200SP interface module.

CTR_REC

	Name	Data type	Default value	A...	V...	S...	Comment
1	Block_Lenght	USInt	134	☑	☑	☐	4 + (2 x number of Slots)
2	Block_ID	USInt	196	☑	☑	☐	
3	Version	USInt	2	☑	☑	☐	ET 200SP
4	Subversion	USInt	0	☑	☑	☐	
5	Slot 1	USInt	1	☑	☑	☐	assigned "real" slot
6	Add 1	USInt	0	☑	☑	☐	additional function
7	Slot 2	USInt	2	☑	☑	☐	assigned "real" slot
8	Add 2	USInt	0	☑	☑	☐	additional function
9	Slot 3	USInt	3	☑	☑	☐	assigned "real" slot
10	Add 3	USInt	0	☑	☑	☐	additional function
11	Slot 4	USInt	4	☑	☑	☐	assigned "real" slot
12	Add 4	USInt	0	☑	☑	☐	additional function
		USInt	5	☑	☑	☐	

Figure 1-129 Creating control data record 196 using an IM 155-6 PN HF as an example

2. Create a global data block.
3. In the data block, create an array that is based on the created PLC data type.

4. In the control data records, enter the slot assignments in the "Start value" column.
   The figure below shows the global data block "ConfDB". The data block "ConfDB" contains an array [0..5] of the PLC_DataType "CTR_REC".

ConfDB

	Name	Data type	Start value	R..	A...	V...	S..	Comment
1	Static			☐	☐	☐	☐	
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..5] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	Block_Length	USInt	0	☐	☑	☑	☐	4 + (2 x number of slots)
7	Block_ID	USInt	196	☐	☑	☑	☐	
8	Version	USInt	2	☐	☑	☑	☐	ET 200SP
9	Subversion	USInt	0	☐	☑	☑	☐	
10	Slot 1	USInt	1	☐	☑	☑	☐	assigned "real" slot
11	Add 1	USInt	0	☐	☑	☑	☐	additional function
12	Slot 2	USInt	2	☐	☑	☑	☐	assigned "real" slot
13	Add 2	USInt	0	☐	☑	☑	☐	additional function
14	Slot 3	USInt	3	☐	☑	☑	☐	assigned "real" slot
15	Add 3	USInt	0	☐	☑	☑	☐	additional function
16	Slot 4	USInt	4	☐	☑	☑	☐	assigned "real" slot
17	Add 4	USInt	0	☐	☑	☑	☐	additional function

Figure 1-130 Data block for configuration control

Rules

Observe the following rules:

- Slot entries in the control data record outside the station master are ignored by the CPU/interface module.
- The control data record must contain the entries up to the last slot of the station option.
- Multiple configured slots may not be assigned to the same actual slot. In other words, each station option slot may be present only once in the control data record.

Using communication modules

When configuration control (option handling) is used, you may insert the following communication modules:

- CM DP
- CP 1542SP-1
- CP 1543SP-1
- CP 1542SP-1 IRC
- BusAdapter BA-Send 1xFC

For the communication modules listed above, special slot rules apply for use with the ET 200SP CPUs:

If you insert the communication modules as mentioned above (e.g. CM DP) in the central configuration, then these modules cannot be influenced by the configuration control. You

must therefore leave these modules in the slots preassigned in the station master and enter the slot numbers from the station master in the control data record ("Station option slot = Station master slot").

In a station option, all slots up to the module furthest from the CPU (see list above) must be present in the control data record.

The CM AS-i Master and F-CM AS-i Safety communication modules can be used for configuration control without the above-mentioned restrictions relating to slot numbers.

12.2.2 Control data record for an ET 200SP CPU

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP CPU:

Table 1-371 Slot assignment

Modules	Possible slots	Comment
CPU	1	Slot 1 is always the CPU
Station extension BA-Send	2	In a mixed configuration with ET 200AL modules, BA-Send is always on slot 2.
I/O modules	2 - 65	Downstream of CPU
Server module	2 - 66	The server module completes the configuration of the ET 200SP station after the CPU/the last I/O module.
ET 200AL I/O modules	67 - 82	For mixed configuration with ET 200AL modules

Control data record

For the configuration control of an ET 200SP CPU, you define a control data record 196 V2.0, which includes a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or last slot of an ET 200AL I/O module (in a mixed ET 200SP/ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-372 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + (maximum slot × 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1 of the station master	Slot assignment 1 in the station option (always 1, because the CPU is always in slot 1)	**Control element** Contains the information on which module is inserted in which slot.
5	Additional function for slot 1		
6	Slot 2 of the station master	Slot assignment in the station option	

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Byte	Element	Code	Explanation
7	Additional function for slot 2		The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0. **Additional function** Contains information on whether a new potential group will be opened in the station option - by replacing a dark-colored BaseUnit with a light-colored BaseUnit. • If you replace a dark-colored BaseUnit with a light-colored BaseUnit, enter 1 as additional function. • If you accept the BaseUnit from the station master, enter 0 as additional function.
8	Slot 3 of the station master	Slot assignment in the station option	
9	Additional function for slot 3		
:	:	:	
4 + ((server module slot - 1) × 2)	Server module slot	Server module slot assignment in the station option*	
4 + ((server module slot - 1) × 2) + 1	Additional function for server module slot		
:	:	:	:
136	First slot of ET 200AL (slot 67)	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
137	Reserved		
:	:	:	
166	Last slot of ET 200AL (slot 82)	Slot assignment in the station option	
167	Reserved		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

12.2.3 Control data record for an interface module

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP interface module:

Table 1-373 Slot assignment

Modules	Possible slots	Comment
Interface module	0	The interface module (slot 0) is not an element of the configuration control, but instead controls this.
Station extension BA-Send	1	For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.

Modules	Possible slots		Comment
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF, IM 155-6 MF HF	
	1 - 65	for IM 155-6 PN HF, IM 155-6 PN/3 HF	
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	

Simplified control data record (V1)

For the configuration control of interface modules of the ET 200SP distributed I/O system, you define a control data record 196 V1.0, which includes a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-374 Structure of the simplified control data record V1.0

Byte	Element	Code	Explanation
0	Block length	4 + maximum slot	Header
1	Block ID	196	
2	Version	1	
3	Version	0	

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Byte	Element	Code	Explanation
4	Slot 1 of the station master	Slot assignment in the station option	**Control element ET 200SP** Contains the information on which ET 200SP module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0.
5	Slot 2 of the station master	Slot assignment in the station option	
:	:	:	
4 + (slot server module - 1)	Server module slot	Server module slot assignment in the station option*	
:	:	:	:
4 + (first slot ET 200AL - 1)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
:	:	:	
4 + (last slot ET 200AL - 1)	Last slot ET 200AL	Slot assignment in the station option	

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Control data record (V2)

If you change the potential groups in the station option compared to the station master, define a control data record 196 V2.0 for the ET 200SP interface module which contains a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-375 Structure of control data record 196 V2.0

Byte	Element	Code	Explanation
0	Block length	4 + (maximum slot x 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1 of the station master	Slot assignment in the station option	**Control element ET 200SP** Contains the information on which ET 200SP module is inserted in which slot.
5	Additional function for slot 1		
6	Slot 2 of the station master	Slot assignment in the station option	
7	Additional function for slot 2		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Byte	Element	Code	Explanation
8	Slot 3 of the station master	Slot assignment in the station option	The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0. **Additional function** Contains information on whether a new potential group will be opened in the station option - by replacing a dark-colored BaseUnit with a light-colored BaseUnit. • If you replace a dark-colored BaseUnit with a light-colored BaseUnit, enter 1 as additional function. • If you accept the BaseUnit from the station master, enter 0 as additional function.
9	Additional function for slot 3		
:	:	:	
4 + ((server module slot - 1) × 2)	Server module slot	Server module slot assignment in the station option*	
4 + ((server module slot - 1) × 2) + 1	Additional function for server module slot		
:	:	:	:
4 + ((first slot ET 200AL - 1) x 2)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
4 + ((first slot ET 200AL - 1) x 2) + 1	Reserved		
:	:	:	
4 + ((last slot ET 200AL - 1) x 2)	Last slot ET 200AL	Slot assignment in the station option	
4 + ((last slot ET 200AL - 1) x 2) + 1	Reserved		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

NOTE

If a BU cover or no I/O module is plugged on a light-colored BaseUnit, you should enter 1 in the additional function for the slot.

The function "Group diagnostics: Missing supply voltage L+" requires proper assignment of the slots to a shared supply voltage L+ (potential group). All light-colored BaseUnits must be known to the interface module. By entering 1 in the additional function, you make a light-colored BaseUnit known to the interface module, even if an I/O module is not inserted.

Combination of configuration control and shared device (for PROFINET)

The configuration control function in a shared device is therefore only for the I/O modules of the IO controller to which the interface module has subscribed. I/O modules that are assigned to no controller or a different controller behave like a station without activated configuration control.

You cannot make any change to the slot assignment for modules that are assigned to another IO controller or are not assigned to an IO controller (shared device on module level). The CPU assumes a one-to-one assignment for the modules.

If additional IO controllers subscribe to a module intended for configuration control (shared device on submodule level), only one-to-one assignment is permitted for this module. It is not possible to deselect such a module using the control data record (code 0 for this slot in the control data record). This means the combination of "Configuration control" and "Shared device on submodule level" is only possible to a limited extent.

Please note that all modules affected by the configuration control including all assigned submodules are reset when you change the module assignment. Submodules that are assigned to a second IO controller are affected as well.

Combination of configuration control and virtual IO modules

A combination of configuration control and virtual IO modules (interface-local coupling of IO data) is possible. However, you can only create the control data record for configuration control up to the last real slot. The virtual IO modules cannot be contained in the control data record. Virtual IO modules have a fixed slot/subslot that cannot be mapped and also cannot be contained in the remap record. If the control data record contains the virtual IO modules, the control data record becomes too long and the error code $80B1_H$ is returned. See section Feedback data record for interface modules (Page 264).

12.2.4 Feedback data record for interface modules

Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0. The feedback data record exists only with configured configuration control.

Slot assignment

The feedback data record refers to the configured station configuration and always includes the maximum configuration limits. The maximum configuration limits comprise 13/49/81 slots depending on the interface module in use. Partial reading of the feedback data record is possible.

The following table shows the slot assignment of the modules:

Table 1-376 Slot assignment

Modules	Possible slots		Comment
Station extension BA-Send	1		For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 65	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	

Feedback data record

Table 1-377 Feedback data record

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots x 2)	Header
1	Block ID	197	

* Not possible if the slot is marked as not available.

Byte	Element	Code	Explanation
2	Version	2	Header
3		0	
4	Slot 1 status	0/1	Status = 1: • Module from station master is inserted in the station option • Slot is marked as not available in the control data record Status = 0: • Module pulled • Incorrect module is inserted in the station option*
5	Reserved	0	
6	Slot 2 status	0/1	
7	Reserved	0	
:	:	:	
4 + ((max. slot - 1) × 2)	Max. slot status	0/1	
4 + ((max. slot - 1) × 2) + 1	Reserved	0	

* Not possible if the slot is marked as not available.

NOTE

The data in the feedback data record is always mapped for all modules. In a shared device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record has been sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

Error messages

In case of error, the RDREC instruction returns the following error messages via the STATUS block parameter while reading the feedback data record:

Table 1-378 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 197 is not correct.
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error The following events cause a parameter error: • Incorrect block ID in the header (not equal to 197) • Invalid version identifier in the header • A reserved bit has been set • The same slot in the station option has been assigned to more than one slot in the station master

12.2.5 Data records and functions

Supported data records and functions

The table below shows a comparison of the supported data records and functions depending on the CPU/interface module used.

	CPU...		Interface module (IM...)					
Supported data records and functions	**151xSP-1 (F) PN 1514SP-2 (F) PN**	**1515SP PC2**	**155-6 PN HS**	**155-6 PN HF 155-6 MF HF**	**155-6 PN/2 HF 155-6 PN/3 HF**	**155-6 PN ST**	**155-6 PN BA**	**155-6 DP HF**
Control data record (V2)	✓	✓	✓	✓	✓	✓	✓	✓
Simplified control data record (V1)	--	--	✓	✓	✓	✓	✓	--
Read back control data record*	✓	✓	✓	✓	✓	✓	✓	✓
Read feedback data record	--	--	✓	✓	✓	✓	✓	✓

* You can read back the control data record with the RDREC instruction.

12.3 Transferring control data record in the startup program of the CPU

Required steps

Transfer the created control data record 196 to the CPU/the interface module using the instruction WRREC (Write data record) instruction.

Parameters of the instruction WRREC

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

ID	Hardware identifier • Use the HW identifier of the CPU for the configuration control for centrally arranged modules. If you have selected the CPU in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "Local~Configuration". • Use the HW identifier of the interface module for the configuration control for distributed I/O. If you have selected the interface module in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "<Name_of_the_interface_module>~Head".

INDEX	Data record number: 196 (decimal)
RECORD	Control data record to be transferred. See the section Creating the control data record (Page 256) for the structure of the control data record.

Error messages

In case of error, the instruction WRREC returns the following error messages via the STATUS block parameter:

Table 1-379 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 196 is not correct.
$80B5_H$	Configuration control parameters not assigned.
$80E2_H$	Data record was transferred in the wrong OB context. The data record must be transferred in the startup program.
$80B8_H$	Parameter error A parameter error is caused by: • Incorrect block ID in the header (not equal to 196) • Invalid version identifier in the header • A reserved bit was set • A station master slot was assigned an invalid slot in the station option • Multiple slots in the station master are assigned to the same slot in the station option • For shared device on submodule level: Violation of defined restrictions

Selection of the station option in the user program

In order for the CPU to know which station option you want to operate, you must set up a possibility to select between the various control data records in the user program. You can implement the selection, for example, via an Int tag which references an array element.

Note that the tag used to select the control data record must be stored in the retentive memory area. If the tag is not retentive it will be initialized during the startup of the CPU and thus be unavailable for selection of the station option.

Special aspects relating to the transfer of the control data record to the CPU

- If you have enabled configuration control, the CPU is not ready for operation without a control data record. The CPU returns from startup to STOP if a valid control data record is not transferred in the startup OB. The central I/O is not initialized in this case. The cause for the STOP mode is entered in the diagnostics buffer.

  NOTE
  If an incorrect control data record is transferred to the CPU in the startup OB, the startup of the CPU may be prevented.
  In this case, perform a reset to factory settings of the CPU and then transfer a correct control data record.

- The CPU processes the WRREC instruction for transfer of the control data record asynchronously. For this reason, you must call WRREC in the startup OB repeatedly in a loop until the output parameters "BUSY" or "DONE" indicate that the data record has been transferred.
  - Tip: To program the loop, use the SCL programming language with the REPEAT ... UNTIL instruction.

```
REPEAT
 "WRREC_DB"(REQ := "start_config_control",
            ID := "Local~Configuration",
            INDEX := 196,
            LEN := "conf_LEN",
            DONE => "conf_DONE",
            BUSY => "conf_BUSY",
            RECORD := "ConfDB".ConfigControl["ConfDB".Option],
//Selection of control data record
            ERROR => "conf_ERROR",
            STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

– In the graphical programming languages, you implement the loop using instructions for program control.
  Example in FBD: Use the LABEL (jump label) and JMP (jump at RLO=1) instructions to program a loop.

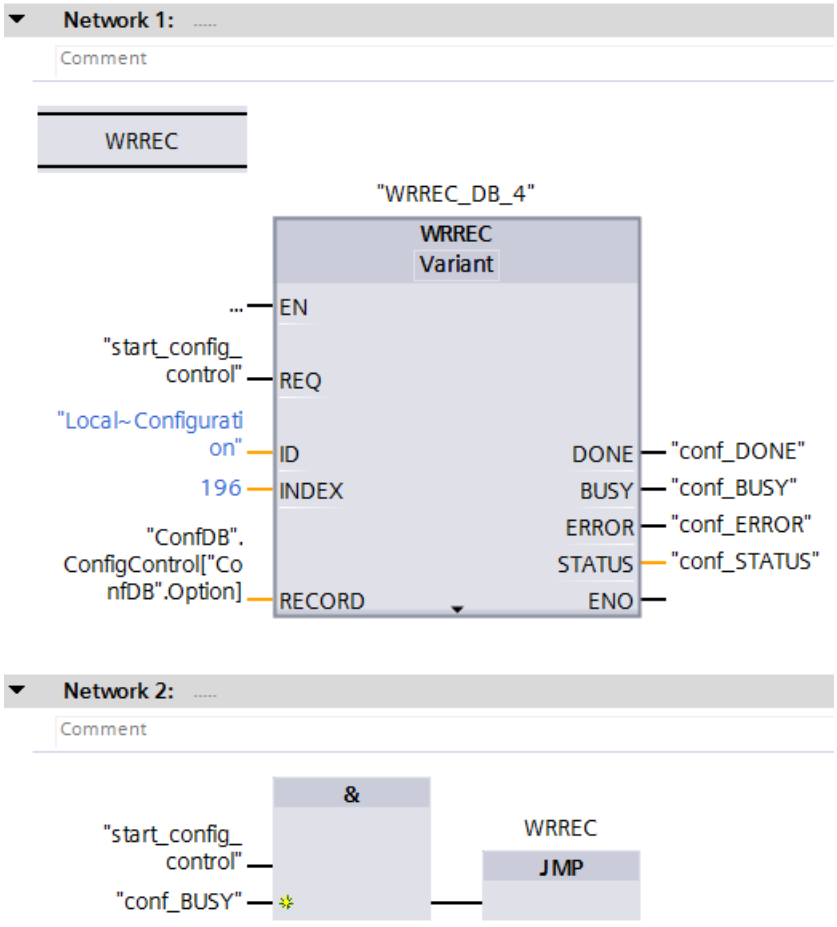


Figure 1-131 WRREC

- The control data record is stored retentively in the CPU. Note:
  – The retentivity of the control data record is independent of the retentivity settings in the STEP 7 memory area. This means that the memory area in which the control data record is configured does not have to be configured as retentive for this purpose.
  – If you write a control data record with modified configuration, the original data record 196 is deleted and the new data record 196 is saved retentively. The CPU will then restart with the modified configuration.
  – The control data record is saved retentively in the CPU, which means that it is not necessary to write the control data record 196 again at a restart if the configuration is unchanged. We recommend that a memory reset of the CPU be performed prior to commissioning to delete any control data record that may be present.

Special aspects relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200SP station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If there have been no changes to the configuration, you do not need to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration to the interface module, it will result in a station failure in the distributed I/O system. The original data record 196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

12.4 Behavior during operation

Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module supplies diagnostic information. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows a faulty module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

Response when modules are missing

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct write access to the outputs that are not present or write access to the process image of the outputs that are not present: Remains without effect; no access error is signaled.
- Direct read access to the inputs that are not present or read access to the process image of the inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: An error is signaled because a valid data record cannot be returned.

Inserting modules on empty slots

If you replace a BU cover placed on an empty slot with an I/O module when configuration control is enabled, the ET 200SP distributed I/O system behaves as follows:

- Interface module: When the BU cover is removed, a removal interrupt is signaled. When the I/O module is inserted, an insertion alarm (wrong module) is signaled.
- CPU: A removal/insertion interrupt is not signaled when the BU cover is removed or when the I/O module is inserted.

12.5 Examples of configuration control

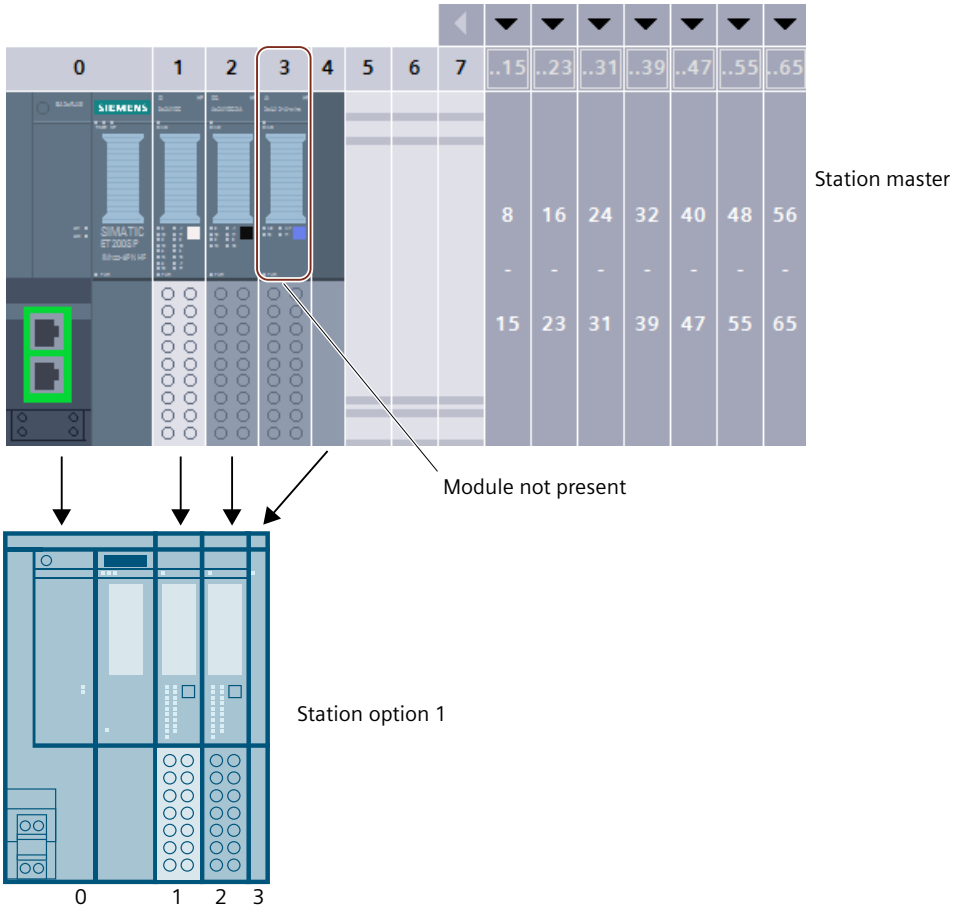
A station master consisting of an interface module, three I/O modules and the server module is configured in STEP 7 in the following section.

Four station options are derived from the station master with the configuration control:

- Station option 1 with module that is not present
- Station option 2 with modified order of modules
- Station option 3 with empty slot
- Station option 4: Opening a new potential group

Station option 1 with module that is not present

The module that is located in slot 3 in the station master is not present in the station option 1. Slot 3 must be designated in the control data record accordingly with 0 (= not present). The server module is located in slot 3 in the station option.

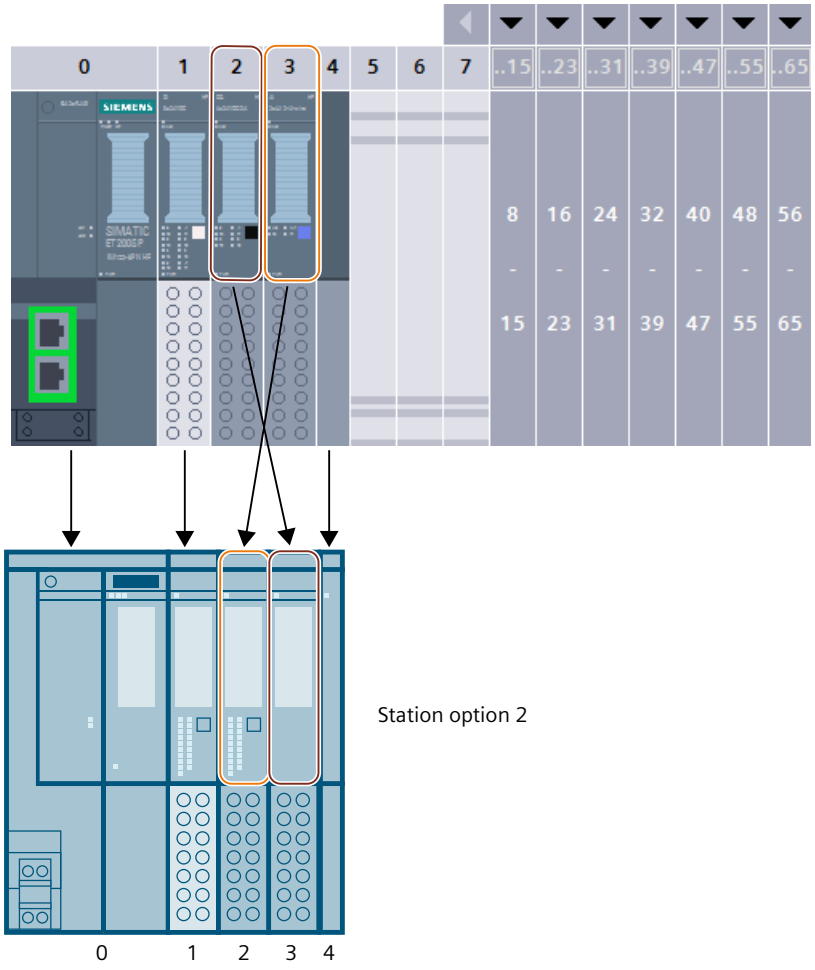


5		ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6		Block_Lenght	USInt	134	☐	☑	☑	☐	4 + (2 x number of slots)
7		Block_ID	USInt	196	☐	☑	☑	☐	
8		Version	USInt	2	☐	☑	☑	☐	ET 200SP
9		Subversion	USInt	0	☐	☑	☑	☐	
10		Slot 1	USInt	1	☐	☑	☑	☐	assigned "real" slot
11		Add 1	USInt	0	☐	☑	☑	☐	additional function
12		Slot 2	USInt	2	☐	☑	☑	☐	assigned "real" slot
13		Add 2	USInt	0	☐	☑	☑	☐	additional function
14		Slot 3	USInt	0	☐	☑	☑	☐	assigned "real" slot
15		Add 3	USInt	0	☐	☑	☑	☐	additional function
16		Slot 4	USInt	3	☐	☑	☑	☐	assigned "real" slot
		Add 4	USInt	0	☐	☑	☑	☐	additional function

Figure 1-132 Example: Hardware configuration of station option 1 with the associated control data record in STEP 7

Station option 2 with modified order of modules

The order of the modules at slots 2 and 3 is interchanged.

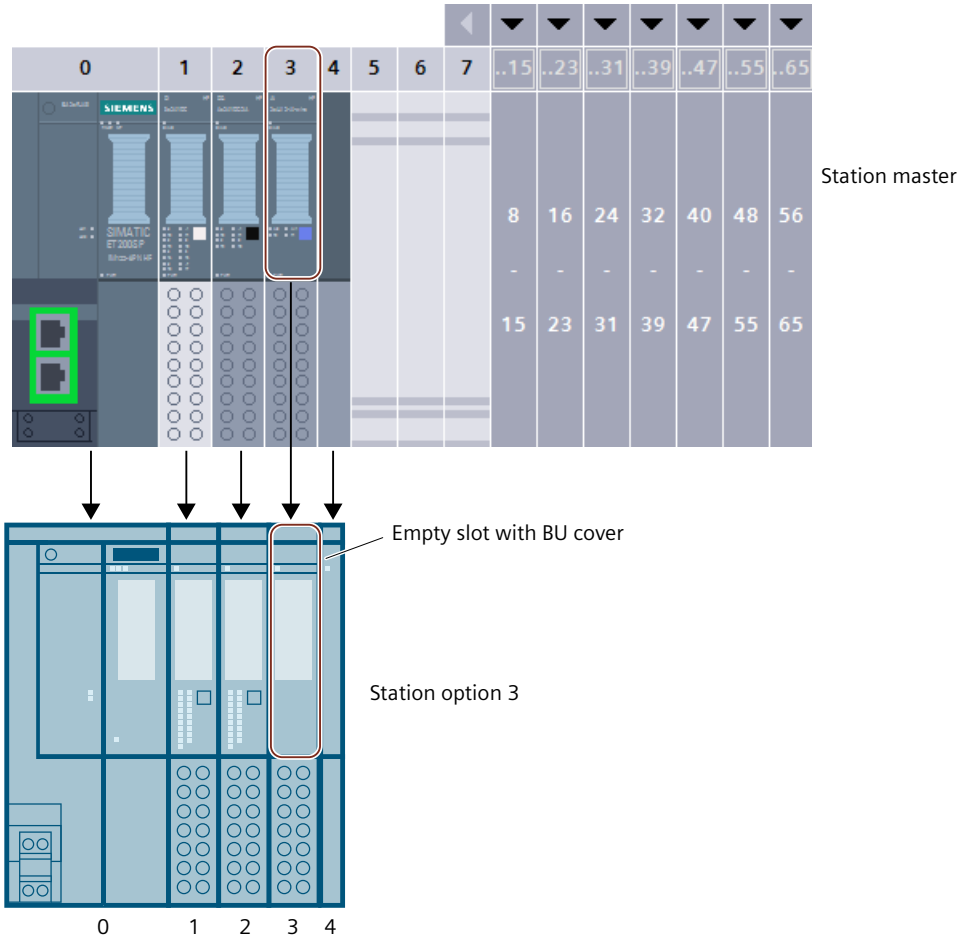


6	ConfigControl[2]	"CTR_REC"			
7	Block_Lenght	USInt	134		4 + (2 x number of slots)
8	Block_ID	USInt	196		
9	Version	USInt	2		ET 200SP
10	Subversion	USInt	0		
11	Slot 1	USInt	1		assigned "real" slot
12	Add 1	USInt	0		additional function
13	Slot 2	USInt	3		assigned "real" slot
14	Add 2	USInt	0		additional function
15	Slot 3	USInt	2		assigned "real" slot
16	Add 3	USInt	0		additional function
17	Slot 4	USInt	4		assigned "real" slot

Figure 1-133 Example: Hardware configuration of station option 2 with the associated control data record in STEP 7

Station option 3 with empty slot

The module that is located in slot 3 in the station master occupies an empty slot with BU cover in the station option. Enter the value 130 in slot 3 in the control data record.

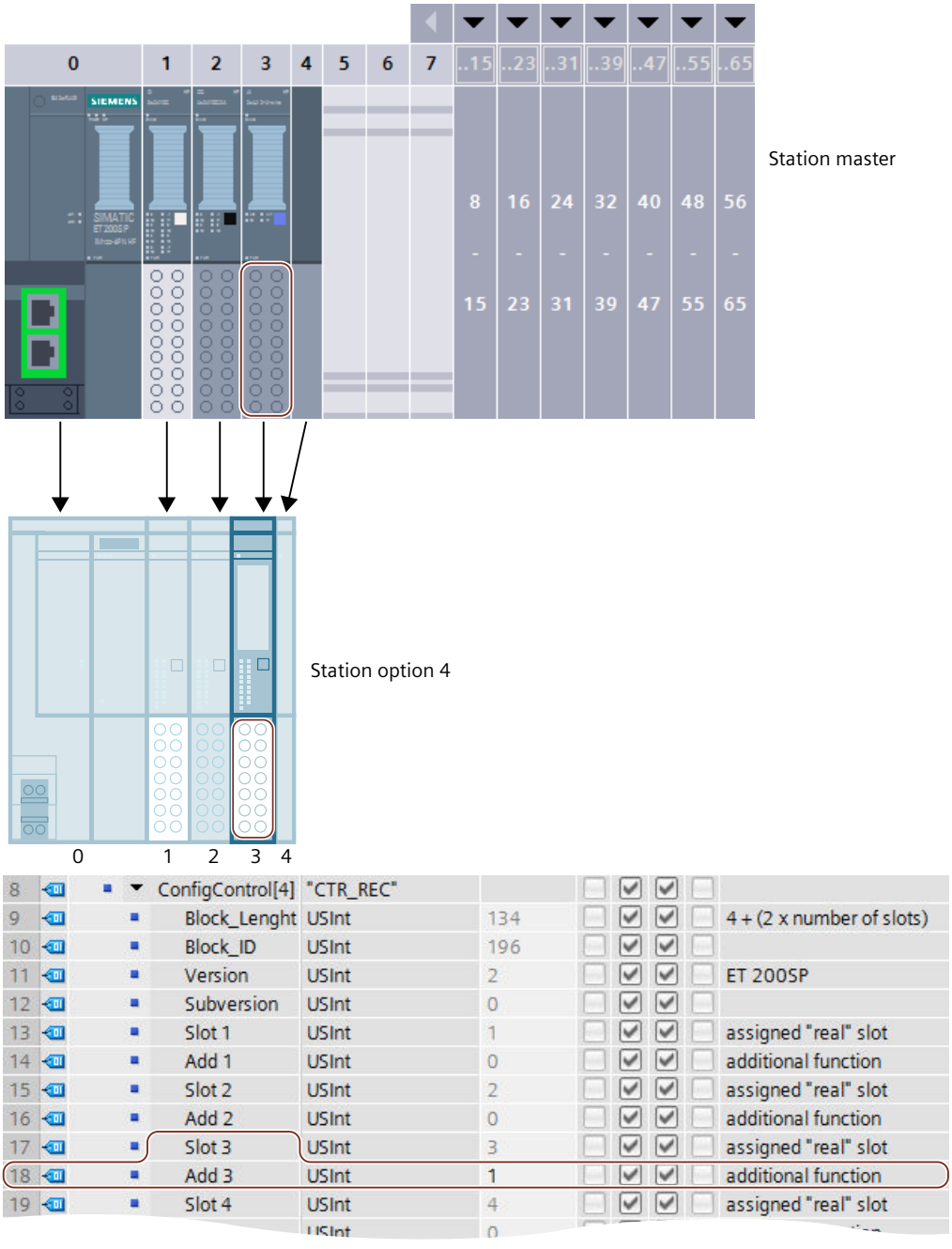


7			ConfigControl[3]	"CTR_REC"					
8			Block_Lenght	USInt	134				4 + (2 x number of slots)
9			Block_ID	USInt	196				
10			Version	USInt	2				ET 200SP
11			Subversion	USInt	0				
12			Slot 1	USInt	1				assigned "real" slot
13			Add 1	USInt	0				additional function
14			Slot 2	USInt	2				assigned "real" slot
15			Add 2	USInt	0				additional function
16			Slot 3	USInt	131				assigned "real" slot
17			Add 3	USInt	0				additional function
			Slot 4	USInt	4				assigned "real" slot

Figure 1-134 Example: Hardware configuration of station option 3 with the associated control data record in STEP 7

Station option 4: Opening a new potential group

A new potential group is opened at slot 3 of station option 4. In contrast to the station master, a dark-colored BaseUnit has been replaced by a light-colored BaseUnit. Enter the value 1 as additional function.



8		ConfigControl[4]	"CTR_REC"					
9		Block_Lenght	USInt	134				4 + (2 x number of slots)
10		Block_ID	USInt	196				
11		Version	USInt	2				ET 200SP
12		Subversion	USInt	0				
13		Slot 1	USInt	1				assigned "real" slot
14		Add 1	USInt	0				additional function
15		Slot 2	USInt	2				assigned "real" slot
16		Add 2	USInt	0				additional function
17		Slot 3	USInt	3				assigned "real" slot
18		Add 3	USInt	1				additional function
19		Slot 4	USInt	4				assigned "real" slot

Figure 1-135 Example: Hardware configuration of station option 4 with the associated control data record in STEP 7

Commissioning 13

13.1 Overview

Introduction

This section includes information on the following topics:

- Commissioning the ET 200SP distributed I/O system on the PROFINET IO
- Commissioning the ET 200SP distributed I/O system on the PROFIBUS DP
- Startup of the ET 200SP distributed I/O system with empty slots
- Removing/inserting the SIMATIC memory card
- Operating modes of the CPU
- CPU memory reset
- Reassigning parameters during operation
- Identification and maintenance data

Commissioning requirements

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to run a complete functional test and make the necessary safety checks before the final commissioning of a plant.
Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

NOTE

Check coding element in the I/O module

Make sure that the coding element is present in the I/O module before you plug in the I/O module for the first time. This reduces the risk of plugging the wrong type of module onto a wired BaseUnit when replacing a module.

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the system network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.automation.siemens.com/WW/view/en/67460624).

MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for bulk firmware update of ET 200 devices with MultiFieldbus-support and reading of service data for many other Siemens devices.

You can find MFCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773881).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of the TIA Portal.

General function overview:

- Network browsing and creation of a table showing the accessible devices in the network.
- Flashing of device LEDs or HMI display to locate a device
- Loading addresses (IP, subnet, gateway) into a device
- Loading the PROFINET name (station name) into a device name
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your programming device/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- General reset of a CPU's memory
- Resetting devices to factory settings
- Downloading a firmware update to a device

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/de/view/98161300).

13.2 Commissioning the ET 200SP for PROFINET IO

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

13.2.1 ET 200SP CPU as an IO controller

Configuration example

To use the ET 200SP distributed I/O system as an IO controller, you require the CPU 151xSP-1 PN.

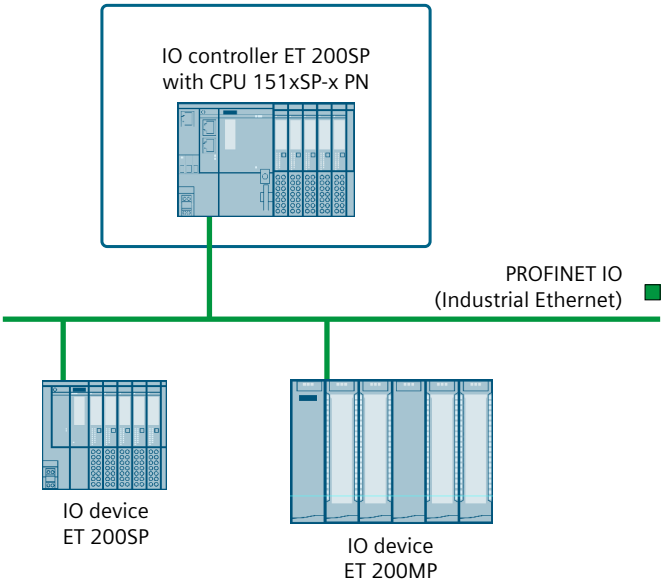


Figure 1-136 ET 200SP CPU as an IO controller

Commissioning procedure

To commission the ET 200SP distributed I/O system CPU as an IO controller for PROFINET IO, we recommend the following procedure:

Table 1-380 Procedure for commissioning the ET 200SP CPU as an IO controller for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 116)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 148)
3	Inserting a SIMATIC memory card in the IO controller	Section Removing/inserting a SIMATIC memory card on the CPU (Page 287)
4	Configuring the IO controller[1]	Section Configuring (Page 193)
5	Checking the protective measures	-

[1] The IO devices are configured with the IO controller.

Step	Procedure	See ...
6	Switching on supply voltages for the IO controller	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
7	Switching on supply voltages for IO devices	Documentation of the IO device
8	Downloading the configuration to the IO controller	STEP 7 online help
9	Switching IO controller to RUN mode	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 337)

[1] The IO devices are configured with the IO controller.

13.2.2 ET 200SP CPU as an I-device

Configuration example

You need the CPU 151xSP-1 PN to use the ET 200SP distributed I/O system as an I-device.

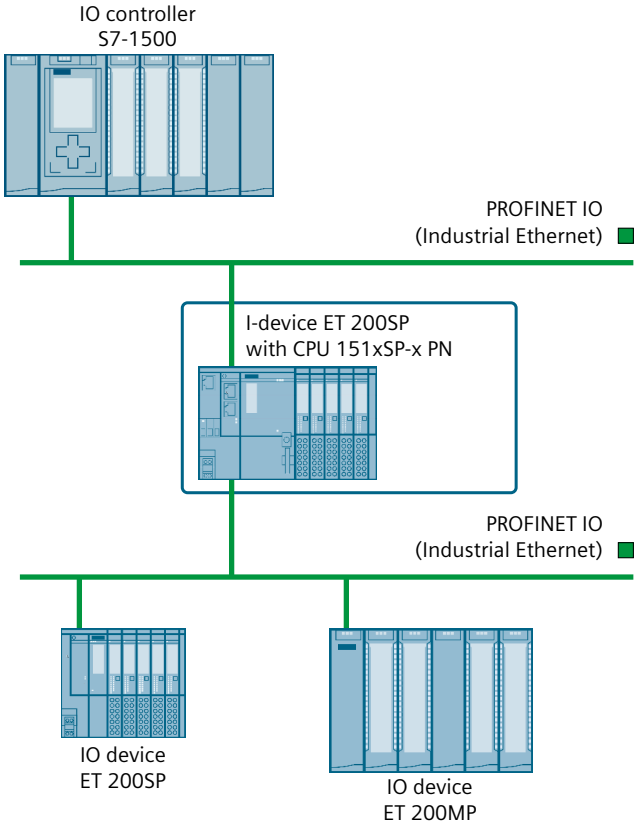


Figure 1-137 ET 200SP CPU as an I-device

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-device on the PROFINET IO, we recommend the following procedure:

Table 1-381 Procedure for commissioning the ET 200SP as an I-device on the PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 116)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 148)
3	Inserting a SIMATIC memory card in the I-device	Section Removing/inserting a SIMATIC memory card on the CPU (Page 287)
4	Configuring the I-device	Section Configuring (Page 193)
5	Checking the protective measures	-

Step	Procedure	See ...
6	Switching on supply voltages for the IO controller	Documentation of the IO controller
7	Switching on supply voltages for I-device and IO devices	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual and documentation of the IO devices
8	Download configuration to the I-device	STEP 7 online help
9	Switching IO controller and I-device to RUN mode	Documentation of the IO controller and CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 337)

13.2.3 ET 200SP as an IO device

Configuration example

To use the ET 200SP distributed I/O system as an IO device, you need the IM 155-6 PNxx interface module.

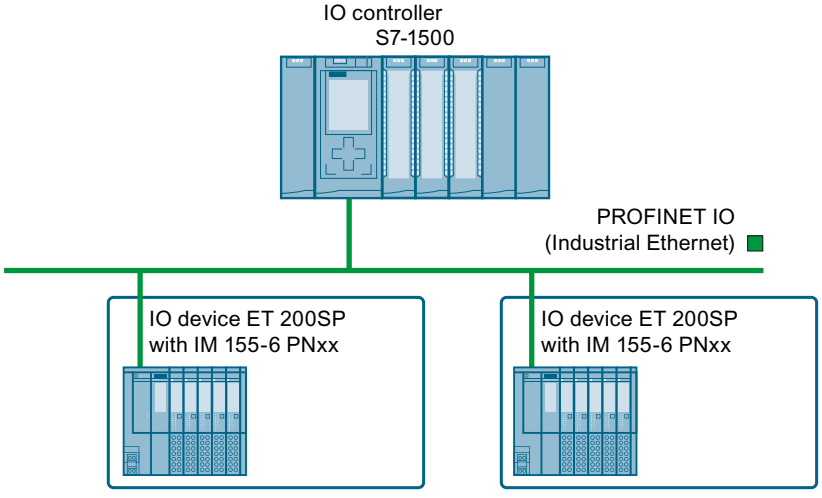


Figure 1-138 ET 200SP as an IO device

You can find information on further configuration variants of the ET 200SP distributed I/O system in redundancy mode in section "Configuration variants" of the Redundant System

S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual.

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an IO device on the PROFINET IO, we recommend the following procedure:

Table 1-382 Procedure for commissioning the ET 200SP as an IO device for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 116)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 148)
4	Configuring IO controller	Documentation of the IO controller
5	Checking the protective measures	-
6	Switching on supply voltages for the IO controller	Documentation of the IO controller
7	Switching on supply voltages for IO devices	Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
8	Downloading the configuration to the IO controller	STEP 7 online help
9	Switching IO controller to RUN mode	Documentation of the IO controller
10	Checking LEDs	Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test and service functions (Page 337)

13.3 Commissioning the ET 200SP on PROFIBUS DP

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

13.3.1 ET 200SP as a DP master

Configuration example

To use the ET 200SP distributed I/O system as a DP master, you need the CPU 151xSP-1 PN and the CM DP communication module.

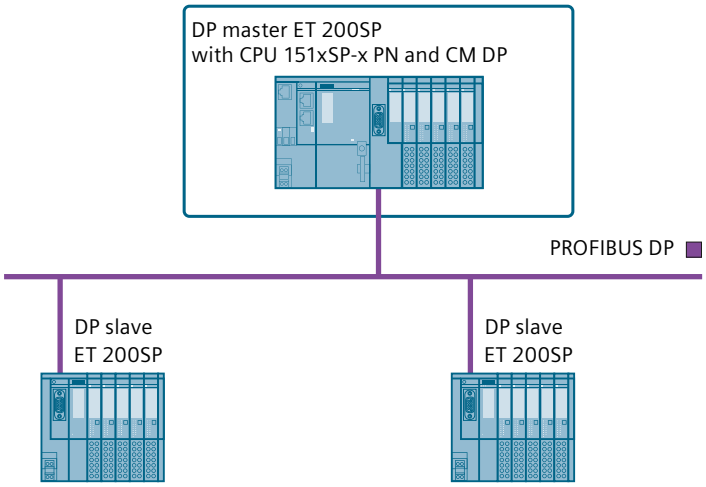


Figure 1-139 ET 200SP as a DP master

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP master on PROFIBUS DP, we recommend the following procedure:

Table 1-383 Procedure for commissioning the ET 200SP as a DP master on the PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 116)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 148)
3	Inserting a SIMATIC memory card in the DP master (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 287)
4	Configuring DP master (including PROFIBUS address)	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
5	Switching on supply voltages for DP master	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
6	Switching on supply voltages for DP slaves	Documentation of the DP slave
7	Download configuration to the DP master	STEP 7 online help

Step	Procedure	See ...
8	Switching DP master to RUN	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
9	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 337)

13.3.2 ET 200SP as I-slave

Configuration example

To use the ET 200SP distributed I/O system as I-slave, you need the CPU 151xSP-1 PN and the CM DP communication module.

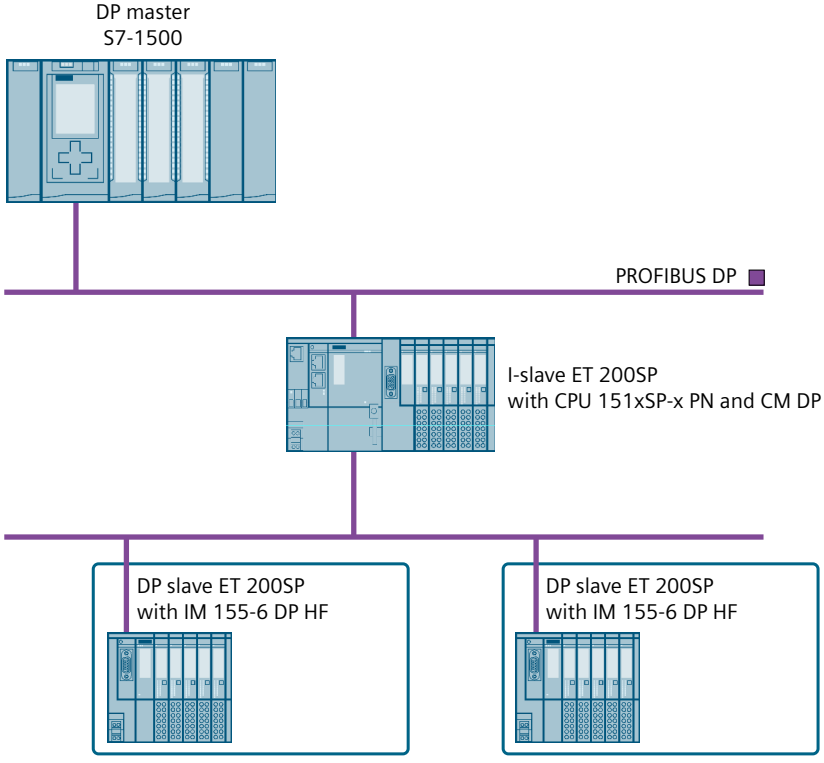


Figure 1-140 ET 200SP as I-slave

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-slave on the PROFIBUS DP, we recommend the following procedure:

Table 1-384 Procedure for commissioning the ET 200SP as an I-slave for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 116)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 148)
3	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
4	Inserting a SIMATIC memory card in the I-slave (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 287)
5	Configuring I-slave (including PROFIBUS address)	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
6	Switching on supply voltages for DP master	Documentation of the DP master
7	Switching on supply voltages for I-slaves	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
8	Loading configuration in the DP master and I-slaves	STEP 7 online help
9	Switching DP master and I-slaves to RUN	Documentation of the DP master and CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See the Test functions and fault resolution (https://support.automation.siemens.com/WW/view/en/90466439/133300) section

13.3.3 ET 200SP as a DP slave

Configuration example

To use the ET 200SP distributed I/O system as a DP slave, you need the IM 155-6 DP HF.

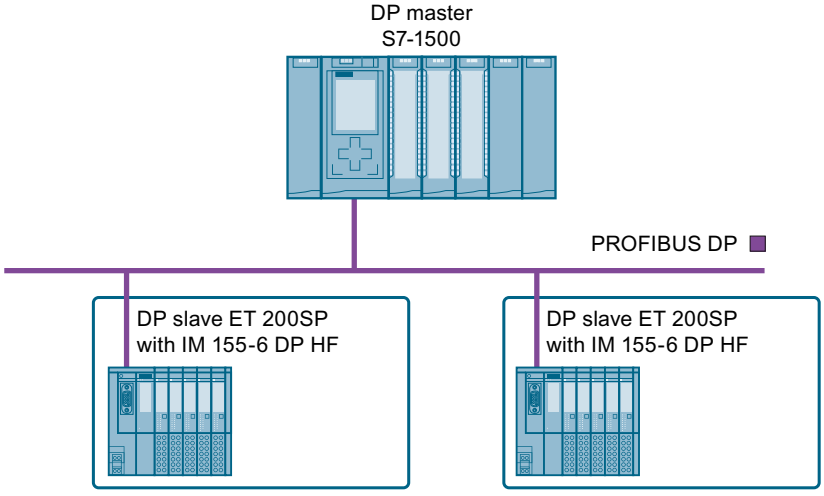


Figure 1-141 ET 200SP as a DP slave

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP slave on PROFIBUS DP, we recommend the following procedure:

Table 1-385 Procedure for commissioning the ET 200SP as a DP master for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with IM 155-6 DP HF)	Section Installation (Page 116)
2	Setting the PROFIBUS address on the interface module	Section Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)
3	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 148)
4	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
5	Switching on supply voltages for DP master	Documentation of the DP master
6	Switching on supply voltages for DP slaves	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
7	Download configuration to the DP master	STEP 7 online help

Step	Procedure	See ...
8	Switching DP master to RUN	Documentation of the DP master
9	Checking LEDs	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test and service functions (Page 337)

13.4 Startup of the ET 200SP with empty slots

Procedure

You can configure the ET 200SP distributed I/O system with any number of empty slots.

To build the ET 200SP distributed I/O system with any number of empty slots, follow these steps:

1. Cover all empty slots with BU covers.
2. Finish the configuration with a server module.

Special consideration: A "Module missing in slot x" diagnostic message is generated by the CPU/interface module for empty slots in which I/O modules are configured.

13.5 Removing/inserting a SIMATIC memory card on the CPU

Requirement

The CPU only supports pre-formatted SIMATIC memory cards. If necessary, delete all previously stored data before using the SIMATIC memory card. You can find more information on deleting the content of the SIMATIC memory card in the function manual Structure and use of the CPU memory.

In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. If it is, move the slider out of the lock position.

Inserting the SIMATIC memory card

To insert a SIMATIC memory card, follow these steps:

1. Ensure that the CPU is either switched off or in STOP mode.
2. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.

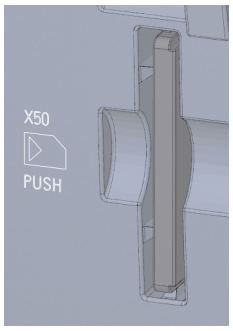


Figure 1-142 Slot for the SIMATIC memory card

3. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removal of the SIMATIC memory card

To remove a SIMATIC memory card, follow these steps:

1. Switch the CPU to STOP mode.
2. Press the SIMATIC memory card into the CPU with light pressure. After audible unlatching of the SIMATIC memory card, remove it.

Only remove the SIMATIC memory card in POWER OFF or STOP mode of the CPU. Ensure that no writing functions (online functions with the programming device, e.g. loading/deleting a block, test functions) are active in STOP mode or were active before POWER OFF.

Reactions after removing/inserting the SIMATIC memory card

Inserting and removing the SIMATIC memory card in STOP, STARTUP or RUN mode triggers a re-evaluation of the SIMATIC memory card. The CPU hereby compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset (which means the retentive data is deleted) and then goes to STOP.

The CPU evaluates the SIMATIC memory card, and this is indicated by the RUN/STOP LED flashing.

Reference

You can find more information on the SIMATIC memory card in the function manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101).

13.6 Operating modes of the CPU

Introduction

Operating modes describe the status of the CPU. The following operating modes are possible using the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, for example, via the PROFINET interface.

The status LEDs on the front of the CPU indicate the current operating mode.

13.6.1 STARTUP mode

Behavior

Before the CPU starts to execute the cyclic user program, a startup program is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the startup program. You have the option of programming no, one or several startup OBs.

Special features during startup

Note the following points regarding STARTUP mode:

- The CPU resets the process image input.
- All outputs are disabled or respond as configured for the given module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operational status.
- Before processing the start-up routine, the CPU transfers the I/O inputs to the process image input.
- After processing the start-up routine, the CPU releases the peripheral outputs.

NOTE

To read the current state of inputs during STARTUP, you can access inputs via the process image or via direct I/O access.
To initialize outputs during STARTUP, you can write values via the process image or via direct I/O access. The values are output to the outputs during the transition to RUN mode.

- The CPU always starts up in warm restart mode.
  - The non-retentive bit memory, timers and counters are initialized.
  - The non-retentive tags in data blocks are initialized.
- During startup, cycle-time monitoring is not yet running
- The CPU processes the startup OBs in the order of the startup OB numbers. The CPU processes all programmed startup OBs regardless of the selected startup mode. (Figure "Setting the startup behavior").

- If a corresponding event occurs, the CPU can start the following OBs during startup:
  - OB 82: Diagnostics interrupt
  - OB 83: Pull/plug interrupt for modules
  - OB 86: Rack error
  - OB 121: Programming error (only for global error handling)
  - OB 122: I/O access error (only for global error handling)

    You can find a description of how to use global and local error handling in the STEP 7 online help.

  The CPU does not start all the other OBs until the transition to RUN mode.

Response when expected and actual configurations do not match

The configuration downloaded to the CPU represents the expected configuration. The actual configuration is the actual configuration of the ET 200SP distributed I/O system. If the expected configuration and actual configuration do not match, the setting of the "Comparison preset to actual configuration" parameter determines the behavior of the CPU. You can find additional information on hardware compatibility in the section Operating mode transitions (Page 293).

Cancellation of startup

If errors occur during startup, the CPU cancels startup and returns to STOP mode.

The CPU does not perform the startup or interrupts the startup under the following conditions:

- You have not inserted a SIMATIC memory card or have inserted an invalid one.
- You have not downloaded a hardware configuration to the CPU.

Configuring the startup behavior

You configure the behavior of the CPU in the Startup group in the CPU properties.

Setting the startup behavior

To set the startup behavior, follow these steps:

1. Select the CPU in the device view of the STEP 7 hardware network editor.
2. In the properties under "General" select the "Startup" area.

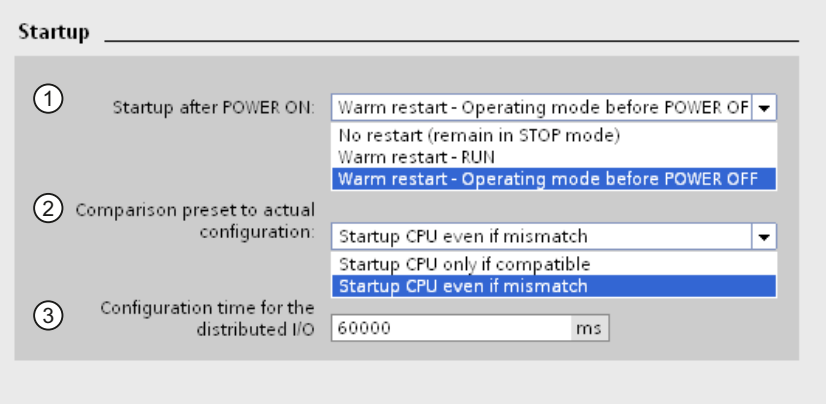


Figure 1-143 Setting the startup behavior

① Sets the startup type after POWER ON

② Defines the startup behavior when a module in a slot does not correspond to the configured module. You can set this parameter centrally, on the CPU or for each module. When you change the setting for a module, the setting made centrally for this module no longer applies.

- Startup CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module. Compatible means that the module matches in terms of the number of inputs and outputs and with respect to its electrical and functional properties.
- Startup CPU even if mismatch: With this setting the CPU starts up regardless of the type of module plugged in.

③ Specifies a maximum period (default: 60000 ms) in which the I/O must be ready for operation. The CPU changes to RUN.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the "Comparison preset to actual configuration" parameter.

Example for the "Comparison preset to actual configuration" parameter

"Startup CPU only if compatible":

The DI 16x24VDC ST input module with 16 digital inputs is a compatible replacement for a DI 8x24VDC ST input module with 8 digital inputs. The pin assignment and all electrical and functional properties are identical.

"Startup CPU even if mismatch":

Instead of a configured digital input module, you insert an analog output module or no module is present in this slot and thus in all subsequent slots. Although the configured inputs cannot be accessed, the CPU starts up.

Note that the user program cannot function correctly in this case and take the appropriate measures.

13.6.2 STOP mode

Behavior

The CPU does not execute the user program in STOP mode.

All outputs are disabled or react according to the parameter settings for the particular I/O module: They provide a substitute value as set in the parameters or retain the last value output keeping the controlled process in a safe operating status.

In STOP mode, the motor starter responds according to how it was parameterized for the CPU STOP state. The CPU STOP state can be circumvented with the manual local control (Local Control) function. If the CPU is switched off, a motor can be switched on in the motor starter's commissioning mode.

You will find additional information in the Motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

13.6.3 RUN mode

Behavior

In "RUN" mode the cyclic, time-driven, and interrupt-driven program is executed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. See also the section Process images and process image partitions (Page 199).

Execution of the user program

Once the CPU has read the inputs, the cyclic program is executed from the first instruction to the last instruction.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time is finished even if the user program is completed sooner.

A cycle monitoring time is set to ensure that the cyclic program is completed within a specified time. You can change the cycle monitoring time to suit your requirements. If the cyclic program has not finished running within this time, the system responds with a time error.

Further events such as hardware interrupts and diagnostics interrupts can interrupt the cyclic program flow and prolong the cycle time.

Reference

Further information about cycle and response times is available in the Function Manual Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

13.6.4 Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:

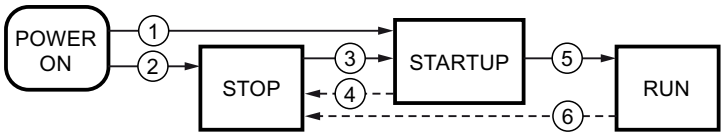


Figure 1-144 Operating modes and operating mode transitions

The table below shows the effects of the operating mode transitions:

Table 1-386 Operating mode transitions

No.	Operating mode transitions		Effects
①	POWER ON → STARTUP	After switching on, the CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The preceding "POWER OFF" was triggered by an interruption in the power supply. • Startup type "Warm restart - RUN" is set. Or • Startup type "Warm restart - mode before POWER OFF" is set and the CPU was in RUN mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
②	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are inconsistent. Or • The "No restart" startup type is set. Or • Startup type "Warm restart - mode before POWER OFF" is set and the CPU was in STOP mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
③	STOP → STARTUP	The CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • You set the CPU to "RUN" mode via the programming device and the mode switch in is RUN position. Or • You set the mode switch from STOP to RUN.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
④	STARTUP → STOP	In the following cases, the CPU goes from "STARTUP" to "STOP" mode when: • The CPU detects an error during startup. • You set the CPU to "STOP" via the programming device or mode switch. • The CPU executes a STOP command in the Startup OB.	These operating mode transitions have no effect on data.

No.	Operating mode transitions		Effects
⑤	STARTUP → RUN	In the following cases, the CPU goes from "STARTUP" to "RUN" mode when: • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.	These operating mode transitions have no effect on data.
⑥	RUN → STOP	In the following cases, the CPU goes from "RUN" back to "STOP" mode when: • The CPU detects an error which prevents further work. • The CPU executes a STOP command in the user program. • You set the CPU to "STOP" via the programming device or mode switch.	

13.7 CPU memory reset

Basics of a memory reset

The CPU must be in STOP mode for a memory reset.

A memory reset returns the CPU to its "initial state".

Memory reset means:

- An existing online connection between your programming device/PC and the CPU is terminated.
- The content of the work memory and the retentive and non-retentive data (applies only to manual memory reset by the user) are deleted.
- The diagnostics buffer, time of day, IP address and the device name are retained.
- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). The CPU copies this data from the load memory to the work memory.

  Result:

  – If you set an IP address in the hardware configuration ("Set IP address in the project" option) and a SIMATIC memory card with the project is in the CPU, this IP address is valid after the memory reset.
  – Data blocks no longer have current values but rather their configured start values.
  – Force jobs remain active.

Detecting a CPU memory reset

The RUN/STOP LED flashes yellow at 2 Hz. After completion, the CPU switches to STOP. The RUN/STOP LED is on (constant yellow light).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Table 1-387 Memory objects after memory reset

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Retentive tags from technology objects (for example, adjustment values of absolute encoders)*	Retained
Diagnostics buffer entries	Retained
IP address	Retained
Device name	Retained
Counter readings of the runtime meters	Retained
Time of day	Retained

* The retentive tags from technology objects are retained but the content of certain tags is re-initialized in some cases.

NOTE

Password for protection of confidential configuration data

The password for protection of confidential configuration data is retained after a memory reset of the CPU. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find additional information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

13.7.1 Automatic memory reset

Possible causes of automatic memory reset

The CPU executes an automatic memory reset if an error occurs that prevents normal further processing.

Causes of such errors are:

- User program is too large, and cannot be completely loaded into work memory.
- The project data on the SIMATIC memory card is corrupt, for example, because a file was deleted.
- If you remove or insert the SIMATIC memory card and the backed-up retentive data differs in structure from that of the configuration on the SIMATIC memory card.

13.7.2 Manual memory reset

Reason for a manual memory reset

CPU memory reset is required to reset the CPU to its "original state".

CPU memory reset

Two options are available for performing a CPU memory reset:

- Using the mode selector
- Using STEP 7

Procedure using the mode selector

NOTE

Memory reset ↔ Reset to factory settings

The procedure described below also corresponds to the procedure for resetting to factory settings:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

To reset the CPU memory using the mode selector, proceed as follows:

1. Set the mode selector to the STOP position.
   Result: The RUN/STOP LED lights up yellow.
2. Set the mode selector to the MRES position. Hold the selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

For information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 328).

Procedure using STEP 7

For a memory reset of the CPU using STEP 7 proceed as follows:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU switches to STOP mode and performs a memory reset.

13.8 Reassigning parameters during operation

Introduction

You have the option of reassigning the parameters for the ET 200SP I/O modules during operation.

Changing parameters during operation

You make the parameter settings of the I/O modules using data records. Each I/O module has a separate data record. The instruction "WRREC" applies the changed parameters to the I/O module. The parameters that you have set with STEP 7 are not changed. After a POWER OFF/POWER ON of the ET 200SP, the parameters set with STEP 7 are valid again.

If you are using the CPU as an I-device, you reassign the parameters of the I/O modules via the I-device.

NOTE

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can evaluate OB83 for this purpose. After inserting a module, the CPU does not call OB83 until the module has started up and its parameters are assigned. This ensures the execution of the data record operations without errors.

NOTE

You need to transfer the new parameters with the "WRREC" instruction after a POWER OFF/POWER ON of the ET 200SP.

Instruction for parameter assignment

The following instruction is provided for assigning parameters to the I/O module in the user program:

Instruction	Application
"WRREC"	Transfer the modifiable parameters to the addressed ET 200SP module.

Error message

In the event of an error, the following return values are reported:

Table 1-388 Error message

Error code	Meaning
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Reference

You can find the structure of the parameter data record and the module-specific error codes in the manuals of the I/O modules (https://support.automation.siemens.com/WW/view/es/55679691/133300).

13.9 Backing up and restoring the CPU configuration

13.9.1 Overview

Backup from online device
You make changes where necessary in the system operation. You add new devices, replace existing devices or adapt the user program. If these changes result in undesirable behavior, you can restore the plant to an earlier state. Before you load a changed configuration to the CPU, first use the option "Backup from online device" to create a complete backup of the current device status. If you have assigned a password to protect confidential PLC configuration data, then this password is not secured.

When a backup is restored that has a password set for protection of confidential configuration data, the following applies:
The password in the CPU must match the password in the backup.
Transfer the password to the CPU before restoring the backup. You transfer the password either using a SIMATIC Memory Card or online in STEP 7 via "Online & Diagnostics". If the password in the CPU does not match the password entered in STEP 7, the SIMATIC Memory Card will be rejected when restoring the backup. The CPU generates an entry in the diagnostic buffer.

You can find more information in section Protection of confidential configuration data (Page 222) and in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) Function Manual.

Upload from device (software)
With the option "Upload from device (software)", you load the software project data from the CPU to an existing CPU in the project.

Upload device as new station
If you are operating a new PG/PC on a system, the STEP 7 project that was used to create the system configuration might not be available. In this case, you upload the data to a project in your PG/PC with the "Upload device as new station" option.

Snapshot of the monitor values
To allow you to restore the actual values after changes, back up the actual values of the data blocks with the "Snapshot of the monitor values" option.

Overview of backup types

The table below shows the backup of CPU data depending on the selected type of backup and its specific characteristics:

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Current values of all DBs (global and instance data blocks) [1]	✓	✓	✓	✓
Blocks of the type OB, FC, FB and DB	✓	✓	✓	--
PLC tags (tag names and constant names)	✓	✓	✓	--
Technology objects	✓	✓	✓	✓ [3]
Hardware configuration	✓	--	✓	--
Actual values (bit memories, timers, counters)*	✓	--	--	--
Contents of the SIMATIC memory card	✓	--	--	--
Archives, recipes	✓	--	--	--
Entries in the diagnostics buffer	--	--	--	--
Current time	--	--	--	--
Properties of the type of backup				
Backup possible for fail-safe CPUs	✓	✓ [2]	--	✓
Backup can be edited	--	✓	✓	✓
Backup possible in operating mode	STOP	RUN, STOP	RUN, STOP	RUN, STOP

1) Only the values of the tags that are set as retentive are saved.

2) Only possible in the STOP operating state and for individual fail-safe blocks.

3) Nur die High_Speed_Counter and SSI_Absolute_Encoder modules

Example: Backup from online device

The following example shows the procedure for a complete backup of the current device state of the CPU in STEP 7. The S7-1500 automation system is in RUN mode. Before the backup, the CPU goes into STOP mode.

To start the backup, proceed as follows:

1. Right-click on the CPU in the project tree.
2. Select the "Backup from online device" command from the context menu.
   The "Upload preview" dialog window summarizes key information about the upcoming backup. You must switch the CPU to STOP mode to perform a backup.
3. In the "Action" column, select the "Stop module" command from the drop-down menu.
4. Click "Upload from device". The CPU switches to STOP mode. The backup of the CPU data starts. The backup is saved in the folder of the CPU under "Online backups" in the project tree.

Example: Restoring backup from online device

If you have backed up the CPU data earlier, you can transfer the backup back to the device. The saved backup is then restored on the CPU.

The automation system is in RUN mode. Before the restore operation, the CPU goes into STOP mode.

To start restoring the backup, proceed as follows:

1. Expand the folder of the CPU in the project tree. The lower-level objects are displayed.
2. Open the "Online backups" folder.
3. Select the backup you want to restore.
4. In the "Online" menu, select the "Download to device" command.
5. The "Load preview" dialog window summarizes key information about the upcoming restore operation. You must switch the CPU to STOP mode to restore a backup.
6. In the "Action" column, select the "Overwrite" command from the drop-down menu.
7. Click "Load". The CPU switches to STOP mode. The backup is transferred to the CPU and restored. The "Load results" dialog then opens. In this dialog, you can check whether the download was successful and select any other actions (no action, start modules).
8. Click the "Finish" button.

Rules for backup and restore

Observe the following rules when backing up/restoring:

- Complete the process quickly and without interruptions.
- The CPU and the programming device must be in a protected network.
- Decide in advance whether you want to back up/restore the data of a CPU in STEP 7 or via the web server of the CPU.
  If you start the operation in STEP 7, you must also finish it in STEP 7. The same applies if you use the web server.
  - To perform the operation in STEP 7, the user requires either the "PLC administrator" role or a role with the "Full access" function right.
  - To perform the operation via the web server of the CPU, the user requires a role with the "Create a backup of the CPU" or "Restore the CPU using a backup file" function right.
- The user who starts the operation must also complete the operation.
- If a user cancels the operation or the CPU cancels the operation due to an error, only the user who canceled the operation can resume it. To do so, the following intermediate steps are required:
  - Reset to factory settings
  - Download from STEP 7
  - Start a new backup/restore

Reference

You can find more information on the different backup types in the STEP 7 online help.

Emergency address (emergency IP)

The emergency address (emergency IP address) of a CPU was conceived for diagnostic and downloading functions, e.g. if the CPU can no longer be reached via the IP protocol due to loading of an incorrect project. You can find information on the emergency address in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Archiving multilingual project texts

When you configure a CPU, different categories of texts come into being, e.g.

- Object names (names of blocks, modules, tags, etc.)
- Comments (for blocks, networks, watch tables, etc.)
- Messages and diagnostic texts

Texts are provided by the system (e.g. diagnostic buffer texts) or are created during configuration (e.g. messages).

In a project, texts exist in one single language or in several languages after a translation process. You can maintain project texts in all languages, which are at your disposal in the project navigator (Languages & Resources > Project Texts). The texts arising during configuration can be loaded into the CPU.

The following texts containing the project data are loaded into the CPU in the chosen languages and are also used by the Web server:

- Diagnostic buffer texts (not editable)
- Module status texts (not editable)
- Message texts with associated text lists
- Tag comments and step comments for S7 GRAPH and PLC Code Viewer
- Comments in watch tables

The following texts containing the project languages are also loaded into the CPU in the chosen languages, but are not used by the Web server:

- Comments in tag tables (for tags and constants)
- Comments in global data blocks
- Comments of elements in block interfaces of FBs, FCs, DBs and UDTs
- Network titles in data blocks that are written in ladder logic (LAD), function block diagram (FBD) or statement list (STL)
- Block comments
- Network comments
- Comments of LAD and FBD elements

The CPUs support archiving of multilingual project texts in up to three different project languages. If the project texts for a particular project language nevertheless exceed the memory space reserved for them, the project cannot be downloaded to the CPU. The download is aborted with a notice that not enough memory space is available. In such a case, take measures to reduce the required storage space, for example by shortening comments.

NOTE

Size of the SIMATIC memory card

If, when loading projects, the required memory space is more extensive/larger than the memory space on the
SIMATIC memory card used, the download to the CPU is canceled. You receive an error message.
Therefore, make sure that there is enough available storage space on your SIMATIC memory card for loading projects.

You will find information on reading out the storage space capacity utilization of the CPU and the SIMATIC memory card in the Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/de/view/59193101/en) function manual.

You will find information on parameterization of multilingual project texts in STEP 7 in the STEP 7 online help.

13.10 Time synchronization

Introduction

All CPUs are equipped with an internal clock. The clock shows:

- The time of day with a resolution of 1 millisecond
- The date and the day of the week

The CPU takes into account the time change caused by daylight saving time.

You can synchronize the time of the CPUs with an NTP server in NTP mode (NTP: Network Time Protocol).

Operating principle

In NTP mode, the device sends time queries at regular intervals (in client mode) to the NTP server in the subnet (LAN). Based on the replies of the servers, the most reliable and most accurate time is calculated and the time of day of the CPU is synchronized. The advantage of this mode is that it allows the time to be synchronized across subnets. You can synchronize the time of day of up to a maximum of four NTP servers. You address a communications processor or an HMI device, for example, as sources for time synchronization via the IP addresses.

The update interval defines the interval between the time queries (in seconds). The value range of the interval is between 10 seconds and one day. In NTP mode, it is generally UTC (Universal Time Coordinated) that is transferred. UTC corresponds to GMT (Greenwich Mean Time).

NTP server for the ET 200SP CPU

You can assign an ET 200SP CPU to up to 4 NTP servers.

You have the following options to reset the IP addresses of the NTP servers:

- Configure IP addresses of the NTP servers in STEP 7.
- Set IP addresses of the NTP servers with the "T_CONFIG" instruction.
- Obtain IP addresses of the NTP servers via DHCP.
  As of firmware version V2.9, the CPU can also obtain the NTP servers via DHCP. You can find more information on the procedure and the DHCP communication protocol in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Configuring IP addresses of the NTP servers in STEP 7

To configure the IP addresses of the NTP servers in STEP 7, follow these steps:

1. Select the ET 200SP CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:", select "Set NTP server in the project" from the drop-down list.
4. Enter the IP addresses of up to four NTP servers for "Server 1" to "Server 4".
5. Set the time interval of time queries for "Update interval". Set the update interval to between 10 s and 86400 s.

Setting the IP addresses of the NTP servers with the "T_CONFIG" instruction

Requirements:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

Proceed as follows to set the IP addresses of the NTP servers with the T_CONFIG instruction:

1. Enter the IP addresses of up to four NTP servers in a tag of the data type IF_CONF_NTP.
2. Interconnect the tag of data type IF_CONF_NTP at the block parameter CONF_DATA of the T_CONFIG instruction.
3. Call the T_CONFIG instruction in the user program.

Result: The addresses of the NTP servers from the T_CONFIG instruction are transferred to the CPU.

If necessary, you can change the addresses of the NTP servers several times with T_CONFIG.

Reference

For additional information on time synchronization in the automation environment, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/de/en/view/86535497).

13.10.1 Example: Configuring and changing NTP server

Automation task

You are using your own NTP server in your network with the IP address 192.168.1.15. Your own server provides you with the following advantages:

- Protection against unauthorized accesses from outside
- Every device that you synchronize with your own NTP server uses the same time.

You want to synchronize the ET 200SP CPU with this NTP server.

The following sections describe how to configure the IP address of the NTP server in STEP 7 or set it in the user program.

Configuring the IP address of the NTP server in STEP 7

Procedure

1. Select the ET 200SP CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:", select "Set NTP server in the project" from the drop-down list.
4. For "Server 1:", enter the IP address of the NTP server: 192.168.1.15.
5. Download the hardware configuration to the CPU.

Result

The CPU synchronizes the time with the NTP server 192.168.1.15.

Set IP addresses of the NTP server with the "T_CONFIG" instruction

Requirements:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

To set the IP address for the NTP server, use the following block parameters of the "T_CONFIG" instruction:

- Req: A positive edge at the block parameter "Req" starts a job of the "T_CONFIG" instruction.
- Interface: Enter the HW ID of the PROFINET interface 1 of the CPU at the block parameter "Interface". In this example, the HW ID is "64".
- Conf_Data: Area in which you save the IP addresses of the NTP server. Use the data type "IF_CONF_NTP" for this purpose.

Procedure

Proceed as follows to set the IP address of the NTP server in the user program to "192.168.1.15":

1. Create a global data block in the project tree under "Program blocks > Add new block". Name the global data block "NTP".
2. Create a tag of the data type "IF_CONF_NTP" in the global data block "NTP".

NTP

	Name	Data type	Start value	Comment
1	Static			
2	NTP_Server	IF_CONF_NTP		
3	Id	UInt	17	
4	Length	UInt	22	
5	Mode	UInt	0	
6	NTP_IP	Array[1..4] of IP_V4		
7	NTP_IP[1]	IP_V4		
8	ADDR	Array[1..4] of Byte		IPv4 address
9	ADDR[1]	Byte	192	IPv4 address
10	ADDR[2]	Byte	168	IPv4 address
11	ADDR[3]	Byte	1	IPv4 address
12	ADDR[4]	Byte	10	IPv4 address
13	NTP_IP[2]	IP_V4		
14	NTP_IP[3]	IP_V4		
15	NTP_IP[4]	IP_V4		
16	change_NTP-Server	Bool	false	
17	done	Bool	false	
18	busy	Bool	false	
19	error	Bool	false	
20	status	DWord	16#0	
21	err_loc	DWord	16#0	

Figure 1-145 Example: Data block with IF_CONF_NTP

3. Create a "T_CONFIG" instruction in the user program.
4. Connect the "T_CONFIG" instruction as follows.

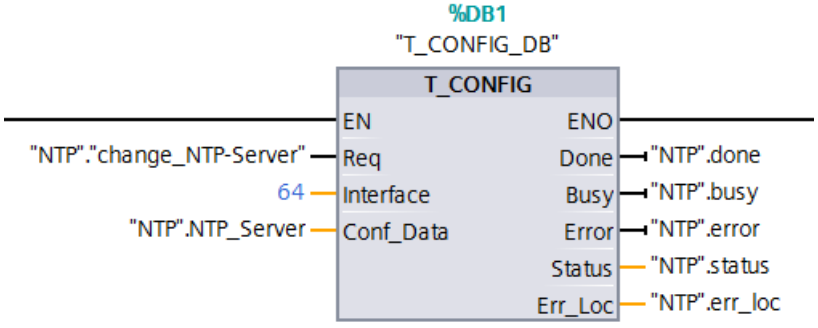


Figure 1-146 Example T_CONFIG: Changing the NTP server

5. In the user program, assign the IP address 192.168.1.15 to the data type "IF_CONF_NTP":
```
"NTP".NTP_Server.NTP_IP[1].ADDR[1] := 192;
"NTP".NTP_Server.NTP_IP[1].ADDR[2] := 168;
"NTP".NTP_Server.NTP_IP[1].ADDR[3] := 1;
"NTP".NTP_Server.NTP_IP[1].ADDR[4] := 15;
```
6. Generate a positive edge for the tag "change_NTP-Server" in the user program:
```
"NTP"."change_NTP-Server" := true;
```

Result
The CPU synchronizes the time with the NTP server 192.168.1.15.

13.11 Identification and maintenance data

13.11.1 Reading out and entering I&M data

I&M data

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a plant
- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

Maintenance data (I&M4): Storage of a CRC checksum for interface modules IM 155-6 PN ST for ensuring data integrity of data used by the interface module.

NOTE
The BusAdapter and the interface module IM 155-6 PN HF support the identification data I&M0 to I&M4 (signature).

Options for reading out I&M data

- Via the user program
- Via STEP 7 or HMI devices
- Via the CPU web server

Reading I&M data via the user program

You have the following options to read the modules' I&M data in the user program:

- Using the RDREC instruction
  The record structure for distributed modules that are accessible via PROFINET IO/PROFIBUS DP, is described in the chapter Record structure for I&M data (Page 308).
- Using the Get_IM_Data instruction

Reference

The description of the instructions can be found in the STEP 7 online help.

Reading I&M data via STEP 7

Requirements: There must be an online connection to the CPU/interface module.

To read I&M data using STEP 7, follow these steps:

1. In the project tree, under "Distributed I/O" select the IO device IM 155-6 PN ST (for example)
2. Select **> IO device > Online & diagnostics > Identification & Maintenance**.

Entering maintenance data via STEP 7

STEP 7 assigns a default module name. You can enter the following information:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)

To enter maintenance data via STEP 7, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the interface module, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data is also loaded.

Procedure for reading I&M data via the Web server

The procedure is described in detail in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) Function Manual.

13.11.2 Data record structure for I&M data

Reading I&M records via the user program (distributed via PROFINET IO)

You directly access specific identification data using **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the relevant data record index.

The data records are structured as follows:

Table 1-389 Basic structure of data records with I&M identification data

Content	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H I&M4: 0024_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H I&M4: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/index $AFF0_H$: 54 I&M1/index $AFF1_H$: 54 I&M2/index $AFF2_H$: 16 I&M3/index $AFF3_H$: 54 I&M4/Index $AFF4_H$: 54	

Table 1-390 Data record structure for I&M identification data

Identification data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
VendorIDHigh	Read (1 byte)	00_H	This is where the name of the manufacturer is stored (42_D = SIEMENS AG).
VendorIDLow	Read (1 byte)	$2\ A_H$	
Order_ID	Read (20 bytes)	6ES7155-6AU02-0BN0	Article number of the module (e.g. of the IM 155-6 PN ST interface module)
IM_SERIAL_NUMBER	Read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	Read (2 bytes)	1	Corresponding HW version

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Identification data	Access	Default	Explanation
IM_SOFTWARE_REVISION	Read	Firmware version	Provides information about the firmware version of the module
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_Enhancement	(1 byte)	00 - FF_H	
• IM_SWRevision_Bug_Fix	(1 byte)	00 - FF_H	
• IM_SWRevision_Internal_Change	(1 byte)	00 - FF_H	
IM_REVISION_COUNTER	Read (2 bytes)	0000_H	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	Read (2 bytes)	0000_H	Generic Device
IM_PROFILE_SPECIFIC_TYPE	Read (2 bytes)	0005_H	Interface modules/BusAdapters
		0003_H	I/O modules and motor starters
		0001_H	CPU
IM_VERSION	Read	0101_H	Provides information on the version of the identification data (0101_H = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	Read (2 bytes)	$000E_H$	Provides information about the available identification data (I&M1 to I&M3)
Maintenance data 1: (data record index AFF1 hex)			
IM_TAG_FUNCTION	Read/write (32 bytes)	-	Enter a module identifier here that is unique plant-wide.
IM_TAG_LOCATION	Read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (data record index AFF2 hex)			
IM_DATE	Read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (data record index AFF3 hex)			
IM_DESCRIPTOR	Read/write (54 bytes)	-	Enter a comment describing the module.
Maintenance data 4: (data record index AFF4 hex)			
USI	Read (4 bytes)	0x63726331	UserstructureIdentifier: Internal, fixed value
CHK_OVERALL	Read (4 bytes)	-	Overall CRC of all individual CRCs
CHK_OVERALL_SUBS	Read (4 bytes)	0 or value*	Overall CRC of all assigned modules of the IM
CHK_STATIC_LOCAL	Read (4 bytes)	-	CRC of static data of the IM
CHK_STATIC_SUBS	Read (4 bytes)	0 or value*	CRC of all static data of the modules of the IM
CHK_OVERALL_SETUP	Read (4 bytes)	-	Overall CRC of all setup data of the IM and modules of the IM
CHK_REMANENT_LOCAL	Read (4 bytes)	-	CRC of retentive data of the IM
CHK_REMANENT_SUBS	Read (4 bytes)	0 or value*	CRC of all retentive data of the modules of the IM

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Identification data	Access	Default	Explanation
CHK_WORKING_LOCAL	Read (4 bytes)	-	CRC of the parameters in STEP 7 for the IM
CHK_WORKING_SUBS	Read (4 bytes)	0 or value*	CRC of all parameters in STEP 7 for the modules of the IM
NOT USED	Read (14 bytes)	0	14 reserved bytes

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Reading I&M data records with data record 255 (distributed via PROFIBUS DP)

The modules support standardized access to identification data via DS 255 (index 65000 to 65003). For more information on the DS 255 data structure, refer to the specifications of the Profile Guidelines Part 1: Identification & Maintenance Functions, Order No.: 3.502, Version 2.1, May 2016

13.11.3 Example: Read out firmware version of the CPU with Get_IM_Data

Automation task

You want to check whether the modules in your automation system have the current firmware. You can find the firmware version of the modules in the I&M0 data. The I&M0 data is the basic information for a device. The I&M0 data contains information such as:

- Manufacturer ID
- Order number, serial number
- Hardware and firmware version

To read out the I&M0 data, use the "Get_IM_Data" instruction. You read the I&M0 data of all the modules in the user program of the CPU using "Get_IM_Data" instructions and store it in a data block.

Conditions and parameters

To read out the I&M data of the CPU, use the following block parameters of the "Get_IM_Data" instruction:

- LADDR: Enter the HW ID of the module at the block parameter "LADDR".
- IM_TYPE: Enter the I&M data number (e.g. "0" for I&M0 data) at the "IM_TYPE" block parameter.
- DATA: Area for storing the read I&M data (e.g. in a global data block). Store I&M0 data in an area of data type "IM0_Data".

This example shows you how to read out the I&M0 data of an ET 200SP CPU. To read out the I&M0 data of a different module, simply use the HW ID of the module at the LADDR parameter.

Solution

Proceed as follows to read out the I&M0 data of the CPU:

1. Create a global data block to store the I&M0 data.
2. Create a structure of the data type "IM0_Data" in the global data block. You can assign any name to the structure ("imData") in this case.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value
1	Static		
2	imData	IM0_Data	
3	done	Bool	false
4	busy	Bool	false
5	error	Bool	false
6	status	Word	16#0

Figure 1-147 Example: Data block for I&M data

3. Create the "Get_IM_Data" instruction in the user program, e.g. in OB 1.
4. Connect the "Get_IM_Data" instruction as follows:

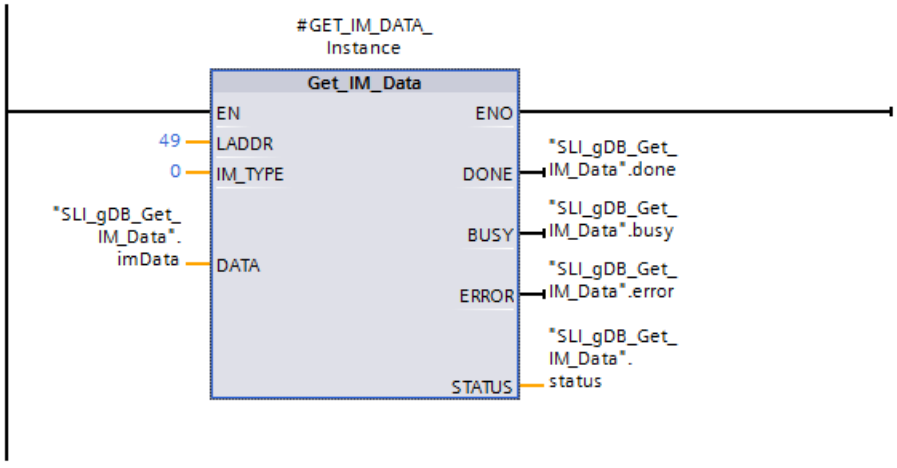


Figure 1-148 Example: Calling the "Get_IM_Data" instruction

5. Call the "Get_IM_Data" instruction in the user program.

Result

The "Get_IM_Data" instruction has stored the I&M0 data in the data block.

You can view the I&M0 data online in STEP 7, for example, in the data block with the "Monitor all" button. The CPU in the example is a 1512SP-1 PN (6ES7512-1DK01-0AK0) with the firmware version V2.5.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value	Monitor value
1	Static			
2	imData	IM0_Data		
3	Manufacturer_ID	UInt	0	42
4	Order_ID	String[20]	''	'6ES7 512-1DK01-0...
5	Serial_Number	String[16]	''	'S C-DOS710132013'
6	Hardware_Revision	UInt	0	3
7	Software_Revision	IM0_Version		
8	Type	Char	' '	'V'
9	Functional	USInt	0	2
10	Bugfix	USInt	0	5
11	Internal	USInt	0	0
12	Revision_Counter	UInt	0	0
13	Profile_ID	UInt	0	0
14	Profile_Specific_Ty...	UInt	0	0
15	IM_Version	Word	16#0	16#0101
16	IM_Supported	Word	16#0	16#001E
17	done	Bool	false	TRUE
18	busy	Bool	false	FALSE
19	error	Bool	false	FALSE
20	status	Word	16#0	16#0000

Figure 1-149 Example: I&M0 data of an ET 200SP CPU

13.12 Shared commissioning of projects

Team Engineering

In Team Engineering several users from various engineering systems work on a project at the same time and access one ET 200SP CPU.

The users can edit separate parts of a master project independently of one another at the same time. The changes of the other editors are displayed in a synchronization dialog during the loading of the configuration in the CPU and synchronized automatically, if possible.

Certain online functions can also be executed at the same time from several engineering systems on a shared CPU, such as:

- Monitoring blocks on the CPU
- Modifying blocks on the CPU
- Trace functions

You can find detailed information on the topic of Team Engineering in the STEP 7 online help.

Maintenance 14

Maintenance of Ex modules

When you use an Ex module group, observe the information in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

14.1 Removing and inserting I/O modules/motor starters (hot swapping)

Introduction

The ET 200SP distributed I/O system supports removal and insertion of I/O modules and motor starters (hot swapping) during operation (RUN mode):

- CPU/interface module HF, HS, R1: You can remove and insert any number of I/O modules/motor starters.
- ST, BA interface module: You can only remove and insert one I/O module/motor starter.

This section provides more information on removing and inserting I/O modules/motor starters.

I/O modules/motor starters must not be removed or inserted during operation (RUN operating state) in hazardous areas.

Requirements

The following table describes which modules you may insert and remove under which conditions:

Table 1-391 Removal and insertion of modules

Modules	Removal and insertion	Conditions
CPU	No	---
BusAdapter	No	---
CM DP module	No	---
Interface module	No	---
Interface module R1	Yes	The second interface module must be operational.
I/O modules	Yes	• Digital output modules: Only when load is switched off • Digital modules: For load voltage above the safe extra-low voltage: Only with switched off load voltage supply • Technology modules: Only with switched off supply voltage L+

Modules	Removal and insertion	Conditions
		• AI Energy Meter: – Only when measuring voltage on primary side is switched off, or – Without the special current transformer terminal, measuring voltage and load current must be through the converters, which means the machine or the load must be switched off in the process. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module, at connections UL1-UL3, still needs to be isolated.
PotDis-TerminalBlock	Yes	Only in de-energized state.
Motor starter	Yes [1)]	Only when the load is disconnected; when switched on, the motor starter switches off automatically when the rotary interlock is operated.
Server module	No	---

1) The motor starter also counts as removed in the parking position

NOTICE

Risk of hazardous system states

If you remove and insert digital output modules with the load switched on or technology modules with the supply voltage switched on, this can result in hazardous system states. The ET 200SP distributed I/O system or the connected sensors may be damaged as a result. Therefore, a digital output module may only be inserted and removed when the load is switched off and a technology module may only be inserted and removed when the supply voltage is switched off.

NOTICE

Risk of hazardous system states

If you remove and insert the AI Energy Meter ST with the primary-side voltage switched on at the current transformer, this can result in hazardous system states.

The ET 200SP distributed I/O system may be damaged as a result.

For this reason, remove and insert the AI Energy Meter ST only in the following cases:

- When measuring voltage is switched off on the primary side, or
- When a special current transformer terminal is used that short-circuits the secondary side of the transformer when the module is removed

Do not remove or insert the AI Energy Meter ST until you have removed this current transformer terminal. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module at the connections UL1-UL3 still needs to be isolated.

⚠ WARNING

Risk of injury from automatic restart
Inserting a motor starter can result in dangerous system states. The motor starter can restart again autonomously if an ON command is active.
This can result in serious injury caused by connected devices that are automatically started up.
Withdraw and insert a motor starter only after disconnecting the load.

Removing and inserting an I/O module or a motor starter in case of CPU/interface module HF, HS, R1

You can remove and insert any number of I/O modules/motor starters during operation. The CPU/interface module and the inserted I/O modules/motor starters remain in operation.

NOTICE

Reaction of the CPU to removal and insertion of the ET 200SP server module
Please note that the backplane bus is deactivated when you remove the server module, regardless of the CPU operating state. Also note that the outputs do not adopt their configured substitute value behavior when you remove the server module.
This means you should not remove the server module when the CPU is in STARTUP, RUN and STOP modes. If you have nevertheless removed the server module, perform a POWER OFF/POWER ON after you have inserted the server module again.

Removing and inserting BusAdapter or CM DP module

Do not remove or insert the BusAdapter or CM DP module when the supply voltage is switched on. If you remove the BusAdapter or CM DP module after CPU startup, the supply voltage of the BusAdapter or CM DP module is switched off automatically. To switch on the supply voltage again, you need to perform a POWER OFF/POWER ON after inserting the BusAdapter/CM DP module.

Removing and inserting I/O module or motor starter with interface module ST, BA

1. You can remove **one** I/O module/**one** motor starter during operation. If you remove another I/O module/motor starter, this results in a station stop of the ET 200SP distributed I/O system:
   - All I/O modules/motor starters of the ET 200SP distributed I/O system fail → Substitute value behavior.
   - The interface module continues to exchange data with the IO controller and report diagnostics.

   NOTE

   If you want to replace several I/O modules/motor starters during operation, you must replace them one after the other.

2. If you insert all but one of the I/O modules/motor starters withdrawn during operation, all I/O modules will start up again.

NOTE
I/O modules/motor starters inserted in empty slots and then removed are also regarded as withdrawn during operation.

3. After a POWER OFF/POWER ON of the supply voltage 1L+ of the interface module, all available I/O modules/motor starters start up again in line with the configuration. Evaluation of the I/O modules/motor starters removed during operation starts again (see 1).

Removing I/O modules

To remove an I/O module, follow these steps:

1. Simultaneously press the top and bottom release buttons of the I/O module.
2. Pull the I/O module out of the BaseUnit, parallel in a forward direction.

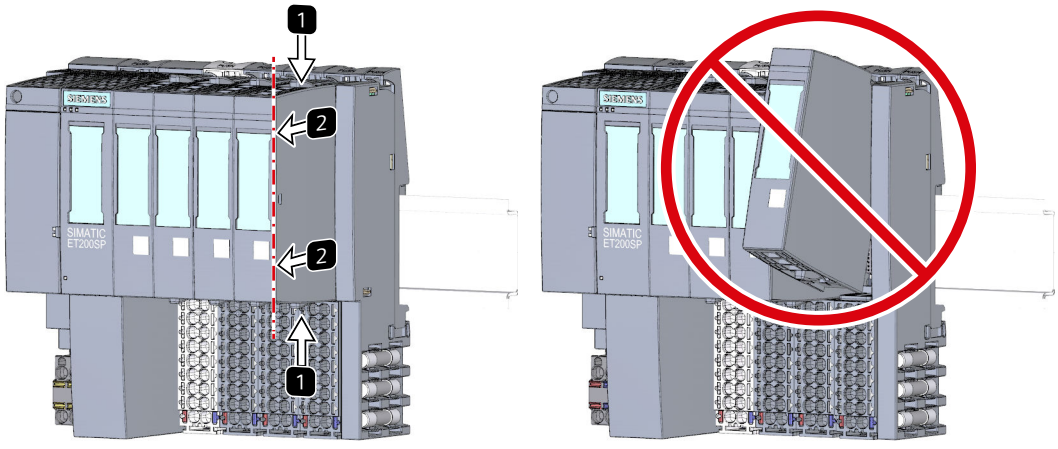


Figure 1-150 Removing I/O modules

14.2 Changing the type of an I/O module

Introduction

The coding element is a two-part element. When shipped from the factory, both parts are in the I/O module. When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. This mechanically prevents the insertion of a different module type.

There are two versions of the ET 200SP distributed I/O system:

- Mechanical coding element: Ensures the mechanical coding described above.
- Electronic coding element: In addition to the above-mentioned mechanical coding, this version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for IO link master).

Requirement

Refer to section Application planning (Page 85).

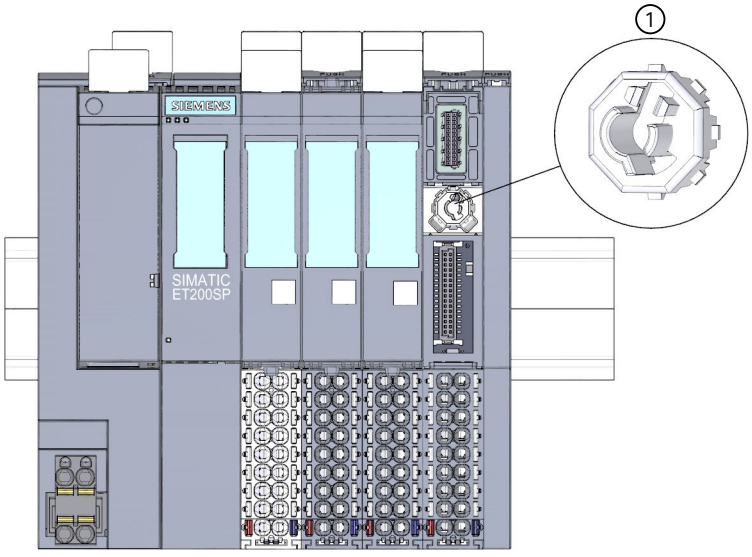
NOTICE
Do not manipulate the coding element Making changes to the coding element may cause dangerous conditions in your plant and/or result in damage to the outputs of the ET 200SP distributed I/O system. To avoid physical damage, do not manipulate the coding.

Changing the type of an I/O module

You have already removed the I/O module.

To make a type change for an I/O module, follow these steps:

1. Push the coding element out of the BaseUnit using a screwdriver.
2. Put the coding element back onto the removed I/O module.
3. Insert the new I/O module (other module type) into the BaseUnit until you hear it click into place.
4. Label the new I/O module.



① Coding element

Figure 1-151 Changing the type of an I/O module

14.3 Replacing an I/O module

Introduction

When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. When you replace an I/O module with the same type of module, the correct coding element is already present in the BaseUnit.

Requirement

Refer to section Application planning (Page 85).

Replacing an I/O module

You have already removed the I/O module.

To replace an I/O module, follow these steps:

1. Remove the coding element (part) from the underside of the new I/O module.
2. Insert the new I/O module (same module type) into the BaseUnit until you hear it click into place.
3. Mark the new I/O module (labeling strip, equipment labeling plate).

14.4 Replacing a motor starter

The SIMATIC ET 200SP motor starter is wired.

To replace a SIMATIC ET 200SP motor starter, proceed as follows:

1. Turn the mechanical rotary interlock counter-clockwise to the assembly/disassembly position.

NOTE

Operating position/READY
Turn the mechanical rotary interlock out of the READY position only in the current-free state (motor off).

2. Remove the SIMATIC ET 200SP motor starter from the BaseUnit.
3. Assemble the new motor starter as described.

NOTE

Mounting the motor starter
You will find out how to mount the motor starter in chapter "Mounting/disassembly of motor starters (Page 180)".

⚠ WARNING

Risk of injury from automatic restart
When you replace the motor starter, the motor starter can restart again autonomously if an ON command is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.
Revoke the ON commands on the motor starter before replacing the motor starter.

⚠ CAUTION

Protection against electrostatic charge
When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

14.5 Replacing the terminal box on the BaseUnit

Introduction

The terminal box is part of the BaseUnit. You can replace the terminal box if necessary. You do not need to dismantle the BaseUnit to do this.

The power and AUX buses of the potential group are not interrupted when you replace the terminal box.

Requirements

- The BaseUnit is mounted, wired and fitted with an I/O module.
- The terminal may only be replaced when the supply voltage is switched off.

Required tools

3 to 3.5 mm screwdriver

Procedure

Viewing the video sequence "Replacing the terminal box on the BaseUnit" (https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to replace the terminal box on a BaseUnit:

1. Switch off the supply voltage at the BaseUnit.
2. Simultaneously press the top and bottom release buttons of the I/O module and pull the module out of the BaseUnit.
3. Disconnect the wiring on the BaseUnit.
4. The release button of the terminal box is located on the underside of the BaseUnit. Use a screwdriver to push in the small opening at an angle from above.
5. Swivel the screwdriver slightly upwards to loosen the latching mechanism of the terminal box and lever the terminal box up out of the BaseUnit at the same time.
6. Remove the coding element (part) from the terminal box and press it onto the coding element (part) of the I/O module that you removed in step 2.
7. Insert the new terminal box into the BaseUnit at the top and swivel it downwards until it clips into the BaseUnit.
8. Wire the BaseUnit.
9. Insert the I/O module into the BaseUnit.
10. Switch on the supply voltage at the BaseUnit.

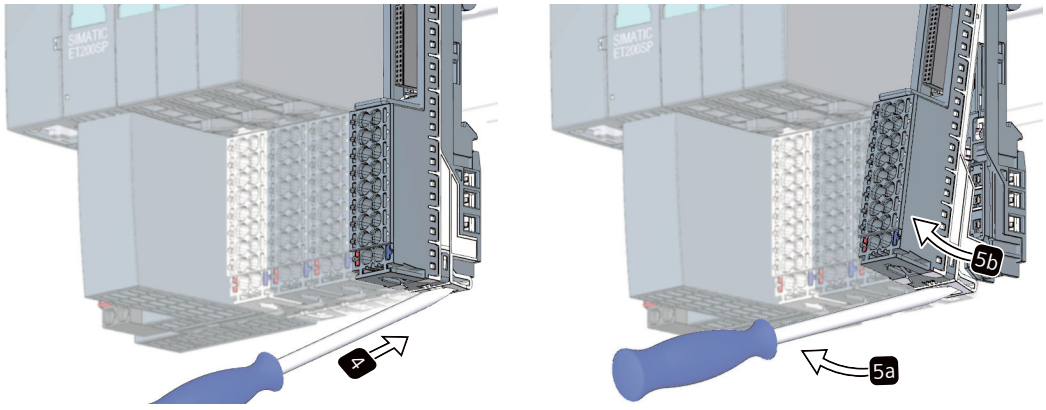


Figure 1-152 Replacing the terminal box on the BaseUnit

NOTE

When replacing the terminal box outside the control cabinet, make sure that you only mount light-colored terminal boxes on the matching BaseUnits with light-colored latch.

14.6 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions).

Update the firmware of the CPU/interface module and the I/O modules using firmware files. The retentive data is retained after the firmware has been updated.

We recommend that you always update to the latest firmware version available for the respective article number. The previous versions of the firmware are only intended as a backup to enable you to downgrade to the original version.

A firmware update has no effects on the user program of the CPU on which the update was performed. However, a downgrade can have effects on the user program if you use new functions in the user program which were not yet supported by the firmware of the CPU.

The following entry (https://support.industry.siemens.com/cs/ww/en/view/109804718) contains the current firmware statuses of the interface modules and modules of the ET 200SP.

The following entry (https://support.industry.siemens.com/cs/de/en/view/109478459) lists all firmware versions for the CPUs. You will also find a description of the new functions of the respective firmware versions.

Requirement

- You have downloaded the file(s) for the firmware update from the Product Support (https://support.industry.siemens.com/cs/ww/en/ps) web page.
  On this web page, select:
  – Automation Technology > Automation Systems > Industrial Automation Systems SIMATIC > SIMATIC ET 200 I/O Systems > ET 200 systems for the cabinet > ET 200SP.

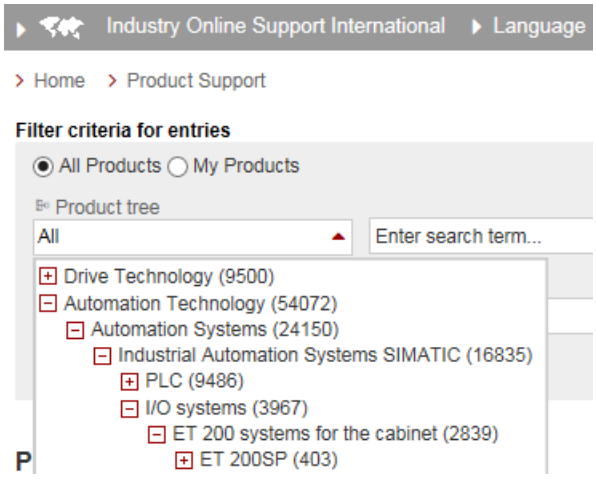


Figure 1-153 ET 200SP in the product tree

From this position, navigate to the specific type of module that you want to update. To continue, click on the "Software downloads" link under "Support". Save the desired firmware update files.

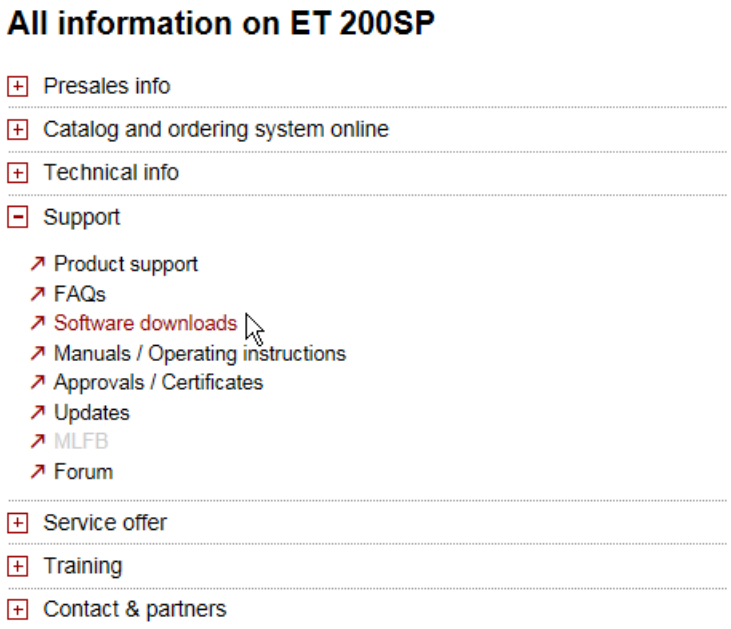


Figure 1-154 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.
- Modules with firmware version V0.0.0 do not support the "firmware update" function.

NOTE

Firmware update of I/O modules

The L+ supply voltage must be present on the module at the start of and during the firmware update.

Additional requirement for fail-safe modules

⚠ WARNING

Check the firmware version for fail-safe approval

When using a new firmware version, always check that the version is approved for use in the module in question.

The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Options for the firmware update

The following options are available for updating firmware:

- Online in STEP 7 via Online & Diagnostics
- Online in STEP 7 via accessible devices (PROFINET)
- Online with the MultiFieldbus Configuration Tool (MFCT) (https://support.industry.siemens.com/cs/ww/en/view/109781837)
- Using a SIMATIC memory card (possible for CPU and central I/O modules)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- Online via the SIMATIC Automation Tool

NOTE

Firmware files of the CPU
If you perform a CPU update with STEP 7, you require STEP 7 (TIA Portal as of V13 Update 3).

The table below provides an overview of the media that can be used to update the firmware of a specific module.

Table 1-392 Overview of firmware update options

Firmware update	CPU	Interface module	I/O module
STEP 7 (TIA Portal)	✓ 1)	✓	✓
STEP 7 (V5.5 SP2 or higher) 2)	--	✓	✓
Accessible devices	✓	✓	✓
MFCT	--	✓	✓
SIMATIC memory card	✓	--	✓
Web server of the CPU	✓	--	✓
SIMATIC Automation Tool	✓	✓	✓

1) V13 update 3 or higher

2) If the firmware files are only available in this format, you can also install the files using STEP 7 (TIA Portal) but not the SIMATIC memory card or the Web server.

Firmware update for the motor starter
The following options are available for updating firmware for the motor starter.

- Online via PROFINET IO/PROFIBUS DP (with STEP 7)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- With the TIA Portal:
  - As of SIMATIC STEP 7 V13 SP1 with installed HSP for the ET 200SP motor starter
  - SIMATIC STEP 7 V14 and higher

  Over a SIMATIC memory card
- With SIMATIC STEP 7 version V5.5 SP4 and higher
- For fail-safe motor starters with the TIA Portal Version V14 SP1 or higher and installed HSP.

NOTE

The firmware update for fail-safe motor starters must take place in a separate ET 200SP system in which only the fail-safe motor starter that is to be updated is inserted.

Downtime during the firmware update

When you start a firmware update, for example online in STEP 7 via "Online & Diagnostics", the CPU goes into STOP mode and executes the firmware update. The time from start of the firmware update until RUN of the CPU with the new firmware takes a few minutes (typically < 3 minutes).

Installation of the firmware update

⚠ WARNING

Risk of impermissible system states
The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure can have an adverse effect on the operation of an online process or a machine.
Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.
Make sure that the CPU/interface module is not executing any active process before installing the firmware update.

Procedure online in STEP 7 via Online & Diagnostics

Requirements: There is an online connection between the CPU/module and PG/PC.

Proceed as follows to perform an online firmware update via STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.

3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

Updating the firmware

The "Run firmware after update" check box is always selected. When the loading process is complete, the CPU adopts the firmware and then operates with this new firmware.

If you have not selected the "Run firmware after update" check box, the previous firmware remains active until the module is reset (for example by power cycling). The new firmware only becomes active after the module has been reset.

You can find more information in the online help for STEP 7 under "General information on firmware update of a module".

NOTE

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure online in STEP 7 via accessible devices

To perform a firmware update online via accessible devices, follow these steps:

1. From the "Online" menu, select the "Accessible devices" menu item.
2. In the "Accessible devices" dialog, search for the accessible devices for the selected PROFINET interface.
3. To go to a device in the project tree, select the desired device from the list of accessible devices and click the "Show" button.
4. In the project tree, select the "Online & diagnostics" option of the relevant device and perform the firmware update under the category "Functions/Firmware Update" (CPU, Local modules).

You can find information on how to perform a firmware update when your project has no connection to a CPU in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/89257657).

Procedure using the SIMATIC memory card

To perform a firmware update using the SIMATIC memory card, follow these steps:

1. Insert a SIMATIC memory card into the SD card reader of your programming device/computer.
2. To store the update file on the SIMATIC memory card, select the SIMATIC memory card in the "Card Reader/USB memory" folder in the project tree.
3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.

4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card with the firmware update files into the CPU.

Point to note when updating firmware for analog modules and the IO-Link Master CM 4xIO-Link communication module
If you want to update firmware for analog modules or the IO-Link Master CM 4xIO-Link communication module, you must supply a load current of 24 V DC to the modules through the infeed element.

Procedure
1. Remove any inserted SIMATIC memory card.
2. Insert the SIMATIC memory card with the firmware update files into the CPU.
3. The firmware update begins shortly after the SIMATIC memory card has been inserted.
4. Remove the SIMATIC memory card after the firmware update has been completed. The RUN LED on the CPU lights up yellow, the MAINT LED flashes yellow.

If you want to use the SIMATIC memory card later as a program card, delete the firmware update files manually.

NOTE
If your hardware configuration contains several modules, the CPU updates all affected modules in the slot sequence, which means in ascending order of the module position in the STEP 7 device configuration.

NOTE
Memory size of the SIMATIC memory card
If you perform a firmware update via the SIMATIC memory card, you must use a large enough card based on the CPU used and the associated I/O modules.
Note the specified file sizes of the update files when downloading them from Siemens Industry Online Support. The file size information is especially important when you perform the firmware update not only for the CPU but also for the associated I/O modules, communication modules, etc. The total size of the update files must not exceed the available memory size of your SIMATIC memory card.
You can find more information on the capacity of SIMATIC memory cards in the section Accessories/spare parts (Page 370)and in the function manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/en/view/59193101).

Procedure: via the integrated Web server

The procedure is described in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure: online via the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Behavior during the firmware update

Note the following behavior of the relevant I/O module when carrying out a firmware update:

- The DIAG LED display flashes red.
- The I/O module retains its current diagnostic status.
- Diagnostics alarm: Channel temporarily unavailable (error code $31_D/1F_H$)
- All outputs are in a current-free/voltage-free state

Note the following behavior when carrying out the firmware update of the motor starter:

- RN flashes green and ER flashes red.
- ST/OL flashes green and MAN flashes yellow.
- The motor starter powers up after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the TMM and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module.

Reference

You will find more information on these procedures in the STEP 7 online help.

14.7 Resetting the CPU/interface module (PROFINET IO) to factory settings

14.7.1 Resetting the CPU to factory settings

Introduction

The CPU can be reset to its delivery state using "Reset to factory settings". The function deletes all information saved internally on the CPU.

If you want to remove a PROFINET CPU and use it elsewhere with a different program, or put it into storage, we recommend that you reset the CPU to its factory settings. When restoring the factory settings, remember that you also delete the IP address parameters.

Recommendation

Put the CPU into its delivery state if:

- You remove a CPU and use it elsewhere with a different program
- You return the CPU to stock

When resetting to factory settings, remember that the IP address parameters are also deleted.

Options for resetting a CPU to factory settings

The following options are available for resetting the CPU to its factory settings:

- Using the mode selector
- Using STEP 7
- Using the SIMATIC Automation Tool

Procedure using the mode selector

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (the RUN/STOP LED is lit yellow).

NOTE

Reset to factory settings ↔ Memory reset

The procedure described below also corresponds to the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

---

Perform a reset to factory settings when there is no SIMATIC memory card inserted as follows:

1. Set the mode selector to the STOP position.
   Result: The RUN/STOP LED lights up yellow.
2. Set the mode selector to the MRES position. Hold the mode selector in this position until the RUN/STOP LED lights up for the second time and remains lit (this takes 3 seconds). After this, release the switch.
3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

NOTE

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the mode selector.

For information on the memory reset of the CPU, refer to the section CPU memory reset (Page 294).

Procedure using STEP 7

Make sure that an online connection to the CPU exists.

To reset a CPU to factory settings using STEP 7, follow these steps:

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. If you want to keep the IP address, select the "Retain IP address" option button. If you want to delete the IP address, select the "Reset IP address" option button.

NOTE

"Delete IP address" deletes all IP addresses, regardless of how you established the online connection.

If there is a SIMATIC memory card inserted, selecting the "Delete IP address" option has the following effect:

- The IP addresses are deleted and the CPU is reset to factory settings.
- The configuration (including IP address) on the SIMATIC memory card is then downloaded to the CPU. If there is no saved configuration (because the SIMATIC memory card has been cleared or formatted, for example), no new IP address is assigned.

4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Procedure using the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 1-393 Result after resetting to factory settings

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Initialized
Entries in the diagnostic buffer	Initialized, including a startup entry that informs about the reset to factory settings.
Entries in the syslog storage	Now only contains a startup entry that informs about the reset to factory settings.

Memory object	Content
IP address	Depends on the procedure: • Using mode switch: is deleted • Using STEP 7: Depending on the setting of the "Keep IP address"/"Delete IP address" option buttons
Device name	Is set to "CPU"
Counter readings of the runtime meters	Initialized
Time of day	Is set to "00:00:00, 01.01.2012"
Deleting passwords for protecting confidential PLC configuration data	Depends on the procedure: • Using mode switch: Retained • Using STEP 7: Depends on the setting of the "Delete password for the protection of confidential PLC configuration data" option button

If a SIMATIC memory card was inserted prior to the factory reset, the CPU downloads the configuration contained on the SIMATIC memory card (hardware and software). A configured IP address then becomes valid again.

NOTE

Password for protecting confidential configuration data after resetting the CPU to factory settings

- **Via the mode selector (SIMATIC Memory Card is not inserted):** The password for protection of confidential configuration data is retained.
- **Using STEP 7:** The password for protection of confidential configuration data is retained. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find more information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual.

Reference

Additional information on the topic "Resetting to factory settings" can be found in the Structure and use of the CPU memory (https://support.automation.siemens.com/WW/view/en/59193101) function manual, section on memory areas and retentivity, and in the STEP 7 online help.

14.7.2 Resetting interface module (PROFINET IO) to factory settings

Function

The "Reset to factory settings" function returns the interface module (PROFINET) to its delivery state.

Reset options

- Using STEP 7 (online via PROFINET IO)
- Using a reset button on the interface module (on rear). Exception: There is no reset button on the IM 155-6 PN BA and the IM 155-6 PN R1. See section Resetting the interface module (PROFINET IO) to factory settings with a RESET button (Page 333).

Procedure using STEP 7

To reset an interface module to factory settings using STEP 7, follow these steps:

Make sure that an online connection to the interface module exists.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Click the "Reset" button.
4. Click "OK" in response to the confirmation prompt.

Result: The interface module then performs "Reset to factory settings".

Result after resetting to factory settings

The following table shows the values of the interface module properties after a factory reset:

Table 1-394 Properties of the interface module as shipped

Properties	Value
Parameters	Default setting
IP address	Not available
Device name	Not available
MAC address	Available
I&M data	Identification data (I&M0) available Maintenance data (I&M1, 2, 3, 4) reset *
Firmware version	Available

NOTE

Failure of downstream stations is possible

Downstream stations on a bus segment can fail when the factory settings are restored on an interface module.

NOTE

Behavior of the installed I/O modules during reset to factory settings

The I/O modules of the ET 200SP distributed I/O system assume the unconfigured state after a reset to factory settings. The interface module does not acquire any input data and does not output any output data.

Reference

You will find more information on the procedure in the STEP 7 online help.

14.7.3 Resetting the interface module (PROFINET IO) to factory settings with a RESET button

Requirement

The supply voltage to the interface module is turned on.

Required tools

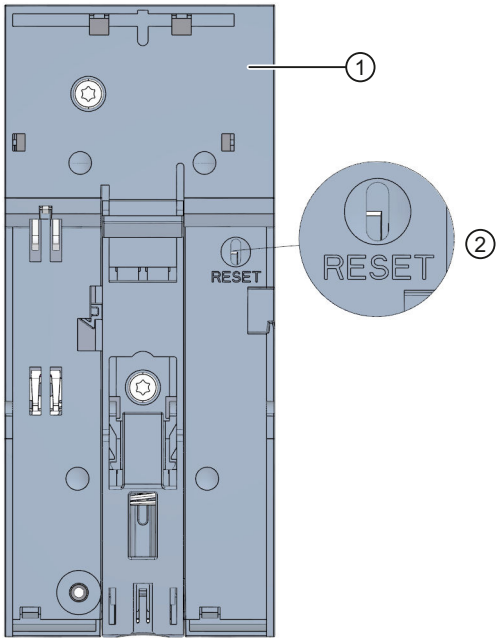
3 to 3.5 mm screwdriver (for resetting with a RESET button)

Procedure

Proceed as follows to reset an interface module to factory settings by means of the RESET button:

1. Remove the interface module from the mounting rail (see Mounting the CPU/interface module (Page 122)) and swivel it downwards.
2. The RESET button is located on the rear of the interface module behind a small opening: Press a screwdriver into the small opening for at least 3 seconds to activate the RESET button.
3. Install the interface module back on the mounting rail (see Mounting the CPU/interface module (Page 122)).

4. Assign parameters to the interface module again.



① Rear of the interface module
② RESET button

Figure 1-155 RESET button

14.8 Reaction to faults in fail-safe modules and fail-safe motor starters

Safe state (safety concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

NOTE

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators. In the case of the fail-safe motor starters, the load is shut down in a fail-safe manner.

Fault reactions and startup of the F-system

The safety function means that fail-safe modules use substitute values (safe state) instead of process values (**passivation of the fail-safe module**) in the following situations:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- If F-I/O faults or channel faults are detected (e.g. crossover or discrepancy errors)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. After a POWER OFF / POWER ON, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

For channels that you set to "deactivated" in STEP 7, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).

Remedying faults in the F-system

To remedy faults in your F-system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

The following steps must be performed:

1. Diagnosing and repairing the fault
2. Revalidation of the safety function
3. Recording in the service report

Substitute value output for fail-safe modules

In the case of F-modules with inputs, if there is passivation, the F-system provides substitute values (0) for the safety program instead of the process data pending at the fail-safe inputs.

In the case of F-modules with outputs, if there is passivation, the F-system transfers substitute values (0) to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized. This also applies when the F-CPU goes to STOP mode. Assignment of substitute values is not possible.

Substitute values are used either for the relevant channel only or for all channels of the relevant failsafe module depending on:

- The F-system used
- The type of error that occurred (F-I/O, channel fault or communication error)
- The F-module parameter assignment

Reintegration of a fail-safe module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in the section Diagnostic messages of the respective F-module.

After reintegration, the following occurs:

- In the case of an F-module with inputs, the process data pending at the fail-safe inputs is made available to the safety program again
- In the case of an F-module with outputs, the output values provided in the safety program are transferred to the fail-safe outputs again

Additional information on passivation and reintegration

For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety, Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) manual.

Behavior of the fail-safe module with inputs in the event of a communication disruption

F-modules with inputs respond differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F-module. There is no passivation of the channels. The current process values are passivated in the F-CPU.

14.9 Maintenance and repair

The components of the ET 200SP distributed I/O system are maintenance-free.

NOTE

Repairs to a SIMATIC ET 200SP system may only be carried out by the manufacturer.

NOTE

Cleaning the ET 200SP

Requirement: All supply voltages on the ET 200SP distributed I/O system are switched off.
Observe the five safety rules for working in and on electrical installations.
If you need to clean the devices, use dry ESD cleaning cloths (observing the ESD protective measures).

14.10 Warranty

To meet the conditions of the warranty, you must observe the safety and commissioning instructions.

Test and service functions

15

15.1 Test functions

Introduction

You can test the flow of your user program on the CPU. You monitor signal states and values of tags, and preassign tags with values so that you can simulate specific situations for the program flow.

NOTE

Using test functions

The use of test functions can influence the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirements

- There is an online connection to the relevant CPU.
- An executable program is in the CPU.

Test options

- Testing with program status
- Testing with breakpoints
- Testing with a watch table
- Testing with a force table
- Testing with PLC tag table
- Testing with data block editor
- Testing with the LED flash test
- Testing with trace function

Testing with program status

The program status allows you to monitor the execution of the program. You can display the values of operands and the results of logic operations (RLO) allowing you to recognize and fix logical errors in your program.

NOTE

Restrictions for the "Program status" function

The monitoring of loops can significantly increase the cycle time. The increase in cycle time depends on the following factors:

- The number of tags to be monitored
- The actual number of loops run through

⚠ WARNING

Testing with program status

A test with the "Program status" function can produce serious property damage and personal injury in the event of malfunctions or program errors.

Make sure that you take appropriate measures to exclude the risk of hazardous conditions occurring before running a test with the "Program status" function.

Testing with breakpoints

With this test option, you set breakpoints in your program, establish an online connection, and enable the breakpoints on the CPU. You then execute a program from one breakpoint to another.

Requirements:

- Setting breakpoints is possible in the programming language SCL or STL.

Testing with breakpoints provides you with the following advantages:

- Localization of logic errors step by step
- Simple and quick analysis of complex programs prior to actual commissioning
- Recording of current values within individual executed loops
- Use of breakpoints for program validation also possible in SCL/STL networks within LAD/FBD blocks

NOTE

Restriction during testing with breakpoints

- When you test with breakpoints, there is a risk of overwriting the cycle time of the CPU.
- If you are using technology objects and test them with breakpoints, the CPU switches to STOP mode.

NOTE

F-System SIMATIC Safety

The setting of breakpoints in the standard user program results in errors in the safety program:

- Sequence of F cycle time monitoring
- Error in communication with the fail-safe I/O
- Error during safety-oriented CPU-CPU communication
- Internal CPU error

If you still wish to use breakpoints for testing, you must deactivate the safety mode beforehand. This will result in the following errors:

- Error in communication with the fail-safe I/O
- Error during safety-oriented CPU-CPU communication

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  With watch tables, you can monitor the current values of individual tags of a user program or a CPU on the PG/PC and Web server. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the watch table.

  You can monitor the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs
  – Timers and counters

- Modifying tags

  Use this function to assign fixed values to the individual tags of a user program or CPU. Modifying is also possible for testing with program status.

  You can control the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)
  – Timers and counters

- "Enable peripheral outputs" and "Control immediately"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with the force table

The following functions are available in the force table.

- Monitoring of tags

  With force tables, you can display the current values of individual tags of a user program or a CPU on the PG/PC and Web server. You can monitor the table with or without a trigger condition. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the force table.

  You can monitor the following tags:

  – Bit memory
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Modifying tags

  With this function, you assign fixed values to the individual tags of a user program or a CPU on the PG/PC and Web server. Modifying is also possible for testing with program status.

  You can control the following tags:

  – Bit memories
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.

  – Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) represents the "bypassing" of sensors/inputs by specifying fixed values to the program. Instead of the actual input value (via process image or via direct access) the program receives the force value.
  – Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) represents the "bypassing" of the complete program by setting fixed values for the actuators.

You can use the force table to simulate different test environments and also overwrite tags in the CPU with a fixed value. This enables you to intervene in the running process to control it.

Difference between modifying and forcing

The fundamental difference between the modifying and forcing functions consists in the storage behavior:

- Modifying: Modifying of tags is an online function and is not stored in the CPU. You can end modifying of tags in the watch table or by disconnecting the online connection.
- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with PLC tag table

You can monitor the data values that tags currently assume in the CPU directly in the PLC tag table. To do this, open the PLC tag table and start monitoring.

Additionally, you have a possibility of copying PLC tags to a monitoring or force table and of monitoring, controlling or forcing them there.

Testing with data block editor

Various possibilities of monitoring and controlling tags are at your disposal in the data block editor. These functions directly access the current values of the tags in the online program. Current values are the values that the tags assume at the current time during program execution in the CPU's work memory. The following functions for monitoring and control are possible via the data block editor:

- Monitoring tags online
- Controlling individual actual values
- Creating a snapshot of the actual values
- Overwriting actual values with a snapshot

NOTE

Setting data values during commissioning

During commissioning of a system, data values often have to be adjusted to optimally adapt the program to the general conditions prevailing locally. To this end, the declaration table offers a few functions for data blocks.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This function is useful, for example, when you are not sure which device in the hardware configuration corresponds to the device currently selected in the software.

When you click the "Flash LED" button, an LED flashes on the currently selected device. In the case of the CPU, the RUN/STOP, ERROR and MAINT LEDs flash. They flash until you cancel the flashing test.

Testing with trace function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, the drive parameters or system and user tags of a CPU. The CPU saves the recordings. You can display and evaluate the recordings with STEP 7, if necessary.

The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

In connection with trace functions, also pay attention to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102781176).

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

You can find more information on test functions in the STEP 7 online help.

Further information about testing with trace and logic analyzer functions is available in the Function Manual Using the trace and logic analyzer function (https://support.automation.siemens.com/WW/view/en/64897128).

15.2 Reading out/saving service data

Service data

In addition to the contents of the diagnostics buffer, the service data contains a wide range of extra information about the internal status of the CPU. If a problem occurs with the CPU that cannot be solved with other methods, send the service data to Service & Support. The service data allows Service & Support to run fast analysis of the problems that have occurred.

NOTE

You cannot simultaneously execute a download to the device while reading out the service data of the CPU.

Methods of reading service data

You can read service data with:

- The Web server
- STEP 7
- the SIMATIC memory card
- MultiFieldbus Configuration Tool (MFCT)

Procedure using the Web server

To read service data using the Web server, follow these steps:

1. Open a Web browser that is suitable for communication with the CPU.
2. Enter the following address in the address bar of the web browser:
   https://<CPU IP address>/save_service_data, e.g. https://172.23.15.3/save_service_data

3. The service data page will appear on your screen, with a button for saving the service data.

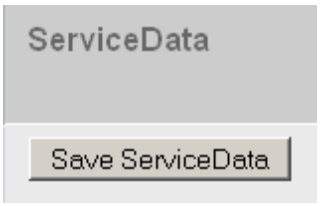


Figure 1-156 Reading out service data with the Web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The CPU stores the data in a .dmp file with the following naming convention: "<Article number> <Serial number> <Time stamp>.dmp". The file name cannot be changed.

NOTE

If you have defined your user page as the Web server's home page, direct access to the service data by entering the CPU's IP address is not possible. You will find more information on reading out service data via a user-defined page in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure using STEP 7

You can find more information on saving service data of the CPU (and interface module) in the STEP 7 online help using keyword "Saving service data".

Procedure via the SIMATIC memory card

If Ethernet communication with the CPU is not possible, use the

SIMATIC memory card to read out the service data. In all other cases, read the service data via the web server or STEP 7..

The procedure using the SIMATIC memory card is more time-consuming than the other options for reading out the service data. You must also ensure before reading out that there is sufficient memory space on the SIMATIC memory card.

To read service data using the SIMATIC memory card, follow these steps:

1. Insert the SIMATIC memory card into the card reader of your PC / programming device.
2. Open the job file S7_JOB.S7S in an editor.
3. Overwrite the entry PROGRAM with the string DUMP in the editor.
   Do not use any spaces/line breaks/quotation marks to ensure that the file size is exactly 4 bytes.
4. Save the file under the existing file name.
5. Ensure that the SIMATIC memory card is not write-protected and insert the SIMATIC memory card in the card slot of the CPU. Pay attention to the procedure described in Removing/inserting the SIMATIC memory card on the CPU (Page 287).

Result: The CPU writes the service data file DUMP.S7S to the SIMATIC memory card and remains in STOP mode.

Service data transfer is complete when the STOP LED stops flashing and is lit continuously. If the service data transfer was successful, only the STOP LED lights up.

In the event of errors during the transfer, the STOP LED is lit continuously and the ERROR LED flashes. The CPU also stores a text file with information on the error that occurred in the DUMP.S7S folder.

Technical specifications 16

16.1 Introduction

Introduction

This chapter lists the technical specifications of the system:

- The standards and test values that the ET 200SP distributed I/O system complies with and fulfills.
- The test criteria according to which the ET 200SP distributed I/O system was tested.

Technical specifications of the (F-)modules

The technical specifications of the individual (F-)modules can be found in the equipment manuals of the corresponding (F-)modules. In the event of deviations between the statements in this document and the manuals, the statements in the manuals take priority.

Technical specifications of the Ex modules

You can find the technical specifications of the Ex modules in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533) and in the Ex I/O modules manuals.

Technical specifications of the motor starters

You can find the technical specifications of the motor starters in the ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) Equipment Manual.

16.2 Safety information

Safety information

⚠ WARNING

Personal injury and damage to property may occur

In hazardous areas, personal injury and damage to property may occur if you disconnect plug-in connections during operation of an ET 200SP distributed I/O system.

Always switch off the power to the ET 200SP distributed I/O system when disconnecting plug-in connections in hazardous areas.

⚠ WARNING
Explosion hazard If you replace components, compliance with Class I, Div. 2 or zone 2 may become invalid.

⚠ WARNING
Area of application This device is only suitable for use in Class I, Div. 2, Group A, B, C, D; Class I, zone 2, Group IIC, or in non-hazardous areas.

Safety of the plant or the system

NOTICE
Safety is the responsibility of the assembler The safety of any plant or system incorporating the equipment is the responsibility of the assembler of the plant or system.

16.3 Marks and approvals

Marks and approvals on the nameplate

The following overview provides information about the possible marks and approvals. Only the marks and approvals specified on the nameplate apply to the device.

You can find the associated certificates for download on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert).

CE marking

CE

The ET 200SP distributed I/O system meets the requirements and protection targets of the following directives. The distributed I/O system complies with the harmonized European standards (EN) for programmable logic controllers published in the official journals of the European Union.

- Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits; OJ L 96, 29/03/2014, pp. 357-374
- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive) Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the member states relating to electromagnetic compatibility; Official Journal of the European Union L96, 29/03/2014, pp. 79-106

- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast); Official Journal of the European Union L96, 29/03/2014, pp. 309–356
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, Official Journal of the European Union L174, 01/07/2011, pp 88-110
- 2006/42/EC "Machinery, and amending Directive 95/16/EC (Machinery directive) for F-modules" ET 200SP Directive of the European Parliament and of the Council of 17 May, 2006 on machinery, and amending Directive 95/16/EC (recast); official journal of the EU, L157, 09/06/2006, pp. 24–87

The EC Declarations of Conformity are available for the responsible authorities and are kept at the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS
PO Box 1963
D-92209 Amberg

You can also find the EC Declarations of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/es/ps/14031/cert?ct=444&ci=526).

UK Conformity Assessed marking



The ET 200SP distributed I/O system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The ET 200SP distributed I/O system meets the requirements and protection targets of the following regulations and associated supplements:

- The Electrical Equipment (Safety) Regulations 2016 (S.I. 2016 No. 1101), and related amendments
- Electromagnetic Compatibility Regulations 2016 (S.I. 2016 No. 1091), and related amendments
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (S.I. 2016 No. 1107), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments
- Supply of Machinery (Safety) Regulations 2008 (S.I. 2008 No. 1597), and related amendments for ET 200SP safety components (fail-safe modules)

The UK Declarations of Conformity are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS

PO Box 1963
D-92209 Amberg
You can also find the UK Declarations of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=5596).

cULus approval

Underwriters Laboratories Inc.:

- UL 508 (Industrial Control Equipment) OR UL 61010-1 and UL 61010-2-201
- CAN/CSA C22.2 No. 142 (Process Control Equipment) OR CAN/CSA C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201

cULus HAZ. LOC. approval

HAZ. LOC.

Underwriters Laboratories Inc.:

- UL 508 (Industrial Control Equipment) OR UL 61010-1 and UL 61010-2-201
- CAN/CSA C22.2 No. 142 (Process Control Equipment) OR CAN/CSA C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201
- ANSI/ISA 12.12.01
- CAN/CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for cULus haz.loc.

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

CSA

CSA C22.2 (Industrial Control Equipment Motor Controllers)

UL



UL 60947-4-2 Low-Voltage Switchgear and Controlgear

FM approval



Factory Mutual Research (FM):

- Approval Standard Class Number 3600, 3611, 3810
- ANSI/UL 121201
- ANSI/UL 61010-1
- CAN/CSA C22.2 No. 213
- CAN/CSA C22.2 No. 61010-1

APPROVED for use in Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for FM

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

ATEX approval



According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements).

II 3 G Ex nA IIC T4 Gc
DEKRA 12ATEX0038 X

OR

According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 20ATEX0002 X

T-CPUs:

According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 23ATEX0006 X

Special conditions in hazardous areas:

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

UKEX approval



According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 21UKEX0009 X

T-CPUs:
According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 23UKEX6001 X

Special conditions in explosive atmospheres:

1. The equipment shall only be used in an area of not more than degree of pollution 2, as defined in EN 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

IECEx approval



According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex nA IIC T4 Gc
IECEx DEK 13.0011X

OR
According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc
IECEx DEK 19.0086 X

T-CPUs:
According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc
IECEx DEK 23.0005 X

Special conditions in hazardous areas:

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in IEC 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

CCCEx approval



In accordance with GB/T 3836.3 (Explosive atmospheres - Part 3: Equipment protection by increased safety "e"), GB/T 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements).

Ex ec IIC T4 Gc

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in GB/T 16935.1.
- The equipment must be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with GB/T 3836.1. The ambient conditions must be taken into consideration for use.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

RCM Australia/New Zealand



The ET 200SP distributed I/O system meets the requirements of EN 61000-6-4 Generic standards – Emission standard for industrial environments.

Korea Certificate



Note that this device conforms to Limit Class A for emission of radio interference. This device is not intended to be used in residential areas.
이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Mark for Eurasian Economic Union

The EAC (Eurasian Conformity) mark confirms conformity with the technical regulations (TR) of the Eurasian Economic Union.

16.4 Certificates

Shipbuilding certificates

The following shipbuilding certificates are planned:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)
- KR (Korean Register of Shipping)
- CCS (China Classification Society)
- RINA (Registro Italiano Navale)

Following approval, you will find the certificates with the certified article numbers on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=446).

16.5 Standards and requirements

The ET 200SP distributed I/O system meets the following standards and requirements.

IEC 61131-2

The ET 200SP distributed I/O system fulfills the requirements and criteria of IEC 61131-2 (Programmable controllers, Part 2: Equipment requirements and tests) and the EMC requirements for use in Zone B.

IEC 61010-2-201

The ET 200SP distributed I/O system fulfills the requirements and criteria of standard IEC 61010-2-201 (Safety requirements for electrical equipment for measurement, control, and laboratory use Part 2-201: Particular requirements for control equipment).

IEC 60695-11-10

The ET 200SP distributed I/O system fulfills the requirements and criteria of standard IEC 60695-11-10 (Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flames test methods).

UL 94

The ET 200SP distributed I/O system fulfills the requirements and criteria of UL 94 (Tests for Flammability of Plastic Materials for Parts in Devices and Appliances).

IEC 60947

The motor starters belonging to the ET 200SP distributed I/O system meet the requirements and criteria of the IEC 60947 standard.

PROFINET

The PROFINET interfaces of the ET 200SP distributed I/O system are based on IEC 61158 Type 10.

PROFIBUS

The PROFIBUS interfaces of the ET 200SP distributed I/O system are based on IEC 61158 Type 3.

IO-Link

The ET 200SP distributed I/O system is based on IEC 61131-9.

Use in industrial environments

The ET 200SP distributed I/O system is suitable for use in industrial environments. It meets the following standards for this type of use:

- Requirements on interference emission EN 61000-6-4: 2007 + A1
- Requirements for immunity EN 61000-6-2

Use in mixed areas

Under specific prerequisites you can use the ET 200SP distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact the residential purpose.

If you want to use the ET 200SP distributed I/O system in residential areas, you must ensure that its radio frequency interference emission complies with limit class B in accordance with EN 61000-6-3. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the ET 200SP distributed I/O system in grounded control cabinets
- Use of filters in the supply lines

An additional individual acceptance test is also required.

Use in residential areas

The ET 200SP distributed I/O system is **not** intended for use in residential areas. If you are using the ET 200SP distributed I/O system in residential areas, radio and TV reception may be affected.

Environmental Product Declaration (EPD)

Siemens is committed to the development and production of environmentally compatible and sustainably produced equipment.

With the help of an Environmental Product Declaration (EPD), you can obtain information on the "ecological footprint" of your Siemens product.

The EPD is based on the international ISO 14021 standard "Environmental labels and declarations – Self declared environmental claims – Type II".

EPDs are based on independently verified data from life cycle assessments, life cycle inventory analyses and information modules that comply with the ISO 14040 series of standards. The EPD contains comprehensive data relating to ingredients and substances (REACH, RoHS), fire load, energy consumption, packaging and disposal information for your Siemens product.

You can find the current Environmental Product Declarations (EPDs) for the ET 200SP distributed I/O system on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=5669).

Importer addresses

In the following table, you can find the importer addresses for specific countries:

Countries	Address
United Kingdom (UK)	Siemens plc. Manchester M20 2UR
Türkiye (TR)	Siemens San. ve Tic. A.Ş. Yakacık Cad. No: 111 34870 Kartal/İstanbul

16.6 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

The ET 200SP distributed I/O system meets the legal requirements for electromagnetic compatibility of equipment. The prerequisite is that the ET 200SP distributed I/O system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The ET 200SP distributed I/O system meets the EMC specifications of the NAMUR recommendation NE21.

Pulse-shaped disturbance variables of the ET 200SP system

The table below shows the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to pulse-shaped disturbance variables.

Table 1-395 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Electrostatic discharge in accordance with IEC 61000-4-2 *)	Air discharge ±8 kV Contact discharge: ±6 kV	3 3
Burst pulses (fast transient interference) in accordance with IEC 61000-4-4 *)	±2 kV (power supply line) ±2 kV (signal line >30 m) ±1 kV (signal cable <30 m)	3 4 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 **)		
• Asymmetric coupling (phase-ground) ***)	±1 kV (24 V DC supply cable)	2
	±1 kV (24 V DC signal/data line only > 30 m)	2
	2 kV (230 V AC supply cable)	3
• Symmetric coupling (phase-phase) ***)	±0.5 kV (24 V DC supply cable)	2
	±1 kV (230 V AC supply cable)	3
*) The maximum short-term influence of analog modules during the duration of the EMC tests can be ±10% of the full-scale value. **) Analog value deviation beyond the limits of the nominal range and diagnostics possible. ***) If higher phase-ground or phase-phase values are required, you will need an additional external protective circuit (see Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual).		

Pulse-shaped disturbance variables of motor starters

The following table shows the electromagnetic compatibility of the ET 200SP motor starters with regard to pulse-shaped interference.

Table 1-396 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Burst pulses (fast transients) in accordance with IEC 61000-4-4, tested with 5 kHz.	±2 kV (24 V supply cables) ±2 kV (500 V AC infeed*) ±1 kV (signal cable <30 m)	3
If you mount the motor starter to the right of a 15 mm or 20 mm I/O module or immediately next to a head module, use a dummy module. You will find more information in "Selecting a motor starter with suitable BaseUnit (Page 91)".		
High-energy single pulse (surge) in accordance with IEC 61000-4-5	500 V AC infeed: ±2 kV conducted interference - phase to ground ±1 kV conducted interference - phase to phase 24 V supply cable: ±1 kV conducted interference - phase to ground **)	3

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
	±0.5 kV conducted interference - phase to phase **)	
**) An RC circuit is not required for hybrid switching devices. If higher values 2 kV (phase-ground) or 1 kV (phase-phase) are required, you will need an additional external protective circuit (see Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual).		

Sinusoidal disturbance variables

The tables below show the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to sinusoidal disturbance variables.

- RF radiation

RF radiation in accordance with IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		Corresponds to degree of severity
80 MHz to 2.7 GHz	10 V/m	3
2.7 GHz to 6 GHz	3 V/m	2
80% AM (1 kHz)		

- RF coupling

RF coupling in accordance with IEC 61000-4-6	Corresponds to degree of severity
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

The maximum short-term influence of analog modules during the duration of the EMC tests can be ±1% of the full-scale value.

Emission of radio frequency interference

Interference emission of electromagnetic fields according to EN 55016.

Table 1-397 Interference emission of electromagnetic fields

Frequency	Interference emission	Measuring distance
30 MHz to 230 MHz	<40 dB (µV/m) Q	10 m
230 MHz to 1000 MHz	<47 dB (µV/m) Q	10 m
1 GHz to 3 GHz	<76 dB (µV/m) P	3 m
3 GHz to 6 GHz	<80 dB (µV/m) P	3 m

Interference emission via the AC power supply according to EN 55016.

Table 1-398 Interference emission via the AC power supply

Frequency	Interference emission
0.15 MHz to 0.5 MHz	<89 dB (µV) Q < 66 dB (µV/m) M
0.5 MHz to 30 MHz	< 73 dB (µV/m)Q < 60 dB (µV/m) M

16.7 Electromagnetic compatibility of fail-safe modules

Protecting ET 200SP with fail-safe modules against overvoltages

If your equipment requires protection from overvoltage, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the BaseUnits to ensure surge immunity for the ET 200SP with fail-safe modules.

NOTE

Overvoltage protection measures always require a case-by-case examination of the entire plant. Almost complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.

For detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure shows an example configuration with fail-safe modules. Voltage is supplied by one power supply unit. Note, however, that the total current of the modules fed by the power supply unit must not exceed the permissible limits. You can also use multiple power supply units.

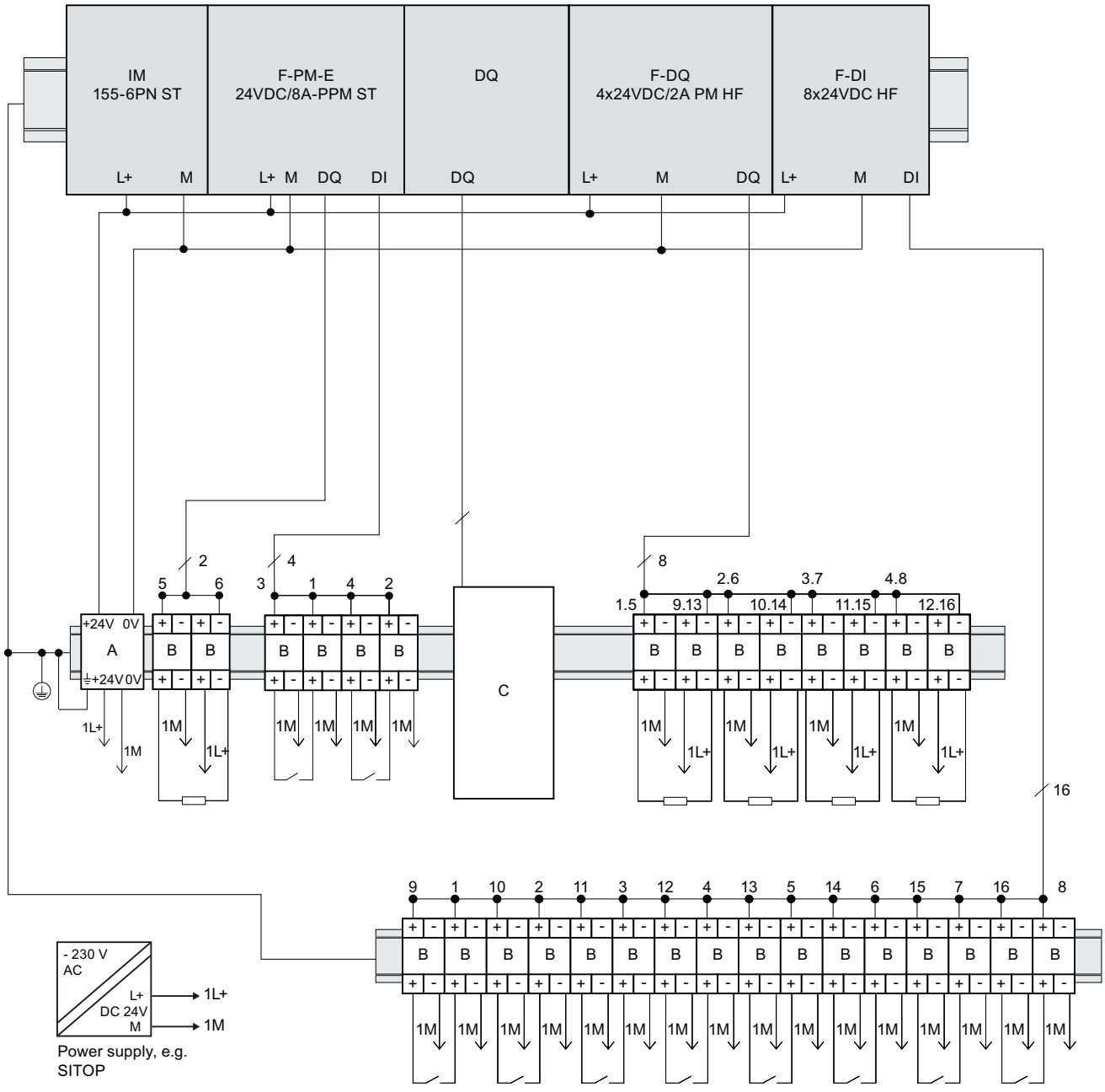


Figure 1-157 External protective circuit (surge filter) for ET 200SP with failsafe modules

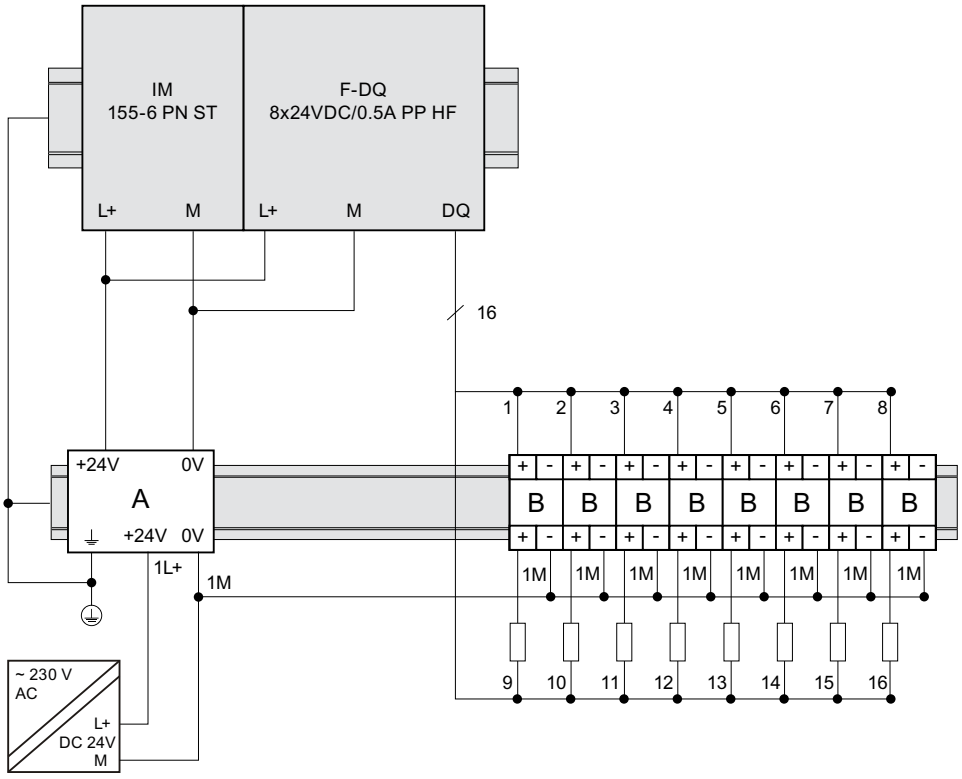


Figure 1-158 External protective circuit (surge filter) for ET 200SP with fail-safe modules

Name	Part number of Dehn Co.
A = BVT AVD 24	918 422
B = DCO RK D 5 24	919 986
C = The external protective circuit required at the outputs of the modules F-PM-E power module load group can be found in the Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.	

Electromagnetic compatibility of fail-safe motor starters

The safety versions of the motor starters are additionally tested according to the requirements of IEC 61000-6-7:2014 (taking into consideration the failure criteria for the STO safety function).

16.8 Shipping and storage conditions

Introduction

The ET 200SP distributed I/O system meets the requirements in terms of shipping and storage conditions according to IEC 61131-2. The following information applies to modules that are shipped and/or stored in their original packaging.

- Transport condition class: TTH4 (Minimum relative humidity 5%)
- Storage condition class: STH4 (Minimum ambient temperature -40 °C, minimum relative humidity 5%)

Table 1-399 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	from 1140 to 660 hPa (corresponds to an elevation of -1000 to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal oscillations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Impact acc. to IEC 60068-2-27[1)]	250 m/s^2, 6 ms, 1000 shocks

1) Not applicable to motor starters

16.9 Mechanical and climatic environmental conditions

Operating conditions

The ET 200SP distributed I/O system is suitable for use in weather-proof, fixed locations. The operating conditions are based on the requirements of IEC 61131-2.

- OTH4 (Minimum ambient temperature, see the Climatic ambient temperatures table)

You will find the permissible ambient conditions for the motor starter in the Technical data of the motor starter (https://support.industry.siemens.com/cs/ww/en/ps/21859/td).

Mechanical environmental conditions

The following table shows the mechanical environmental conditions in the form of sinusoidal vibrations.

Table 1-400 Mechanical environmental conditions

Frequency band	ET 200SP with IM 155-6 DP HF, BusAdapters BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12, BA 2xLC-LD and BA LC-LD/M12	ET 200SP with BusAdapters BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45 and BA LC-LD/RJ45	ET 200SP with IM 155-6 PN BA and IM 155-6 PN R1	ET 200SP with digital output module F-RQ 1x24VDC/24..230V-AC/5A
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude			
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration			
10 ≤ f ≤ 60 Hz	0.35 mm amplitude	---	---	---
60 ≤ f ≤ 1000 Hz	5 g constant acceleration			

Table 1-401 Mechanical environmental conditions for ET 200SP with CPU (from article number 6ES7xxx-xxx03-0AB0)

Frequency band	ET 200SP with CPU and BusAdapter BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12	ET 200SP with CPU and BusAdapter BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45, BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12	ET 200SP with CPU and digital output module F-RQ 1x24VDC/24..230VAC/5A
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude		
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration		
10 ≤ f ≤ 60 Hz	0.35 mm amplitude	---	---
60 ≤ f ≤ 1000 Hz	5 g constant acceleration[1)]		

[1)] Without using an RJ45 connector on the integrated PROFINET IO interface (RJ45 port) X1 Port 3 or X2 Port 1; the strain relief (6ES7193-6RA00-1AN0) must be mounted (for more information, refer to the ET 200SP BusAdapter Equipment Manual).

The mechanical ambient conditions for the Ex modules can be found in the system manual. T 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533).

Tests of mechanical environmental conditions

The following table provides important information with respect to the type and scope of the tests of environmental mechanical conditions.

Table 1-402 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibrations [2)]	Vibration test according to IEC 60068-2-6	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute.

Condition tested	Test standard	Comment
	(sinusoidal)	BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45, BA LC-LD/RJ45, IM 155-6 PN BA, IM 155-6 PN R1, digital output module F-RQ 1x24VDC/24..230VAC/5A • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration IM 155-6 DP HF, BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12, BA 2xLC-LD, BA LC-LD/M12 • 10 Hz ≤ f ≤ 60 Hz, 0.35 mm constant amplitude • 60 Hz ≤ f ≤ 1000 Hz, 5 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock [2]	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 15 g peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes
Repetitive shock [1] [2]	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks in each direction (+/-) at each of three vertically aligned axes

1) Not applicable in the case of the digital output module F-RQ 1x24VDC/24..230VAC/5A

2) Not applicable for motor starters

The type and scope of the tests for mechanical ambient conditions for the Ex modules can be found in the system manual. ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533).

Climatic environmental conditions

The following table shows the permissible climatic ambient conditions for the ET 200SP distributed I/O system during operation.

Table 1-403 Climatic environmental conditions

Environmental conditions	Permissible range	Comments
Temperature: horiz. mounting position: vertical mounting position:	 -30 °C to 60 °C -30 °C to 50 °C	The lower permissible ambient temperature was extended for the ET 200SP system to -30 °C. Differences may exist for specific modules and depending on the mounting position and, if applicable, load. Detailed information on this is described in the technical specifications of the respective equipment manual. The product data sheets with daily updated technical specifications can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td) at Industry Online Support. Enter the article number or the short description of the desired module on the website.
Permitted temperature change	10 K/h	-

Environmental conditions	Permissible range	Comments
Relative humidity	from 10 to 95%	Without condensation or icing.
Barometric pressure	from 1140 to 795 hPa	Corresponds to an altitude of -1000 to 2000 m. Note the following section "Using the distributed I/O system ET 200SP more than 2000 m above sea level".
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

SIPLUS products based on ET 200SP are offered for reliable operation under heavy to extreme operating conditions.

Using the distributed I/O system ET 200SP more than 2000 m above sea level

The maximum "operating height above sea level" depends on the module and is described in the technical specifications of the respective module. The product data sheets with daily updated technical specifications can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td) at Industry Online Support. Enter the article number or the short description of the desired module on the website.

For altitudes > 2000 m, the following constraints apply to the maximum specified ambient temperature:

Restrictions of the specified maximum ambient temperature in reference to the installation altitude

Installation altitude	Derating factor for ambient temperature [1]
-1000 m to 2000 m	1.0
2000 m to 3000 m	0.9
3000 m to 4000 m	0.8
4000 m to 5000 m	0.7

[1] Base value for application of the derating factor is the maximum permissible ambient temperature in °C for 2000 m.

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. This is based on the IEC 61131-2 standard.
- Make sure that the power supplies you use are rated for altitudes > 2000 m.

Effects on the availability of modules
The higher cosmic radiation present during operation at altitudes above 2000 m will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases this can result in a transition of modules to the safe state, especially for fail-safe modules. However, the functional safety of the modules is fully retained.

NOTE
Fail-safe modules are certified for operation in safety mode up to the maximum altitude listed in the product data sheet.
All other markings and certifications are currently based on an altitude of up to 2000 m.

Information on PFDavg, PFH values for ET 200SP F
PFDavg and PFH values for F-CPUs at operating altitudes up to 5,000 m. Below you will find the probability of failure values (PFDavg and PFH values) for the F-CPUs with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode low demand mode **According to IEC 61508:2010:** **PFDavg = Average probability of a dangerous failure on demand**	**Operation in high demand or continuous mode** high demand/continuous mode **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h-1]**
< 2E-05	< 1E-09

NOTE
For fail-safe I/O modules, you can find the relevant details on PFDavg and PFH values on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481784).

16.10 Insulation, protection class, degree of protection and rated voltage

Insulation

The isolation for the I/O modules is dimensioned according to the requirements of EN 61131-2 and EN 61010-2-201: The insulation for the motor starters is designed in accordance with the requirements of IEC 60947-1.

NOTE
In the case of modules with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Severity for voltage interruption according to IEC 61131-2

Interface modules, CPUs meet the severity class PS1 for voltage interruptions (1 ms).

Pollution degree/overvoltage category in accordance with IEC 61131 and IEC 61010-2-201

- Pollution degree: 2 (macro environment)
- Overvoltage category: II

Pollution degree/overvoltage category according to IEC 60947

- Pollution degree 2
- Overvoltage category: III

Protection class according to IEC 61131-2:2007 and IEC 61010-2-201

The ET 200SP distributed I/O system meets protection class I and includes parts of protection classes II and III.

The grounding of the mounting rail must meet the requirements for a functional earth FE.

Recommendation: For an interference-proof installation, the ground conductor should have a cross-section > 6 mm^2.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 according to IEC 60529 for all modules of the ET 200SP distributed I/O system, which means:

- Protection against contact with standard probes
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

NOTE

Use a BU cover

To meet the requirements of the degree of protection "IP20", fit a BU cover onto unfitted BaseUnits.

To ensure touch safety, fit a cover onto the opening of the infeed bus contacts belonging to the last plugged-in motor starter BaseUnit.

Rated voltage for operation

The ET 200SP distributed I/O system works with the rated voltage and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 1-404 Rated voltage for operation

Rated voltage	Tolerance range
24 V DC	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]
120 V AC (50/60 Hz)	93 to 132 V AC
230 V AC (50/60 Hz)	187 to 264 V AC
400 V AC (50/60 Hz) [3]	48 to 500 V AC

[1] Static value: Generation as protective extra low voltage with safe electrical separation in accordance with IEC 61131-2 or. IEC 61010-2-201.

[2] Dynamic value: Including ripple, e.g. as in the case of three-phase bridge power rectification

[3] Valid for the infeed bus of the modules and BaseUnits of motor starters only

16.11 Use of the ET 200SP distributed I/O system in zone 2 potentially explosive atmospheres

See product information "Use of subassemblies/modules in Zone 2 Hazardous Area" (https://support.automation.siemens.com/WW/view/en/19692172).

NOTE

Use of Ex modules

When you use Ex modules and the ET 200SP is located in a hazardous area of Zone 2, observe the notes in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

NOTE

Zone 22: Observe standards and regulations, and individual acceptance test required

If you install, use and maintain the ET 200SP in hazardous area Zone 22, you must comply with the relevant standards, installation/setup regulations and country-specific regulations for Zone 22 (for example, the ET 200SP must be installed in an enclosure suitable for Zone 22). A individual acceptance test by a certification body (Ex) is also required.

Dimension drawings

A

A.1 SIMATIC system rail

SIMATIC system rail dimension drawing

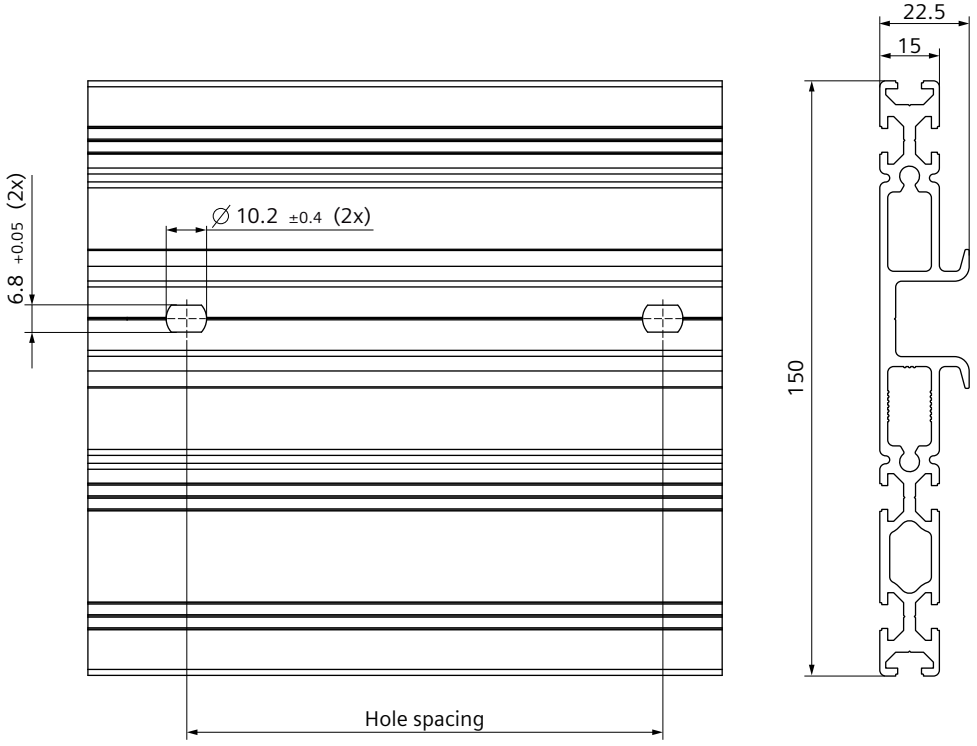


Figure 1-159 SIMATIC system rail dimension drawing

Article number	Hole spacing	Comment
6ES7193-6MR00-0AA0	466 ± 0.4 mm	With holes
6ES7193-6MR00-0BA0	500 ± 0.4 mm	With holes
6ES7193-6MR00-0CA0	800 ± 0.4 mm	With holes
6ES7193-6MR00-0DA0	-	Without holes

You can find additional dimensions of the SIMATIC system rail in section Accessories/Spare parts (Page 370).

A.2 Shield connector

Dimensional diagram of the shield connector

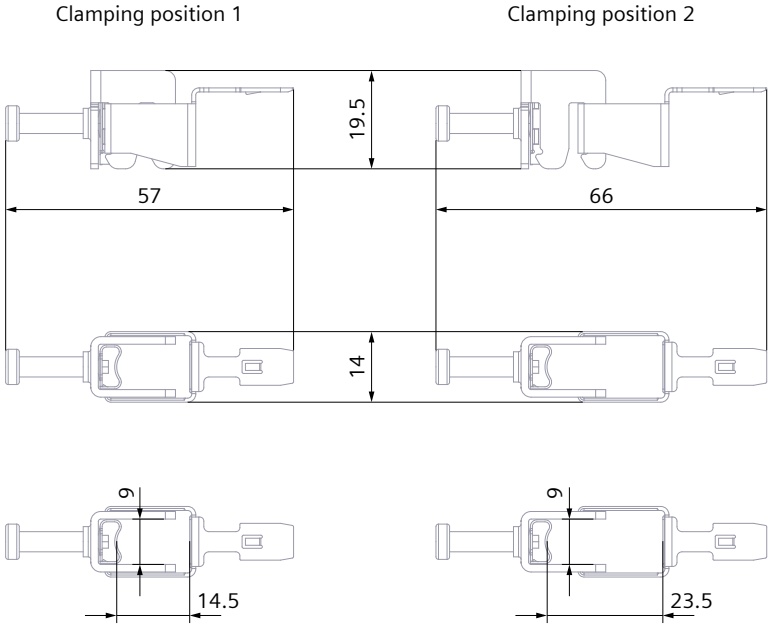


Figure 1-160 Dimensional diagram of the shield connector

A.3 Labeling strip

Dimension drawing of the labeling strips (roll)

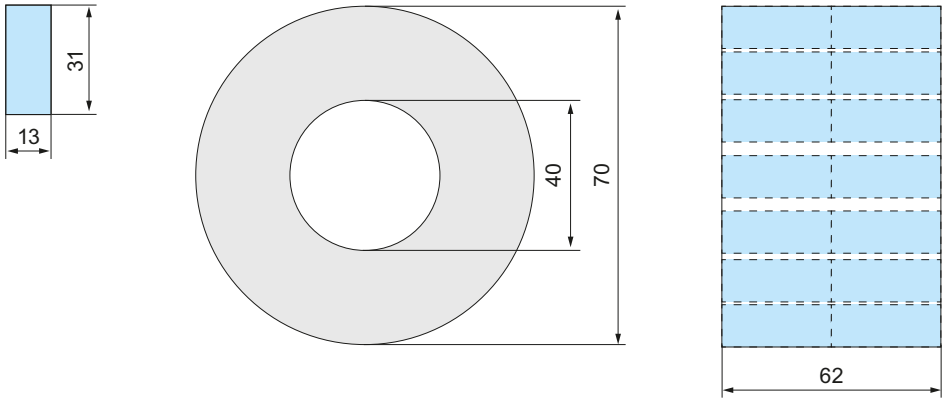


Figure 1-161 Dimension drawing of the labeling strips (roll)

Dimension drawing of the labeling strips (DIN A4 sheet)

The product information for the labeling strips (DIN A4 sheets) is available for download on the Internet (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7193-6LA10-0AA0).

A.4 Reference identification labels

Dimensional diagram of reference identification label and sheet

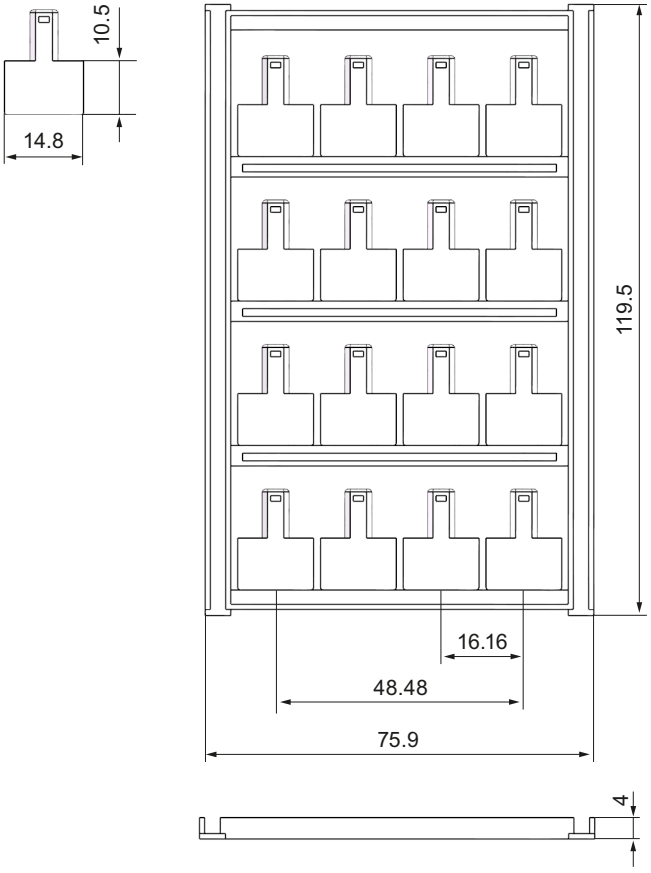


Figure 1-162 Dimensional diagram of reference identification label and sheet

Accessories/spare parts

B

Accessories for the ET 200SP distributed I/O system

Table 1-405 Accessories, general

Accessories, general	Packing unit	Article number
Strain relief units incl. screws	5 units	6ES7193-6RA00-1AN0
Cover for the BusAdapter interface	5 units	6ES7591-3AA00-0AA0
PROFIBUS FastConnect bus connector	1 unit	6ES7972-0BB70-0XA0
Server module (spare part)	1 unit	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	5 units	6ES7133-6CV15-1AM0
• 20 mm wide	5 units	6ES7133-6CV20-1AM0
24 V DC connector (spare part)	10 units	6ES7193-4JB00-0AA0
Shield connection for BaseUnit (shield contacts and shield terminals)	5 units	6ES7193-6SC20-1AM0
Reference identification label, sheet with 16 labels	10 units	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray labeling strips (with a total of 500 strips), film, for labeling with thermal transfer roll printer	1 unit	6ES7193-6LR10-0AA0
• Roll, yellow labeling strips (with a total of 500 strips), film, for labeling with thermal transfer roll printer	1 unit	6ES7193-6LR10-0AG0
• DIN A4 sheets, light gray labeling strips (with a total of 1000 labels), paper, perforated, for labeling with laser printer	10 units	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow labeling strips (with a total of 1000 labels), paper, perforated, for labeling with laser printer	10 units	6ES7193-6LA10-0AG0
Mechanical coding element (spare part)[1)]		
• Coding element (type A)	20 units	6ES7193-6KA00-3AA0
• Coding element (type B)	20 units	6ES7193-6KB00-3AA0
• Coding element (type C)	20 units	6ES7193-6KC00-3AA0
• Coding element (type D)	20 units	6ES7193-6KD00-3AA0
Electronic coding element (spare part)[1)]		
• Coding element (type F, for fail-safe modules)	5 units	6ES7193-6EF00-1AA0
• Coding element (type H)	5 units	6ES7193-6EH00-1AA0
Mounting rails, tinned steel strip[2)]		
• Length: 483 mm	1 unit	6ES5710-8MA11
• Length: 530 mm	1 unit	6ES5710-8MA21
• Length: 830 mm	1 unit	6ES5710-8MA31
• Length 2000 mm	1 unit	6ES5710-8MA41
SIMATIC system rails[2)]		
• Length 483 mm	1 unit	6ES7193-6MR00-0AA0

Accessories, general	Packing unit	Article number
• Length 530 mm	1 unit	6ES7193-6MR00-0BA0
• Length 830 mm	1 unit	6ES7193-6MR00-0CA0
• Length 2000 mm	1 unit	6ES7193-6MR00-0DA0

[1] For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module (Page 317).

[2] The length of the DIN rails and SIMATIC system rails can be shortened as required.

Table 1-406 Accessories, color identification labels (push-in terminals), 15 mm wide

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit	Article number
16 process terminals (see I/O module manual)		
• Gray (terminals 1 to 16); color code CC00	10 units	6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	10 units	6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	50 units	6ES7193-6CP01-4MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	10 units	6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	50 units	6ES7193-6CP02-4MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	10 units	6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	10 units	6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16)	10 units	6ES7193-6CP05-2MA0
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)		
• Yellow-green (terminals 1 A to 10 A); color code CC71	10 units	6ES7193-6CP71-2AA0
• Red (terminals 1 A to 10 A); color code CC72	10 units	6ES7193-6CP72-2AA0
• Blue (terminals 1 A to 10 A); color code CC73	10 units	6ES7193-6CP73-2AA0
• Blue (terminals 1 A to 10 A); color code CC73	50 units	6ES7193-6CP73-4AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)		
• Red (terminals 1B to 5B), blue (terminals 1 to 5C); color code CC74	10 units	6ES7193-6CP74-2AA0
16 potential terminals (for PotDis-BU-**P1**/x-R)		
• Red (terminals 1 to 16); color code CC62	10 units	6ES7193-6CP62-2MA0
16 potential terminals (for PotDis-BU-**P2**/x-B)		
• Blue (terminals 1 to 16); color code CC63	10 units	6ES7193-6CP63-2MA0
18 potential terminals (for PotDis-TB-**P1**-R)		
• Red (terminals 1 to 18); color code CC12	10 units	6ES7193-6CP12-2MT0
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**P2**-B)		
• Blue (terminals 1 to 18); color code CC13	10 units	6ES7193-6CP13-2MT0

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit	Article number
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**BR**-W)		
• Yellow/green (terminals 1 to 18); color code CC11	10 units	6ES7193-6CP11-2MT0
• Red (terminals 1 to 18); color code CC12	10 units	6ES7193-6CP12-2MT0
• Blue (terminals 1 to 18); color code CC13	10 units	6ES7193-6CP13-2MT0
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**n.c.**-G)		
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0

Table 1-407 Accessories, color identification labels (push-in terminals), 20 mm wide

Accessories, color identification labels (push-in terminals), 20 mm wide	Packing unit	Article number
12 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	10 units	6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	10 units	6ES7193-6CP42-2MB0
6 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	10 units	6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	10 units	6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)		
• Yellow-green (terminals 1 A to 4 A); color code CC81	10 units	6ES7193-6CP81-2AB0
• Red (terminals 1 A to 4 A); color code CC82	10 units	6ES7193-6CP82-2AB0
• Blue (terminals 1 A to 4 A); color code CC83	10 units	6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)		
• Yellow-green (terminals 1 A and 2 A); color code CC84	10 units	6ES7193-6CP84-2AC0
• Red (terminals 1 A and 2 A); color code CC85	10 units	6ES7193-6CP85-2AC0
• Blue (terminals 1 A and 2 A); color code CC86	10 units	6ES7193-6CP86-2AC0

Table 1-408 SIMATIC memory card accessories

Capacity	Packing unit	Article number
4 MB	1 unit	6ES7954-8LCxx-0AA0
12 MB	1 unit	6ES7954-8LExx-0AA0
24 MB	1 unit	6ES7954-8LFxx-0AA0
256 MB	1 unit	6ES7954-8LL02-0AA0
2 GB	1 unit	6ES7954-8LPxx-0AA0
32 GB	1 unit	6ES7954-8LTxx-0AA0

Table 1-409 Accessories for motor starters

Short designation	Packing unit	Article number
3DI/LC module (connecting terminal)	1 unit	3RK1908-1AA00-0BP0
Fan	1 unit	3RW4928-8VB00

Short designation	Packing unit	Article number
BU cover 30	1 unit	3RK1908-1CA00-0BP0
Touch protection cover for the infeed bus	10 units	3RK1908-1DA00-2BP0
Mechanical bracket for BaseUnit	5 units	3RK1908-1EA00-1BP0

Components for lightning protection

If you need surge protection devices for lightning protection, you can find additional information in the function manual Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566).

Online catalog

Additional article numbers for ET 200SP can be found on the Internet (https://mall.industry.siemens.com) in the online catalog and online ordering system.

See also

Firmware update (Page 322)

B.1 Lightning protection and overvoltage protection for fail-safe modules

Overvoltage arrestors for fail-safe modules

NOTE

This section only lists the overvoltage arrestors that may be used to protect the fail-safe modules.

Be sure to observe the detailed information on lightning protection and overvoltage protection of the ET 200SP distributed I/O system in Electromagnetic compatibility of fail-safe modules (Page 357).

Components for overvoltage protection of fail-safe modules (lightning protection zone transition 0_B to 1)

The overvoltage arrestors are only required for unshielded cables. The Configuring interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual lists the overvoltage arrestors which you may use for fail-safe modules.

Use over 2 000 m above sea level and extended temperature range

C

C.1 Ambient temperature and installation altitude

Extension of the temperature range and the installation altitude

The previously permissible range of ambient temperatures of **0 °C** to 60 °C for the horizontal mounting position has been extended for a large number of modules to a range of ambient temperatures of **-30 °C** to 60 °C or **-25 °C** to 60 °C (in each case without condensation or icing). Furthermore, the permissible installation altitude have been extended to installation altitudes of up to 5 000 m depending on the module.

The accessory components offered for ET 200SP (labeling strips, shield terminals, etc.) can also be used down to -30 °C and for altitudes up to 5 000 m.

The following tables show an overview of the current climatic ambient conditions for ambient temperature and installation altitude of modules of the ET 200SP product families.

For modules that are not listed, the current information in the "Technical specifications" section of the corresponding Equipment Manual applies.

Reference

The current status of the respective modules can be found in the online published technical specifications.

In general, the module-dependent extended climatic operating conditions are described in the "Technical specifications" section of the respective modules in the equipment manuals.

C.2 CPUs

CPUs

Standard CPU	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1510SP-1 PN	6ES7510-1DJ01-0AB0	-25 to +60	FS 05	5 000
CPU 1510SP-1 PN	6ES7510-1DK03-0AB0	-30 to +60	FS 01	5 000
CPU 1512SP-1 PN	6ES7512-1DK01-0AB0	-25 to +60	FS 05	5 000
CPU 1512SP-1 PN	6ES7512-1DM03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP-2 PN	6ES7514-2DN03-0AB0	-30 to +60	FS 01	5 000

Fail-safe CPUs	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1510SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 01	5 000

CPU 1510SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000
CPU 1512SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 01	5 000
CPU 1512SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand or continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 m < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Technology CPUs	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CPU 1514SP T-2 PN	6ES7514-2VN03-0AB0	-30 to +60	FS 01	5 000

Communications processor

Communications processor	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CP 1542SP-1	6GK7542-6UX00-0XE0	-30 to +60	FS 01	2 000
CP 1542SP-1 IRC	6GK7542-6VX00-0XE0	-30 to +60	FS 01	2 000
CP 1543SP-1	6GK7543-6WX00-0XE0	-30 to +60	FS 01	2 000

Open Controller

Standard Open Controller	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CPU 1515SP PC, 32-bit	6ES7677-2AA31-0EB0	0 to +60	FS 07	2 000
CPU 1515SP PC F, 32-bit	6ES7677-2FA31-0EB0	0 to +60	FS 03	2 000
CPU 1515SP PC, WES7P	6ES7677-2AA41-0FB0	0 to +60	FS 06	2 000
CPU 1515SP PC, WES7P + HMI (128PT)	6ES7677-2AA41-0FK0	0 to +60	FS 06	2 000
CPU 1515SP PC, WES7P + HMI (512PT)	6ES7677-2AA41-0FL0	0 to +60	FS 06	2 000
CPU 1515SP PC, WES7P + HMI (2kPT)	6ES7677-2AA41-0FM0	0 to +60	FS 06	2 000
CPU 1515SP PC2	6ES7677-2DB42-0GB0 6ES7677-2DB42-0GB1	-20 to +60	FS 04 FS 01	2 000

CPU 1515SP PC2 + HMI (128PT)	6ES7677-2DB42-0GK0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 + HMI (512PT)	6ES7677-2DB42-0GL0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 + HMI (2kPT)	6ES7677-2DB42-0GM0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 IndOS	6ES7677-2DB43-0GB1	-20 to +60	FS 03	2 000

Fail-safe Open Controllers	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CPU 1515SP PC F, WES7P	6ES7677-2FA41-0FB0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (128PT)	6ES7677-2FA41-0FK0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (512PT)	6ES7677-2FA41-0FL0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (2kPT)	6ES7677-2FA41-0FM0	0 to +60	FS 03	2 000
CPU 1515SP PC2 F	6ES7677-2SB42-0GB0 6ES7677-2SB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 F + HMI (128PT)	6ES7677-2SB42-0GK0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F + HMI (512PT)	6ES7677-2SB42-0GL0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F + HMI (2kPT)	6ES7677-2SB42-0GM0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F IndOS	6ES7677-2SB43-0GB1	-20 to +60	FS 03	2 000
CPU 1515SP PC2 TF	6ES7677-2WB42-0GB0 6ES7677-2WB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 TF + HMI (128PT)	6ES7677-2WB42-0GK0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 TF + HMI (512PT)	6ES7677-2WB42-0GL0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 TF + HMI (2kPT)	6ES7677-2WB42-0GM0	-20 to +60	FS 01	2 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand or continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Open Controller technology	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	

CPU 1515SP PC2 T	6ES7677-2VB42-0GB0 6ES7677-2VB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 T + HMI (128PT)	6ES7677-2VB42-0GK0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 T + HMI (512PT)	6ES7677-2VB42-0GL0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 T + HMI (2kPT)	6ES7677-2VB42-0GM0	-20 to +60	FS 01	2 000

C.3 Interface modules

Interface module	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
IM 155-6 PN BA	6ES7155-6AR00-0AN0	-30 to +60	FS 04	5 000
IM 155-6 PN ST incl. BA 2xRJ45	6ES7155-6AA02-0BN0	0 to +60	FS 01	5 000
IM 155-6 PN ST	6ES7155-6AU02-0BN0	-30 to +60	FS 01	5 000
IM 155-6 PN/2 HF	6ES7155-6AU01-0CN0	-30 to +60	FS 02	5 000
IM 155-6 PN/3 HF 3-port	6ES7155-6AU30-0CN0	-30 to +60	FS 02	5 000
IM 155-6 PN R1	6ES7155-6AU00-0HM0	-30 to +60	FS 01	2 000
IM 155-6 MF HF	6ES7155-6MU00-0CN0	-30 to +60	FS 01	5 000
IM 155-6 MF HF	6ES7155-6MU01-0CN0	-30 to +60	FS 01	5 000
IM 155-6 PN HS	6ES7155-6AU00-0DN0	-25 to +60	FS 02	5 000
IM 155-6 DP HF - Bundle	6ES7155-6BA01-0CN0	0 to +60	FS 01	5 000
Server module (spare part)	6ES7193-6PA00-0AA0	-30 to +60	FS 07	5 000

C.4 BusAdapter

BusAdapter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BA 2x RJ45	6ES7193-6AR00-0AA0	-30 to +60	FS 06	5 000
BA 2x FC	6ES7193-6AF00-0AA0	-30 to +60	FS 04	5 000
BA 2x M12	6ES7193-6AM00-0AA0	-30 to +60	FS 01	5 000
BA 2x LC	6ES7193-6AG00-0AA0	-30 to +60	FS 05	5 000
BA LC/RJ45	6ES7193-6AG20-0AA0	-30 to +60	FS 04	5 000
BA LC/FC	6ES7193-6AG40-0AA0	-30 to +60	FS 04	5 000
BA 2x LC-LD	6ES7193-6AG50-0AA0	-30 to +60	FS 01	5 000
BA LC-LD/RJ45	6ES7193-6AG60-0AA0	-30 to +60	FS 01	5 000
BA LC-LD/M12	6ES7193-6AG70-0AA0	-30 to +60	FS 01	5 000
BA 2x SCRJ	6ES7193-6AP00-0AA0	-25 to +60	FS 04	5 000
BA SCRJ/RJ45	6ES7193-6AP20-0AA0	-25 to +60	FS 04	5 000

BA SCRJ/FC	6ES7193-6AP40-0AA0	-25 to +60	FS 04	5 000
DP connector	6ES7972-0BB70-0XA0	-25 to +60	FS 03	2 000
BA-SEND BA 1xFC	6ES7193-6AS00-0AA0	-30 to +60	FS 05	2 000

C.5 BaseUnits

BaseUnits

BaseUnit BU type P0	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BU30-MS1	3RK1908-0AP00-0AP0	-25 to +60	FS 01	4 000
BU30-MS3	3RK1908-0AP00-0BP0	-25 to +60	FS 01	4 000
BU30-MS2	3RK1908-0AP00-0CP0	-25 to +60	FS 01	4 000
BU30-MS4	3RK1908-0AP00-0DP0	-25 to +60	FS 01	4 000
BU30-MS5	3RK1908-0AP00-0EP0	-25 to +60	FS 01	2 000
BU30-MS6	3RK1908-0AP00-0FP0	-25 to +60	FS 01	2 000
BU30-MS7	3RK1908-0AP00-0GP0	-25 to +60	FS 01	2 000
BU30-MS8	3RK1908-0AP00-0HP0	-25 to +60	FS 01	2 000
BU30-MS9	3RK1908-0AP00-0JP0	-25 to +60	FS 01	2 000
BU30-MS10	3RK1908-0AP00-0KP0	-25 to +60	FS 01	2 000

BaseUnits BU type A0 and A1	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BU15-P16+A0+2B	6ES7193-6BP00-0BA0	-30 to +60	FS 06	5 000
BU15-P16+A0+2D	6ES7193-6BP00-0DA0	-30 to +60	FS 06	5 000
BU15 double BU+2B	6ES7193-6BP60-0BA0	-30 to +60	FS 03	5 000
BU15 double BU+2DB	6ES7193-6BP60-0DA0	-30 to +60	FS 03	5 000
BU15-P16+A10+2B	6ES7193-6BP20-0BA0	-30 to +60	FS 06	5 000
BU15-P16+A10+2D	6ES7193-6BP20-0DA0	-30 to +60	FS 07	5 000
BU15-P16+A0+2B/T	6ES7193-6BP00-0BA1	-30 to +60	FS 06	5 000
BU15-P16+A0+2D/T	6ES7193-6BP00-0DA1	-30 to +60	FS 06	5 000
BU15-P16+A0+12B/T	6ES7193-6BP40-0BA1	-30 to +60	FS 06	5 000
BU15-P16+A0+12D/T	6ES7193-6BP40-0DA1	-30 to +60	FS 07	5 000

BaseUnits BU type B0 to U0	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BU20-P12+A4+0B	6ES7193-6BP20-0BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P12+A0+4B	6ES7193-6BP20-0BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P6+A2+4D	6ES7193-6BP20-0DC0	-30 to +60	FS 03	5 000 (SELV/PELV supplied)

BU20-P6+A2+4B	6ES7193-6BP20-0BC1	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU20-P12+A0+0B	6ES7193-6BP00-0BD0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BaseUnit BU-SEND	6ES7193-6BN00-0NE0	-30 to +60	FS 04	2 000
BU20-P8+A4+0B	6ES7193-6BP20-0BF0	-30 to +60	FS 04	2 000
BU20-P16+A0+2B	6ES7193-6BP00-0BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P16+A0+2D	6ES7193-6BP00-0DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 V AC)

BaseUnit BU type M0	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
BU type M0	6ES7193-6BR00-0HM0	-30 to +60	FS 01	2 000

C.6 I/O modules

Information on PFDavg, PFH values for ET 200SP fail-safe I/O modules

The safety parameters specified in the Equipment Manual of the fail-safe I/O module ET 200SP (PFD_{avg}, PFH values) already reflect the influence of higher cosmic radiation (soft error rate) for operation up to 4 000 m above sea level.

I/O modules

Digital input modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
DI 4x120...230VAC ST	6ES7131-6FD01-0BB1	-30 to +60	FS 02	2 000
DI 8x24VDC BA	6ES7131-6BF01-0AA0	-30 to +60	FS 03	5 000
DI 8x24VDC SRC BA	6ES7131-6BF61-0AA0	-30 to +60	FS 02	2 000
DI 8x24VAC/48VUC BA	6ES7131-6CF00-0AU0	-30 to +60	FS 02	4 000 (48 V AC/48 V DC)
DI 8x24VDC ST	6ES7131-6BF01-0BA0	-30 to +60	FS 02	5 000
DI 8x24VDC HF	6ES7131-6BF00-0CA0	-30 to +60	FS 07	5 000
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	-30 to +60	FS 04	5 000
DI 8x24VDC HS	6ES7131-6BF00-0DA0	-30 to +60	FS 04	5 000
DI 16x24VDC ST	6ES7131-6BH01-0BA0	-30 to +60	FS 02	5 000

Fail-safe digital input modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	0 to +60	FS 04	4 000 [1]
F-DI 8x24VDC HF	6ES7136-6BA01-0CA0	0 to +60	FS 01	4 000

[1] As of revision FS 04

Digital output modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	-30 to +60	FS 08	5 000
	6ES7132-6BD21-0BA0	-30 to +60	FS 01	5 000
DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	-30 to +60	FS 06	5 000
	6ES7132-6BD21-0CA0	-30 to +60	FS 01	5 000
DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	-30 to +60	FS 05	3 000 (277 V AC)
DQ 4x24..230VAC/2A HF	6ES7132-6FD00-0CU0	-30 to +60	FS 04	3 000 (277 V AC)
DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	-30 to +60	FS 05	5 000
DQ 8x24VDC/0.5A BA	6ES7132-6BF01-0AA0	-30 to +60	FS 02	5 000
DQ 8x24VDC/0.5A SNK BA	6ES7132-6BF61-0AA0	-25 to +60	FS 02	5 000
DQ 8x24VDC/0.5A ST	6ES7132-6BF01-0BA0	-30 to +60	FS 02	5 000
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	-30 to +60	FS 07	5 000
	6ES7132-6BF01-0CA0	-30 to +60	FS 01	5 000
DQ 16x24VDC/0.5A BA	6ES7132-6BH00-0AA0	-30 to +60	FS 03	5 000
DQ 16x24VDC/0.5A ST	6ES7132-6BH01-0BA0	-30 to +60	FS 03	5 000
DQ 16x24VDC/0.5A HF	6ES7132-6BH00-0CA0	-30 to +60	FS 01	5 000

Fail-safe digital output modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	0 to +60	FS 04	4 000 [1]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB01-0CA0	0 to +60	FS 01	4 000
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	0 to +60	FS 01	4 000

[1] As of revision FS 04

Digital input/output modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DI 8x/DQ 8x24VDC/0.5A ST	6ES7133-6BH00-0BA0	-30 to +60	FS 01	5 000

Relay modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
RQ 4x24VUC/2A CO ST	6ES7132-6GD51-0BA0	-30 to +60	FS 02	2 000
RQ 4x120VDC-230VAC/5A NO ST	6ES7132-6HD01-0BB1	-30 to +60	FS 02	2 000

RQ 4x120VDC-230VAC/5A NO MA ST	6ES7132-6MD00-0BB1	-30 to +60	FS 03	2 000
RQ 3x120VDC-230VAC/5A CO ST	6ES7132-6HC50-0BU0	-30 to +60	FS 01	2 000
RQ 3x120VDC-230VAC/5A CO n.i. ST	6ES7132-6HC70-0BU0	-30 to +60	FS 01	2 000

Fail-safe relay modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-RQ 1x24VDC/24..230VAC/5A ST	6ES7136-6RA00-0BF0	0 to +60	FS 01	2 000

Analog input modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
AI 2xI 2/4-wire ST	6ES7134-6GB00-0BA1	-30 to +60	FS 04	5 000
AI 2xU ST	6ES7134-6FB00-0BA1	-30 to +60	FS 04	5 000
AI 2xU/I 2/4-wire HF	6ES7134-6HB00-0CA1	-30 to +60	FS 06	5 000
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	-30 to +60	FS 07	5 000
AI 2x SG 4-/6-wire HS	7MH4134-6LB00-0DA0	-25 to +60	FS 01	3 000
AI 4xI 2-wire 4...20mA HART HF	6ES7134-6TD00-0CA1	-30 to +60	FS 01	5 000
AI 4xI 2-/4-wire ST	6ES7134-6GD01-0BA1	-30 to +60	FS 02	5 000
AI 4xU/I 2-wire ST	6ES7134-6HD01-0BA1	-30 to +60	FS 02	5 000
AI 8xU BA	6ES7134-6FF00-0AA1	-30 to +60	FS 04	5 000
AI 4xTC HS	6ES7134-6JD00-0DA1	-30 to +60	FS 02	5 000
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	-30 to +60	FS 08	5 000
AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	-30 to +60	FS 05	5 000
AI Energy Meter 480V ST	6ES7134-6PA20-0BD0	0 to +60	FS 01	3 000
AI Energy Meter HF CT	6ES7134-6PA00-0CU0	-30 to +60	FS 01	2 000 [2]
AI Energy Meter HF RC	6ES7134-6PA20-0CU0	-30 to +60	FS 01	2 000 [2]
AI Energy Meter CT ST	6ES7134-6PA01-0BU0	-30 to +60	FS 01	3 000
AI Energy Meter CT HF	6ES7134-6PA01-0CU0	-30 to +60	FS 01	3 000
AI Energy Meter RC ST	6ES7134-6PA21-0BU0	-30 to +60	FS 01	3 000
AI Energy Meter RC HF	6ES7134-6PA21-0CU0	-30 to +60	FS 01	3 000

[2] Installation altitude higher than 2 000 m on request

Fail-safe analog input modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-AI 4xI (0)4..20mA HF	6ES7136-6AA00-0CA1	0 to +60	FS 01	4 000
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	0 to +60	FS 01	4 000

Analog output modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
AQ 2xI ST	6ES7135-6GB00-0BA1	-30 to +60	FS 03	5 000

AQ 2xU ST	6ES7135-6FB00-0BA1	-30 to +60	FS 03	5 000
AQ 2xU/I HF	6ES7135-6HB00-0CA1	-30 to +60	FS 04	5 000
AQ 2xU/I HS	6ES7135-6HB00-0DA1	-30 to +60	FS 06	5 000
AQ 4xU/I ST	6ES7135-6HD00-0BA1	-30 to +60	FS 07	5 000
AQ 4xI HART HF	6ES7135-6TD00-0CA1	-30 to +60	FS 01	5 000

Technology modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
TM Count 1x24V	6ES7138-6AA01-0BA0	-30 bis +60	FS 03	5 000
TM Pulse 2x24V	6ES7138-6DB00-0BB1	-30 bis +60	FS 03	5 000
TM PTO 2x24V	6ES7138-6EB00-0BA0	-30 bis +60	FS 00	5 000
TM WP321 1x5VDC#1-4mV/V ST	7MH4138-6AA00-0BA0	-25 bis +60	FS 04	5 000
TM WP351 HF	7MH4138-6BA00-0CU0	-30 bis +60	FS 01	5 000
TM ECC PL ST	6FE1242-6TM20-0BB1	-30 bis +60	FS 00	2 000
TM ECC 2xPWM ST	6FE1242-6TM10-0BB1	-30 bis +60	FS 00	2 000
Pneumatic valve island Airline SP 8647	Bürkert	0 bis +55	-	2 000
TM StepDrive 1x24..48V/5A*	phytron 10020273	0 bis +60	-	2 000
TM SITRANS FCT070	7ME4138-6AA00-0BB1	-30 bis +60	FS 00	2 000

Fail-safe technology modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-TM ServoDrive 1x24..48V 5A ST	6BK1136-6AB00-0BU0	-30 bis +60	FS 00	3 000

Communications modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CM PtP	6ES7137-6AA00-0BA0	-30 bis +60	FS 03	5 000
CM 1xDALI	6ES7137-6CA00-0BU0	-30 bis +60	FS 03	3 000
CM 4xIO-Link	6ES7137-6BD00-0BA0	-30 bis +60	FS 03	2 000
CM DP (für CPU)	6ES7545-5DA00-0AB0	-25 bis +60	FS 04	5 000
CM AS-I MASTER ST (AS-I V3.0)	3RK7137-6SA00-0BC1	-25 bis +60	FS 20	2 000
CM CAN	6ES7137-6EA00-0BA0	-30 bis +60	FS 03	5 000

Fail-safe communications modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-CM AS-I SAFETY ST	3RK7136-6SC00-0BC1	0 bis +60	FS 01	2 000

[1] As of revision FS 05

Fail-safe power modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	0 bis +60	FS 05	4 000 [1]

[1] As of revision FS 05

C.7 Motor starter

Motor starter

Direct starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DS 0.1 - 0.4A HF	3RK1308-0AA00-0CP0	-25 to +60	FS 01	4 000
DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0	-25 to +60	FS 01	4 000
DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0	-25 to +60	FS 01	4 000
DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0	-25 to +60	FS 01	4 000
DS 4.0 - 12 A HF	3RK1308-0AE00-0CP0	-25 to +60	FS 01	4 000

Reversing starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
RS 0.1 - 0.4A HF	3RK1308-0BA00-0CP0	-25 to +60	FS 01	4 000
RS 0.3 - 1A HF	3RK1308-0BB00-0CP0	-25 to +60	FS 01	4 000
RS 0.9 - 3A HF	3RK1308-0BC00-0CP0	-25 to +60	FS 01	4 000
RS 2.8 - 9A HF	3RK1308-0BD00-0CP0	-25 to +60	FS 01	4 000
RS 4.0 - 12A HF	3RK1308-0BE00-0CP0	-25 to +60	FS 01	4 000

Fail-safe direct starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-DS 0.1 - 0.4A HF	3RK1308-0CA00-0CP0	-25 to +60	FS 01	4 000
F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0	-25 to +60	FS 01	4 000
F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0	-25 to +60	FS 01	4 000
F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0	-25 to +60	FS 01	4 000
F-DS 4.0 - 12 A HF	3RK1308-0CE00-0CP0	-25 to +60	FS 01	4 000

Fail-safe reversing starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-RS 0.1 - 0.4A HF	3RK1308-0DA00-0CP0	-25 to +60	FS 01	4 000
F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0	-25 to +60	FS 01	4 000
F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0	-25 to +60	FS 01	4 000
F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0	-25 to +60	FS 01	4 000
F-RS 4.0 - 12 A HF	3RK1308-0DE00-0CP0	-25 to +60	FS 01	4 000

C.8 Potential distributor

Potential distributor	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
PotDis-BU-P1/D-R	6ES7193-6UP00-0DP1	-30 to +60	FS 04	5 000
PotDis-BU-P1/B-R	6ES7193-6UP00-0BP1	-30 to +60	FS 04	5 000
PotDis-BU-P2/D-B	6ES7193-6UP00-0DP2	-30 to +60	FS 04	5 000
PotDis-BU-P2/B-B	6ES7193-6UP00-0BP2	-30 to +60	FS 04	5 000
PotDis TB P1-R	6ES7193-6TP00-0TP1	-30 to +60	FS 03	5 000
PotDis TB P2-B	6ES7193-6TP00-0TP2	-30 to +60	FS 03	5 000
PotDis TB BR-W	6ES7193-6TP00-0TP0	-30 to +60	FS 03	5 000
PotDis TB n.c.-G	6ES7193-6TP00-0TN0	-30 to +60	FS 03	5 000
BU cover - 15 mm (PU* 5) [1]	6ES7133-6CV15-1AM0	-40 to +60	FS 01	5 000
BU cover - 20 mm (PU* 5) [1]	6ES7133-6CV20-1AM0	-40 to +60	FS 01	5 000

[1] Packing unit: Pack of 5

C.9 Restrictions

Restrictions of the max. ambient temperature specified with regard to the installation altitude

Installation altitude	Derating factor for ambient temperature [1)]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 meters	0.7

1) Base value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air in higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. The basis is the standard IEC 61131-2.
- Make sure that the power supplies you use are also rated for altitudes > 2 000 m.
- The "Safety-related shutdown of standard modules" function, as described on the Internet (https://support.industry.siemens.com/cs/ww/en/view/39198632), is only released up to a maximum of 2 000 m.

Effects on availability

The higher cosmic radiation present during operation at altitudes above 2 000 m will also start to have an effect on the failure rate of electronic components (referred to as the soft error rate). In rare cases this can result in a transition of the module into the safe state, especially for safety modules. However, the functional safety of the module is fully retained.

NOTE

Information on the components of the ET 200SP I/O system
The markings and approvals printed on the components of the ET 200SP I/O system are currently based on operation at an altitude of up to 2 000 m above sea level. The fail-safe components are certified for operation in safety mode up to the specified maximum altitudes (according to "Z10 067803 0020" certificate (https://support.industry.siemens.com/cs/ww/de/view/57141281/en)).

Reference

You can find more information in the Mechanical and climatic environmental conditions (Page 360) section.

Calculating the leakage resistance

D

Introduction

If you wish to protect the ET 200SP using a ground-fault detector or a residual current circuit breaker, then you need the leakage resistance to select the correct safety components.

Ohmic resistance

When determining the leakage resistance of the ET 200SP, you must take into account the ohmic resistance from the RC combination of the module in question:

Table 1-410 Ohmic resistance

Module	Ohmic resistance from RC network
CPU/interface module	10 MΩ (±5 %)
BaseUnit BU15...D	10 MΩ (±5 %)
BaseUnit BU30-MSx	10 MΩ (±5 %)

Formula

You can calculate the leakage resistance of the ET 200SP using the following formula if you protect all of the modules listed above with one ground-fault detector:

$R_{ET200SP} = R_{module} / N$

$R_{ET200SP}$ = Leakage resistance of the ET 200SP

R_{module} = Leakage resistance of a module

N = Number of BaseUnits BU15...D and interface module in the ET 200SP

$R_{CPU/IM} = R_{BU15...D} = R_{Module} = 9.5\ M\Omega$

$R_{CPU/IM}$ = Leakage resistance of CP/interface module

$R_{BU15...D}$ = Leakage resistance of the BaseUnit BU15...D

If you protect the modules listed above within an ET 200SP with several ground-fault detectors, you must determine the leakage resistance for each individual ground-fault detector.

Example

The structure of an ET 200SP system consists of an IM 155-6 PN ST, two BaseUnits BU15...D and various input and output modules. The entire ET 200SP is protected with **one** ground-fault detector:

$$R_{ET\ 200SP} = \frac{9{,}5\ M\Omega}{3} = 3{,}17\ M\Omega$$

Figure 1-163 Calculation example for leakage resistance

SIMATIC ET 200SP data

E

E.1 Introduction

The EU Data Act, a key component of the European data strategy, went into effect on January 11, 2024.

The following information provides an overview of data that the ET 200SP automation system generates and that is accessible to you.

E.2 CPU data

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and program data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, system and security events, service data	Time formats, string formats, CSV, binary formats	Depending on application Several hundred bytes per event
Operating data (runtimes, cycle times, CPU utilization)	Numeric formats, time formats, JSON	Depending on application
Log data	Time formats, string formats, CSV	Depending on application

Continuous and real-time data generation

The ET 200SP is able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The CPU operates with defined cycle times in which process data is acquired and processed.

Data storage and storage duration

Local data storage

The ET 200SP stores data in integrated memory areas of the CPU and on the SIMATIC Memory Card.

Local data storage	Storage capacity	Storage duration
Load memory (via SIMATIC Memory Card)	4 MB to 32 GB, depending on SIMATIC Memory Card	Permanent
Code work memory	100 kB to 900 kB, depending on CPU	During operation of the CPU
Data work memory	750 kB to 3.5 MB	During operation of the CPU
Retentive memory	Up to 512 KB, depending on CPU	Permanent

More information
You can find more information on memory areas, retentivity, and memory usage in the Structure and Use of the CPU Memory function manual (https://support.industry.siemens.com/cs/ww/en/view/59193101).

Remote data storage
Data can be transmitted to external systems via various communications interfaces of ET 200SP, such as PROFINET and Industrial Ethernet.

The ET 200SP can send data to various remote systems, including SCADA systems, SQL databases, cloud platforms (e.g. Insights Hub), and file servers.

The ET 200SP can send logging data to a SIEM system in the form of Syslog messages.

The storage duration on external systems depends on the configuration of the respective system.

The ET 200SP CPU can be integrated as a data source into the Siemens Industrial Edge concept.

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	TIA Portal Web server OPC UA HMI/SCADA systems	User management Authentication Certificates	Prioritization of control tasks over data access Data throughputs up to 1 Gbps via PROFINET Encrypted data transmission available (HTTPS, TLS)
Configuration and program data	TIA Portal Web server SIMATIC Memory Card	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Diagnostics data, system and security events, service data	TIA Portal SIMATIC Automation Tool Web server	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Operating data (runtimes, cycle times, CPU utilization)	TIA Portal Web server HMI/SCADA systems SIMATIC Controller Profiling	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Log data	TIA Portal Trace and logic analyzer function	User management Authentication	Encrypted data transmission available (HTTPS, TLS)

* "Quality of service" refers to the ability of ET 200SP to efficiently manage network resources and ensure that certain performance requirements relating to data transfer are fulfilled.

Deletion of data from CPUs

To delete all data from the data memories of the CPU, the "Reset to factory settings" function is available.

A reset of the CPU to factory settings can be implemented using any of the following:

- Mode selector keys/switches of the CPU
- TIA Portal
- SIMATIC Automation Tool

More information
You can find more information on deleting data in the System Manual ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293), in the sections “Securely removing data” and “Reset to factory settings”.

E.3 Data of the interface and I/O modules

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFIBUS, PROFINET, EtherNet/IP, Modbus TCP (only for interface modules as MultiFieldbus devices)

Continuous and real-time data generation

The interface and I/O modules are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the CPU.

Data storage and storage duration

Local data storage
The interface and I/O modules store data in integrated memory areas.

Local data storage	Storage capacity	Storage duration
Retentive memory (for I&M data, configuration and parameter data*, service data, energy meters **)	Up to 16 MB for interface modules 1 To 6 MB for I/O modules	Permanent
Work memory (for process data, diagnostics data, fieldbus metadata, configuration and parameter data, service data)	Up to 1 MB for interface modules Several hundred KB for I/O modules	During operation of the module

* only interface modules as MultiFieldbus devices, IO-Link masters and CM 1xDALI

** only AI Energy Meter

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 388)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughputs up to 1 Gbps via PROFINET
Configuration and parameter data (upload to programming device/PC)	TIA Portal (via CPU) S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 388)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 388)	Standard fieldbus transmission mechanisms
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 388)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from interface and I/O modules

Interface modules

To delete all data from the data memories of the interface module, the "Reset to factory settings" function is available.

A reset of the IM to factory settings can be implemented using any of the following:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA
- STEP 7

I/O modules

The data of an IO-Link master can be deleted using S7-PCT by executing the "Reset to factory settings" function.

The data of a CM 1xDALI can be deleted via the CPU. For all other I/O modules, no delete function is available.

More information

You can find more information on deleting data in the System Manual ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293), in the sections “Securely removing data” and “Reset to factory settings”.

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Product information on the system manuals

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://new.siemens.com/cert.

General amendments to the documentation

This product information contains amendments to the system manuals. The product information is part of the product supplied. Consider the statements provided in it as more up-to-date than other documentation if uncertainties arise.
This product information is valid for all products which reference this product information.

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Operation of a system in an environment with low relative humidity

You have the possibility to operate the products in an environment with low relative humidity (calculated values: Dew point temperature -60 °C, 100 % humidity).
To do this, follow the following points in this product information.

Shock, vibrations
In the chapter "Mechanical and climatic environmental conditions" of the system manuals the "Tests for mechanical environmental conditions" table is replaced by the following table:

Table 1 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibrations	Vibration test according to IEC 60068-2-6 (sinusoidal)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each one of the three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes

ESD
Comply with the requirements of the table "Pulse-shaped disturbance variables" in the chapter "Electromagnetic compatibility" of the system manuals.

⚠ WARNING

Loss of the safety function, personal injury, property damage and destruction of the modules
When operating the system in an environment with low relative humidity (RH) < 10 % expect a rise of the electrostatic charge.
Take appropriate measures to ensure that the test levels specified in the "Pulse-shaped disturbance variables" table are not exceeded during this use.

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ET 200SP
Product information on the documentation of the ET 200SP distributed I/O system
Product Information

Module overview of ET 200SP
Module firmware corrected for R1 redundancy

A firmware update is required for some electronic modules to obtain the full compatibility for the ET 200SP R1 system. If an older firmware version of the module is used than the one specified below, a process data surge can occur during a redundancy switchover of the interface modules.

NOTE

All electronic modules not listed here do not require a firmware update to obtain full compatibility for the ET 200SP R1 system.

The following table shows which modules support a bumpless R1 switchover as of which firmware version:

Module	Article number	As of firmware version
F-CM AS-i Safety ST**	3RK7136-6SC00-0BC1	-
CM AS-i Master ST	3RK7137-6SA00-0BC1	V1.1.11
F-TM ServoDrive 1x24..48V ST	6BK1136-6AB00-0BU0	V1.3.0 or higher
F-TM ServoDrive 1x24..48V HF	6BK1136-6AB00-0CU0	V1.1.0 or higher
F-TM StepDrive 1x24..48V ST	6BK1136-6SB00-0BU0	V1.0.1 or higher
DI 8x24VDC BA*	6ES7131-6BF00-0AA0	-
DI 8x24VDC ST*	6ES7131-6BF00-0BA0	-
DI 8x24VDC SRC BA*	6ES7131-6BF60-0AA0	-
DI 16x24VDC ST*	6ES7131-6BH00-0BA0	-
DI 4x120..230VAC ST*	6ES7131-6FD00-0BB1	-
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	V2.0 or higher
DQ 8x24VDC/0,5A BA*	6ES7132-6BF00-0AA0	-
DQ 8x24VDC/0,5A ST*	6ES7132-6BF00-0BA0	-
DQ 8x24VDC/0,5A SNK BA*	6ES7132-6BF60-0AA0	-
DQ 16x24VDC/0,5A ST*	6ES7132-6BH00-0BA0	-
RQ 4x24VUC/2A CO ST*	6ES7132-6GD50-0BA0	-
RQ 4x24VUC...230VUC/5A*	6ES7132-6HD00-0BB1	-
AI 4xI 2-/4-wire ST*	6ES7134-6GD00-0BA1	-
AI 2xU/I 2-/4-wire HF	6ES7134-6HB00-0CA1	V2.0.5
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V2.0.3
AI 4xU/I 2-wire ST*	6ES7134-6HD00-0BA1	-
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	V2.1.1

* No firmware update is offered for these modules since there are compatible successor products

** No firmware update with the error correction is currently offered for these modules

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Module	Article number	As of firmware version
AI 4xTC HS	6ES7134-6JD00-0DA1	V1.0.3
AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	V2.1.1
AI Energy Meter*	6ES7134-6PA00-0BD0	-
AI Energy Meter 400VAC ST*	6ES7134-6PA01-0BD0	-
AI Energy Meter 480VAC ST*	6ES7134-6PA20-0BD0	-
AI Energy Meter 480VAC HF*	6ES7134-6PAx0-0CU0	-
AI4 x I HART	6ES7134-6TD00-0CA1	V1.1.1
AQ 2xU/I HF	6ES7135-6HB00-0CA1	V1.0.3
AQ 2xU/I HS	6ES7135-6HB00-0DA1	V2.0.4
AQ 4xU/I ST	6ES7135-6HD00-0BA1	V1.1.3
AQ 4xI HART	6ES7135-6TD00-0CA1	V1.0.1
F-AI 4xI	6ES7136-6AA00-0CA1	V1.0.2
F-AI 4xU	6ES7136-6AB00-0CA1	V1.0.1
F-DI 8X24VDC HF	6ES7136-6BA00-0CA0	V1.0.7
F-DI 8X24VDC HF	6ES7136-6BA01-0CA0	V1.0.0
F-TM Count sin/cos 1x1Vpp HF	6ES7136-6CB00-0CA0	V1.0.0
F-DQ 4XDC 24V/2A	6ES7136-6DB00-0CA0	V2.0.2
F-DQ 8X 24VDC/0.5A PP	6ES7136-6DC00-0CA0	V1.0.1
F-PM-E PPM, 24V DC	6ES7136-6PA00-0BC0	-
CM PtP*	6ES7137-6AA00-0BA0	-
CM PtP	6ES7137-6AA01-0BA0	V2.0.0
CM 4xIO-Link	6ES7137-6BD00-0BA0	V2.2.2
CM DALI	6ES7137-6CA00-0BU0	V1.0.1
CM 1xCAN	6ES7137-6EA00-0BA0	V1.2
TM Count 1x24V*	6ES7138-6AA00-0BA0	-
TM Count 1x24V	6ES7138-6AA01-0BA0	V2.0.2
TM PosInput 1*	6ES7138-6BA00-0BA0	-
TM PosInput 1	6ES7138-6BA01-0BA0	V2.0.1
TM Timer DIDQ 10x24V	6ES7138-6CG00-0BA0	V1.0.3
TM Pulse 2x24V	6ES7138-6DB00-0BB1	V1.0.2
TM ECC 2xPWM 12V ST*	6FE1242-6TM10-0BB1	-
AI 2x SG 4-/6-wire HS (DMS)	7MH4134-6LB00-0DA0	V1.0.2
SIWAREX WP321	7MH4138-6AA00-0BA0	V1.4.4
SIWAREX WP351	7MH4138-6BA00-0CU0	V1.1.0
Buerkert Ventile	AirLINE SP Typ 8647	V1.1.1
TM StepDrive 24-48V/5A**	PHYTRON 10020273	-

* No firmware update is offered for these modules since there are compatible successor products

** No firmware update with the error correction is currently offered for these modules

You can find the latest firmware versions for the modules on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109804718).
You can find a description of how to update the firmware of the modules in the "Firmware update" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Possible combinations of BaseUnits and I/O modules

Contents

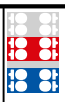
This product information includes amendments and corrections to the documentation of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Which I/O modules / motor starters fit on a BaseUnit?

The following table provides an overview of the I/O modules / motor starters that fit on the corresponding compatible BaseUnits:

Table 1 Possible combinations of BaseUnits and I/O modules

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
Digital I/O modules											
DI 16x24VDC ST	✓									CC00	
DI 8x24VDC ST	✓									CC01	
DI 8x24VDC HF	✓									CC01	
DI 8x24VDC HS	✓									CC01	
DI 8x24VDC BA	✓									CC01	
DI 8x24VDC SRC BA	✓									CC02	
DI 8xNAMUR HF	✓									CC01	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
DI 4x120..230VAC ST				✓						CC41	
DQ 16x24VDC/0.5A ST	✓									CC00	
DQ 16x24VDC/0.5A HF	✓									CC00	
DQ 8x24VDC/0.5 ST	✓									CC02	
DQ 8x24VDC/0.5A HF	✓									CC02	
DQ 8x24VDC/0.5A BA	✓									CC02	
DQ 8x24VDC/0.5A SNK BA	✓									CC01	
DQ 4x24..230VAC/2A ST				✓						CC41	
DQ 4x24..230VAC/2A HF				✓						---	---
DQ 4x24VDC/2A ST	✓									CC02	
DQ 4x24VDC/2A HF	✓									CC02	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
DQ 4x24VDC/2A HS	✓									CC00	
DI 8x/DQ 8x24VDC/-0.5A ST	✓									CC00	
RQ 4x24VUC/2A CO ST	✓									CC00	
RQ 4x120VDC-230VAC/5A NO ST			✓	✓						---	---
RQ 4x120VDC-230VAC/5A NO MA ST			✓	✓						---	---
RQ 3x120VDC-230VAC/5A CO ST									✓	---	---
RQ 3x120VDC-230VAC/5A CO n.i. ST									✓	---	---
Analog I/O modules											
AI 4xRTD/TC 2-/3-/4-wire HF	✓	✓								CC00	
AI 8xRTD/TC 2-wire HF	✓	✓								CC00	
AI 8xU BA	✓	✓								CC02	
AI 2xU ST	✓	✓								CC00	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
AI 2xI 2-/4-wire ST	✓	✓								CC05	
AI 4xU/I 2-wire ST	✓	✓								CC03	
AI 4xTC HS	✓	✓								CC00	
AI 2xU/I 2-/4-wire HF	✓	✓								CC05	
AI 2xU/I 2-/4-wire HS	✓	✓								CC00	
AI 2xSG 4-/6-wire HS	✓									CC00	
AI 8xI 2-/4-wire BA	✓	✓								CC01	
AI 4xI 2-/4-wire ST	✓	✓								CC03	
AI 4xI 2-wire 4...20mA HART	✓	✓								CC03	
AQ 2xU ST	✓	✓								CC00	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
AQ 2xI ST	✓	✓								CC00	
AQ 4xU/I ST	✓	✓								CC00	
AQ 4xI HART HF	✓	✓								CC00	
AQ 2xU/I HS	✓	✓								CC00	
AQ 2xU/I HF	✓	✓								CC00	
AI Energy Meter 400VAC ST							✓			CC20	Only systematic, but cannot be ordered
AI Energy Meter 480VAC ST							✓			CC20	
AI Energy Meter 480VAC/CT HF									✓	CC20	
AI Energy Meter 480VAC/RC HF									✓	CC20	
AI Energy Meter CT ST									✓	CC20	
AI Energy Meter RC ST									✓	CC20	
AI Energy Meter CT HF									✓	CC20	
AI Energy Meter RC HF									✓	CC20	
Fail-safe modules											
F-PM-E 24VDC/8A PPM ST					✓					CC52	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
F-DI 8x24VDC HF	✓									CC01	
F-DQ 4x24VDC/2A PM HF	✓									CC02	
F-DQ 8x24VDC/0.-5A PP HF	✓									CC02	
F-RQ 1x24VDC/2-4..230VAC/5A								✓		CC42	
F-AI 4xI 0(4)..20mA 2-/4-wire HF	✓	✓								CC00	
F-AI 4xU 0..10V HF	✓	✓								CC00	
F-TM Count 1x1Vpp sin/cos HF	✓									CC01	
F-TM ServoDrive ST 1x24 ... 48 V									✓	---	---
F-TM StepDrive ST 1x24..48V 5A									✓	---	---
Communication modules											
CM 4xIO-Link	✓									CC04	
CM AS-i Master ST					✓					---	---
F-CM AS-i Safety ST					✓	✓				---	---

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
CM PtP	✓									---	---
CM 1xDALI									✓	---	---
CM 1xCAN ST	✓									---	---
Technology modules											
TM Count 1x24V	✓									---	---
TM PosInput 1	✓									---	---
TM Timer DIDQ 10x24V	✓									---	---
TM Pulse 2x24V				✓						---	---
SIWAREX WP321	✓									---	---
SIWAREX WP351 HF									✓	CC00	
F-TM ServoDrive ST 1x24 ... 48 V									✓	---	---
F-TM StepDrive ST 1x24..48V 5A									✓	---	---
TM FCT070				✓						---	---
F-TM Count 1x1Vpp sin/cos HF	✓									CC01	

Table 2 Possible combinations of Ex BaseUnits and I/O modules

Ex I/O modules	BaseUnit	
	for Ex I/O modules	for Ex power module
Ex-DI 4xNAMUR	✓	
Ex-DQ 2x17.4VDC/27mA	✓	
Ex-DQ 2x23.1VDC/20mA	✓	
Ex-AQ 2xI HART	✓	
Ex-AI 2xI 2-wire HART	✓	
Ex-AI 4xTC/2xRTD 2-/3-/4-wire	✓	
Ex-PM E		✓

Table 3 Possible combinations of BaseUnits and motor starters

		Selecting the BaseUnit									
		BU-30--MS1	**BU-30--MS2**	**BU-30--MS3**	**BU-30--MS4**	**BU-30--MS5**	**BU-30--MS6**	**BU-30--MS7**	**BU-30--MS8**	**BU-30--MS9**	**BU-30--MS10**
24 V infeed		**x**		**x**							
500 V infeed		**x**	**x**			**x**		**x**	**x**		
F-DI terminals (no routing of the F-DI signal possible)						**x**	**x**				
F-DI infeed								**x**			**x**
F-DI routing									**x**	**x**	
Motor starters											
DS 0.1 - 0.4 A HF	3RK1308-0A-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.3 - 1 A HF	3RK1308-0AB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.9 - 3 A HF	3RK1308-0A-C00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 2.8 - 9 A HF	3RK1308-0A-D00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 4.0 - 12 A HF	3RK1308-0AE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.1 - 0.4 A HF	3RK1308-0BA-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.3 - 1 A HF	3RK1308-0BB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.9 - 3 A HF	3RK1308-0BC-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 2.8 - 9 A HF	3RK1308-0BD-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 4.0 - 12 A HF	3RK1308-0BE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
F-DS 0.1 - 0-.4 A HF	3RK1308-0C-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.3 - 1 A HF	3RK1308-0CB-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.9 - 3 A HF	3RK1308-0CC-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 2.8 - 9 A HF	3RK1308-0C-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 4.0 - 12 A HF	3RK1308-0CE-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.1 - 0.4 A HF	3RK1308-0D-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.3 - 1 A HF	3RK1308-0DB-00-0CP0	x	x	x	x	x	x	x	x	x	x

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

F-RS 0.9 - 3 A HF	3RK1308-0D-C00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 2.8 - 9 A HF	3RK1308-0D-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 4.0 - 12 A HF	3RK1308-0DE-00-0CP0	x	x	x	x	x	x	x	x	x	x

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

Table 4 Combination possibilities between potential distributor BaseUnit and potential distributor terminal block

Potential distributor terminal block	**Potential distributor BaseUnit**			
	PotDis-BU-P1/D-R	**PotDis-BU-P1/B-R**	**PotDis-BU-P2/D-B**	**PotDis-BU-P2/B-B**
PotDis-TB-P1-R	✓	✓	✓	✓
PotDis-TB-P2-B	✓	✓	✓	✓
PotDis-TB-n.c.-G	✓	✓	✓	✓
PotDis-TB-BR-W	✓	✓	✓	✓

CPUs

CPUs

CPU	**Packing unit**	**Article number**
CPU 1510SP-1 PN with server module	Pack of 1	6ES7510-1Dx0x-0AB0
CPU 1510SP F-1 PN with server module	Pack of 1	6ES7510-1Sx0x-0AB0
CPU 1512SP-1 PN with server module	Pack of 1	6ES7512-1Dx0x-0AB0
CPU 1512SP F-1 PN with server module	Pack of 1	6ES7512-1Sx0x-0AB0
CPU 1514SP-2 PN with server module	Pack of 1	6ES7514-2DN03-0AB0
CPU 1514SP F-2 PN with server module	Pack of 1	6ES7514-2SN03-0AB0
CPU 1514SP T-2 PN with server module	Pack of 1	6ES7514-2VN03-0AB0
CPU 1514SP TF-2 PN with server module	Pack of 1	6ES7514-2WN03-0AB0
CPU 1515SP PC with server module	Pack of 1	6ES7677-2AAxx-0xx0

Important differences between the CPUs...PN up to firmware version 2.9				
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) • BA 2xM12 (as of firmware V2.8)[1] RJ45, integrated (X1 Port 3)		PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) • BA 2xSCRJ (as of firmware V1.8)[2] • BA SCRJ/RJ45 (as of firmware V1.8)[2] • BA SCRJ/FC (as of firmware V1.8)[2] • BA 2xLC (as of firmware V2.0)[2] • BA LC/RJ45 (as of firmware V2.0)[2] • BA LC/FC (as of firmware V2.0)[2] • BA 2xM12 (as of firmware V2.8)[2] RJ45, integrated (X1 Port 3)	
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module			

1 Only with article numbers 6ES7510-1DJ01-0AB0 and 6ES7510-1SJ01-0AB0

2 Only with article numbers 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0

3 Only 6ES7510-1DJ01-0AB0, 6ES7512-1SJ01-0AB0, 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0 with FW version V2.0

Important differences between the CPUs...PN up to firmware version 2.9				
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**
Number of modules	64			
Data work memory	750 KB		1 MB	
Code work memory	100 KB	150 KB	200 KB	300 KB
Address space	1280 bytes/2560 bytes[3]			
Multi hot-swapping	Yes			
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes

1 Only with article numbers 6ES7510-1DJ01-0AB0 and 6ES7510-1SJ01-0AB0

2 Only with article numbers 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0

[3] Only 6ES7510-1DJ01-0AB0, 6ES7512-1SJ01-0AB0, 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0 with FW version V2.0

Important differences between the CPUs...PN as of firmware version 3.0								
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**	**CPU 1514SP-2 PN**	**CPU 1514SP F-2 PN**	**CPU 1514SP T-2 PN**	**CPU 1514SP TF-2 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 • BA 2xFC • BA 2xM12 RJ45, integrated (X1 Port 3 or X2 Port 1)							
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module							
Number of modules	64							
Data work memory	1 MB		2 MB		3.5 MB			
Code work memory	200 KB	300 KB	400 KB	600 KB	600 KB	900 KB		
Address space	2560 bytes							
Multi hot-swapping	Yes							
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes	No	Yes	No	Yes

Important differences between CPUs... PN from firmware version 3.1								
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**	**CPU 1514SP-2 PN**	**CPU 1514SP F-2 PN**	**CPU 1514SP T-2 PN**	**CPU 1514SP TF-2 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 • BA 2xFC • BA 2xM12 • BA SCRJ/RJ45 • BA LC/RJ45 • BA 2xSCRJ • BA SCRJ/FC • BA 2xLC • BA LC/FC RJ45, integrated (X1 Port 3 or X2 Port 1)							
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module							
Number of modules	64							
Data work memory	1 MB		2 MB		3.5 MB			
Code work memory	200 KB	300 KB	400 KB	600 KB	600 KB	900 KB		
Address space	2560 bytes							
Multi hot-swapping	Yes							
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes	No	Yes	No	Yes

NOTE

The CM AS-i master ST and F-CM AS-i Safety ST communications modules are supported as of firmware V1.8 of the CPUs. Note the following additional requirements:

CM AS-i master ST:

- Firmware version of the CM AS-i master ST: V1.1
- STEP 7 (TIA Portal): V13 SP1 Update 4 or higher

F-CM AS-i Safety ST

- Firmware version of the CM AS-i Safety ST: V1.0
- STEP 7 (TIA Portal): as of V13 SP1 Update 4 and HSP0070 V3.0

Interface modules

Interface modules

Interface modules	Packing unit	Article number
Interface module IM 155-6 PN BA	Pack of 1	6ES7155-6AR00-0AN0
Interface module IM 155-6 PN ST		
• with BusAdapter BA 2xRJ45 and server module	Pack of 1	6ES7155-6AA02-0BN0
• with server module	Pack of 1	6ES7155-6AU02-0BN0

Interface modules	Packing unit	Article number
Interface module IM 155-6 PN/2 HF with server module	Pack of 1	6ES7155-6AU01-0CN0
Interface module IM 155-6 PN/3 HF with server module	Pack of 1	6ES7155-6AU30-0CN0
Interface module IM 155-6 PN R1 with server module	Pack of 1	6ES7155-6AU00-0HM0
Interface module IM 155-6 MF HF with server module	Pack of 1	6ES7155-6MU00-0CN0
Interface module IM 155-6 PN HS with server module	Pack of 1	6ES7155-6AU00-0DN0
Interface module IM 155-6 DP HF with PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0) and server module	Pack of 1	6ES7155-6BA01-0CN0

Important differences between the interface modules						
Features	**IM 155-6 PN BA**	**IM 155-6 PN ST**	**IM 155-6 PN/2 HF IM 155-6 PN/3 HF**	**IM 155-6 MF HF**	**IM 155-6 PN HS**	**IM 155-6 DP HF**
Bus connection	PROFINET: 2xRJ45, integrated	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V1.0) • BA 2xFC (as of firmware V1.0) • BA 2xM12 (as of firmware V4.2)	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V2.0) • BA 2xFC (as of firmware V2.0) • BA 2xSCRJ (as of firmware V2.2) • BA SCRJ/RJ45 (as of firmware V3.1) • BA SCRJ/FC (as of firmware V3.1) • BA 2xLC (as of firmware V3.3) • BA LC/RJ45 (as of firmware V3.3) • BA LC/FC (as of firmware V3.3) • BA 2xM12 (as of firmware V4.2)	PROFINET, EtherNet/IP, Modbus TCP: BusAdapter • BA 2xRJ45 • BA 2xM12 (as of firmware V5.0) • BA 2xFC • BA 2xLC • BA 2xSCRJ • BA SCRJ/RJ45 • BA SCRJ/FC • BA LC/RJ45 • BA LC/FC	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V4.0) • BA 2xFC (as of firmware V4.0) • BA 2xSCRJ (as of firmware V4.0) • BA SCRJ/RJ45 (as of firmware V4.0) • BA SCRJ/FC (as of firmware V4.0) • BA 2xLC (as of firmware V4.0) • BA LC/RJ45 (as of firmware V4.0) • BA LC/FC (as of firmware V4.0)	PROFIBUS: PROFIBUS DP connection socket
Number of modules	12	32	64	64	30	32
RESET button	No	Yes	Yes	Yes	Yes	Not necessary
Address space (I/O data)	32 bytes	1440 bytes	1440 bytes	1440 bytes	968 bytes	244 bytes
Multi hot-swapping	No	Yes	Yes	Yes	Yes	Yes

Table 5 Station expansion via ET-Connection (mixed configuration ET 200SP/ET 200AL)

Modules	Packing unit	Article number
BU-Send	Pack of 1	6ES7193-6BN00-0NE0
BA-Send 1xFC	Pack of 1	6ES7193-6AS00-0AA0

BusAdapter

BusAdapter

BusAdapter	Packing unit	Article number
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	Pack of 1	6ES7193-6AR00-0AA0
• BA 2×M12 (PROFINET BusAdapter with M12 Ethernet socket)	Pack of 1	6ES7193-6AM00-0AA0
• BA 2×FC (PROFINET BusAdapter with FastConnect Ethernet connection)	Pack of 1	6ES7193-6AF00-0AA0
• BA 2xSCRJ (PROFINET BusAdapter with POF/PCF fiber-optic cable connection)	Pack of 1	6ES7193-6AP00-0AA0
• BA SCRJ/RJ45 (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AP20-0AA0
• BA SCRJ/FC (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AP40-0AA0
• BA 2xLC (PROFINET BusAdapter with glass fiber-optic cable connection multi-mode)	Pack of 1	6ES7193-6AG00-0AA0
• BA LC/RJ45 (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AG20-0AA0
• BA LC/FC (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AG40-0AA0
• BA 2xLC-LD (PROFINET BusAdapter with single-mode glass fiber-optic cable connection, long distance)	Pack of 1	6ES7193-6AG50-0AA0
• BA LC-LD/RJ45 (media converter, PROFINET BusAdapter with single-mode glass fiber-optic connection, long distance ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AG60-0AA0
• BA LC-LD/M12 (media converter, PROFINET BusAdapter with single-mode glass fiber-optic connection, long distance ⇔ M12 Ethernet socket)	Pack of 1	6ES7193-6AG70-0AA0

BaseUnits

BaseUnits

Table 6 BaseUnits for I/O modules

BU type	BaseUnits (short name)	Color-coded labels*	Packing unit	Article number
A0	BU15-P16+A10+2D	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0DA0
			Pack of 10	6ES7193-6BP20-2DA0
A0	BU15-P16+A0+2D	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA0
			Pack of 10	6ES7193-6BP00-2DA0
A0	BU15-P16+A10+2B	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0BA0
			Pack of 10	6ES7193-6BP20-2BA0
A0	BU15-P16+A0+2B	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA0
			Pack of 10	6ES7193-6BP00-2BA0
A1	BU15-P16+A0+12D/T	**P16:** CC00 to CC05 **12D:** CC74	Pack of 1	6ES7193-6BP40-0DA1
A1	BU15-P16+A0+2D/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA1
A1	BU15-P16+A0+12B/T	**P16:** CC00 to CC05 **12B:** CC74	Pack of 1	6ES7193-6BP40-0BA1

* not included in the scope of delivery of the BaseUnit

BU type	BaseUnits (short name)	Color-coded labels*	Packing unit	Article number
A1	BU15-P16+A0+2B/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA1
B0	BU20-P12+A4+0B	**A4:** CC81 to CC83	Pack of 1	6ES7193-6BP20-0BB0
			Pack of 10	6ES7193-6BP20-2BB0
B1	BU20-P12+A0+4B	**P12:** CC41	Pack of 1	6ES7193-6BP20-0BB1
			Pack of 10	6ES7193-6BP20-2BB1
C0	BU20-P6+A2+4D	**P6:** CC51, CC52 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0DC0
C1	BU20-P6+A2+4B	**P6:** CC51 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0BC1
D0	BU20-P12+A0+0B	---	Pack of 1	6ES7193-6BP00-0BD0
F0	BU20-P8+A4+0B	**P8:** CC42	Pack of 1	6ES7193-6BP20-0BF0
U0	BU20-P16+A0+2D	**P16**: CC00 to CC05	Pack of 1	6ES7193-6BP00-0BU0
			Pack of 10	6ES7193-6BP00-2BU0
U0	BU20-P16+A0+2B	**P16**: CC00 to CC05	Pack of 1	6ES7193-6BP00-0DU0
			Pack of 10	6ES7193-6BP00-2DU0

* not included in the scope of delivery of the BaseUnit

Table 7 BaseUnit Ex I/O modules

BU type	Ex BaseUnits	Color-coded labels	Packing unit	Article number
W0	for Ex power module	-	Pack of 1	6DL1193-6BP00-0DW0
X1	for Ex I/O modules	-	Pack of 1	6DL1193-6BP00-0BX1

Table 8 BaseUnit PotDis

PotDis type	Potential distributor (short name)	Color-coded labels	Packing unit	Article number
P1	PotDis-BU-P1/D-R	CC62	Pack of 1	6ES7193-6UP00-0DP1
P1	PotDis-BU-P1/B-R	CC62	Pack of 1	6ES7193-6UP00-0BP1
P2	PotDis-BU-P2/D-B	CC63	Pack of 1	6ES7193-6UP00-0DP2
P2	PotDis-BU-P2/B-B	CC63	Pack of 1	6ES7193-6UP00-0BP2

Table 9 BaseUnit PotDis-TB

Terminal block type	Terminal block (short name)	Color-coded labels	Packing unit	Article number
P1	PotDis-TB-P1-R	CC12	Pack of 1	6ES7193-6TP00-0TP1
P2	PotDis-TB-P2-B	CC13	Pack of 1	6ES7193-6TP00-0TP2
N0	PotDis-TB-n.c.-G	CC10	Pack of 1	6ES7193-6TP00-0TN0
P0	PotDis-TB-BR-W	CC10 to CC13	Pack of 1	6ES7193-6TP00-0TP0

Table 10 BaseUnits for motor starters

BU type	BaseUnits (short name)	Color-coded labels	Packing unit	Article number
MS1	BU30-MS1	-	Pack of 1	3RK1908-0AP00-0AP0
MS2	BU30-MS2	-	Pack of 1	3RK1908-0AP00-0CP0
MS3	BU30-MS3	-	Pack of 1	3RK1908-0AP00-0BP0
MS4	BU30-MS4	-	Pack of 1	3RK1908-0AP00-0DP0

BU type	BaseUnits (short name)	Color-coded labels	Packing unit	Article number
MS5	BU30-MS5	-	Pack of 1	3RK1908-0AP00-0EP0
MS6	BU30-MS6	-	Pack of 1	3RK1908-0AP00-0FP0
MS7	BU30-MS7	-	Pack of 1	3RK1908-0AP00-0GP0
MS8	BU30-MS8	-	Pack of 1	3RK1908-0AP00-0HP0
MS9	BU30-MS9	-	Pack of 1	3RK1908-0AP00-0JP0
MS10	BU30-MS10	-	Pack of 1	3RK1908-0AP00-0KP0

Table 11 BaseUnit interface module

BU type	Interface module	Color-coded labels	Packing unit	Article number
M0	IM 155-6 PN R1	-	Pack of 1	6ES7193-6BR00-0HM0

I/O modules

I/O modules

Digital I/O modules	Coding element type	Packing unit	Article number
DI 16x24VDC ST	A	Pack of 1	6ES7131-6BH01-0BA0
		Pack of 10	6ES7131-6BH01-2BA0
DI 8x24VDC ST	A	Pack of 1	6ES7131-6BF01-0BA0
		Pack of 10	6ES7131-6BF01-2BA0
DI 8x24VDC HF	A	Pack of 1	6ES7131-6BF00-0CA0
		Pack of 10	6ES7131-6BF00-2CA0
DI 8x24VDC HS	A	Pack of 1	6ES7131-6BF00-0DA0
DI 8xNAMUR HF	A	Pack of 1	6ES7131-6TF00-0CA0
DI 8x24VDC BA	A	Pack of 1	6ES7131-6BF01-0AA0
		Pack of 10	6ES7131-6BF01-2AA0
DI 8x24VDC SRC BA	B	Pack of 1	6ES7131-6BF61-0AA0
DI 8x24VAC/48VUC BA	C	Pack of 1	6ES7131-6CF00-0AU0
DI 4x120..230VAC ST	C	Pack of 1	6ES7131-6FD01-0BB1
DQ 16x24VDC/0.5A ST	A	Pack of 1	6ES7132-6BH01-0BA0
		Pack of 10	6ES7132-6BH01-2BA0
DQ 16x24VDC/0.5A HF	A	Pack of 1	6ES7132-6BH00-0CA0
DQ 16x24VDC/0.5A BA	A	Pack of 1	6ES7132-6BH00-0AA0
		Pack of 10	6ES7132-6BH00-2AA0
DQ 8x24VDC/0.5A ST	A	Pack of 1	6ES7132-6BF01-0BA0
		Pack of 10	6ES7132-6BF01-2BA0
DQ 8x24VDC/0.5A HF	A	Pack of 1	6ES7132-6BF01-0CA0
		Pack of 10	6ES7132-6BF01-2CA0
DQ 8x24VDC/0.5A BA	A	Pack of 1	6ES7132-6BF01-0AA0
		Pack of 10	6ES7132-6BF01-2AA0
DQ 8x24VDC/0.5A SNK BA	B	Pack of 1	6ES7132-6BF61-0AA0
DQ 4x24VDC/2A ST	A	Pack of 1	6ES7132-6BD21-0BA0
		Pack of 10	6ES7132-6BD21-2BA0
DQ 4x24..230VAC/2A ST	C	Pack of 1	6ES7132-6FD00-0BB1
		Pack of 10	6ES7132-6FD00-2BB1

Digital I/O modules	Coding element type	Packing unit	Article number
DQ 4x24..230VAC/2A HF	C	Pack of 1	6ES7132-6FD00-0CU0
DQ 4x24VDC/2A HF	A	Pack of 1	6ES7132-6BD21-0CA0
DQ 4x24VDC/2A HS	A	Pack of 1	6ES7132-6BD20-0DA0
DI 8x/DQ 8x24VDC/0.5A ST	A	Pack of 1	6ES7133-6BH00-0BA0
RQ 4x24VUC/2A CO ST	C	Pack of 1	6ES7132-6GD51-0BA0
RQ 4x120VDC-230VAC/5A NO ST	C	Pack of 1	6ES7132-6HD01-0BB1
		Pack of 10	6ES7132-6HD01-2BB1
RQ 4x120VDC-230VAC/5A NO MA ST	C	Pack of 1	6ES7132-6MD00-0BB1
RQ 3x120VDC-230VAC/5A CO ST	C	Pack of 1	6ES7132-6HC50-0BU0
RQ 3x120VDC-230VAC/5A CO n.i. ST	C	Pack of 1	6ES7132-6HC70-0BU0

Analog I/O modules	Coding element type	Packing unit	Article number
AI 8xU BA	B	Pack of 1	6ES7134-6FF00-0AA1
AI 2xU ST	A	Pack of 1	6ES7134-6FB00-0BA1
AI 4xU/I 2-wire ST	A	Pack of 1	6ES7134-6HD01-0BA1
		Pack of 10	6ES7134-6HD01-2BA1
AI 2xU/I 2-/4-wire HF	A	Pack of 1	6ES7134-6HB00-0CA1
AI 2xU/I 2-/4-wire HS	A	Pack of 1	6ES7134-6HB00-0DA1
AI 2xSG 4-/6-wire HS	A	Pack of 1	7MH4134-6LB00-0DA0
AI 8xI 2-/4-wire BA	A	Pack of 1	6ES7134-6GF00-0AA1
AI 2xI 2-/4-wire ST	A	Pack of 1	6ES7134-6GB00-0BA1
AI 4xI 2-/4-wire ST	A	Pack of 1	6ES7134-6GD01-0BA1
		Pack of 10	6ES7134-6GD01-2BA1
AI 8xRTD/TC 2-wire HF	A	Pack of 1	6ES7134-6JF00-0CA1
		Pack of 10	6ES7134-6JF00-2CA1
AI 4xRTD/TC 2-/3-/4-wire HF	A	Pack of 1	6ES7134-6JD00-0CA1
		Pack of 10	6ES7134-6JD00-2CA1
AI 4xTC HS	A	Pack of 1	6ES7134-6JD00-0DA1
AI 4xI 2-wire 4...20mA HART	A	Pack of 1	6ES7134-6TD00-0CA1
AQ 2xU ST	A	Pack of 1	6ES7135-6FB00-0BA1
AQ 2xI ST	A	Pack of 1	6ES7135-6GB00-0BA1
AQ 4xU/I ST	A	Pack of 1	6ES7135-6HD00-0BA1
AQ 4xI HART HF	A	Pack of 1	6ES7135-6TD00-0CA1
AQ 2xU/I HF	A	Pack of 1	6ES7135-6HB00-0CA1
AQ 2xU/I HS	A	Pack of 1	6ES7135-6HB00-0DA1
AI Energy Meter CT HF	C	Pack of 1	6ES7134-6PA01-0CU0
AI Energy Meter RC HF	C	Pack of 1	6ES7134-6PA21-0CU0
AI Energy Meter CT ST	C	Pack of 1	6ES7134-6PA01-0BU0
AI Energy Meter RC ST	C	Pack of 1	6ES7134-6PA21-0BU0

Fail-safe modules	Coding element type	Packing unit	Article number
F-PM-E 24VDC/8A PPM ST	F	Pack of 1	6ES7136-6PA00-0BC0
F-DI 8x24VDC HF	F	Pack of 1	6ES7136-6BA01-0CA0
F-DQ 4x24VDC/2A PM HF	F	Pack of 1	6ES7136-6DB00-0CA0

Fail-safe modules	Coding element type	Packing unit	Article number
F-DQ 8x24VDC/0.5A PP HF	F	Pack of 1	6ES7136-6DC00-0CA0
F-RQ 1x24VDC/24..230VAC/5A	C	Pack of 1	6ES7136-6RA00-0BF0
F-AI 4xI 0(4)..20mA 2-/4-wire HF	F	Pack of 1	6ES7136-6AA00-0CA1
F-AI 4xU 0..10V HF	H	Pack of 1	6ES7136-6AB00-0CA1
F-TM ServoDrive ST 1x24V..48V		Pack of 1	6BK1136-6AB00-0BU0
F-TM ServoDrive HF 1x24..48V 5A		Pack of 1	6BK1136-6AB00-0CU0
F-TM StepDrive ST 1x24..48V 5A		Pack of 1	6BK1136-6SB00-0BU0
F-TM Count 1x1Vpp sin/cos HF	H	Pack of 1	6ES7136-6CB00-0CA0
F-CM AS-i Safety ST	H	Pack of 1	3RK7136-6SC00-0BC1

Communications modules	Coding element type	Packing unit	Article number
CM 4xIO-Link	H	Pack of 1	6ES7137-6BD00-0BA0
CM AS-i Master ST	D	Pack of 1	3RK7137-6SA00-0BC1
F-CM AS-i Safety ST	H	Pack of 1	3RK7136-6SC00-0BC1
CM PtP	D	Pack of 1	6ES7137-6AA01-0BA0
		Pack of 10	6ES7137-6AA01-2BA0
CM DP (for CPU)		Pack of 1	6ES7545-5DA00-0AB0
CM 1xDALI	D	Pack of 1	6ES7137-6CA00-0BU0
CM 1xCAN ST	C	Pack of 1	6ES7137-6EA00-0BA0

Technology module	Coding element type	Packing unit	Article number
TM Count 1x24V	B	Pack of 1	6ES7138-6AA01-0BA0
		Pack of 10	6ES7138-6AA01-2BA0
TM PosInput 1	B	Pack of 1	6ES7138-6BA01-0BA0
		Pack of 10	6ES7138-6BA01-2BA0
TM PTO 2x24V		Pack of 1	6ES7138-6EB00-0BA0
TM Timer DIDQ 10x24V	B	Pack of 1	6ES7138-6CG00-0BA0
TM Pulse 2x24V	C	Pack of 1	6ES7138-6DB00-0BB1
SIWAREX WP321	B	Pack of 1	7MH4138-6AA00-0BA0
SIWAREX WP351 HF	B	Pack of 1	7MH4138-6BA00-0CU0
F-TM ServoDrive ST 1x24V..48V		Pack of 1	6BK1136-6AB00-0BU0
F-TM ServoDrive HF 1x24..48V 5A		Pack of 1	6BK1136-6AB00-0CU0
F-TM StepDrive ST 1x24..48V 5A		Pack of 1	6BK1136-6SB00-0BU0
TM SITRANS FCT070	D	Pack of 1	7ME4138-6AA00-0BB1
TM SITRANS FST070		Pack of 1	7ME3448-6AA00-0BB1
F-TM Count 1x1Vpp sin/cos HF	H	Pack of 1	6ES7136-6CB00-0CA0
TM ECC 2xPWM ST		Pack of 1	6FE1242-6TM20-0BB1
TM ECC PL ST		Pack of 1	6FE1242-6TM20-0BB1

Ex module	Packing unit	Article number
Ex-DI 4xNAMUR	Pack of 1	6DL1131-6TD00-0HX1
Ex-DQ 2x17.4VDC/27mA	Pack of 1	6DL1132-6CB00-0HX1

Ex module	Packing unit	Article number
Ex-DQ 2x23.1VDC/20mA	Pack of 1	6DL1132-6EB00-0HX1
Ex-AQ 2xI HART	Pack of 1	6DL1135-6TB00-0HX1
Ex-AI 2xI 2-wire HART	Pack of 1	6DL1134-6TB00-0HX1
Ex-AI 4xTC/2xRTD 2-/3-/4-wire	Pack of 1	6DL1134-6JD00-0HX1
Ex-PM E	Pack of 1	6DL1133-6PX00-0HW0

Encoder modules for Module-to-Module Communication (MtM)

You can use the following modules as encoder modules for Module-to-Module Communication (MtM) with the module DQ 4x24VDC/2A HS in the "Cam control" operating mode:

Module	Article number	Firmware
DI 8x24VDC HS	6ES7131-6BF00-0DA0	V1.0 or higher
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	V2.0 or higher
AI 2xSG 4-,6-Wire HS	7MH4134-6LB00-0DA0	V1.0 or higher
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V1.0 or higher
TM PosInput 1	6ES7138-6BA00-0BA0 6ES7138-6BA01-0BA0	V1.0 or higher V2.0 or higher
TM Count 1x24V	6ES7138-6AA00-0BA0 6ES7138-6AA01-0BA0	V1.0 or higher V2.0 or higher

See also

"Digital output module DQ 4x24VDC/2A HS" Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/109475185)
ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)

Motor starters

Motor starters

Direct starter	Packaging unit	Article number
DS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0AA00-0CP0
DS 0.3 - 1 A HF	Pack of 1	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	Pack of 1	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	Pack of 1	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF	Pack of 1	3RK1308-0AE00-0CP0

Reversing starter	Packaging unit	Article number
RS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0BA00-0CP0
RS 0.3 - 1 A HF	Pack of 1	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	Pack of 1	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	Pack of 1	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF	Pack of 1	3RK1308-0BE00-0CP0

Failsafe direct starter	Packaging unit	Article number
F-DS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0CA00-0CP0
F-DS 0.3 - 1 A HF	Pack of 1	3RK1308-0CB00-0CP0

Failsafe direct starter	Packaging unit	Article number
F-DS 0.9 - 3 A HF	Pack of 1	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	Pack of 1	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF	Pack of 1	3RK1308-0CE00-0CP0

Fail-safe reversing starter	Packaging unit	Article number
F-RS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0DA00-0CP0
F-RS 0.3 - 1 A HF	Pack of 1	3RK1308-0DB00-0CP0
F-RS 0.9 - 3 A HF	Pack of 1	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	Pack of 1	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF	Pack of 1	3RK1308-0DE00-0CP0

Accessories

Accessories

General accessories	Packing unit	Article number
Strain relief units incl. screws	Pack of 5	6ES7193-6RA00-1AN0
Cover for the BusAdapter interface	Pack of 5	6ES7591-3AA00-0AA0
PROFIBUS FastConnect bus connector	Pack of 1	6ES7972-0BB70-0XA0
Female connector, 2x2 pin	Pack of 1	6ES7193-4JB00-0AA0
Server module (spare part)	Pack of 1	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	Pack of 5	6ES7133-6CV15-1AM0
• 20 mm wide	Pack of 5	6ES7133-6CV20-1AM0
24 V DC plug (spare part)	Pack of 10	6ES7193-4JB00-0AA0
Shield connector for BaseUnit (shield contacts and shield terminals)	Pack of 5	6ES7193-6SC20-1AM0
Reference identification label, sheet with 16 labels	Pack of 10	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AA0
• Roll, yellow (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AG0
• DIN A4 sheets, light gray (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AG0
Electronic coding element (spare part)[1)]		
• Coding element (type A)	Pack of 20	6ES7193-6KA00-3AA0
• Coding element (type B)	Pack of 20	6ES7193-6KB00-3AA0
• Coding element (type C)	Pack of 20	6ES7193-6KC00-3AA0
• Coding element (type D)	Pack of 20	6ES7193-6KD00-3AA0

1) For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module.

2) You may shorten the length of the standard mounting rails and SIMATIC system rails as needed.

General accessories	Packing unit	Article number
Electronic coding element (spare part)[1]		
• Coding element (type F, for fail-safe modules)	Pack of 1	6ES7193-6EF00-1AA0
• Coding element (type H)	Pack of 1	6ES7193-6EH00-1AA0
Mounting rails, tin-plated steel strip[2]		
• Length: 483 mm	Pack of 1	6ES5710-8MA11
• Length: 530 mm	Pack of 1	6ES5710-8MA21
• Length: 830 mm	Pack of 1	6ES5710-8MA31
• Length: 2000 mm	Pack of 1	6ES5710-8MA41
SIMATIC system rails[2]		
• Length 483 mm	Pack of 1	6ES7193-6MR00-0AA0
• Length 530 mm	Pack of 1	6ES7193-6MR00-0BA0
• Length 830 mm	Pack of 1	6ES7193-6MR00-0CA0
• Length: 2000 mm	Pack of 1	6ES7193-6MR00-0DA0

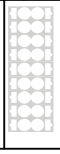
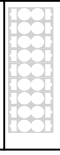
1) For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module.

2) You may shorten the length of the standard mounting rails and SIMATIC system rails as needed.

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit		Article number
16 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 16); color code CC00	Pack of 10		6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	Pack of 10		6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	Pack of 10		6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	Pack of 10		6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	Pack of 10		6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16); color code CC05	Pack of 10		6ES7193-6CP05-2MA0

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit		Article number
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)			
• Yellow-green (terminals 1A to 10A); color code CC71	Pack of 10		6ES7193-6CP71-2AA0
• Red (terminals 1A to 10A); color code CC72	Pack of 10		6ES7193-6CP72-2AA0
• Blue (terminals 1A to 10A); color code CC73	Pack of 10		6ES7193-6CP73-2AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)			
• Red (terminals 1B to 5B), blue (terminals 1 to 5C); color code CC74	Pack of 10		6ES7193-6CP74-2AA0

Accessories, color identification labels (push-in terminals), 20 mm wide	Packing unit		Article number
12 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	Pack of 10		6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	Pack of 10		6ES7193-6CP42-2MB0
6 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	Pack of 10		6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	Pack of 10		6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)			
• Yellow-green (terminals 1A to 4A); color code CC81	Pack of 10		6ES7193-6CP81-2AB0
• Red (terminals 1A to 4A); color code CC82	Pack of 10		6ES7193-6CP82-2AB0
• Blue (terminals 1A to 4A); color code CC83	Pack of 10		6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)			
• Yellow-green (terminals 1A and 2A); color code CC84	Pack of 10		6ES7193-6CP84-2AC0
• Red (terminals 1A and 2A); color code CC85	Pack of 10		6ES7193-6CP85-2AC0
• Blue (terminals 1A and 2A); color code CC86	Pack of 10		6ES7193-6CP86-2AC0

Accessories, color identification labels (push-in terminals) PotDis	Packing unit		Article number
PotDis-BU, 16 potential terminals			
• Red for PotDis-BU-P1/x-R (terminals 1 to 16); color code CC62	Pack of 10		6ES7193-6CP62-2MA0
• Blue for PotDis-BU-P2/x-B (terminals 1 to 16), color code CC63	Pack of 10		6ES7193-6CP63-2MA0
PotDis-TB-P1-R, 18 potential terminals			
• Red (terminals 1 to 18); color code CC12	Pack of 10		6ES7193-6CP12-2MT0
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-P2-B, 18 potential terminals			
• Blue (terminals 1 to 18); color code CC13	Pack of 10		6ES7193-6CP13-2MT0
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-BR-W, 18 potential terminals			
• Yellow/green (terminals 1 to 18); color code CC11	Pack of 10		6ES7193-6CP11-2MT0
• Red (terminals 1 to 18); color code CC12	Pack of 10		6ES7193-6CP12-2MT0
• Blue (terminals 1 to 18); color code CC13	Pack of 10		6ES7193-6CP13-2MT0

Accessories, color identification labels (push-in terminals) PotDis	Packing unit		Article number
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-n.c.-G, 18 potential terminals			
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0

Accessories for motor starter	Packing unit	Article number
3DI / LC module	Pack of 1	3RK1908-1AA00-0BP0
Fan	Pack of 1	3RW4928-8VB00
Additional mechanical bracket for BaseUnit	Pack of 1	3RK1908-1EA00-1BP0
Cover for an empty BaseUnit	Pack of 1	3RK1908-1CA00-0BP0
Touch protection cover for infeed bus	Pack of 1	3RK1908-1DA00-2BP0

Technical specifications for BU cover

Article number	6ES7133-6CV20-1AM0
General information	
Product type designation	BU cover
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	35.3 mm

Article number	6ES7133-6CV15-1AM0
General information	
Product type designation	BU cover
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-40 °C

Article number	6ES7133-6CV15-1AM0
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	35.3 mm

Supplements to ET 200SP documentation

BaseUnits manual

Special consideration for BaseUnits with functional versions < 04

The following BaseUnits with functional version < 04 can only be used in potential groups with rated voltages ≤ 48 V DC or 24 V AC:

- BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1).
- BaseUnit BU20-P12+A0+0B (6ES7193-6BP00-0BD0).

BusAdapter Equipment Manual

Strain relief
The strain relief 6ES7193-6RA00-1AN0 with FS01 is not suitable for the optical PROFINET cables of the BusAdapters.

BusAdapter BA 2xFC
A further cable has been added to the recommended types of Fast Connect Cable: IE FC TP Marine Cable (6XV1840-4AH10)

CPU manuals

CPU Equipment Manuals, Edition 11/2024

Section Product overview, New functions

New functions for FW version 4.1	Applications	Customer benefits
Backup and restore of the configuration of the CPU by a central user	As of FW version V4.1 of a CPU, a central user can also back up and restore the configuration.	Rules you need to follow for backup and restore. More information is available in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the section Backing up and restoring the CPU configuration.
Integrated security		
Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts in the case of CPUs as of FW version V4.1.	The temporary account lockout provides protection against brute force attacks.
SIMATIC ET 200SP data	This appendix provides you with an overview of the data that the CPU generates and makes available to you.	More information is available in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the appendix SIMATIC ET 200SP data.

New functions for FW version 4.1	Applications	Customer benefits
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	For more information, please refer to the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
Activating IP forwarding through a data record transfer	For CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU through data record transfer.	
Technology functions of the CPU		
General functions	Distribution of the processing of motion jobs across multiple cores Improved performance	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
Axis functions (only CPU 1514SP T-2 PN)	Specification of the motion setpoints of a superimposing axis in addition to the basic motion of the axis Extended range of functions	Axis functions (https://support.industry.siemens.com/cs/us/en/view/109817884) Function Manual
Synchronous operation functions (only CPU 1514SP T-2 PN)	Cam can be used as a time-based position profile Extended range of functions	Synchronous operation functions (https://support.industry.siemens.com/cs/us/en/view/109817888) Function Manual
	Area scaling at a cam before or during active camming Extended range of functions	
	Cross-PLC synchronous operation with communication via isochronous I-device Extended range of functions	
Kinematics functions (only CPU 1514SP T-2 PN)	New predefined kinematics type "6-axis articulated arm with offset wrist" available Extended range of functions	Kinematics functions (https://support.industry.siemens.com/cs/us/en/view/109817886) Function Manual
Interpreter functions (only CPU 1514SP T-2 PN)	Value of a tag can be changed at a breakpoint in debug program mode Extended range of functions	Interpreter functions (https://support.industry.siemens.com/cs/us/en/view/109817891) Function Manual
Trace functionality of the CPU		
Creating a long-term trace configuration from a long-term trace measurement	Extended range of functions	Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
Recording, display and analysis of events in TIA Portal	Diagnostics of Motion Control jobs Extended range of functions	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
PID control		
New version V2.0 of PID_Temp controller	Use for cooling-only applications	PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036) Function Manual
	Temporary shutdown of the heating	
	Manual stopping of the integral-action component	
	Active limiting of the integral-action component and change of output value limits in automatic mode	
	Improved anti-windup behavior in the cascade	

Technical specifications section

Equipment Manual	Technical specifications for FW version V4.1
CPU 1510SP-1 PN (6ES7510-1DK03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7510-1DK03-0AB0/td?dl=en)
CPU 1512SP-1 PN (6ES7512-1DM03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7512-1DM03-0AB0/td?dl=en)
CPU 1514SP-2 PN (6ES7514-2DN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2DN03-0AB0/td?dl=en)
CPU 1514SP T-2 PN (6ES7514-2VN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2VN03-0AB0/td?dl=en)

Interface module manuals

Compilation error up to STEP 7 V15.1 for IM 155-6 PN HF as of V2.1, IM 155-6 PN HS V4.0
Affected components:

- IM 155-6 PN HF as of V2.1
- IM 155-6 PN HS V4.0

A compilation error can occur in isochronous mode of the ET 200SP (IM 155-6 PN HF as of V2.1, IM 155-6 PN HS V4.0) with the setting "From OB" even if the settings are valid. The typical error message is: "The specific Ti value is invalid" or "The specific To value is invalid". But other error messages are possible as well.
Solution:
Upgrade the module description of the IM in this case. You can upgrade the module description of the IM in the network view or in the device view of the Inspector window using the "Update module description" function. The error can still occur with the current module description after the first compilation. If you have selected valid settings, the error will no longer occur with the subsequent compilation.

Equipment Manual IM 155-6 PN BA, Edition 03/2015
Status of the supply voltage
Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Order number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0

Equipment Manual IM 155-6 PN ST, Edition 04/2017
Response times
The response time of the IM 155-6 PN ST is made up of:
- Backplane bus cycle time
- Operating system processing time.

NOTE
Validity of the formula
The following formula applies to the ET 200SP backplane bus.
The formula does not apply to the ET-Connection bus.

Backplane bus cycle time
The backplane bus cycle time is the time the interface module requires to output new output data, read new input data and then copy the data to the PROFINET send buffer.
The backplane bus cycle time is the result of the update time configured for the interface module as IO device and amounts to at least 1 ms.
- If the configured update time ≥ 1 ms, the backplane bus cycle time is equal to the configured update time.
- If the configured update time < 1 ms, the backplane bus cycle time is the product of an integer multiple of the configured update time.

Table 12 Example calculation

Configured update time	Backplane bus cycle time (integer multiple, minimum 1 ms)
250 µs	4 x 250 µs = 1000 µs
750 µs	2 x 750 µs = 1500 µs
1000 µs	1000 µs
2000 µs	2000 µs

Operating system processing time
The **operating system processing time** is calculated based on the following formula:
Operating system processing time output
Operating system processing time_output[µs] = 147 + 3.775 number_m + 0.275 bytes_out
Operating system processing time input
Operating system processing time_input[µs] = 158.3 + 2.325 number_m + 0.325 bytes_in

Explanation of the parameters:
Number_m: Total number of all modules (incl. server module)
Bytes_out: Sum of all output bytes
Bytes_in: Sum of all input bytes

Calculating the response time
Response time output
The response time output of the IM 155-6 PN ST is made up of:
- Backplane bus cycle time
- Operating system processing time_output.

Response time input
The response time input of the IM 155-6 PN ST is made up of:
- Backplane bus cycle time
- Operating system processing time_input.

Equipment Manual IM 155-6 PN ST, Edition 04/2017
You can perform a firmware update to V4.1 for IM 155-6 PN ST interface modules with the article number 6ES7155-6AU00-0BN0.
If you perform hardware detection of the IO device in the TIA Portal as of V15.0 after the firmware update to V4.1, the device name is displayed as not assigned in the "PROFINET device name" column in the "Topology comparison" tab of the interface module.
The reason is that the online combination of article number and firmware version of the IO device is not offered in the hardware catalog.
In this case, the hardware catalog for the interface module IM 155-6 PN ST offers the combination of article number 6ES7155-6AU00-0BN0 and FW up to V3.3.
Solution: In the "Topology comparison" tab, assign the device name offered from the selection list in the "PROFINET device name" column.

Equipment Manual IM 155-6 PN/2 HF, Edition 10/2018

Section 2.1 Properties

Maximum configuration
- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface module)

Server module
The server module supports the identification data I&M 0 to 3.

Section 2.2 Functions

Module-to-Module Communication (MtM)
At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Equipment Manual IM 155-6 PN/3 HF, Edition 10/2018

Section 2.1 Properties

Maximum configuration
- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface module)

Section 2.2 Functions
The "Interface-local coupling of IO data" function can also be used in addition to GSDML with STEP 7 (TIA Portal) as of V15.1 with HSP285.

Section 2.2.20 Interface-local coupling of I/O data
When using MSO local modules, make sure that you choose the same number of bytes in all shared configurations involved. Failure to do so will result in a parameterization error when establishing the connection.

Module-to-Module Communication (MtM)
At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Table 2-1 Version dependencies of the module functions
The "Interface-local coupling of IO data" function is possible with STEP 7 (TIA Portal) as of V15.1 with HSP285.

Section 3 Wiring
Notes

NOTE
To set up a ring topology, use only the P1 R and P2 R ports.

NOTE

Operation with only one BusAdapter

You can operate the interface module with only one BusAdapter on P1 R and P2 R. Disable the P3 port in the port options in STEP 7 for this. Cover the free BusAdapter port P3 with a BusAdapter interface cover (6ES7591-3AA00-0AA0).

NOTE

For IRT operation, both BusAdapters must be plugged in.

Section 5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

The virtual MSO Local modules are not affected by the failure.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

Section 6 Compatibility

Restoring the factory settings on the interface module via the RESET button

There is a special operation for interface module IM 155-6 PN/3 HF to reset it to the factory settings using the Reset button.

Requirements

The supply voltage to the interface module must be switched on.

Required tool

3 To 3.5 mm screwdriver (for resetting with a RESET button)

Procedure

1. Remove the interface module from the mounting rail and swivel it downwards.
2. The RESET button is located on the back of the interface module behind a small opening: Push a screwdriver into the small opening, thus pressing the RESET button.
3. Release the RESET button.
4. Press the RESET button for another 3 seconds.
5. Look at the LED display of the interface module to see whether the reset was successful: RUN LED flashes for 3 seconds, ERROR and MAINT LED are off.
6. Install the interface module back on the mounting rail.
7. Configure the interface module again.

Equipment Manual IM 155-6 PN HF, Edition 12/2015

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

Equipment Manual IM 155-6 PN HS, Edition 09/2016
Section 3.1 Pin assignment
PROFINET interface X1 Port 2:
If autonegotiation is disabled, the RJ45 socket (X1 Port 2) has the switch assignment (MDI-X).

Section 7 Technical specifications
- The PROFINET certification of network Class 3 is in preparation.
- Technical specifications of the BusAdapters BA 2×SCRJ, BA SCRJ/RJ45, BA SCRJ/FC:
  The maximum length of the PCF-GI fiber-optic cable is 250 m.

Equipment Manual IM 155-6 DP HF, Edition 10/2018

Section 2.2.1 Requirements

Table 13 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)/third-party software [1]	STEP 7 as of V5.5 SP3 with HSP0242	STEP 7 (TIA Portal) as of V13
Interface module; article number: 6ES7155-6BA01-0CN0	1	V4.2	X	X [2]	X (as of V15.1)

1 Systems of third-party manufacturers: dependent on the range of functions of the third-party system

2 Configure the module as version 6ES7155-6BA00-0CN0 FW V3.1 (as of HSP0242 V3)

Compatibility with BusAdapter BA 2xM12
The following table shows the compatibility of the BusAdapter BA 2xM12 with the interface modules:

Interface module	BA 2xM12 is supported	Configurable with		
		PROFINET GSD	STEP 7	STEP 7 (TIA Portal)
IM155-6 PN HS (6ES7155-6AU00-0DN0)	No	-	-	-
IM155-6 PN ST (6ES7155-6AU01-0BN0)	Yes, as of FW V4.2	Yes	-	V16 or higher with HSP205
IM155-6 PN HF (6ES7155-6AU00-0CN0)			V5.5.4.0 or higher with HSP0250 V5.0	V16 or higher with HSP302
IM155-6 PN/2 PN HF (6ES7155-6AU01-0CN0)				
IM155-6 PN/3 PN HF (6ES7155-6AU30-0CN0)				
IM155-6 MF HF (6ES7155-6MU00-0CN0)	Yes, as of FW V5.0		V5.5.4.0 or higher with HSP0250 V5.0 configured as IM155-6 PN/2 PN HF V4.2	V16 or higher with HSP302 configured as IM155-6 PN/2 PN HF V4.2

Compatibility with BusAdapter BA 2xLC-LD, BA LC-LD/RJ45 and BA LC-LD/M12
The following table shows the compatibility of the BusAdapter BA 2xLC-LD, BA LC-LD/RJ45 and BA LC-LD/M12 with the interface modules:

Interface module	BA 2xLC-LD	BA LC-LD/RJ45	BA LC-LD/M12	Configurable with		
				PROFINET GSD	STEP 7	STEP 7 (TIA Portal)
IM155-6 PN HS (6ES7155-6AU00-0DN0)	No			-	-	-
IM155-6 PN ST (6ES7155-6AU01-0BN0)						
IM155-6 PN HF (6ES7155-6AU00-0CN0)						
IM155-6 PN/2 PN HF (6ES7155-6AU01-0CN0)	Yes, as of FW V4.2 configured as BA 2xLC and monitor port disabled	Yes, as of FW V4.2 configured as BA LC/RJ45 and monitor port disabled		Yes	V5.5.4.0 or higher with HSP0250 V4 / HSP0255 V5.0	V15.1 or higher
IM155-6 PN/3 PN HF (6ES7155-6AU30-0CN0)						
IM155-6 MF HF (6ES7155-6MU00-0CN0)	Yes, as of FW V5.1 configured as BA 2xLC and monitor port disabled	Yes, as of FW V5.1 configured as BA LC/RJ45 and monitor port disabled; max. cable length 3 km			V5.5.4.0 or higher with HSP0250 V4 / HSP0255 V5.0 configured as IM155-6 PN2-/2 PN HF V4.2	V15.1 or higher, configured as IM155-6 PN/2 PN HF V4.2
IM155-6 R1 (6ES7155-6AU00-0HM0)	Yes				-	V18 or higher

IM 155-6 MF HF FW 5.2
For IM 155-6 MF HF with FW 5.2, the following applies in Function Manual "MultiFieldbus", section 4.2.3.5 "Data record interface":

Record response (big-endian, read-only access)

Register Offset	Block	Field	Size	Description
0x0041		Processed Length	Unsigned16	Processed length of the PROFINET data record in bytes **Read:** Length of the PROFINET data record read **for Request Control == "Execute read" (0x0000 for "Continue read")** **Write:** Record length of the executed write job = Record Length (Zero in case of an error)

Equipment Manual IM 155-6 MF HF, Edition 01/2022

NOTE

Use in STEP 7 or STEP 7 TIA Portal
To use the interface module in STEP 7 or STEP 7 TIA Portal, install the GSD file. You can find the latest GSD file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/57138621).
After installation, the interface module can be found under "Other field devices".

Data record interface for MF Shared Device
The MF device supports the simultaneous use of the data record interface for max. 2 fieldbuses.

Section 2.2 Functions

Module-to-Module Communication (MtM)
At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Section 3.1.11 Configuration control (option handling)
Configuration control is possible, but modules with submodules distributed on different ARs/fieldbuses may not be part of the AR for active configuration control.

Section 7.2.5 Connection hold time
After the hold time has elapsed, the outputs react as described in the section "Substitute value behavior".

Section 7.2.5 Hold time after connection reset
After the hold time has elapsed, the outputs react as described in the section "Substitute value behavior".

Equipment Manual IM 155-6 PN ST (6ES7155-6AU02-0BN0), Edition 11/2023
Enhanced by the following two features:

1. Media redundancy (MRP and MRPD)
Function for ensuring communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission link fails.
You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) Function Manual.
- As of STEP 7 V5.5 in the PROFINET System Description (https://support.automation.siemens.com/WW/view/en/19292127) System Manual.

2. Interface-local coupling of I/O data
Module-internal shared output
In this example, IO data are transferred from one controller to other controllers over the PROFINET interface X1 by means of the module-internal shared output.

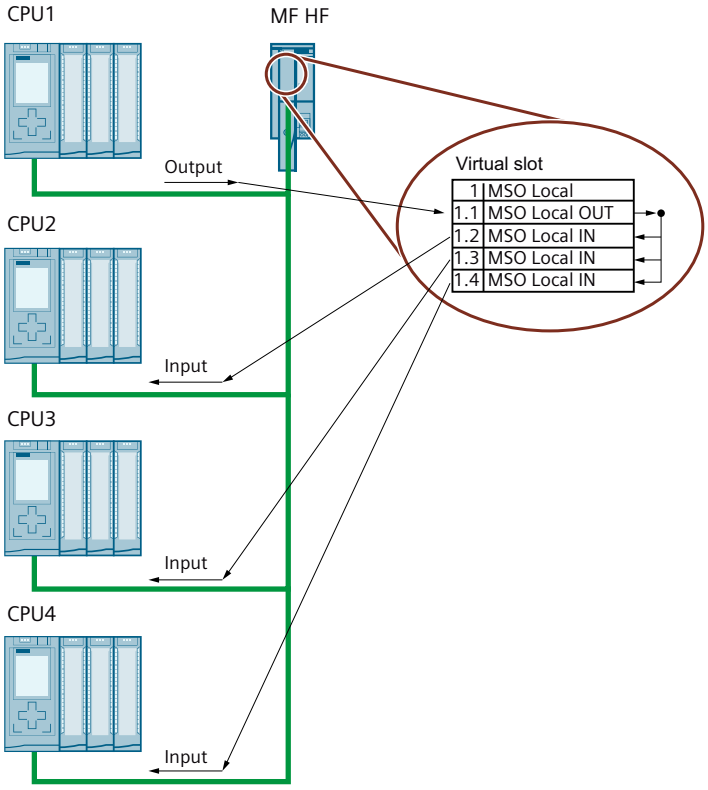


Figure 1 I/O data are transferred to other controllers in the same PROFINET network

Configuration

Table 14 Example configuration

Virtual slot	Type	I length	Q length	Access
1	MSO Local	-	-	-
1.1	MSO Local OUT	-	4 Bytes	CPU 1
1.2	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 2
1.3	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 3
1.4	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 4

Editing in the user program

The controller CPU 1 writes I/O data to the MSO Local OUT module with virtual slot 1.1 of the interface module. The data is available to CPUs 2 to 4 for reading with the remaining MSO Local IN modules. The validity of the provided user data is displayed by the data status byte (DS) of the MSO Local IN modules.

You can also use this example

- with fewer controllers and
- Configure it with other virtual modules.

NOTE

Virtual IO modules

Using virtual IO modules increases the communication load. This increases the data update time of all IO data accordingly.

I/O module manuals
Extended spare parts compatibility

Extended spare parts compatibility of DQ modules
The following table shows the modules you can replace without having to adapt the configuration.
If spare parts are installed, the functions of the configured module are retained.

You have configured and plugged in one of the following modules:	The following module is spare parts compatible:
• Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH00-0BA0) • Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH01-0BA0)	Digital output module DQ 16x24VDC/0.5A HF (6ES7132-6BH00-0CA0)
• Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF00-0AA0) • Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF01-0AA0)	Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF01-0CA0) If you replace one of these modules with an HF module, you must observe the residual current at signal "0". More information can be found in the technical specifications of the respective modules.
• Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF00-0BA0) • Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF01-0BA0)	Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF01-0CA0)
• Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0) • Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD21-0BA0)	Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD21-0CA0)

Safety-related shutdown of standard modules
You can find the latest information on the standard modules that support safety-related shutdown, up to which SIL and Cat./PL and wiring examples, in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/39198632) and in the online version of the technical specifications.

Configuration notes on the I/O modules (supplement to Product overview section in the manual)

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Digital input modules	DI 16x24VDC ST	6ES7131-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0229 V6.0
	DI 8x24VDC BA	6ES7131-6BF00-0AA0	V1.0.0	HSP0126	HSP0229 V5.0
	DI 8x24VDC ST	6ES7131-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0229 V4.0
	DI 8x24VDC HF	6ES7131-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0229 V6.0
	DI 8x24VDC HS	6ES7131-6BF00-0DA0	V1.0.2	Integrated as of V14	HSP0229 V5.0
Digital output modules	DQ 8x24VDC/0.5A BA	6ES7132-6BF00-0AA1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0
	DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Digital output modules	DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	V1.0.2	Integrated as of V14	HSP0230 V5.0
	DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	V1.0	as of V13	HSP0230 V3.0
	DQ 4x24...230VAC/2A HF	6ES7132-6FD00-0CU0	V1.0.0	as of V14 with HSP0240	HSP 0230 as of V8.0
	RQ 4x120VDC-230VAC/-5A NO ST	6ES7132-6HD00-0BB1	V1.0.0	HSP0128	HSP0232 V5.0
	RQ 4x120VDC-230VAC/-5A NO MA ST	6ES7132-6MD00-0BB1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0232 V6.0
Analog input modules	AI 8xU BA	6ES7134-6FF00-0AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 2xU ST	6ES7134-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 8xI 2-/4-wire BA	6ES7134-6GF000AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xI 2-/4-wire ST	6ES7134-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xU/I 2-/4-wire HF	6ES7134-6HB00-0CA1	V2.0.0	HSP0161 V13 SP1 or higher	HSP0227 V6.0 V5.5 SP4 HF7 or higher
	AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0227 V5.0
	AI Energy Meter 400VAC ST	6ES7134-6PA01-0BD0	V3.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0
	AI Energy Meter 480VAC ST	6ES7134-6PA20-0BD0	V4.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0 V5.5 SP4 HF7 or higher
	AI Energy Meter 480VAC/CT HF	6ES7134-6PA00-0CU0	V6.0.0	V15 or higher with HSP0253	V5.5 SP3 or higher
	AI Energy Meter 480VAC/RC HF	6ES7134-6PA20-0CU0	V6.0.0	V15 or higher with HSP0253	V5.5 SP3 or higher
Analog output modules	AQ 2xU ST	6ES7135-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Analog output modules	AQ 2xI ST	6ES7135-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0
	AQ 4xU/I ST	6ES7135-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0228 V4.0
	AQ 2xU/I HS	6ES7135-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0228 V5.0

Digital module device manuals

I/O modules Equipment Manuals

LED DIAG

Table 15 LED DIAG fault display

LED DIAG	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics
Flashes	Module parameters assigned and module/channel diagnostics

Equipment Manuals for I/O modules ST, BA
When you have disabled all channels of the I/O module, a diagnostic message is still generated in the case of a fault if the "No supply voltage L+" diagnostics is enabled. For the following I/O modules, this behavior is corrected as of firmware version > V1.1.0:

- DI 16x24VDC ST
- DI 8x24VDC ST
- DQ 16x24VDC/0.5A ST
- DQ 8x24VDC/0.5 A ST
- DQ 4x24VDC/0.5A ST

Equipment Manuals for digital input modules with wire-break check
When wire-break check is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when encoder contacts are open.
If wire-break check is disabled in the configuration, no parallel connection of the resistor is required.
If wire-break check is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical encoder contact.

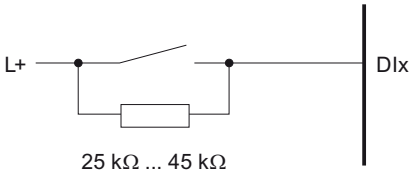


Figure 2 Connect mechanical encoder contact with resistor

Equipment Manual DI 8x24VDC HF, Edition 02/2014
Section 6.1 Technical specifications

- 24 V encoder supply
  - Output current, max.: 700 mA, total current

Equipment Manual DI 8xNAMUR HF, Edition 02/2014
Section A.2 Parameter assignment and structure of parameter data record
With data records 0 to 7, you can configure individual channels.
When the interface module IM 155-6 DP HF (PROFIBUS DP) is used and data records 0 and 1 are read, the module returns the diagnostics data records and not the parameter data records of the DI 8xNAMUR HF.

DQ Modules Equipment Manuals

Equipment Manual	Edition
DQ 8x24VDC/0.5A BA (6ES7132-6BF01-0AA0)	02/2019
DQ 8x24VDC/0.5A HF (6ES7132-6BF00-0CA0)	12/2017
DQ 8x24VDC/0.5A ST (6ES7132-6BF01-0BA0)	02/2019
DQ 8x24VDC/0.5A SNK BA (6ES7132-6BF61-0AA0)	02/2019

NOTICE
Current load of combined return conductors When connecting in 2-wire connection, the static current load of the combined return conductor must not exceed 2A per terminal.

Equipment Manual DQ 4x24VDC/2A HS, Edition 09/2016
Section 6.1 Technical specifications
For this module, the marine approval for the bridge and deck zone is valid from a bus cycle time of at least 250 µs.

DQ 4x24VDC/2A HS Equipment Manual, Edition 05/2021
Section 6.4.1.3 Address space

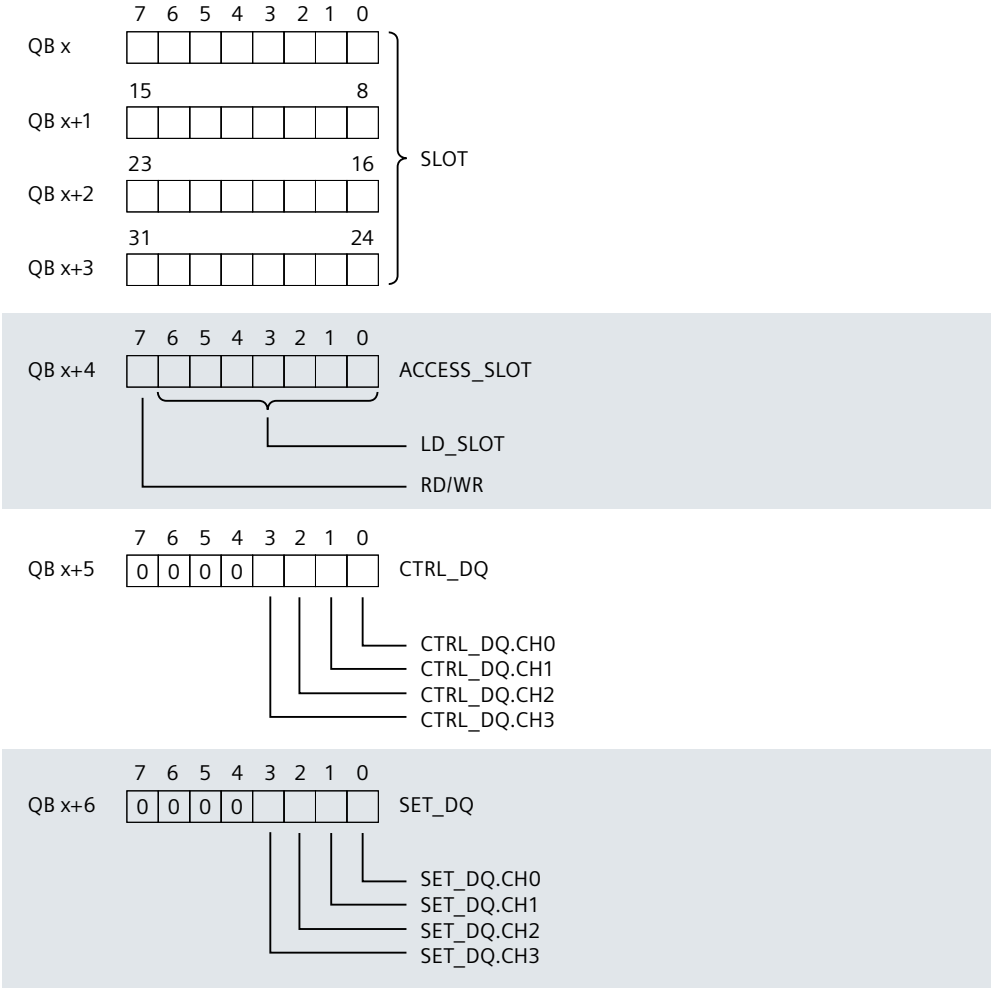
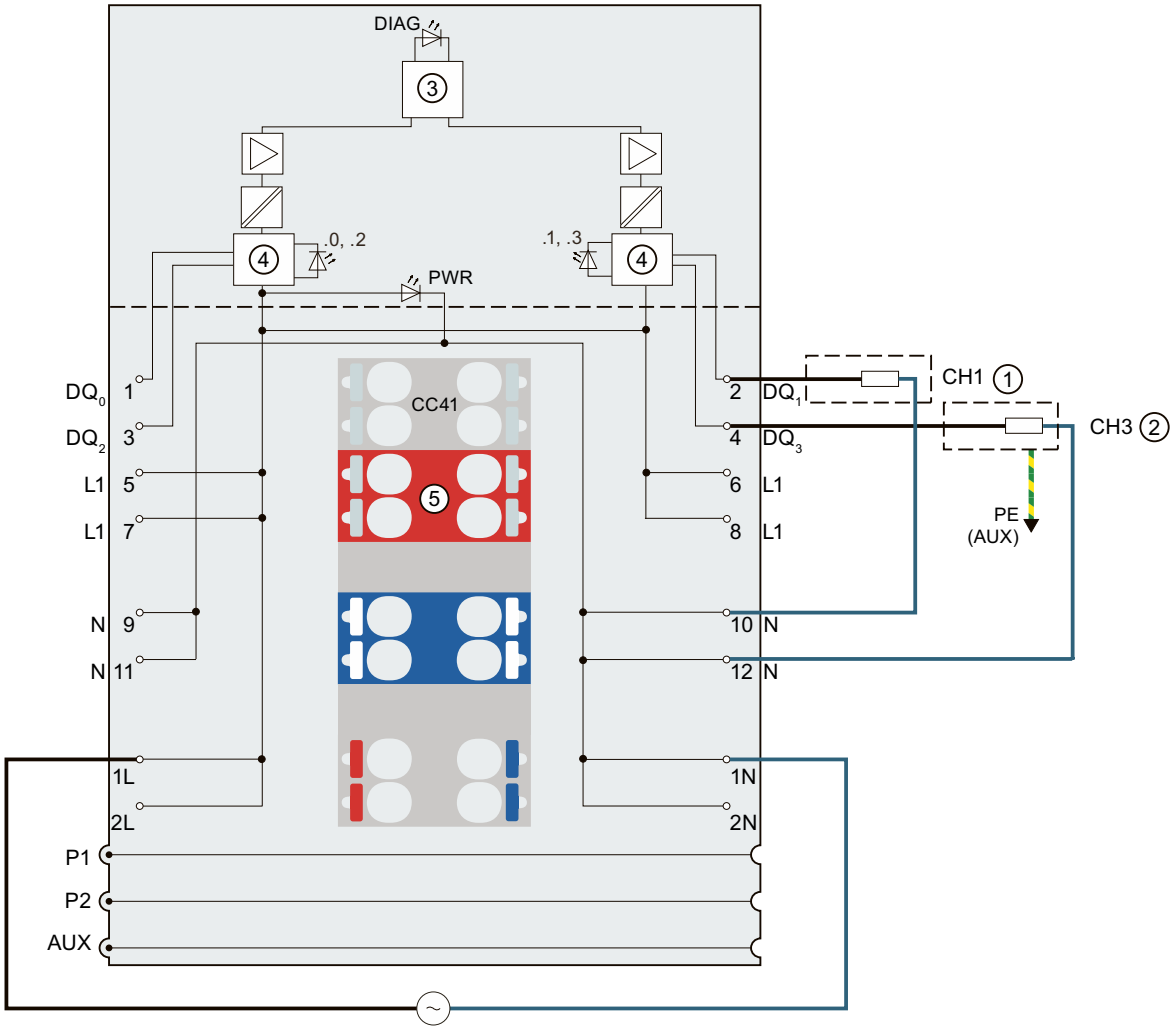


Figure 3 Assignment of the control interface

Section 3.1 Wiring and block diagram

The following figure shows the block diagram and an example of the pin assignment of the digital output module DQ 4x24..230VAC/2A ST on the BaseUnit BU type B1.



①	2-wire connection	N	Neutral conductor
②	3-wire connection	1L, 2L	Supply voltage 24 V AC to 230 V AC
③	Backplane bus interface	1N, 2N	Neutral conductor supply voltage
④	Output electronics	PE (AUX)	Protective conductor connection
⑤	Color-coded label CCxx (optional)	DIAG	Diagnostics LED (red/green)
DQ_n	Output signal, channel n	.0, .1, .2, .3	Channel status LED (green)
L1	Encoder supply	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 4 Wiring and block diagram for 2-wire and 3-wire connection of actuators

Section 3.1 Pin assignment; Supply voltage fuse protection

The module has neither short-circuit protection nor overload protection. Protect the module from being destroyed by impermissible high current and install a fine fuse in the supply line. The maximum rated current of the fine fuse depends on the hardware function status (FS) of the module.

HW functional status of the module	Max. rated current of fuse	Tripping characteristic
FS ≤ 3	8 A	Quick response
FS ≥ 4	10 A	Quick response

Section 6.1 Technical specifications, Switching frequency with inductive load

The switching frequency of the outputs with inductive loads is max. 0.5 Hz.
Higher switching frequency is possible in spite of this, and depends on the alternating voltage and switched inductors or the power factor of the electric motor used.

Alternating voltage	Condition	Max. switching frequency
200 VAC or lower	---	10 Hz
200 VAC or higher	• Power factor of the electric motor cos φ > 0.35 • Electric motor must only be turned off after startup (no jogging mode). Electric motors which are turned off during startup could create inductive shutoff voltages > 600 V, which could destroy the output electronics (Triac).	10 Hz

Section 6.1 Technical specifications

Supply voltage	
Rated value (AC)	24 V to 230 V

Equipment Manual DQ 4x24..230VAC/2A HF, Edition 02/2018
Section 3.1.1. and 4.1.1 Wiring and block diagram
The following figure shows an example of the pin assignment of the digital output module DQ 4x24..230VAC/2A HF on BaseUnit BU type U0 (3-wire connection) in combination with a potential distribution module and terminal block.
For a 3-wire connection you connect the protective earth (PE) of the actuator to the terminal block.

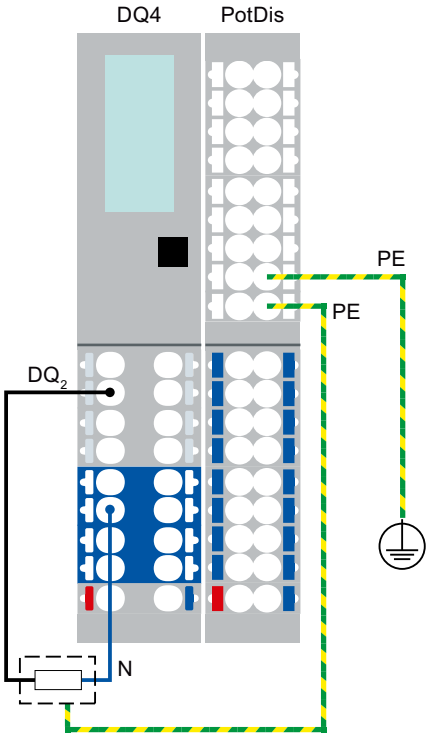


Figure 5 3-wire connection of actuators with potential distribution module at the digital output module DQ 4x24..230VAC/2A HF

Equipment Manuals DQ 16x24VDC/0.5A HF, Edition 01/2024; DQ 8x24VDC/0.5A HF, Edition 04/2024; DQ 4x24VDC/2A HF, Edition 04/2024
Section 7.1 Technical specifications

Module	Load resistance range (high limit, at nominal voltage)
DQ 16x24VDC/0.5A HF	2.4 kΩ
DQ 8x24VDC/0.5A HF	2.4 kΩ
DQ 4x24VDC/2A HF	1.6 kΩ

Equipment Manuals RQ 4x120VDC-230VAC/5A NO MA ST; Edition 06/2020, RQ 4x120VDC-230VAC/5A NO ST, Edition 06/2020
Section 3.1 Wiring and block diagram

NOTICE
The relay channels have no integrated short-circuit protection. Provide external short-circuit protection in the form of a miniature fuse with a maximum tripping current of 6.3 A and a fast tripping characteristic. A breaking capacity of at least 1500 A is required for mains voltages. For all other applications and for supply networks with a short-circuit current greater than 1500 A, you need to use a miniature fuse with an appropriately adapted breaking capacity.

⚠ WARNING

Do not connect exposed extra-low-voltage (SELV/PELV) and dangerous live voltages between channels at the same time!
If you only use dangerously live voltages, keep a maximum voltage difference of 230 V between the channels.

Observe the information on the inductive DC loads in Section 6.1 "Technical specifications".

Section 6.1 Technical specifications

NOTICE

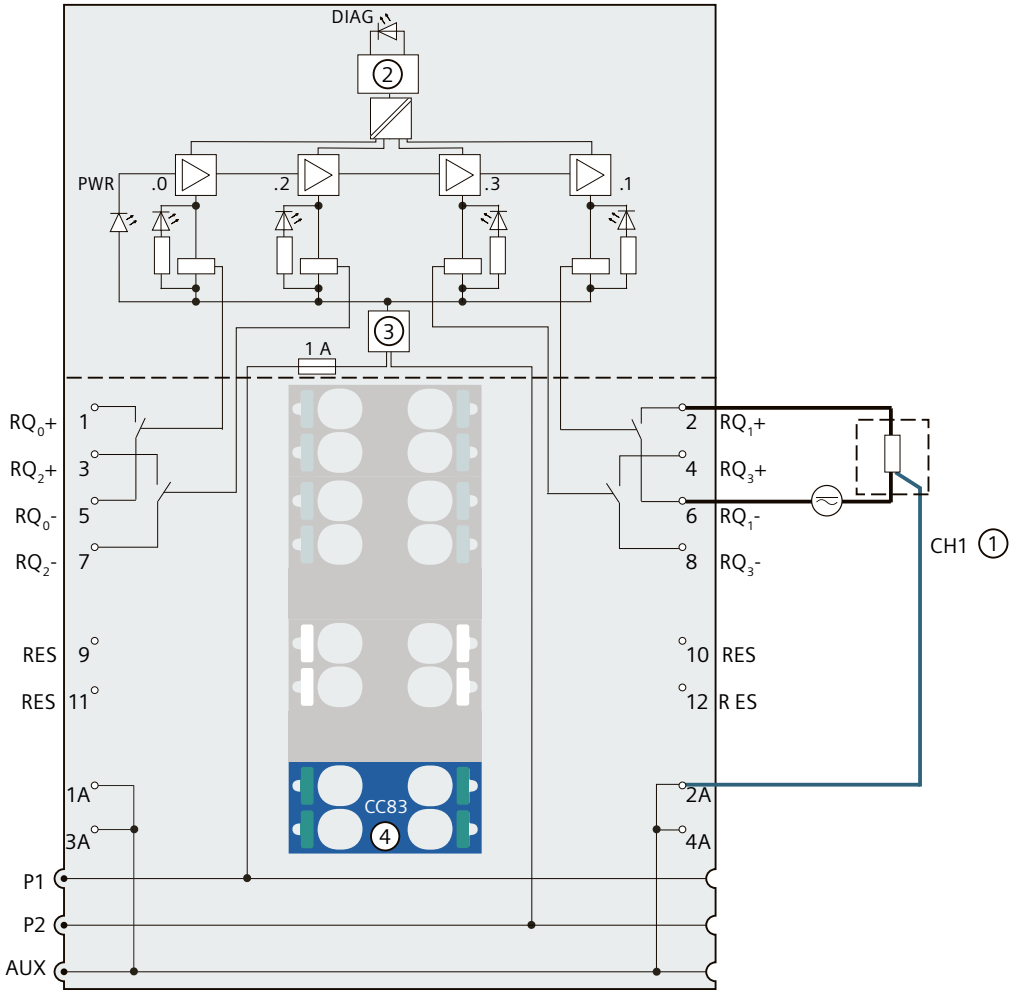
Required measures in the case of inductive DC loads and switching frequencies greater than 0.1 Hz
Install an external freewheel in the form of a diode for switching frequencies greater than 0.1 Hz.

Equipment Manual RQ 4x24VUC/2A CO ST, Edition 02/2019
Switching capacity and service life of contacts
The list shows the switching capacity and lifetime of the relay contacts:

- Resistive DC load 24VDC/1.0A: 0.5 million switching cycles (typical)
- Resistive DC load 24VDC/2.0A: 0.1 million switching cycles (typical)
- Resistive AC load 24V: 0.1 million switching cycles (typical)
- Mechanical service life (free of load): 100 million switching cycles (typical)

The voltage specifications are nominal voltages.

Section 3.1 Wiring and block diagram
Connection: 3-wire connection of actuators
The following figure shows the block diagram and an example of the pin assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B0.



①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1 A to 4 A	AUX terminals
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color identification label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 6 Wiring and block diagram for 3-wire connection of actuators

Equipment Manual RQ 3x120VDC-230VAC/5A CO n.i. ST, Edition 01/2024
Section 4.3 Address space
Configuration options of the RQ 3x120VDC-230VAC/5A CO n.i. ST
You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 16 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 3-channel without value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0	V16 or higher with HSP 0321 *	X	X
1 x 3-channel with value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0, QI	V16 or higher with HSP 0321 *	X	---

* in compatibility mode of the RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)

RQ Modules Equipment Manuals

Equipment Manual	Edition
RQ 4x24VUC/2A CO ST (6ES7132-6GD51-0BA0)	10/2019
RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)	06/2020
RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD01-0BB1)	06/2020
RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)	01/2024
RQ 3x120VDC-230VAC/5A CO n.i. ST (6ES7132-6HC70-0BU0)	01/2024

New Section 6.3 Mechanical environmental conditions
The mechanical ambient conditions are specified in the following table as sinusoidal oscillations.

Table 17 Test of mechanical environmental conditions

Condition tested	Test standard	Remarks
Vibrations	Vibration test according to IEC 60068-2-6 (Sinus)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of oscillation: 10 frequency sweeps per axis, along each of the 3 mutually perpendicular axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 100 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks each in +/- direction, along each of the 3 perpendicular axes
Continuous shock	Shock, tested according to IEC 60068-2-27	Is not supported by the RQ module

Analog module device manuals

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xI 2-wire 4..20mA HART	11/2014

Section 5.2 "Parameters"

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xTC HS (6ES7134-6JD00-0DA1)	03/2019

For user calibration with a calibration device, deactivate the "Wire-break check" parameter or function.

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xU/I 2-wire ST (6ES7134-6HD01-0BA1)	09/2019
AI 2xI 2/4-wire ST (6ES7134-6GB00-0BA1)	04/2018
AI 2xU/I 2/4-wire HF (6ES7134-6HB00-0CA1)	12/2015
AI 4xI 2/4-wire ST (6ES7134-6GD01-0BA1)	09/2018

New section in Appendix B: "Measured values for wire break"

Table 18 Measured values at a wire break depending on enabled diagnostics

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	Enable	32767	$7FFF_H$	The "wire break" diagnostics is reported, because this has a higher priority.
Disable	Enable	-32768	8000_H	The "Lower limit violated" diagnostics is reported.
Disable	Disable	-32768	8000_H	No diagnostics reported.

Equipment Manual Analog Input Module AI 4xRTD/TC 2-/3-/4-wire HF, Edition 07/2021

Section "Measurement types and measuring ranges"

Table 19 Using PTC resistors

Property	Technical specifications	Remarks
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)

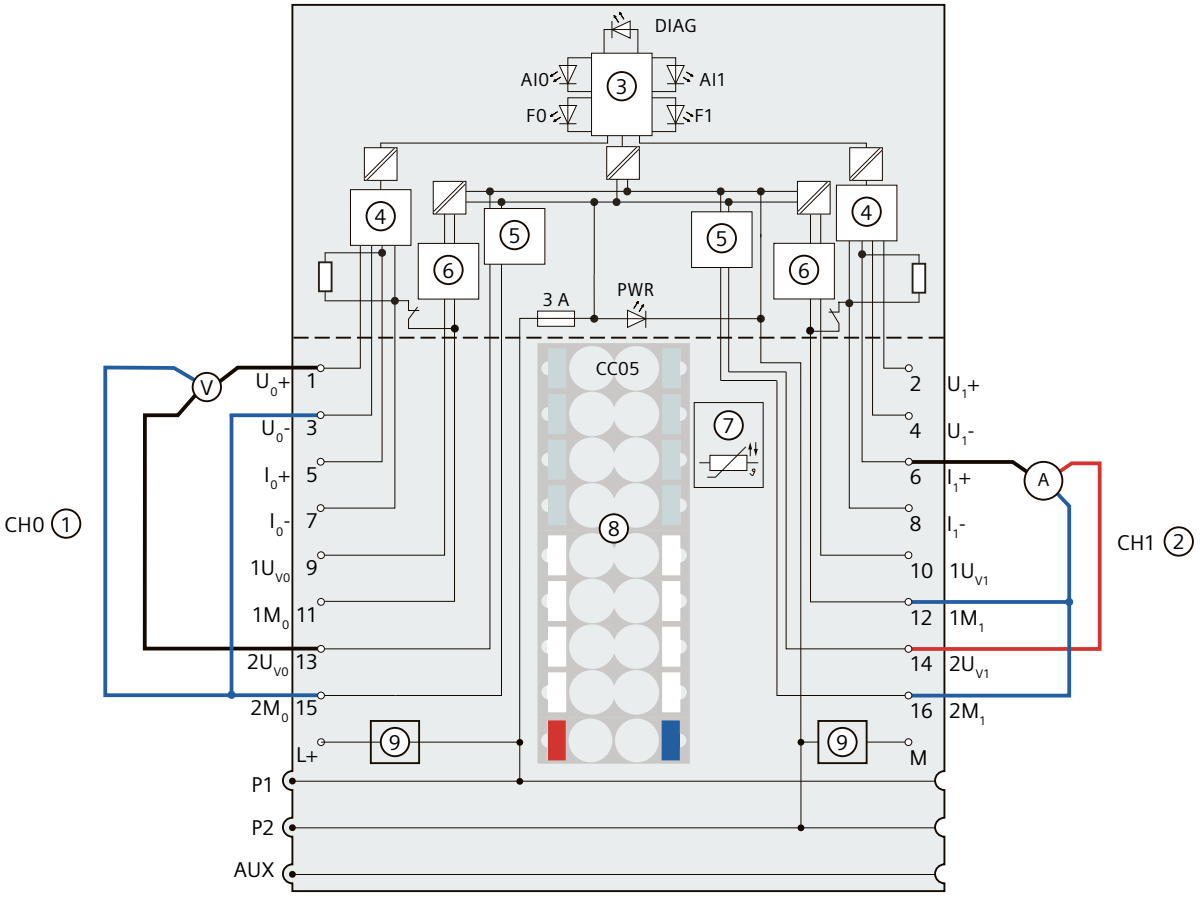
[1] Below 23 kΩ

Property	Technical specifications	Remarks
Switching points	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Behavior after short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω Min. 1330 Ω Min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Connection: Voltage and current measurement 3-wire connection

The following figure shows the block diagram and an example of the pin assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

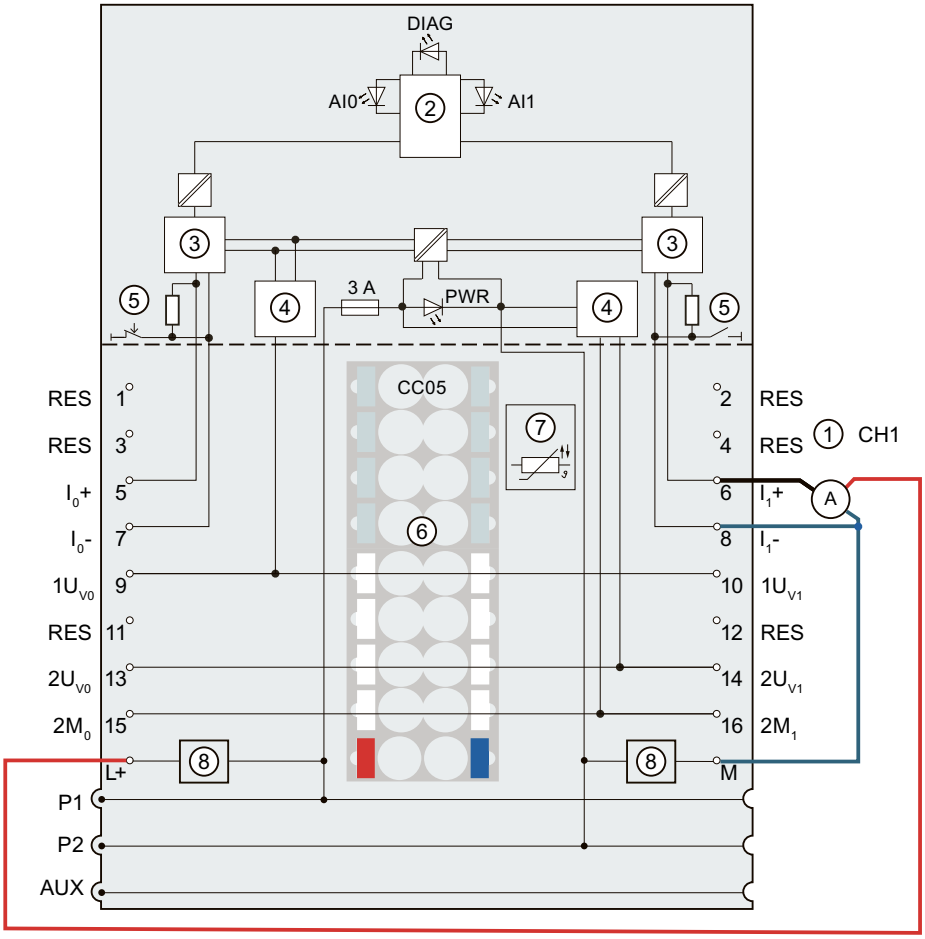


①	3-wire connection for voltage measurement	I_n+	Current input positive, channel n
②	3-wire connection for current measurement	I_n-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire or 3-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Supply voltage filter circuit (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
U_n+	Voltage input positive, channel n	PWR	Power LED (green)
U_n-	Voltage input negative, channel n		

Figure 7 Wiring and schematic circuit diagram for voltage measurement 3-wire connection

Connection: Current measurement 3-wire connection (3-wire transducer)

The following figure shows the block diagram and an example of the pin assignment of the analog input module AI 2xI 2-/4-wire ST on the BaseUnit BU type A0/A1.



①	3-wire connection for current measurement (3-wire transducer)	$1U_{Vn}$	Supply voltage (2-wire transducer), channel n
②	Backplane bus interface	$2U_{Vn}$	Supply voltage (4-wire transducer), channel n
③	Analog-to-digital converter (ADC)	$2M_n$	Reference potential (4-wire transducer)
④	Current limitation	RES	Reserve, must remain unused for future function extensions
⑤	Switchover 2-wire / 4-wire	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Color-coded label with color code CC05 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Supply voltage filter circuit (only when light-colored BaseUnit is present)	AI0, AI1	Channel status LED (green)
I_n+	Current input positive, channel n	PWR	Power LED (green)
I_n-	Current input negative, channel n		

Figure 8 Wiring and block diagram for current measurement 3-wire connection (3-wire transducer)

NOTE
With this interconnection, the sensor supply is not limited. Up to a total current of 200 mA, you can use $2U_{Vn}$ to power the encoder.

NOTE
For 3-wire connection, configure the parameter "Measurement type/range" with "Current (4-wire transducer) 0..20 mA" or "Current (4-wire transducer) 4..20 mA".

"Parameters" section
You can only assign the parameters diagnostics on a module-by-module basis.

Equipment Manual AI 4xTC HS, Edition 03/2019

"Parameters" section

Table 20 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Fixed reference temperature	0 °C	0 °C	No	Channel	-

"Technical specifications" section
The abbreviation SFU stands for interference frequency suppression.

Equipment Manuals AI Energy Meter

Equipment Manual	Edition
AI Energy Meter CT HF (6ES7134-6PA01-0CU0)	04/2022
AI Energy Meter RC HF (6ES7134-6PA21-0CU0)	04/2022
AI Energy Meter CT ST (6ES7134-6PA01-0BU0)	04/2022
AI Energy Meter RC ST (6ES7134-6PA21-0BU0)	04/2022

Section 3.2 Connection examples
Any phase of the connected 3-phase system can be connected to the 4th measuring channel, not just the neutral conductor.

Section 3.1 Wiring and block diagram *and* section 3.2 Connection examples
Current transformer connection requirements
You must connect a current transformer to the infeed with K/P1 and to the ground/neutral point with L/P2.
The energy meter has the current transformer inputs ILx+ and ILx-. The current transformer on the secondary side via the outputs k/S1 and l/S2.
You must wire the k/S1 output of the current transformer to the ILx+ input of the energy meter. You must wire the output l/S2 of the current transformer to the input ILx- of the energy meter.

Chap. 4.2.1 Module versions at configuration with STEP 7
Module variants with fixed payload data assignment

Module version	Payload	Address space	Comment
2 I / 2 O	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version.
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3".
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	

Section 7.2.4 Notes for the detection of wiring errors and incorrect rotating field
Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. You can see whether the wiring is correct by referring to the figure "Quadrant in the quality bits" in section 7.2.3 "Operating quadrant".

Section 14.2 Explanation of parameters
Reactive power compensation
Reactive power Qtot Lx: Power of fundamental oscillation and the harmonic components
Reactive power Qn Lx: Power of harmonic components only
Fundamental reactive power Lx: Power of fundamental oscillation

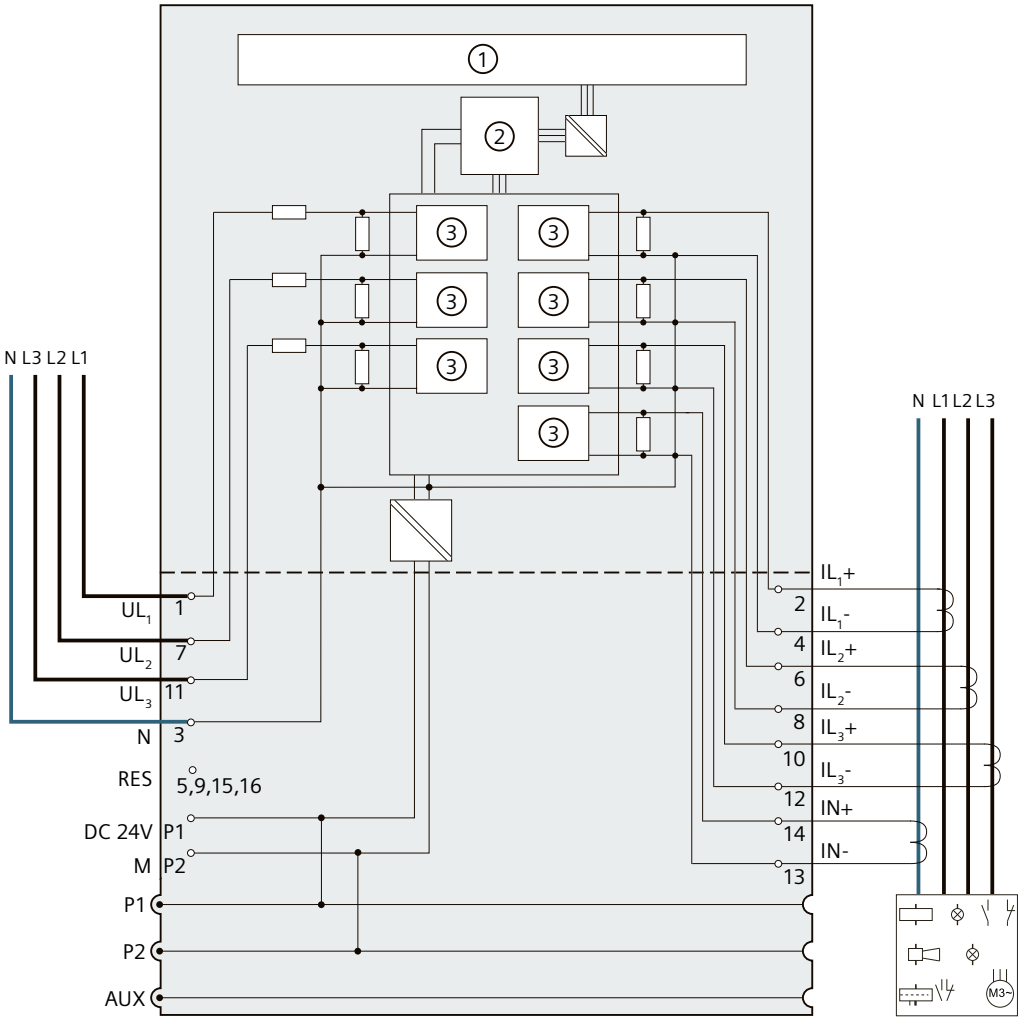
Appendix E.11 Measured value data record for maximum values with time stamp (DS 154) *and* E.12 Measured value data record for minimum values with time stamp (DS 155)
The measured value IDs listed in the table refer only to the measured values and do not include the time stamps.

Appendix E.17 Information data record on available measured values (DS 170)
Measured variables of the module

Byte	Name	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2...3	Number of IDs	UINT16	-	599
4...5	ID measured value 1	UINT16	-	-
6...7	ID measured value 2	UINT16	-	-
...	...	...	-	-
1200 ... 1201	ID measured value 599	UINT16	-	-

Equipment Manual AI Energy Meter 480VAC/CT HF, Edition 03/2021

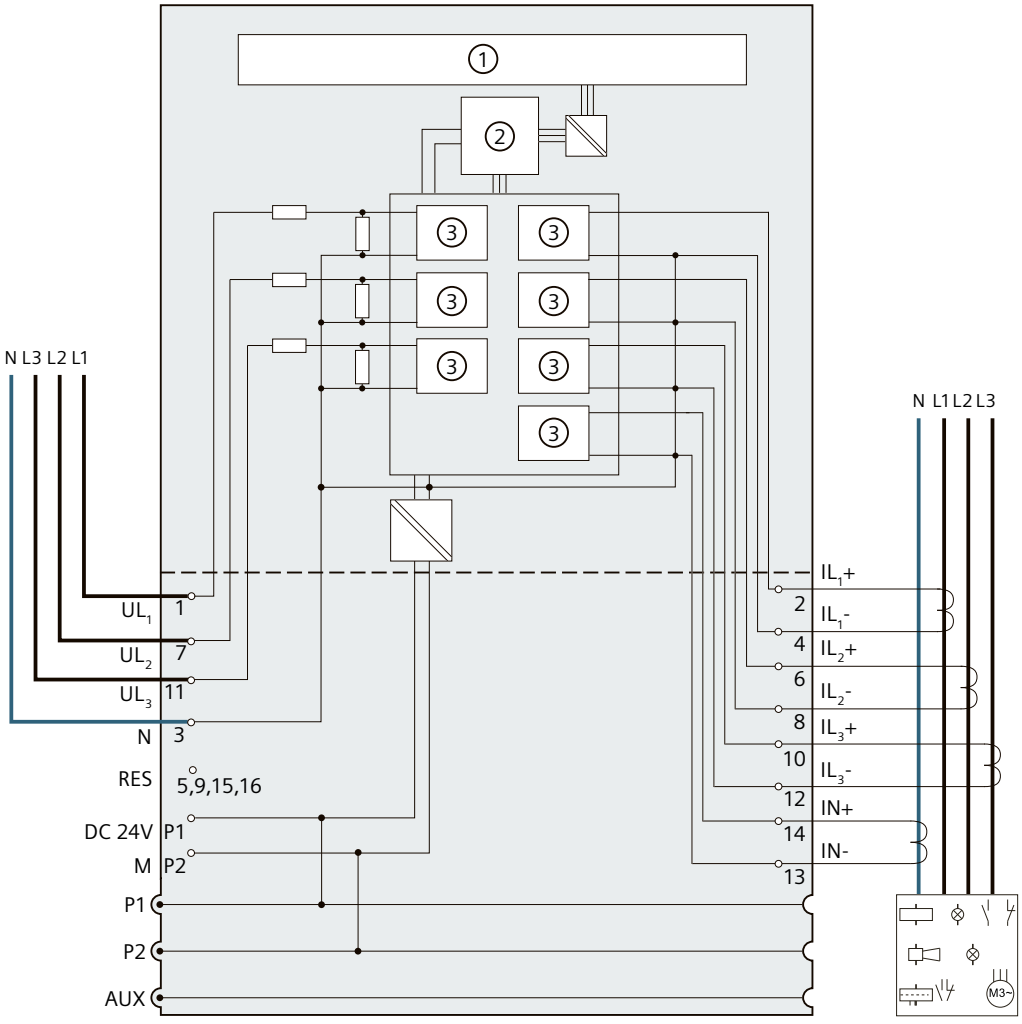
Wiring and block diagram



①	Backplane bus interface	UL_n	Connection voltage
②	Microcontroller	IL_n+ / IL_n-	Connection of current transformers
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral conductor
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Equipment Manual AI Energy Meter 480VAC/RC HF

Wiring and block diagram



①	Microcontroller	UL_n	Connection voltage
②	Backplane bus interface	IL_n+ / IL_n-	Connection of current/voltage transformers and Rogowski coils
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral conductor
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Equipment Manual AI Energy Meter 480VAC ST, Edition 12/2015

For configuration with STEP 7 V13 or higher (TIA Portal), real values between -7x10^{28} and +7x10^{28} can be input. This is true for configuration via HSP and via GSD file (PROFINET).
For configuration with STEP 7 V5.5 SP4 as of HF7, configuration by means of GSD file (PROFINET) with REAL values of -1.175x10^{38} to +3.402x10^{38} is possible.
With STEP 7 SP4 to HF6, parameter assignment of REAL values is not possible. Functions that require REAL values are not available in this case.

Equipment Manuals AI Energy Meter 480VAC/CT HF, Edition 03/2021, and AI Energy Meter 480VAC/RC HF, Edition 03/2021

Below the "Measured variables for data records and user data" table in the section "Measured variables for connection type" it should correctly read in Italian:

[4] Valore medio aritmetico in virgola mobile calcolato su 10 s, disponibile se UL-N>3V

Equipment Manuals AI Energy Meter

Equipment Manual	Edition
AI Energy Meter 480VAC/CT HF	03/2021
AI Energy Meter 480VAC/RC HF	03/2021

Section 7.2.2 "Quality information with measured value IDs"

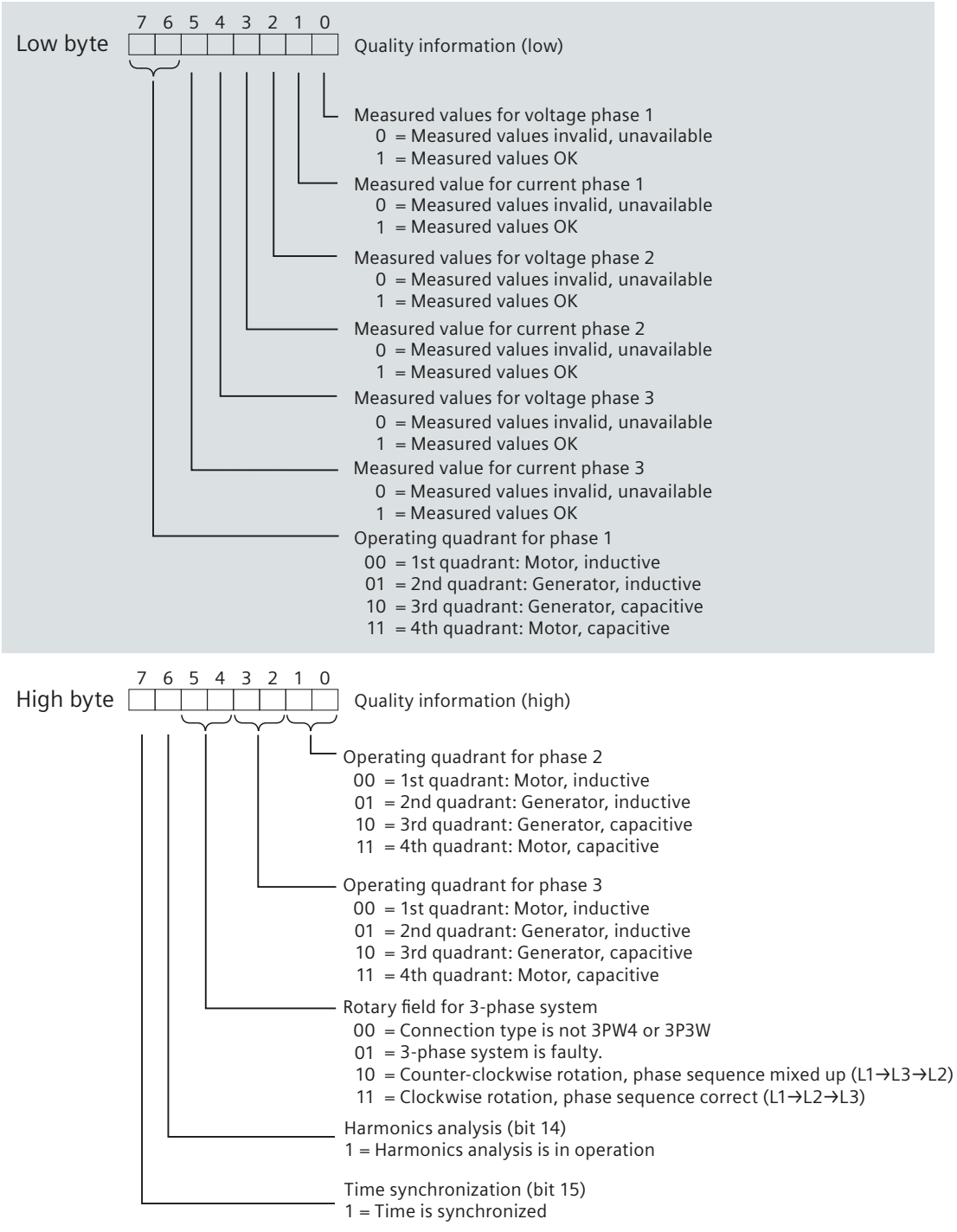


Figure 9 Quality information for low and high byte of the measured value ID 65503

Section "7.2.3 Operating quadrant"
The figure below shows the quality information of the operating quadrants.

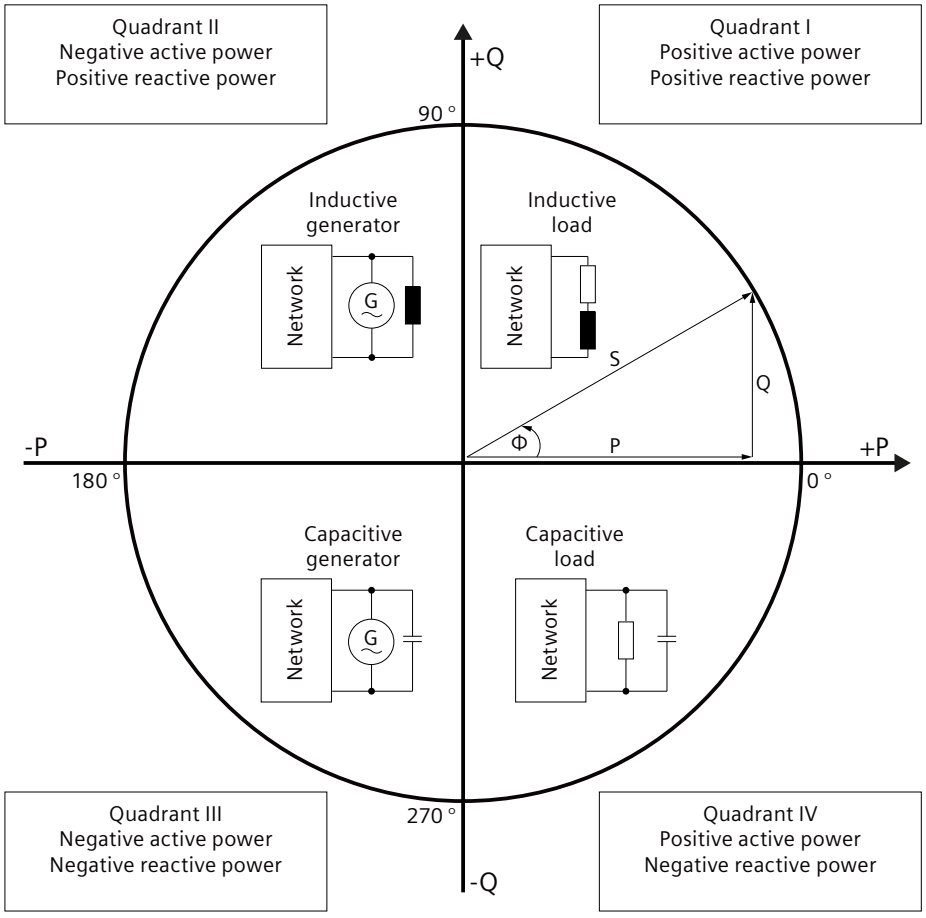


Figure 10 Quadrant in the quality bits

Section "7.2.4 Notes for the detection of wiring errors and incorrect rotating field"
Requirements
Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

The "See also" paragraph is omitted.

Section "8 Energy counter"
Introduction
"Outflow" describes the regenerative operation of the connected system.
"Inflow" describes the motor operation of the connected system.

Section 9.2.1 "Start values for operating hours counter"
Byte 158 ... byte 169: Start values for operating hours counter
The start values for operating hours counters in data record 143 are 32-bit floating point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

Appendix F.1 "Tips and tricks"
Rotating field
To recognize wiring errors and evaluate the generated rotating field, use the combined measurement functions from the section "Notes for the detection of wiring errors and incorrect rotating field".

Equipment Manuals AI Energy Meter 400VAC ST, Edition 12/2015; AI Energy Meter 480VAC ST, Edition 12/2015
Requirements for the operation of the AI Energy Meter on slot 1 of the ET 200SP:

Interface module / CPU	AI Energy Meter 400VAC ST (6ES7134-6PA01-0BD0)	AI Energy Meter 480VAC ST (6ES7134-6PA20-0BD0)
IM 155-6 PN BA (6ES7155-6AR00-0AN0)	Can be operated on slot 1 for all IM 155-6 PN BA	
IM 155-6 PN ST (6ES7155-6AU00-0BN0)	Can be operated on slot 1 for IM 155-6 PN ST from firmware version V3.1 and higher and functional status FS 07	
IM 155-6 PN HF (6ES7155-6AU00-0CN0)	Can be operated on slot 1 for IM 155-6 PN HF from firmware version V3.0 and higher and functional status FS 05	
IM 155-6 DP HF (6ES7155-6BU00-0CN0)	Can be operated on slot 1 for IM 155-6 DP HF from firmware version V3.0 and higher	
CPU 1510SP-1 PN, CPU 1512SP-1 PN, CPU 1515SP PC	Can be operated on slot 1 for all CPUs	

Incorrect value range for information on power (INT variables)
Refers to the table of measured quantities in Appendix B and the tables of useful data variants in Appendix D.
Correct value range: -32768 to 32767

Product overview, Figure 2-1 Use of the AI Energy Meter
Display incorrect.
Replace figures as follows:

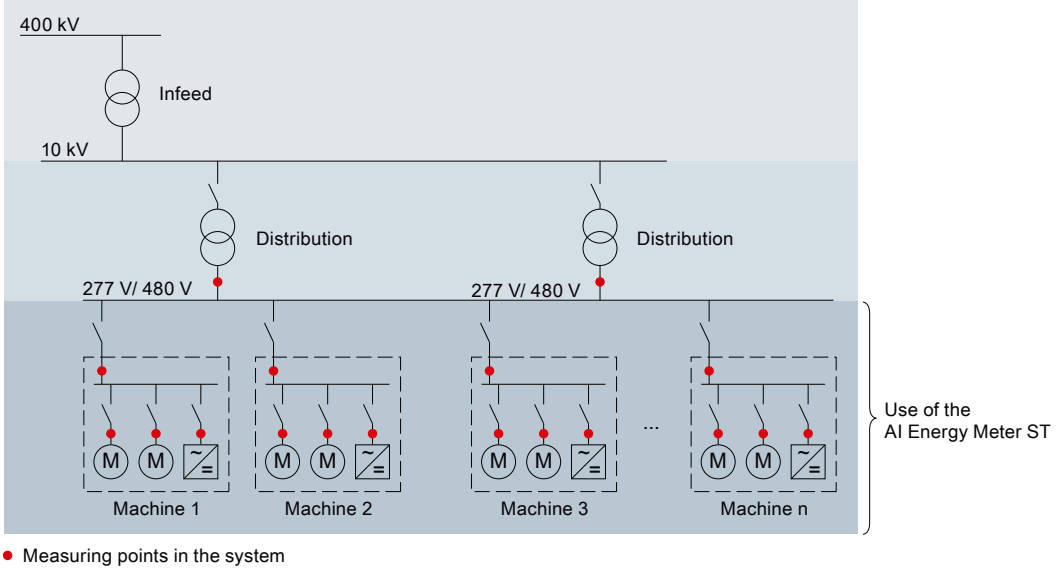
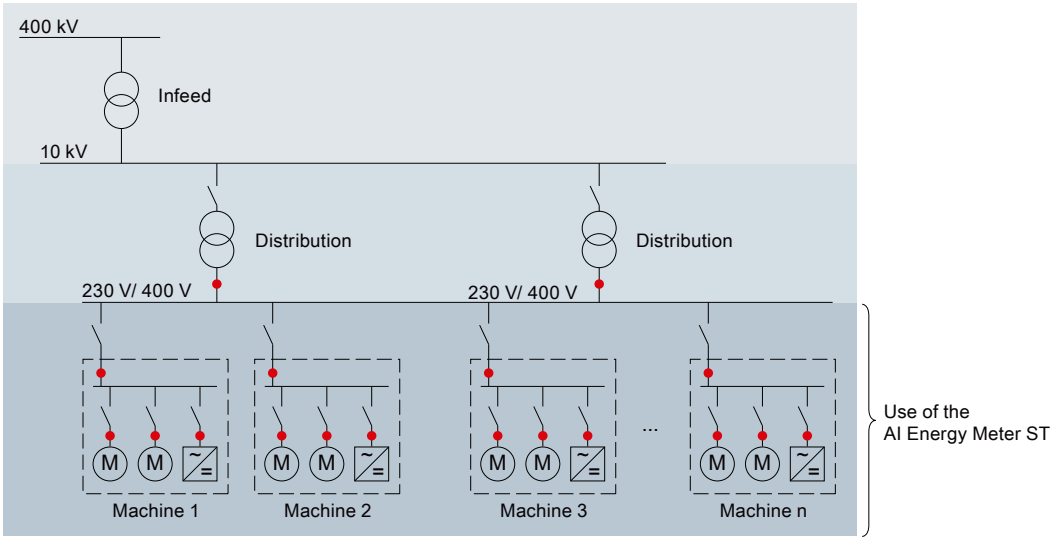


Figure 11 Use of the AI Energy Meter 480VAC ST

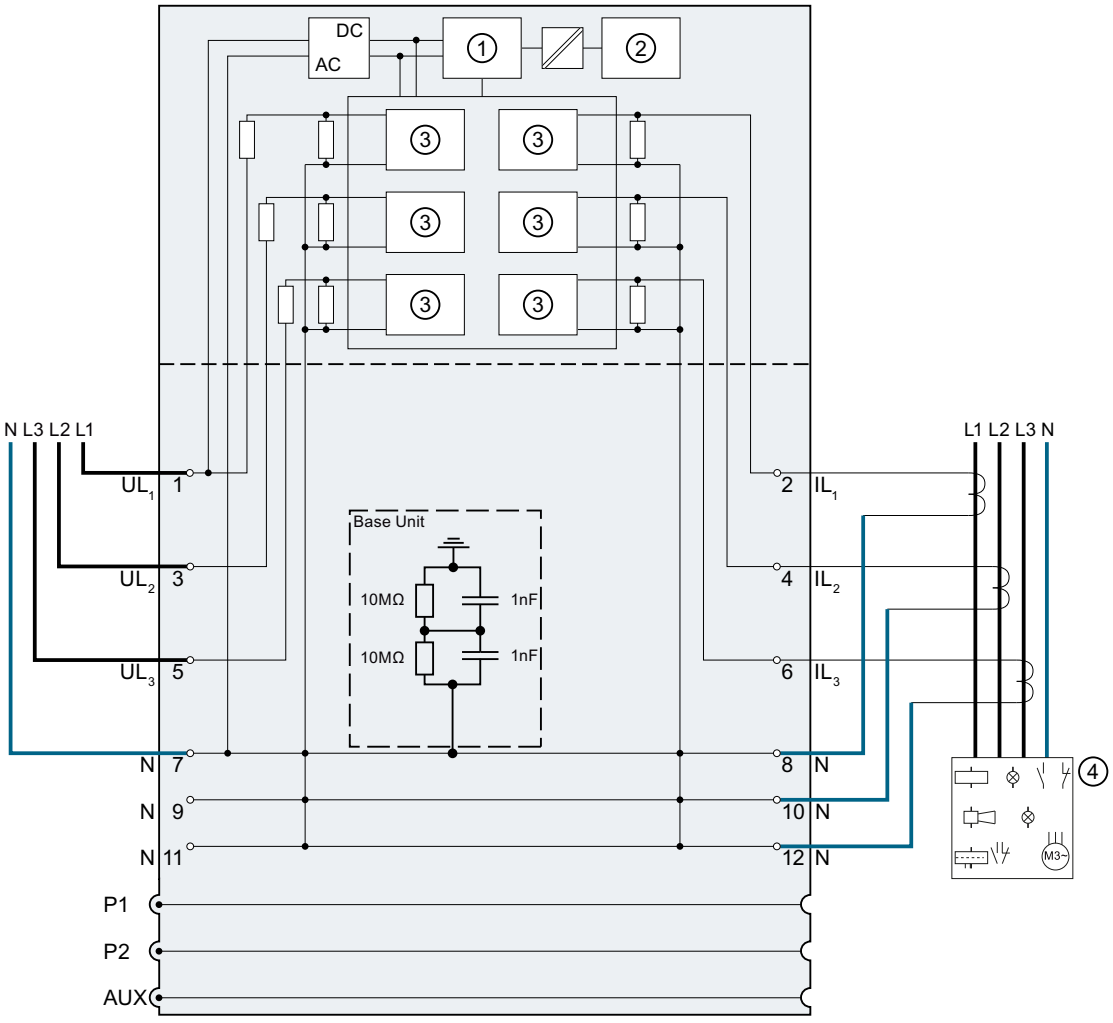


● Measuring points in the system

Figure 12 Use of the AI Energy Meter ST 400V

Section 3.1 Wiring and block diagram, paragraph on Fuse protection of the connection lines
AI Energy Meter 400VAC ST, replace set with:
If the cables are short-circuit proof according to IEC 61439-1:2009, e.g. in a conduit or on separate cable trays, separate line protection for the AI Energy Meter 400VAC ST can be omitted.
AI Energy Meter 480VAC ST, replace set with:
If the cables are short-circuit proof according to IEC 61439-1:2009, e.g. in a conduit or on separate cable trays, separate line protection for the AI Energy Meter 480VAC ST can be omitted.

Section 3.1 Wiring and block diagram, Figure 3-1
Replace wiring diagram, add note:



①	Microcontroller	UL_n	Voltage connection
②	Backplane bus interface	IL_n	Current connection
③	Analog-to-digital converter (ADC)	N	Neutral conductor
④	Power measurement		

Figure 13 Block diagram of the AI Energy Meter 480VAC ST

NOTE

The BaseUnit of the Energy Meter 400/480VAC, 6ES7193-6BP00-0BD0, BU20-P12+A0+0B, contains a connection from N to FE, or to the potential connected to the DIN rail. This connection consists of two Y2 capacitors in series, each with a capacitance of 1 nF, and two resistors in parallel, each with a resistance of 10 MOhm.

Equipment Manual for Energy Meter 480VAC ST, Edition 12/2015
In the Equipment Manual for Energy Meter 480VAC ST, the measured value ID and the associated measured variables for the complete performance are reversed. The correct association is shown in the table below:

Measured value ID	Measured variables	Unit
34	Total active power L1L2L3	W
35	Total reactive power L1L2L3	var
36	Total apparent power L1L2L3	VA
65	Max. total active power	W
66	Max. total reactive power	var
67	Max. total apparent power	VA
95	Min. total active power	W
96	Min. total reactive power	var
97	Min. total apparent power	VA

If you use the user-data mapping via data record DS 130, note that the texts for the measured variables are also displayed incorrectly during configuration.
During configuration of the measured variables for the total active, reactive, and apparent power, select the following texts:

Desired measured variable for the user-data mapping	Text to select during configuration
Total active power L1L2L3	Total apparent power L1L2L3 (ID00034)
Total reactive power L1L2L3	Total active power L1L2L3 (ID00035)
Total apparent power L1L2L3	Total reactive power L1L2L3 (ID00036)
Max. total active power	Max. total apparent power (ID00065)
Max. total reactive power	Max. total active power (ID00066)
Max. total apparent power	Max. total reactive power (ID00067)
Min. total active power	Min. total apparent power (ID00095)
Min. total reactive power	Min. total active power (ID00096)
Min. total apparent power	Min. total reactive power (ID00097)

The project configuration modification described above is no longer required if the following tools and GSD files are used:
- STEP 7 (TIA Portal) as of V14
- STEP 7 V5.5 SP4 or higher with HSP 0227
- GSD file GSDML-V2.32-ET200SP-20160706

Section 11.1 Phase-related measured values
Assignment of the user data variants swapped between L1 and L3.
Correct assignment:
- Phase-specific measurement Phase L1 with user data variants 158 ($9E_H$) and 159 ($9F_H$)
- Phase-specific measurement Phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
- Phase-specific measurement Phase L3 with user data variants 154 ($9A_H$) and 155 ($9B_H$)

Appendix D User data variants
Table D-13 Basic energy counter measurement variables (periodic) Overflow counter (ID 239 or EFH).
Replace measured value IDs:

Table 21 Basic energy-counter-measurement variables (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
2 ... 3	Overflow counter for active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter for active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter for reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter for reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter for apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter for active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter for active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter for reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter for reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter for apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter for active energy inflow L3	UINT	-	0 ... 65535	61230
24 ... 25	Overflow counter for active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter for reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter for reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter for apparent energy L3	UINT	-	0 ... 65535	61234

Equipment Manuals for analog output modules

Equipment Manual	Edition
Analog output module AQ 2xU/I HS	09/2016
Analog output module AQ 4xU/I ST	03/2016

"Representation of analog values in the current output ranges" section

Table 22 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25 %	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	16 mA	
0.003617 %	1	1	4 mA + 578.7 nA	
0 %	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5 %	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519 %	-32768	8000		

* Outputs positive maximum value or negative minimum value

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xU/I 2-wire ST (6ES7134-6HD01-0BA1)	09/2019
AI 2xI 2/4-wire ST (6ES7134-6GB00-0BA1)	04/2018
AI 4xI 2/4-wire ST (6ES7134-6GD01-0BA1)	09/2018
AI 4xTC HS (6ES7134-6JD00-0DA1)	03/2019

"Diagnostic messages" section
Diagnostic messages in the measured value of analog input modules
Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected.

Equipment Manual AI 4xTC HS (6ES7134-6JD00-0DA1)
New section in Appendix B: "Measured values for wire break and reference channel mode"

Table 23 Measured values for a wire break depending on enabled diagnostics and parameters in TC operating mode

Parameters			Measured value		Explanation
Wire break check	Diagnostics wire break	Diagnostics underflow			
Enable	Enable	*	32767	$7FFF_H$	The "wire break" diagnostics is reported.
Enable	Disable	*	32767	$7FFF_H$	No diagnostics reported. A wire break check is carried out (i.e. test current flows).
Disable	Disable	*	Undefined		No "wire break" diagnostics is reported. No wire break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

* Parameter assignment not relevant

Table 24 Measured values for a wire break in a TC measurement with enabled reference junction (reference channel) depending on enabled diagnostic information and parameters

Case	Parameters					Measured value			
	Reference channel		TC channel			Reference channel		TC channel	
	Diagnostics Wire break	Diagnostics underflow	Wire break check	Diagnostics wire break	Diagnostics underflow				
1	Enable[3]	*[3]	*	*	*[1]	32767[3]	$7FFF_H$[3]	32767[2]	$7FFF_H$[2]
2	Disable[3]	*[3]	*	*	*[1]	32767[3]	$7FFF_H$[3]	32767[2]	$7FFF_H$[2]
3	*	*	Enable[3]	Enable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
4	*	*	Enable[3]	Disable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
5	*	*	Disable[3]	Disable[3]	*[3]	Valid	Valid	Undefined[3]	

* Parameter assignment not relevant

1 Diagnostics is suppressed in the event of a reference channel error.

2 Measured value taken from the reference channel

3 Channel with line break

Explanations of the cases:

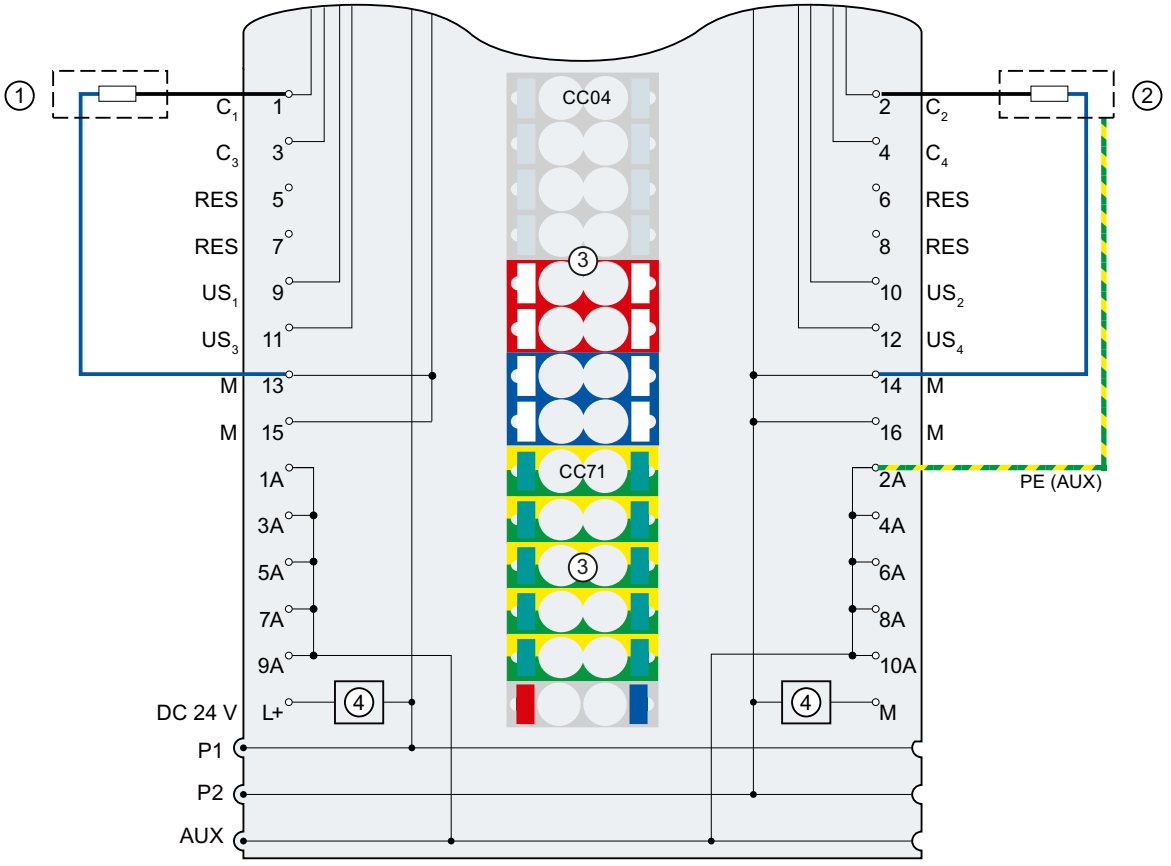
Case	Reference channel	TC channel
1	The "wire break" diagnostics is reported. This has a higher priority than the "Underflow" diagnostics.*	The "Reference channel error" diagnostics is reported if this is enabled. Where own pending diagnostic information ("overflow" or "underflow") is reported as outgoing. Wire break diagnostics is detected independently of the measured value and has the same priority as the "Reference channel error" diagnostics. Both items of diagnostic information can be pending simultaneously. The measured value of the reference channel (RTD channel) is adopted for the TC channel. The validity of the measured value of the TC channel is irrelevant.
2	No diagnostics reported. A wire break check is carried out (i.e. test current flows).*	*Behavior corresponds to case 1*.
3	*(Measured values are in the valid measuring range)*	The "wire break" diagnostics is reported.*
4	*(Measured values are in the valid measuring range)*	No diagnostics reported. A wire break check is carried out (i.e. test current flows).*
5	*(Measured values are in the valid measuring range)*	No "wire break" diagnostics is reported. No wire break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.*

* Channel with wire break

Communications module manuals

Communications module CM DP, Edition 12/2014
The communications module CM DP supports the PROFIsafe protocol V2.
Exception: Fail-safe modules that only support PROFIsafe V1 mode.

Communications module IO-Link Master CM 4xIO-Link, Edition 10/2017
Section "Connecting, Wiring and block diagram"
Connection: 2-wire and 3-wire connection in DQ operating mode:



①	2-wire connection	1 A ... 10 A	AUX terminals
②	3-wire connection	PE (AUX)	Protective conductor connection
③	Color-coded labels with color code CC04 and CC71 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to the left (dark-colored BaseUnit) Connection to the left interrupted (light-colored BaseUnit)
④	Supply voltage filter circuit (only when light-colored BaseUnit is present)	C_n	Communication signal, DI, DQ
24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)	RES	Reserved, must not be assigned
M	Ground	US_n	Supply voltage (positive)

Figure 14 Terminal assignment for 2-wire and 3-wire connection in DQ operating mode

Section "Replacement of the IO-Link Master CM 4xIO-Link communication module with an electronic coding element type H"
The "IO_LINK_MASTER" function block is now called "LIOLink_Master".

Using ET 200SP higher than 2 000 m above sea level.

Ambient temperature and installation altitude

Extension of the temperature range and the installation altitude

The previously permissible ambient temperature range of **0 °C** to 60 °C has been extended for a large number of modules to an ambient temperature range of **-30 °C** to 60 °C or **-25 °C** to 60 °C (in each case without condensation or icing). In addition, depending on the module, the permitted installation altitudes has been extended to installation heights of up to 5 000 meters.
The accessory components offered for ET 200SP (labeling strips, shield terminals, mounting rails, front connectors, etc.) can also be used down to -30 °C and for altitudes up to 5 000 m.
The following tables show an overview of the current climatic ambient conditions for ambient temperature and installation altitude of modules of the ET 200SP product family. For modules that are not listed, the current information in the "Technical specifications" section of the corresponding Equipment Manual applies.

Reference
You can find the current status of the respective modules in the technical specifications published online.
In general, the module-dependent extended climatic operating conditions are described in the "Technical specifications" section of the respective modules in the Equipment Manuals.
Constraints on operating ET 200SP at altitudes > 2 000 m are described in SIMATIC ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Shipping and storage conditions for modules
ET 200SP meets the requirements of IEC 61131-2 regarding transport and storage conditions. The following information applies to modules that are shipped and/or stored in their original packaging.

Type of condition	Permitted range
Air pressure	1140 to 540 hPa (corresponds to an altitude of -1 000 to 5 000 m above sea level)

Listing of the modules

CPUs

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
CPU	CPU 1510 SP-1 PN	6ES7510-1DJ01-0AB0	-25 to +60	FS 05	5 000
CPU	CPU 1512 SP-1 PN	6ES7512-1DK01-0AB0	-25 to +60	FS 05	5 000
CPU	CPU 1510 SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 03	5 000
CPU	CPU 1512 SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 03	5 000
CPU	CPU 1510 SP-1 PN	6ES7510-1DK03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1512 SP-1 PN	6ES7512-1DM03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP-2 PN	6ES7514-2DN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP T-2 PN	6ES7514-2VN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1510 SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1512 SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
CP	CP 1542SP-1	6GK7542-6UX00-0XE0	-30 to +60	FS 01	2 000
CP	CP 1542SP-1 IRC	6GK7542-6VX00-0XE0	-30 to +60	FS 01	2 000
CP	CP 1543SP-1	6GK7543-6WX00-0XE0	-30 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC, 32-bit	6ES7677-2AA31-0EB0	0 to +60	FS 07	2 000
Open Controller	CPU 1515SP PC F, 32-bit	6ES7677-2FA31-0EB0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC, WES7P	6ES7677-2AA41-0FB0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (128PT)	6ES7677-2AA41-0FK0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (512PT)	6ES7677-2AA41-0FL0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (2kPT)	6ES7677-2AA41-0FM0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC F, WES7P	6ES7677-2FA41-0FB0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (128PT)	6ES7677-2FA41-0FK0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (512PT)	6ES7677-2FA41-0FL0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (2kPT)	6ES7677-2FA41-0FM0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2	6ES7677-2DB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (128PT)	6ES7677-2DB42-0GK0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (512PT)	6ES7677-2DB42-0GL0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (2kPT)	6ES7677-2DB42-0GM0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F	6ES7677-2SB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (128PT)	6ES7677-2SB42-0GK0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (512PT)	6ES7677-2SB42-0GL0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (2kPT)	6ES7677-2SB42-0GM0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 (Ready4Linux)	6ES7677-2DB40-0GB0	-20 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2 F (Ready4Linux)	6ES7677-2SB40-0GB0	-20 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2 T	6ES7677-2VB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 T + HMI (128PT)	6ES7677-2VB42-0GK0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 T + HMI (512PT)	6ES7677-2VB42-0GL0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 T + HMI (2kPT)	6ES7677-2VB42-0GM0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF	6ES7677-2WB42-0GB0	-20 to +60	FS 04	2 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
Open Controller	CPU 1515SP PC2 TF + HMI (128PT)	6ES7677-2WB42-0GK0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF + HMI (512PT)	6ES7677-2WB42-0GL0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF + HMI (2kPT)	6ES7677-2WB42-0GM0	-20 to +60	FS 01	2 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.
Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand/continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Interface modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
IM	IM 155-6 PN BA	6ES7155-6AR00-0AN0	-30 to +60	FS 04	5 000
IM	IM 155-6 PN ST incl. BA 2xRJ45	6ES7155-6AA01-0BN0	0 to +60	FS 01	5 000
IM	IM 155-6 PN ST	6ES7155-6AU02-0BN0	-30 to +60	FS 01	5 000
IM	IM 155-6 PN/2 HF	6ES7155-6AU01-0CN0	-30 to +60	FS 02	5 000
IM	IM 155-6 PN/3 HF 3-port	6ES7155-6AU30-0CN0	-30 to +60	FS 02	5 000
IM	IM 155-6 MF HF	6ES7155-6MU01-0CN0	-30 to +60	FS 01	5 000
IM	IM 155-6 PN HS	6ES7155-6AU00-0DN0	-25 to +60	FS 02	5 000
IM	IM 155-6 DP HF - Bundle	6ES7155-6BA01-0CN0	0 to +60	FS 01	5 000
IM	IM 155-6 DP HF	6ES7155-6BU01-0CN0	0 to +60	FS 01	5 000
IM	Server module (spare part)	6ES7193-6PA00-0AA0	-30 to +60	FS 07	5 000
BA	BA 2x RJ45	6ES7193-6AR00-0AA0	-30 to +60	FS 06	5 000
BA	BA 2x FC	6ES7193-6AF00-0AA0	-30 to +60	FS 04	5 000
BA	BA 2x M12	6ES7193-6AM00-0AA0	-30 to +60	FS 01	5 000
BA	BA 2x LC	6ES7193-6AG00-0AA0	-30 to +60	FS 05	5 000
BA	BA LC/RJ45	6ES7193-6AG20-0AA0	-30 to +60	FS 04	5 000
BA	BA LC/FC	6ES7193-6AG40-0AA0	-30 to +60	FS 04	5 000
BA	BA 2x LC-LD	6ES7193-6AG50-0AA0	-30 to +60	FS 01	5 000
BA	BA LC-LD/RJ45	6ES7193-6AG60-0AA0	-30 to +60	FS 01	5 000
BA	BA LC-LD/M12	6ES7193-6AG70-0AA0	-30 to +60	FS 01	5 000
BA	BA 2x SCRJ	6ES7193-6AP00-0AA0	-25 to +60	FS 04	5 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BA	BA SCRJ/RJ45	6ES7193-6AP20-0AA0	-25 to +60	FS 04	5 000
BA	BA SCRJ/FC	6ES7193-6AP40-0AA0	-25 to +60	FS 04	5 000
BA	DP connector	6ES7972-0BB70-0XA0	-25 to +60	FS 03	2 000
BA	BA-SEND BA 1xFC	6ES7193-6AS00-0AA0	-30 to +60	FS 05	2 000

Digital input modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DI	DI 4x120...230VAC ST	6ES7131-6FD01-0BB1	-30 to +60	FS 02	2 000
DI	DI 8x24VDC BA	6ES7131-6BF01-0AA0	-30 to +60	FS 03	5 000
DI	DI 8x24VDC BA (PU* 10) [1]	6ES7131-6BF01-2AA0	-30 to +60	FS 03	5 000
DI	DI 8x24VDC SRC BA	6ES7131-6BF61-0AA0	-30 to +60	FS 02	5 000
DI	DI 8x24VAC/48VUC BA	6ES7131-6CF00-0AU0	-30 to +60	FS 02	4 000 (48VAC/48VDC)
DI	DI 8x24VDC ST	6ES7131-6BF01-0BA0	-30 to +60	FS 02	5 000
DI	DI 8x24VDC ST (PU* 10) [1]	6ES7131-6BF01-2BA0	-30 to +60	FS 02	5 000
DI	DI 8x24VDC HF	6ES7131-6BF00-0CA0	-30 to +60	FS 07	5 000
DI	DI 8x24VDC HF (PU* 10) [1]	6ES7131-6BF00-2CA0	-30 to +60	FS 07	5 000
DI	DI 8xNAMUR HF	6ES7131-6TF00-0CA0	-30 to +60	FS 04	5 000
DI	DI 8x24VDC HS	6ES7131-6BF00-0DA0	-30 to +60	FS 04	5 000
DI	DI 16x24VDC ST	6ES7131-6BH01-0BA0	-30 to +60	FS 02	5 000
DI	DI 16x24VDC ST (PU* 10) [1]	6ES7131-6BH01-2BA0	-30 to +60	FS 02	5 000
F-DI	F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	0 to +60	FS 04	4 000 [2]
F-DI	F-DI 8x24VDC HF	6ES7136-6BA01-0CA0	0 to +60	FS 01	4 000

[1] Packaging unit: Pack of 10

[2] As of revision FS 04

Digital output modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DQ	DQ 8x24VDC/0.5A BA	6ES7132-6BF01-0AA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A BA (PU* 10) [1]	6ES7132-6BF01-2AA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0,5A SNK BA	6ES7132-6BF61-0AA0	-25 to +60	FS 02	5 000
DQ	DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	-30 to +60	FS 08	5 000
DQ	DQ 4x24VDC/2A ST (PU* 10) [1]	6ES7132-6BD20-2BA0	-30 to +60	FS 08	5 000
DQ	DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	-30 to +60	FS 05	3 000 (277 VAC)
DQ	DQ 4x24...230VAC/2A ST (PU* 10) [1]	6ES7132-6FD00-2BB1	-30 to +60	FS 05	3 000 (277 VAC)
DQ	DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	-30 to +60	FS 06	5 000
DQ	DQ 4x24..230VAC/2A HF	6ES7132-6FD00-0CU0	-30 to +60	FS 04	3 000 (277 VAC)
DQ	DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	-30 to +60	FS 05	5 000
DQ	DQ 16x24VDC/0.5A BA	6ES7132-6BH00-0AA0	-30 to +60	FS 03	5 000
DQ	DQ 16x24VDC/0.5A BA (PU* 10) [1]	6ES7132-6BH00-2AA0	-30 to +60	FS 03	5 000
DQ	DQ 8x24VDC/0.5A ST	6ES7132-6BF01-0BA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A ST (PU* 10) [1]	6ES7132-6BF01-2BA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	-30 to +60	FS 07	5 000
DQ	DQ 8x24VDC/0.5A HF (PU* 10) [1]	6ES7132-6BF00-2CA0	-30 to +60	FS 07	5 000
DQ	DQ 16x24VDC/0.5A ST	6ES7132-6BH01-0BA0	-30 to +60	FS 03	5 000
DQ	DQ 16x24VDC/0.5A ST (PU* 10) [1]	6ES7132-6BH01-2BA0	-30 to +60	FS 03	5 000
F-DQ	F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	0 to +60	FS 04	4 000 [2]
F-DQ	F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	0 to +60	FS 01	4 000
RQ	RQ 4x24VUC/2A CO ST	6ES7132-6GD51-0BA0	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO ST	6ES7132-6HD01-0BB1	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO ST (PU* 10)	6ES7132-6HD01-2BB1	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO MA ST	6ES7132-6MD00-0BB1	-30 to +60	FS 03	2 000

1 Packaging unit: Pack of 10

2 As of revision FS 04

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
RQ	RQ 3x120VDC-230VAC/5A CO ST	6ES7132-6HC50-0BU0	-30 to +60	FS 01	2 000
RQ	RQ 3x120VDC-230VAC/5A CO n.i. ST	6ES7132-6HC70-0BU0	-30 to +60	FS 01	2 000
F-RQ	F-RQ 1x24VDC/24..230VAC/5A ST	6ES7136-6RA00-0BF0	0 to +60	FS 01	2 000

1 Packaging unit: Pack of 10

2 As of revision FS 04

Analog modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
AI	AI 2xI 2/4-wire ST	6ES7134-6GB00-0BA1	-30 to +60	FS 04	5 000
AI	AI 2xU ST	6ES7134-6FB00-0BA1	-30 to +60	FS 04	5 000
AI	AI 2xU/I 2/4-wire HF	6ES7134-6HB00-0CA1	-30 to +60	FS 06	5 000
AI	AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	-30 to +60	FS 07	5 000
AI	AI 2x SG 4-/6-wire HS	7MH4134-6LB00-0DA0	-25 to +60	FS 01	3 000
AI	AI 4xI 2-wire 4...20mA HART HF	6ES7134-6TD00-0CA1	-30 to +60	FS 01	5 000
AI	AI 4xI 2-/4-wire ST	6ES7134-6GD01-0BA1	-30 to +60	FS 02	5 000
AI	AI 4xI 2-/4-wire ST (PU* 10) [1]	6ES7134-6GD01-2BA1	-30 to +60	FS 02	5 000
AI	AI 4xU/I 2-wire ST	6ES7134-6HD01-0BA1	-30 to +60	FS 02	5 000
AI	AI 4xU/I 2-wire ST (PU* 10) [1]	6ES7134-6HD01-2BA1	-30 to +60	FS 02	5 000
AI	AI 8xI 2/4-wire BA	6ES7134-6GF00-0AA1	-30 to +60	FS 04	5 000
AI	AI 8xU BA	6ES7134-6FF00-0AA1	-30 to +60	FS 04	5 000
AI	AI 4xTC HS	6ES7134-6JD00-0DA1	-30 to +60	FS 02	5 000
AI	AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	-30 to +60	FS 08	5 000
AI	AI 4xRTD/TC 2-/3-/4-wire HF (PU* 10) [1]	6ES7134-6JD00-2CA1	-30 to +60	FS 08	5 000
AI	AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	-30 to +60	FS 05	5 000
AI	AI 8xRTD/TC 2-wire HF (PU* 10) [1]	6ES7134-6JF00-2CA1	-30 to +60	FS 05	5 000
AI	AI Energy Meter 400V ST	6ES7134-6PA01-0BD0	0 to +60	FS 01	3 000
AI	AI Energy Meter 480V ST	6ES7134-6PA20-0BD0	0 to +60	FS 01	3 000
AI	AI Energy Meter HF CT	6ES7134-6PA00-0CU0	-30 to +60	FS 01	2 000 [2]
AI	AI Energy Meter HF RC	6ES7134-6PA20-0CU0	-30 to +60	FS 01	2 000 [2]
F-AI	F-AI 4XI (0)4..20mA HF	6ES7136-6AA00-0CA1	0 to +60	FS 01	4 000
F-AI	F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	0 to +60	FS 01	4 000

1 Packaging unit: Pack of 10

2 Installation altitude higher than 2 000 m on request

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
AQ	AQ 2xI ST	6ES7135-6GB00-0BA1	-30 to +60	FS 03	5 000
AQ	AQ 2xU ST	6ES7135-6FB00-0BA1	-30 to +60	FS 03	5 000
AQ	AQ 2xU/I HF	6ES7135-6HB00-0CA1	-30 to +60	FS 04	5 000
AQ	AQ 2xU/I HS	6ES7135-6HB00-0DA1	-30 to +60	FS 06	5 000
AQ	AQ 4xU/I ST	6ES7135-6HD00-0BA1	-30 to +60	FS 07	5 000
AQ	AQ 4xI HART HF	6ES7135-6TD00-0CA1	-30 to +60	FS 01	5 000

1 Packaging unit: Pack of 10

2 Installation altitude higher than 2 000 m on request

Technology modules and communication modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
TM	TM Count 1x24V	6ES7138-6AA01-0BA0	-30 to +60	FS 03	5 000
TM	TM Count 1x24V (PU* 10) [1]	6ES7138-6AA01-2BA0	-30 to +60	FS 03	5 000
TM	TM PosInput 1	6ES7138-6BA01-0BA0	-30 to +60	FS 03	5 000
TM	TM PosInput 1 (PU* 10) [1]	6ES7138-6BA01-2BA0	-30 to +60	FS 03	5 000
TM	TM Timer DIQ 10x24V	6ES7138-6CG00-0BA0	-30 to +60	FS 03	5 000
TM	TM Pulse 2x24V	6ES7138-6DB00-0BB1	-30 to +60	FS 03	5 000
TM	TM PTO 2x24V	6ES7138-6EB00-0BA0	-30 to +60	FS 00	5 000
TM	TM WP321 1x5VDC#1-4mV/V ST	7MH4138-6AA00-0BA0	-25 to +60	FS 04	5 000
TM	TM WP351 HF	7MH4138-6BA00-0CU0	-30 to +60	FS 01	5 000
TM	TM ECC PL ST	6FE1242-6TM20-0BB1	-30 to +60	FS 00	2 000
TM	TM ECC 2xPWM ST	6FE1242-6TM10-0BB1	-30 to +60	FS 00	2 000
TM	Pneumatic valve island Air-line SP 8647	Bürkert	0 to +55	-	2 000
TM	TM StepDrive 1x24..48V/5A*	phytron 10020273	0 to +60	-	2 000
TM	TM SITRANS FCT070	7ME4138-6AA00-0BB1	-30 to +60	FS 00	2 000
F-TM	F-TM ServoDrive 1x24..48V 5A ST	6BK1136-6AB00-0BU0	-30 to +60	FS 00	3 000
CM	CM PtP	6ES7137-6AA00-0BA0	-30 to +60	FS 03	5 000
CM	CM 1xDALI	6ES7137-6CA00-0BU0	-30 to +60	FS 03	3 000
CM	CM 4xIO-Link	6ES7137-6BD00-0BA0	-30 to +60	FS 03	2 000
CM	CM DP (für CPU)	6ES7545-5DA00-0AB0	-25 to +60	FS 04	5 000
CM	CM AS-I MASTER ST (AS-I V3.0)	3RK7137-6SA00-0BC1	-25 to +60	FS 20	2 000

1 Packaging unit: Pack of 10

2 As of revision FS 05

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
CM	CM CAN	6ES7137-6EA00-0BA0	-30 to +60	FS 03	5 000
F-CM	F-CM AS-I SAFETY ST	3RK7136-6SC00-0BC1	0 to +60	FS 01	2 000
F-PM-E	F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	0 to +60	FS 05	4 000 [2]

[1] Packaging unit: Pack of 10

[2] As of revision FS 05

Information on PFDavg, PFH values for ET 200SP fail-safe I/O modules

The safety parameters specified in the Equipment Manual of the fail-safe I/O module ET 200SP (PFD_{avg}, PFH values) already reflect the influence of higher cosmic radiation (soft error rate) for operation up to 4 000 m above sea level.

Motor starters and BaseUnits BU type P0

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
MS	DS 0.1 - 0.4A HF	3RK1308-0AA00-0CP0	-25 to +60	FS 01	4 000
MS	DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0	-25 to +60	FS 01	4 000
MS	DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0	-25 to +60	FS 01	4 000
MS	DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0	-25 to +60	FS 01	4 000
MS	DS 4.0 - 12 A HF	3RK1308-0AE00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.1 - 0.4A HF	3RK1308-0BA00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.3 - 1 A HF	3RK1308-0BB00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.9 - 3 A HF	3RK1308-0BC00-0CP0	-25 to +60	FS 01	4 000
MS	RS 2.8 - 9 A HF	3RK1308-0BD00-0CP0	-25 to +60	FS 01	4 000
MS	RS 4.0 - 12 A HF	3RK1308-0BE00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.1 - 0.4A HF	3RK1308-0CA00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 4.0 - 12 A HF	3RK1308-0CE00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.1 - 0.4A HF	3RK1308-0DA00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 4.0 - 12 A HF	3RK1308-0DE00-0CP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS1	3RK1908-0AP00-0AP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS3	3RK1908-0AP00-0BP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS2	3RK1908-0AP00-0CP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS4	3RK1908-0AP00-0DP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS5	3RK1908-0AP00-0EP0	-25 to +60	FS 01	2 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type P0	BU30-MS6	3RK1908-0AP00-0FP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS7	3RK1908-0AP00-0GP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS8	3RK1908-0AP00-0HP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS9	3RK1908-0AP00-0JP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS10	3RK1908-0AP00-0KP0	-25 to +60	FS 01	2 000

BaseUnits BU type A0 and A1

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type A0	BU15-P16+A0+2B	6ES7193-6BP00-0BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A0+2B (PU* 10) [1]	6ES7193-6BP00-2BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A0+2D	6ES7193-6BP00-0DA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A0+2D (PU* 10) [1]	6ES7193-6BP00-2DA0	-30 to +60	FS 06	5 000
BU type A0	BU15 double BU+2B	6ES7193-6BP60-0BA0	-30 to +60	FS 03	5 000
BU type A0	BU15 double BU+2DB	6ES7193-6BP60-0DA0	-30 to +60	FS 03	5 000
BU type A0	BU15-P16+A10+2B	6ES7193-6BP20-0BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A10+2B (PU* 10) [1]	6ES7193-6BP20-2BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A10+2D	6ES7193-6BP20-0DA0	-30 to +60	FS 07	5 000
BU type A0	BU15-P16+A10+2D (PU* 10) [1]	6ES7193-6BP20-2DA0	-30 to +60	FS 07	5 000
BU type A1	BU15-P16+A0+2B/T	6ES7193-6BP00-0BA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+2D/T	6ES7193-6BP00-0DA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+12B/T	6ES7193-6BP40-0BA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+12D/T	6ES7193-6BP40-0DA1	-30 to +60	FS 07	5 000

[1] Packaging unit: Pack of 10

BaseUnits BU type B0 bis U0

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type B0	BU20-P12+A4+0B	6ES7193-6BP20-0BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B0	BU20-P12+A4+0B (PU* 10) [1]	6ES7193-6BP20-2BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B1	BU20-P12+A0+4B	6ES7193-6BP20-0BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B1	BU20-P12+A0+4B (PU* 10) [1]	6ES7193-6BP20-2BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type C0	BU20-P6+A2+4D	6ES7193-6BP20-0DC0	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU type C1	BU20-P6+A2+4B	6ES7193-6BP20-0BC1	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU type D0	BU20-P12+A0+0B	6ES7193-6BP00-0BD0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type E0	BaseUnit BU-SEND	6ES7193-6BN00-0NE0	-30 to +60	FS 04	2 000
BU type F0	BU20-P8+A4+0B	6ES7193-6BP20-0BF0	-30 to +60	FS 04	2 000
BU type U0	BU20-P16+A0+2B	6ES7193-6BP00-0BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)

[1] Packaging unit: Pack of 10

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type U0	BU20-P16+A0+2B (PU* 10) [1]	6ES7193-6BP00-2BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type U0	BU20-P16+A0+2D	6ES7193-6BP00-0DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type U0	BU20-P16+A0+2D (PU* 10) [1]	6ES7193-6BP00-2DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)

[1] Packaging unit: Pack of 10

Potential distributor

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
PotDis	PotDis-BU-P1/D-R	6ES7193-6UP00-0DP1	-30 to +60	FS 04	5 000
PotDis	PotDis-BU-P1/B-R	6ES7193-6UP00-0BP1	-30 to +60	FS 04	5 000
PotDis	PotDis-BU-P2/D-B	6ES7193-6UP00-0DP2	-30 to +60	FS 04	5 000
PotDis	PotDis-BU-P2/B-B	6ES7193-6UP00-0BP2	-30 to +60	FS 04	5 000
PotDis	PotDis TB P1-R	6ES7193-6TP00-0TP1	-30 to +60	FS 03	5 000
PotDis	PotDis TB P2-B	6ES7193-6TP00-0TP2	-30 to +60	FS 03	5 000
PotDis	PotDis TB BR-W	6ES7193-6TP00-0TP0	-30 to +60	FS 03	5 000
PotDis	PotDis TB n.c.-G	6ES7193-6TP00-0TN0	-30 to +60	FS 03	5 000
BU cover	BU cover - 15 mm (PU* 5) [1]	6ES7133-6CV15-1AM0	-40 to +60	FS 01	5 000
BU cover	BU cover - 20 mm (PU* 5) [1]	6ES7133-6CV20-1AM0	-40 to +60	FS 01	5 000

[1] Packaging unit: Pack of 5

Restrictions

Restrictions of the max. ambient temperature specified with regard to the installation altitude

Installation altitude	Derating factor for ambient temperature [1]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 m	0.7

[1] Base value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. This is based on the IEC 61131-2 standard.
- Make sure that the power supplies you use are also rated for altitudes > 2 000 m.
- The "Safety-related shutdown of standard modules" function, as described in the Internet (https://support.industry.siemens.com/cs/ww/en/view/39198632), is only approved up to a maximum of 2 000 m.

Effects on availability

The higher cosmic radiation present during operation at altitudes over 2 000 m above sea level also starts to have an effect on the error rate of electronic components (referred to as the soft error rate). In rare cases, this can result in a transition of the module into the safe state, especially for Safety Modules. However, the functional safety of the module is fully retained.

NOTE

Information printed on the ET 200SP automation system components

The markings and approvals printed on the components of the ET 200SP automation system are currently based on operation at an altitude of up to 2 000 m above sea level. The fail-safe modules are certified for operation in safety mode up to the maximum altitudes indicated in the tables (As certified by the German Technical Inspectorate (https://support.industry.siemens.com/cs/us/en/view/109825198)).

SIEMENS
SIMATIC

Distributed I/O system ET 200SP

Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function
SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity

- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=5596).
- You can find the EU Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18161/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18161/cert?ct=444&ci=5596).

Firmware
You will find the latest firmware versions (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109804718).

Documentation
The complete documentation consists of product information, the system manual, equipment and function manuals. You can find these in the Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/84133942) on the Internet.

Retention of the documentation
Retain this documentation for later use.

1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) and on the nameplate of the device.

NOTE
The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Only install products with IP20 degree of protection according to IEC 60529 in enclosures, cabinets, or electrical equipment rooms suitable for the end use that meet at least this degree of protection.

⚠ WARNING

Electric shock due to externally supplied plant units
Even if the main supply to the plant is disconnected, externally supplied plant units can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.
Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Electric shock due to permissible electric potential difference

Due to the permissible electric potential difference, a dangerous voltage may be present at the inputs of modules. An electric shock on contact with live parts can lead to death or serious injury.

Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Safety functional extra low voltage

The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) of the fail-safe I/O and in the data sheets of the power supplies to be used.

Use a power supply unit with output voltage that does not exceed 36 V DC even in the event of a fault.

Observe the maximum permissible switching conditions specified in the equipment manual for F-RQ modules.

Follow the notes and warnings in the respective equipment manual.

⚠ CAUTION

BusAdapters for fiber-optic cables contain a laser system and are classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid eye contact with the laser beam. Do not open the housing. Read the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

⚠ WARNING

Personal injury due to uncontrolled movement

When using Motion Control, uncontrolled movements can occur which result in personal injury of unknown extent.

Follow the safety instructions described in the Motion Control function manuals (https://support.industry.siemens.com/cs/ww/en/view/84133942).

Electromagnetic Compatibility

The product is intended for operation in the Industrial EMC environment class.

Ensure that your automation system is installed in compliance with EMC requirements, as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) for the product.

NOTICE

Interference emission / Interference immunity

Operation of the product can cause radio interference in residential areas.

If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

ATEX-/UKEX device intended for use in hazardous area
If the product is intended for use in a potentially explosive atmosphere (gas/air or gas/dust mixture), observe the special information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942). The intended use (e.g. ATEX zone, degree of protection, temperature class) is indicated on the product (in the declaration of conformity and usually also on the nameplate).

NOTE
As a rule, country-specific requirements for the operator also apply when a product is used in a potentially explosive atmosphere (e.g. Directive 1999/92/EC for the EU).

Safety in potentially hazardous atmospheres
SIMATIC systems are suitable for use in zones with occasional presence of hazardous gas atmospheres (equipment group II, Cat. 3, gases, vapors, mists). You can find information, restrictions and special conditions in the respective system manuals. To avoid damage, determine a suitable installation location and select suitable products. It is mandatory to define the following points before planning your automation system:

- Hazardous plant areas
- Potentially existing atmosphere
- Relevant requirements for the products

⚠ WARNING
Explosion hazard
If work in areas with potentially hazardous atmospheres is not carried out correctly, an explosion may occur. Explosions can lead to serious personal injury or damage to the plant.
Only suitably qualified specialists are allowed to plan and perform activities in areas with potentially hazardous atmospheres. In hazardous areas, always de-energize the SIMATIC system before starting activities.

Cleaning
If you need to clean the product, use dry ESD cleaning cloths (observing the protective measures for ESD).
Requirement: All supply voltages present on the device are switched off. Observe the five safety rules for working in and on electrical installations.

Maintenance and repair
The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal
For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

Functional safety

⚠ WARNING
Danger to humans and the environment
To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components.

For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether it is approved for the respective device.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

SIEMENS

SIMATIC

ET 200SP
Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)

Equipment Manual

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Introduction

1

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. You can find functions that generally relate to the ET 200SP system in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Important note for maintaining the operational safety of your plant

NOTE

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log onto Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

1.1 ET 200SP documentation guide

1.1.1 Information classes ET 200SP



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)
     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:
     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity

2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

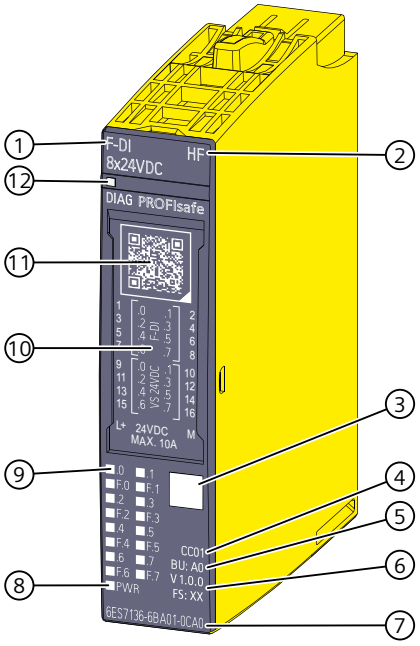
3

3.1 Properties

Article number

6ES7136-6BA01-0CA0

View of the module



① Module type and name
② Function class
③ Color coding module type
④ Color code for selecting the color-coded labels
⑤ BU type
⑥ Firmware and function version
⑦ Article number
⑧ LED for supply voltage
⑨ LEDs for channel status
⑩ Wiring diagram
⑪ QR code for identification link
⑫ LED for diagnostics

Figure 1-178 View of the F-DI 8×24VDC HF module

Properties

The module has the following technical properties:

- Fail-safe digital module
- PROFIsafe
- RIOforFA-Safety
- PROFIsafe address type 2
- 8 inputs (SIL3/Cat.3/PLd) or 4 inputs (SIL3/Cat.4/PLe)
- 8 outputs for sensor supply
- Use of various interconnection types (1oo1, 1oo2) is possible
- Suitable for the connection of 3-wire/4-wire sensors according to IEC 61131, Type 1
- Channel-specific assignable input delay 0.4 ms to 20 ms
- Internal short-circuit proof sensor supplies for each input
- External sensor supply possible
- Supply voltage L+
- Sink input (P-reading)
- Safety mat evaluation (firmware version V2.0.0 or higher)
- Suitable for the connection of 4-wire safety mats and pressure-sensitive protective devices (NO contact operating principle) according to ISO 13856-1, -2, -3
- Fail-safe counter (firmware version V3.0.0 or higher)
- Fail-safe standstill and overspeed monitoring (firmware version V3.0.0 or higher)
- Diagnostic display (DIAG red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g., load voltage missing, module-specific
- Channel-based or module-based passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data

⚠ WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

⚠ WARNING

The safety parameters in the technical data apply for a mission time of 20 years and a repair time of 100 hours. If repair is not possible within 100 hours, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours have elapsed. Proceed for the repair as described in the section Diagnostic messages.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as replacement part (part number 6ES7193-6EF00-1AA0)

For more information on accessories, refer to the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2 Operating modes

The digital input module F-DI 8x24VDC HF can be operated in the following operating modes:

- "Digital inputs (Page 17)"operating mode
- "Counter (Page 53)" operating mode
- "Standstill and overspeed monitoring (Page 82)" operating mode

Digital inputs operating mode

4

4.1 Wiring

4.1.1 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode

Table 1-436 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

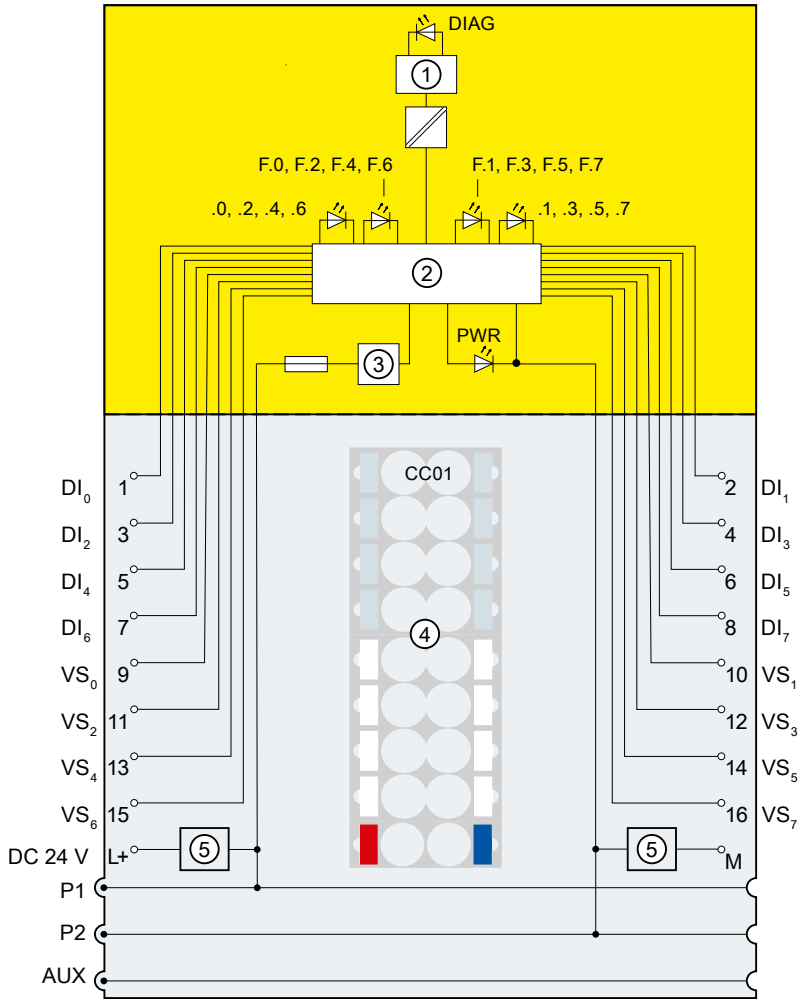
4.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 1-179 Block diagram

4.2 Parameters/address space

"Digital inputs" operating mode is only effective if the operating mode selection is configured as "Digital inputs".

Parameters for the "Digital Inputs" operating mode

⚠ WARNING

You must enable or disable the diagnostic functions in accordance with the application; see section Application cases for inputs (Page 32).

The following parameters are possible:

Table 1-437 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters:				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	• Passivate the entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module
DI parameters:				
Sensor supply				
Sensor supply n				
Short-circuit test	• Disable • Enable	Enable	No	Channel
Time for short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Startup time of sensor after short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Channel parameters				
Channel n, n+4				
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent • Safety mat evaluation	1oo2 evaluation, equivalent	No	Channel pair
Discrepancy behavior	• Supply value 0 • Supply last valid value	Supply value 0	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	No	Channel pair
Channel n				
Activated	• Enable • Disable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Sensor supply	• Sensor supply 0 to 7 • External sensor supply	Sensor supply n	No	Channel

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	3.2 ms	No	Channel
Chatter monitoring	• Disable • Enable	Disable	No	Channel
Number of signal changes	2 to 31	5	No	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	2 s	No	Channel

4.2.1 Explanation of parameters

4.2.1.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- "Counter"
- "Standstill and Overspeed monitoring"

4.2.1.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use on S7-1200/1500 F-CPUs
When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.1.3 Parameters of the sensor supply

Short-circuit test

Here you activate the short-circuit detection for the channels of the F-module for which an internal sensor supply is set.

The short-circuit test can always be performed when you use simple switches which do not have an own power supply. For switches with an own power supply, e.g. 3-/4-wire proximity switches or optical sensors with OSSD outputs (Output Signal Switching Device), you have to adjust the parameter "Startup time of sensor after short-circuit test" depending on the sensor used.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for short-circuit test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input with another channel, if this has a 1-signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

NOTE

During the execution time (Time for short-circuit test + Startup time of sensor after short-circuit test) of the short-circuit test, the last valid value of the input before the start of the short-circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

NOTE

Safety mat evaluation
If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Time for short-circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

Note the following during parameter assignment:

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for short-circuit test" parameter.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Safety mat evaluation
If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Startup time of sensor after short-circuit test

Function

Apart from the switch-off time ("Time for short-circuit test"), a startup time must also be specified for the execution of the short-circuit test. With this parameter you inform the module how long the used sensor requires for the startup after the sensor supply is switched on. This way you avoid an undefined input status due to transient responses in the sensor.

Note the following during parameter assignment:

- This parameter must be larger than the settling time of the sensor used.
- Since the parameterized time affects the response time of the module, we recommend setting this time as short as possible but large enough so that the sensor has stabilized.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Dependencies between the parameters "Startup time of sensor after short-circuit test" and "Time for short-circuit test"
The startup time of the sensor after the short-circuit test must amount to at least 1 % of the time for the short-circuit test.

NOTE

Safety mat evaluation
If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

4.2.1.4 Parameters of the channel pairs

Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo1 evaluation
- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent
- Safety mat evaluation

1oo1 evaluation

The sensor uses only one input channel for the 1oo1 evaluation.

1oo2 evaluation, equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One two-channel sensor
- Two one-channel sensors
- One non-equivalent sensor

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two one-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Safety mat evaluation

With safety mat evaluation, two input channels and two internal sensor supplies are occupied by a 4-wire safety mat (NO contact operating principle). If necessary, you can also connect several 4-wire safety mats connected in series.

Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to short response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown. In the worst possible case, the sensor-actuator response time is extended by the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

NOTE

Dependencies between the parameters "Discrepancy time" und "Input delay"
The discrepancy time must be parameterized greater than the input delay.

Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-Signal necessary"
- "Test 0-Signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Test 0-Signal necessary"

If you have assigned "Test 0-Signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non-equivalent", the result of the channel pair must be "0" again.

"Test 0-Signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.1.5 Parameters of the channels

Activated

You hereby enable the corresponding channel for signal processing in the safety program.

Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module is operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Sensor supply

You can select one of the internal sensor supplies VS_0 to VS_7 or an external sensor supply.

The selection of an internal sensor supply is required for using the short-circuit test.

With safety mat evaluation, the internal sensor supplies are assigned to the channel pair. For additional information, see the section Safety mat evaluation application (from firmware version V2.0.0) (Page 49).

⚠ WARNING

Sensor supply with safety mat evaluation
With safety mat evaluation, the internal sensor supply assigned to the respective channel must be used. The internal sensor supply must not be used for any other channel. The use of a different internal sensor supply or an external sensor supply is prohibited.

See also

Time for short-circuit test (Page 23)

Input delay

Function

To suppress injected interference, you can set an input delay for a channel or a channel pair.

Interference pulses whose pulse time is less than the set input delay are suppressed. Suppressed interference pulse are not visible in the safety program.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The set value for the input delay has to be smaller than the configured "Startup time of sensor after short-circuit test" and smaller than the configured "Time for short-circuit test".

With 1oo2 evaluation, the input delay of the lower-order channel (channel n) automatically applies to the higher-order channel (channel n+4).

NOTE

Input delay with Safety mat evaluation
If the Safety mat evaluation is set, you must configure an input delay of 1.6 ms.

NOTE

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)).
Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Response times (Page 123)
Technical specifications (Page 119)

Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

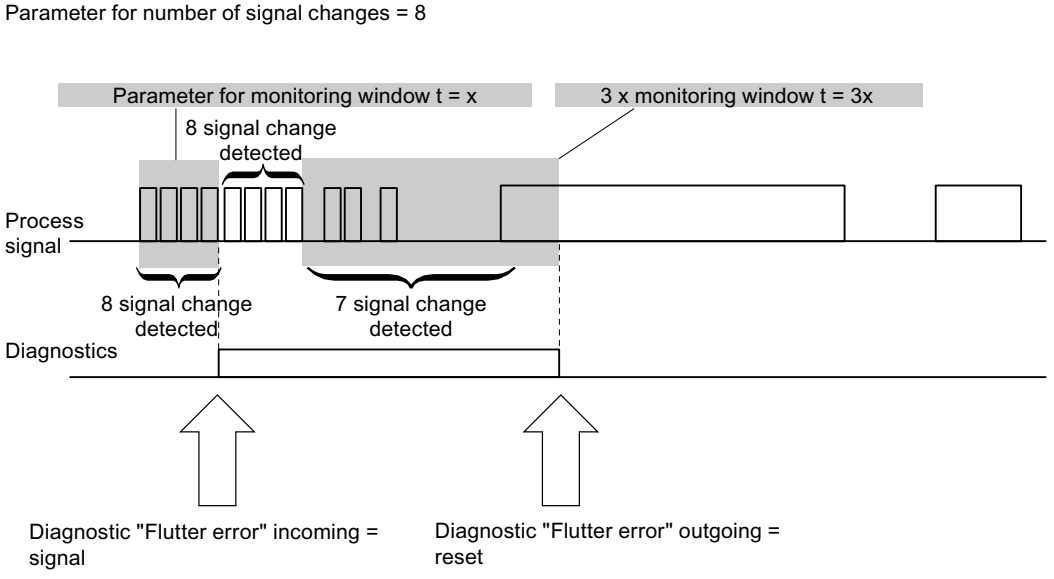


Figure 1-180 Figure chatter monitoring

Number of signal changes

Defines the number of signal changes after whose sequence a chatter error is to be reported.

Monitoring window

Sets the time for the monitoring window of chatter monitoring.
You can set times of 1 s to 100 s in whole seconds for the monitoring window.
If you parameterize 0 s, the monitoring window is 0.5 s long.

4.2.2 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 1-438 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
F-CPUs S7-300/400	IB x + 0 to x + 5	QB x + 0 to x + 3
F-CPUs S7-1200/1500	IB x + 0 to x + 6	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 1-439 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
IB x + 1	Value status for DI_7	Value status for DI_6	Value status for DI_5	Value status for DI_4	Value status for DI_3	Value status for DI_2	Value status for DI_1	Value status for DI_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.
With safety mat evaluation and 1oo2 evaluation of the sensors, the two channels are combined, for example, DI_0 and DI_4. With safety mat evaluation and 1oo2 evaluation of the sensors, you may only access the low order channel in the safety program, for example, DI_0.

More information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

4.3 Applications for inputs

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

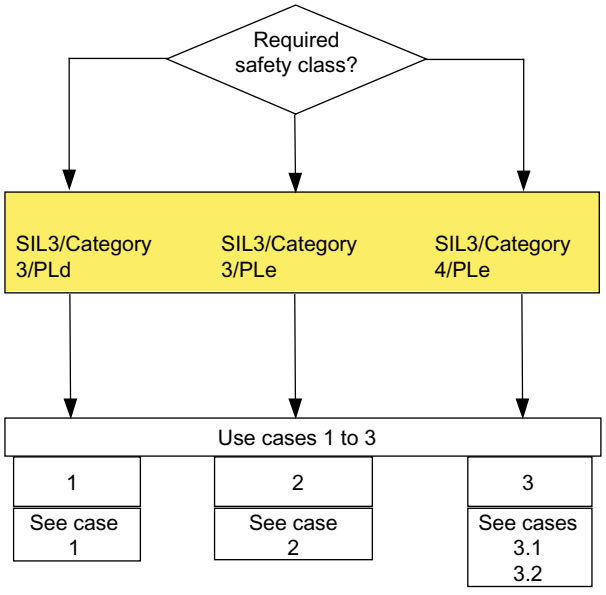


Figure 1-181 Selecting the application – digital input module F-DI 8×24VDC HF

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 1-440 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Internal, with short-circuit test	3 / 3 / d
		Internal, without short-circuit test	
		External	
2	1oo2 equivalent	Internal, without short-circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short-circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	Internal, with short-circuit test	
		Internal, without short-circuit test	
		External	

NOTE

With a module you can realize the applications listed in Table 5-1 simultaneously on different inputs. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-oriented use of sensors can be found in the section Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters in the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

4.3.1 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram – connecting one sensor via one channel

Per process signal, one sensor is connected via one channel (1oo1 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

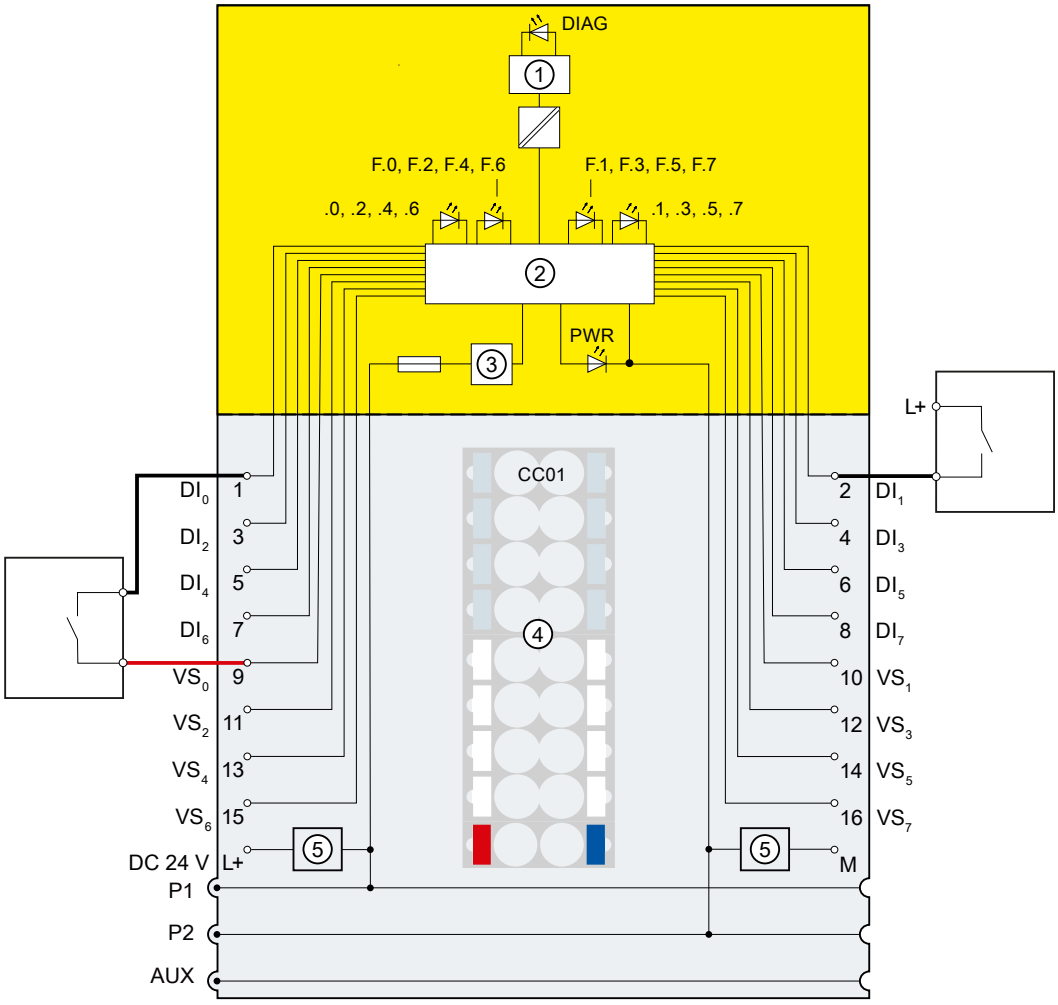


Figure 1-182 One sensor connected via one channel, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

WARNING

To achieve SIL3/Cat.3/PLd with this wiring, you have to route the cables cross-circuit proof and apply the positive opening operation principle for the sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-441 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-442 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit of the input with other channels or other sensor supplies (short-circuit with other channels is detected only if they use a different sensor supply)	Yes*	No	No
Short-circuit of the input with the associated sensor supply	No	No	No
Short-circuit with L+ to DI_n	Yes	No	No
Short-circuit with M to DI_n	Yes*	Yes*	No
Discrepancy error	—	—	—
Short-circuit with L+ to VS_n	Yes	No	—
Short-circuit with M to VS_n or defective	Yes	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.2 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

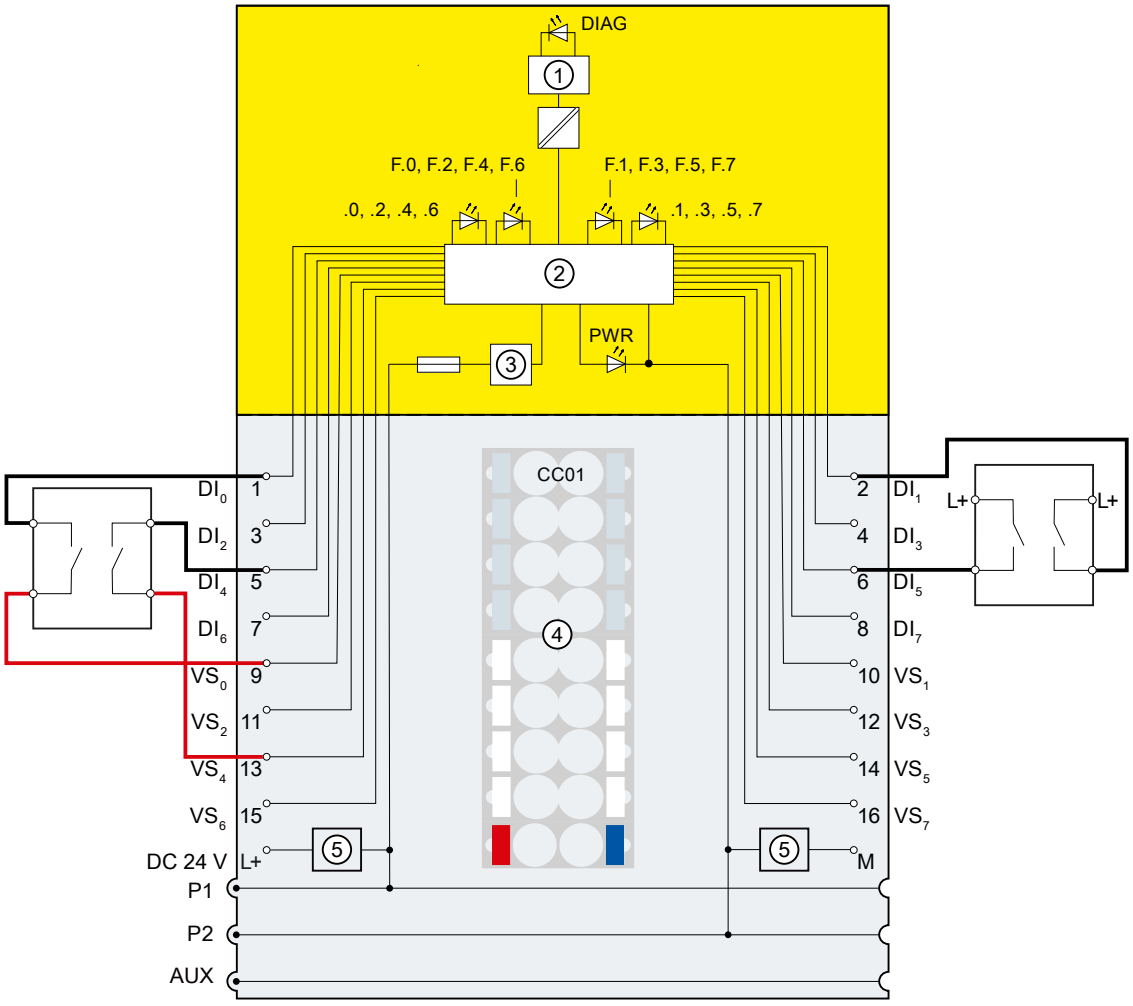


Figure 1-183 A two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

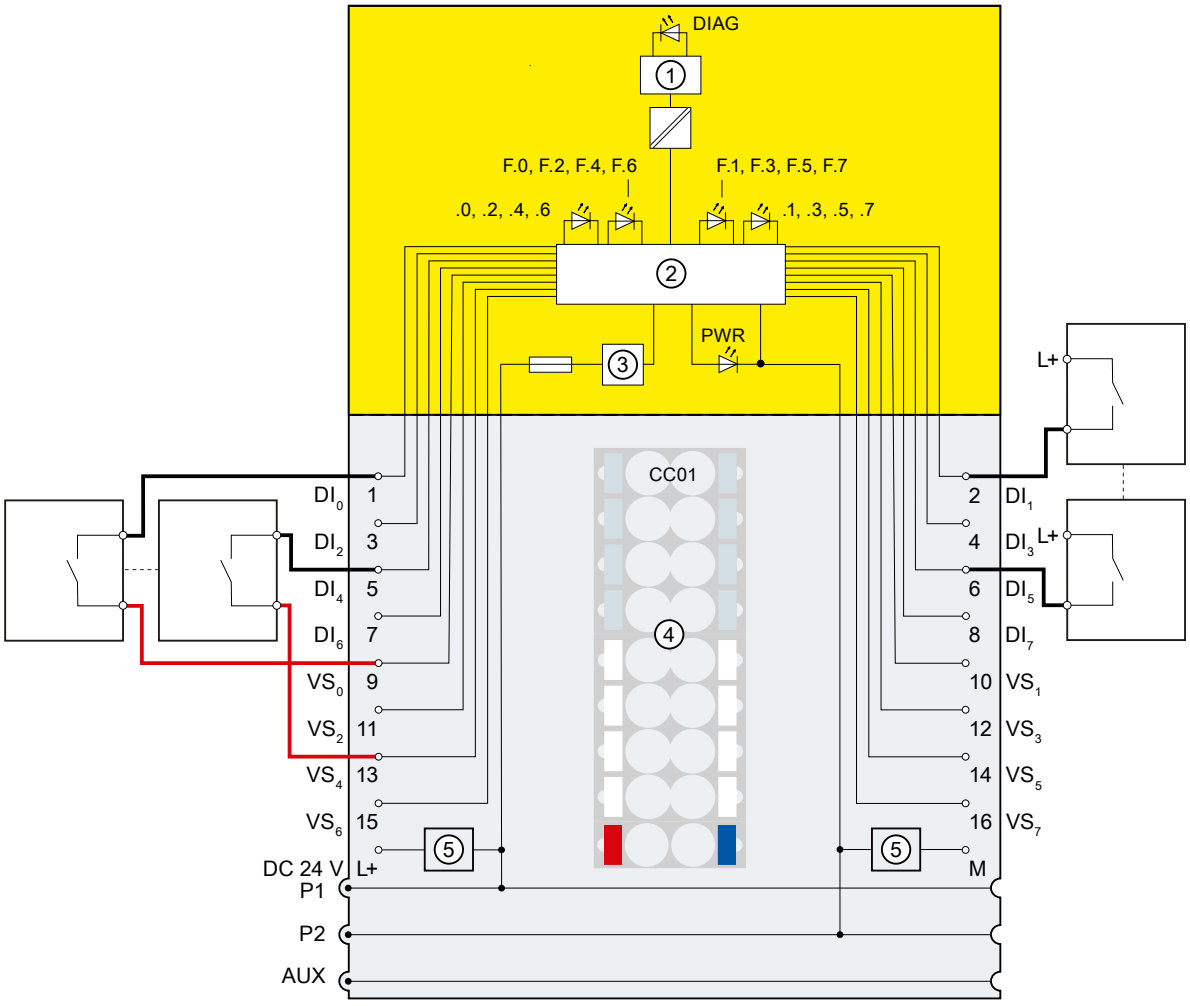


Figure 1-184 Two one-channel sensors connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-443 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-444 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	No	No
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	No	—
Short-circuit with M to VS_n or defective	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 with DI_4
- DI_1 with DI_5
- DI_2 with DI_6
- DI_3 with DI_7

The process signals are provided by channels DI_0,DI_1,DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

For application 3.1, the sensor supply must be set up for at least one channel internally with activated short-circuit test.

The sensor can be supplied internally or externally for application 3.2.

Requirements for applications in machinery protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short-circuits.
- The actuators must be wired as seen in sections Application 3.1: Safety mode SIL3/Cat.4/PLe (Page 43) or Application 3.2: Safety mode SIL3/Cat.4/PLe (Page 46). You only need to detect **one** short-circuit because two faults are required to generate it. This means both signal cables in short-circuit have an isolation fault. A multiple short-circuit analysis is not required.

Procedures for locating all short-circuits are also permitted if single short-circuits are not located. One of the two conditions must be met for this purpose:

- Short-circuits may not corrupt the read signals compared to the sensor signals.
- Short-circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

4.3.3.1 Application 3.1: Safety mode SIL3/Cat.4/PLe

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensor from two different internal sensor supplies or from an internal and an external sensor supply.

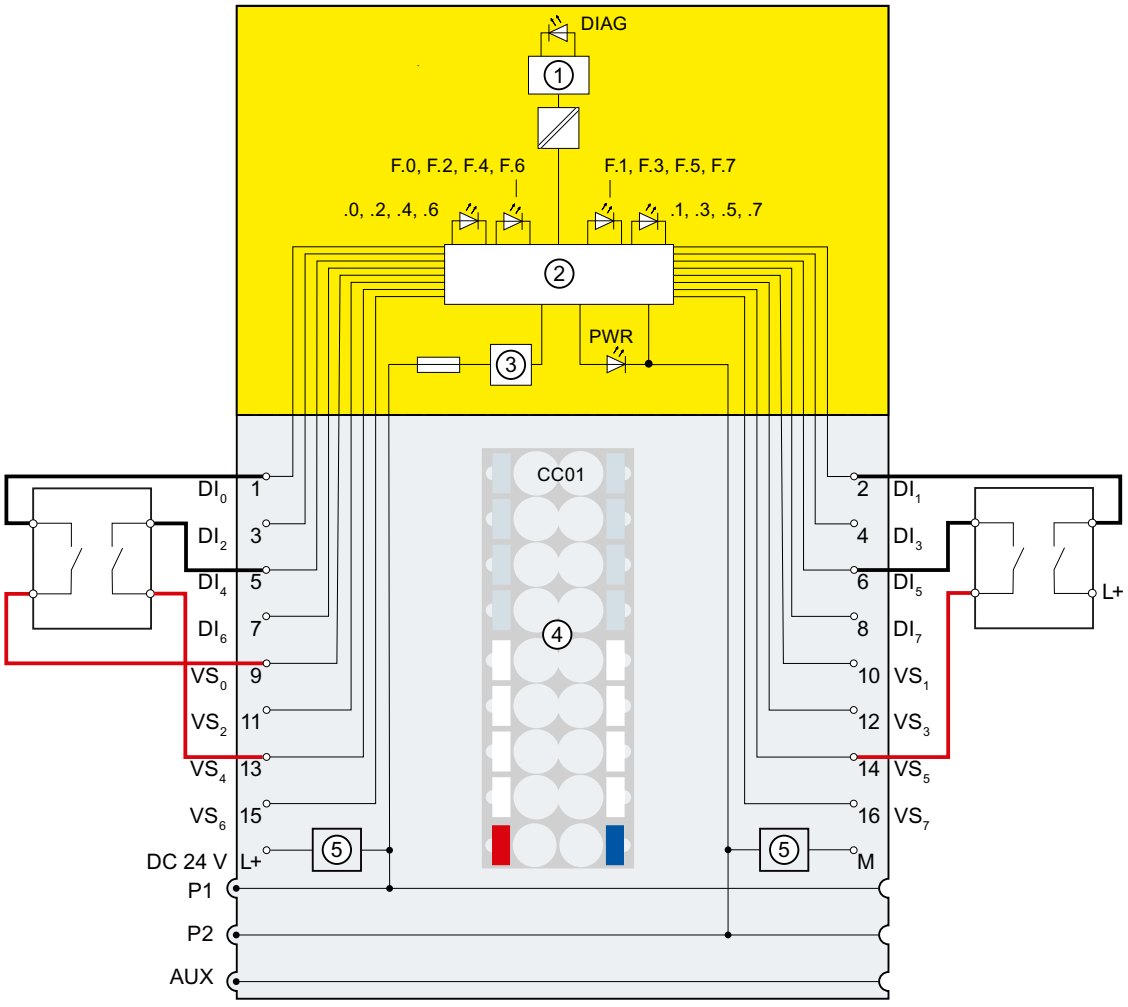


Figure 1-185 A two-channel sensor connected via two channels, internal sensor supply and a two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensors from two different internal sensor supplies or from an internal and an external sensor supply.

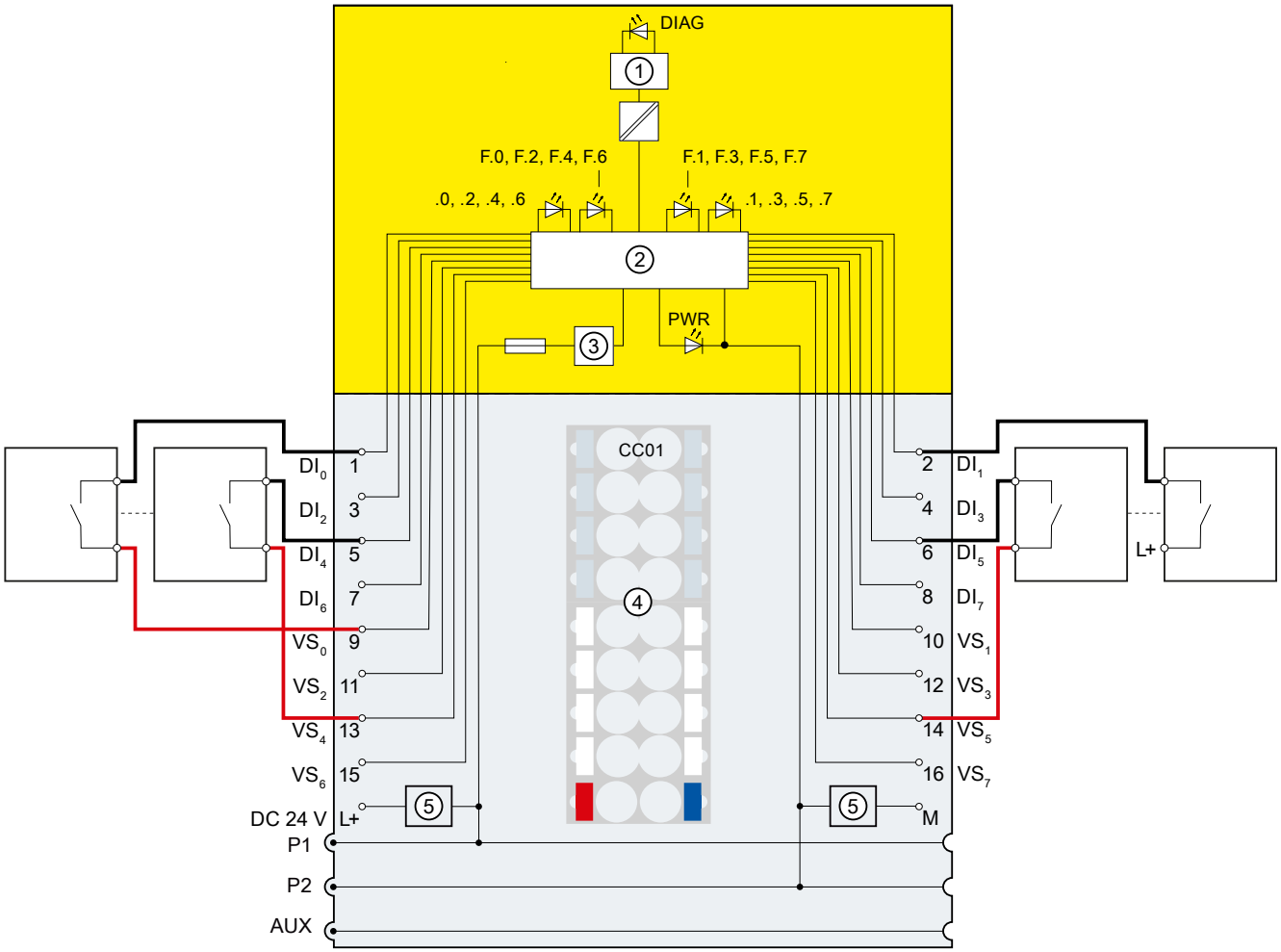


Figure 1-186 Two one-channel sensors connected via two channels, internal sensor supply and two one-channel sensors connected via two channels, internal and external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-445 Parameter assignment

Parameter	Channel with internal sensor supply*	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply**
Short-circuit test	Enable*	Disable

*) The sensor supply must be set up for at least one channel internally with activated short-circuit test.

**) Otherwise a diagnostic message is generated for an activated short-circuit test.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-446 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test activated	External sensor supply
Short-circuit within the channel pair	Yes*	Yes*
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	Yes	-
Short-circuit with M to VS_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3.2 Application 3.2: Safety mode SIL3/Cat.4/PLe

Wiring diagram – connecting a non-equivalent sensor

Per process signal, a non-equivalent sensor is connected to two inputs of the F-module (1oo2 evaluation).

You can supply the sensor via an internal or external sensor supply.

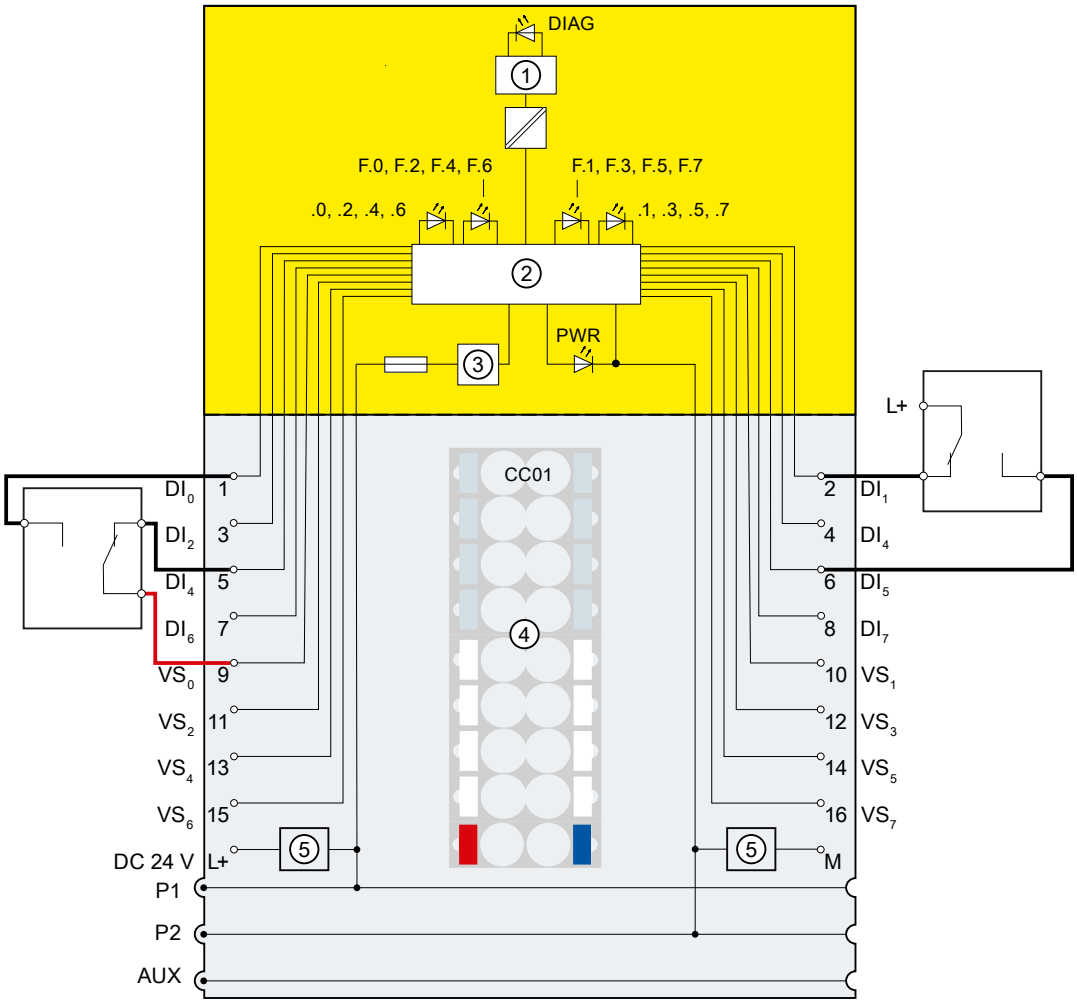


Figure 1-187 One non-equivalent sensor connected, internal sensor supply and one non-equivalent sensor connected, external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors non-equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected non-equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

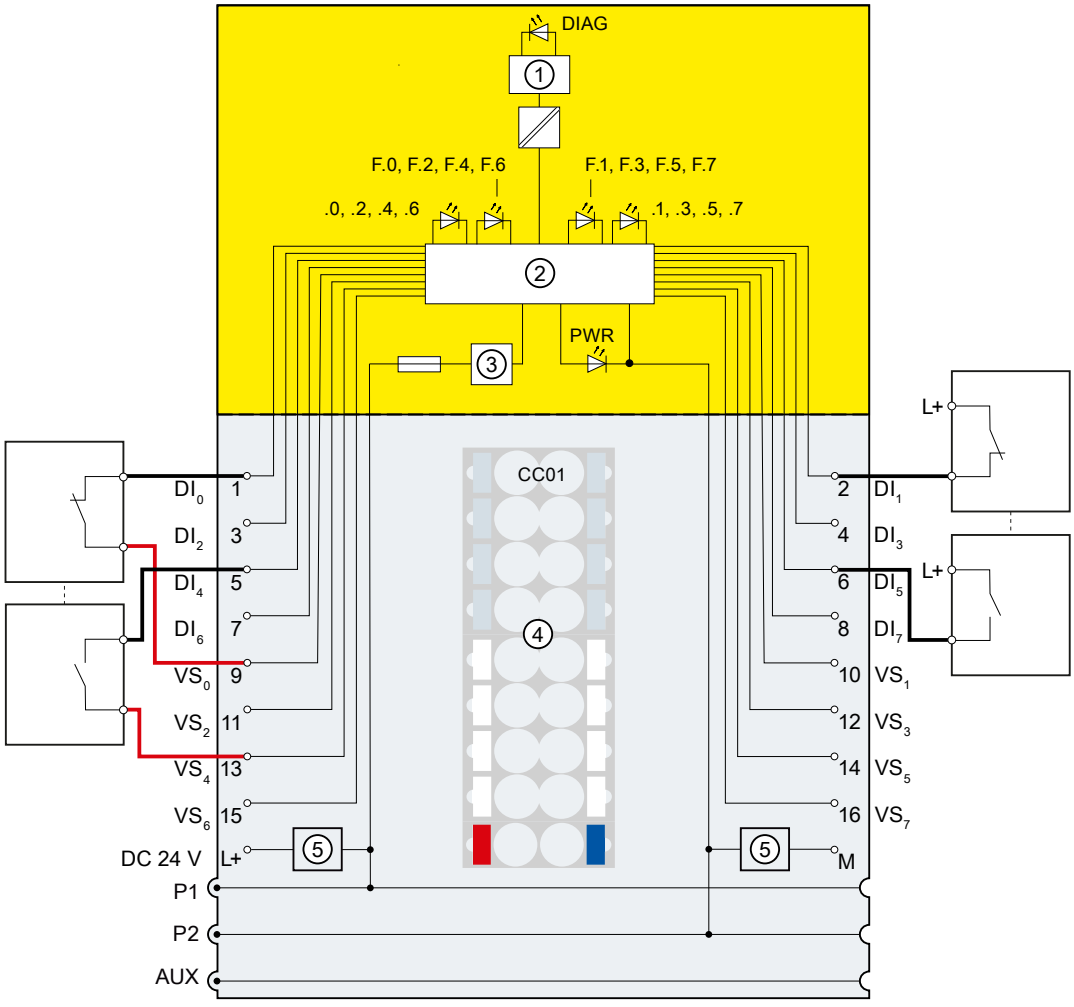


Figure 1-188 Two one-channel sensors connected via two channels non-equivalent, internal sensor supply and two one-channel sensors connected via two channels non-equivalent, external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-447 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, non-equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-448 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	Yes	Yes	Yes
Short-circuit with other channels or other sensor supplies	Yes*	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
Short-circuit with L+ to VS_n	Yes	No	-
Short-circuit with M to VS_n or defective	Yes	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.4 Safety mat evaluation application (from firmware version V2.0.0)

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input and use for the monitoring of safety mats.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

NOTE

Process signal
When a safety mat is activated, the process signal "0" is provided. When a safety mat is not activated, the process signal is "1".

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supplies are operated in the "Safety mat evaluation" mode and must be assigned to the digital inputs as follows:

- VS_0 to DI_0 and VS_4 to DI_4
- VS_1 to DI_1 and VS_5 to DI_5
- VS_2 to DI_2 and VS_6 to DI_6
- VS_3 to DI_3 and VS_7 to DI_7

Wiring diagram – connecting multiple safety mats in series

For each process signal, you can connect multiple 4-wire safety mats in series to two inputs and two internal sensor supplies of the F-module.

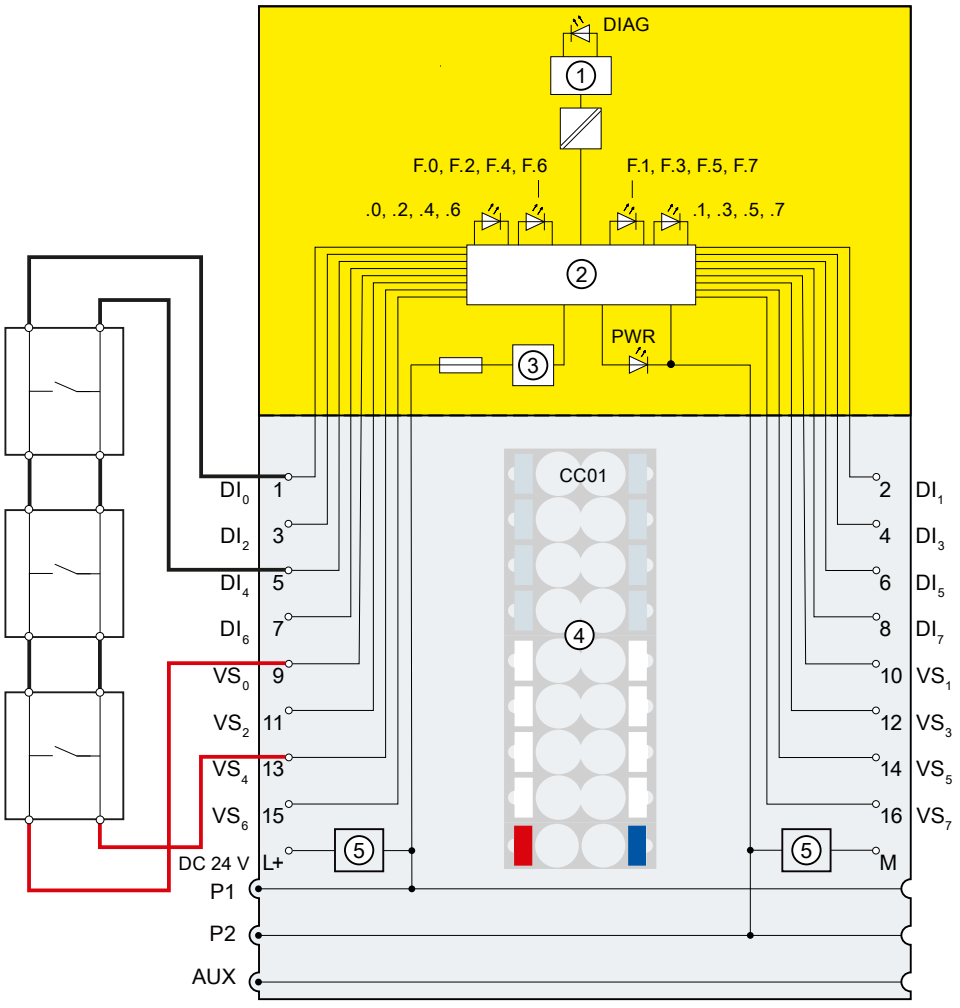


Figure 1-189 Safety mats connected via two channels to two internal sensor supplies

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor. If a regular function test is required, observe the requirements in the application standard or in the manual of the sensor in use.

WARNING

You must ensure short-circuit-proof wiring. Cables intended for the connection of the safety mats must be laid separately from the cables for applications 1 to 3 (Page 32).

⚠ WARNING

You may only use 4-wire safety mats with a current-carrying capacity of at least 100 mA.

⚠ WARNING

If a short-circuit of the sensor supply to ground occurs, you must check after resolving the short-circuit whether the safety mat is functional by activating it. An excessive current load may damage the contact of the safety mat.

⚠ WARNING

When selecting the cables and safety mats, note that the ohmic resistance of the cables including an activated safety mat must not exceed 100 ohms.

Determining the ohmic resistance for connecting a safety mat

If you do not know the resistance of the cables including activated safety mat, you must determine the resistance through measurements.

Proceed as follows:

- Unplug the digital input module from the BaseUnit.
- Measure the resistance of the cables including activated safety mat between VS_n and DI_{n+4}.
- Measure the resistance of the cables including activated safety mat between VS_{n+4} and DI_n.

For the above-mentioned measurements, the resistance must not exceed 100 ohms.

You can use the measuring tap of the BaseUnit for the measurements. For more information, refer to the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-449 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	Safety mat evaluation
Sensor supply	Sensor supply n
Short-circuit test	Enable
Time for short-circuit test	Default value 4.2 ms (not used)

Parameter	Channel with internal sensor supply
Startup time of sensor after short-circuit test	Default value 4.2 ms (not used)
Input delay	1.6 ms
Chatter monitoring	Disable

NOTE

With configured safety mat monitoring, the parameters "Short-circuit test", "Input delay" and "Chatter monitoring" cannot be adjusted since they are fixed with the listed values.

Fault detection

The following table presents fault detection:

Table 1-450 Fault detection

Fault	Fault detection
Short-circuit within the channel pair of the safety mat evaluation	No (activation of the safety mat is detected)
Short-circuit with other channel pairs with configured safety mat evaluation	Yes
Short-circuit with other channels that are used for the applications 1 to 3	No
Short-circuit with L+ to DI_n or DI_{n+4}	Yes*
Short-circuit with M to DI_n or DI_{n+4}	Yes
Wire break	Yes
Short-circuit with L+ to VS_n or VS_{n+4}	Yes*
Short-circuit with M to VS_n or VS_{n+4}	Yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

NOTE

The fault detection diagnostics is not signaled as outgoing until the safety mat function is once again error-free after running self-tests. The safety mat must not be activated in this case.

Counter operating mode

5

5.1 Wiring

5.1.1 Pin assignment “Counter" operating mode

Pin assignment for “Counter" operating mode

Table 1-451 Pin assignment for “Counter" operating mode

Pin assignment for “Counter" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

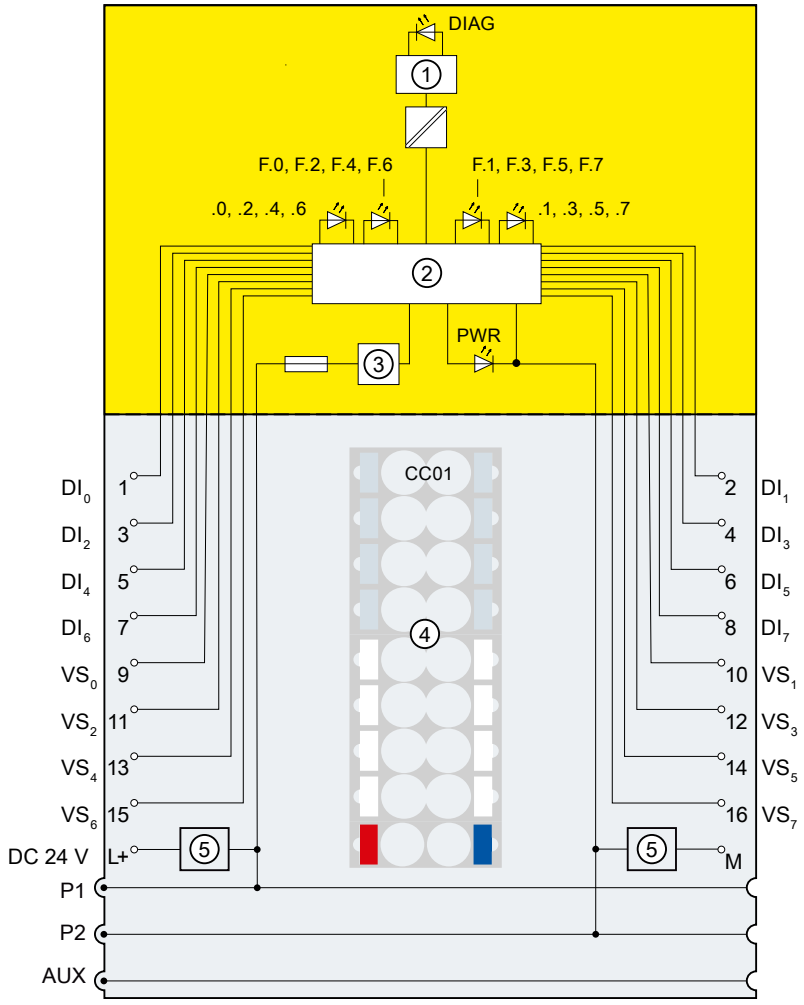
5.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 1-190 Block diagram

5.2 Parameters/address space

5.2.1 Counter

Function

Counting is the detecting and adding up of events. The counter of the module detects sensor signals and pulses and evaluates them accordingly, e.g.:

- For counting piece goods up to a maximum limit
- For counting of continuous pulses

The counting process is performed by non-equivalent 1oo2 evaluation of the DI_0 and DI_4 inputs. You define the properties of the counter with the functions described below.

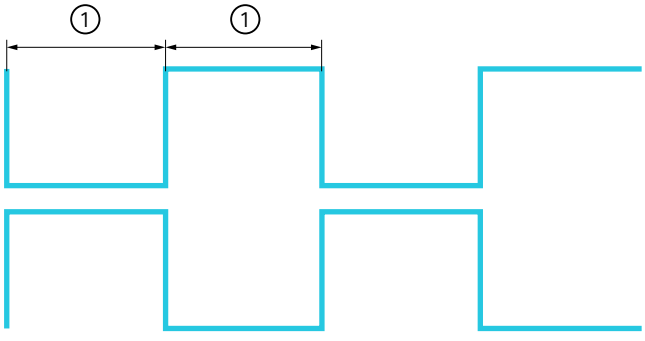
The counter matches relevant edges on DI_0 with relevant edges on DI_4.

The relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

If a relevant edge is detected, the counter is incremented by the value 1 (when counting up) or decremented (when counting down).

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.



① Minimum pulse duration

Figure 1-191 Minimum pulse duration

Table 1-452 Numerical values

Input delay	Minimum pulse duration	Maximum frequency
0.4 ms	0.71 ms	500 Hz
0.8 ms	1.10 ms	400 Hz
3.2 ms	3.60 ms	130 Hz

NOTE

Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

⚠ WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the count value.

Counting limits

The counting limits define the range of the count value. You can only change the counting limits during parameter assignment. It is not possible to change the counting limits during runtime.

The following counting limits can be configured:

- **High counting limit**

The maximum configurable counting limit is 2000000000.

- **Low counting limit**

The minimum configurable counting limit is –2000000000.

You can continue or stop the counting processes when a counting limit is violated (Reaction to violation of a counting limit). In the event of an overflow or underflow of the count value, the respective event bit in the feedback interface is set to "1". See section Assignment of the counter feedback interface (Page 67).

Application examples for counter mode

Information on possible application examples can be found in the section Application examples for counter mode (Page 76).

Reset control

You have two options to reset the counter:

- Using the user program
- Via the digital inputs DI_2 and DI_6 or the user program

You can select one of these two options through parameter assignment. Resetting sets the counter value to the configured start value and clears all counter errors present on counter

input channels DI_0 and DI_4. Counting errors can thus be eliminated and the passivated channel can be reintegrated.

In both cases, a rising edge on a control element (SW or HW) triggers the reset.

A reset is also necessary if errors have occurred on the other HW inputs.

After resetting, the counter starts counting automatically when the gate is at logic 1.

Gate control

The opening and closing of the hardware gate (HW gate) and software gate (SW gate) define the time window in which the counting signals are detected.

You have two options to control the gate:

- Via the user program (SW gate)
- Via the digital inputs DI_1 and DI_5 (HW gate)

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

With the gate open, ensure that the two signals adopt unequal (antivalent) states ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). If the signal on one channel changes, the other channel must change to the opposite state within the adjustable discrepancy time.

The gate control is active as long as no error is present. The gate control remains inactive even after a discrepancy error has been resolved and can only be reactivated by a reset. Only then will the error be reported as resolved and the outgoing error acknowledged.

When the gate is closed, the discrepancy evaluation of the digital inputs DI_0 and DI_4 is not active. However, exceeding the maximum possible frequency will continue to be monitored and will result in an error message even when the gate is closed.

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

⚠ WARNING

Reinitialization after parameter download
When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.
The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

Direction control

You have two options to control the counting direction:

- Using the user program
- Via the digital inputs DI_3 and DI_7

You can select one of these two options through parameter assignment. Changes in direction are only made when the gate is closed. The counting direction is up if the control signal is at logic 0 and down if the control signal is at logic 1.

Exceeding the counting limit

Exceeding the high or falling below the low counting limit is signaled by setting the corresponding event bit in the feedback interface.

You can acknowledge and clear these events via the user data interface (reset event) in the user program.

If a counting limit is exceeded twice without acknowledgment, the counter is deactivated and the "Channel passivated" diagnostics is generated.

5.2.2 Parameters

The "Counter" operating mode is only effective if the operating mode selection is configured as "Counter".

Parameters for "Counter" operating mode

The following parameters are possible:

Table 1-453 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 1-454 Configurable counter parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Counter - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Reset when counting limit is violated	• Start value • Opposite counting limit value	Start value	No	Channel pair
Reaction to violation of a counting limit	• Stop counting • Continue counting	Continue counting	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Discrepancy limit [number of pulses]	1	1 (unchangeable)	No	Channel pair
Discrepancy time limit	5 ms to 30 s	5 ms	No	Channel pair
High counting limit	-2000000000 to 2000000000	2000000000	No	Channel pair
Low counting limit	-2000000000 to 2000000000	-2000000000	No	Channel pair
Start value	-2000000000 to 2000000000	0	No	Channel pair
Counting value change reported	When present on a single channel	When present on a single channel (unchangeable)	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair
Gate, reset, direction control				
Gate controlled by	• Software • Hardware	Software	No	Module
Reset controlled by	• Software • Software or Hardware	Software	No	Module
Direction controlled by	• Software • Hardware	Software	No	Module
Gate, reset, direction hardware control				
Sensor evaluation	1oo2 evaluation, nonequivalent	1oo2 evaluation, nonequivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms (3.2 ms is fixed and unchangeable for reset hardware control)	No	Channel pair

5.2.3 Explanation of parameters

5.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.
The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- "Counter"
- "Standstill and Overspeed monitoring"

5.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You define the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Counter" mode, the parameter must be set to "Passivate channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs
When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

5.2.3.3 Counter parameters

Input delay

Input delay applied to the counting channels. See section Input delay (Page 29).

Reset when counting limit is violated

Determines whether the count value is to be set to the start value or to the opposite counting limit when the high or low counting limit is violated.

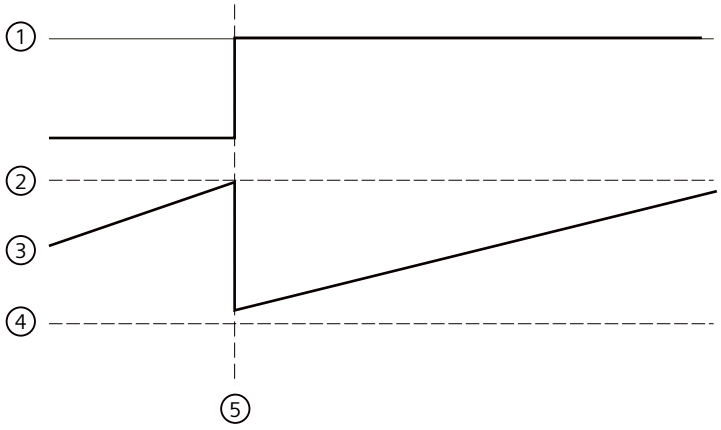
After a count overflow, the specified reset value is adjusted by one counting step to take the overflow pulse into account:

- When counting up: Reset value + 1
- When counting down: Reset value - 1

Reaction to violation of a counting limit

Determines the behavior when the high and low counting limit is violated. You can select whether counting continues or is stopped. If counting is to be stopped, you must close and reopen the gate to resume counting.

The following figure shows the reaction when a counting limit is violated and configured with "Continue counting":



① Overflow status
② High counting limit
③ Evaluated count value
④ Start value/opposite counting limit
⑤ Count value exceeds the configured high counting limit, is reset to the initial value/opposite counting limit value +1 and counting continues.
The user program detects that the "Overflow status" bit changes to high, indicating that the upper counting limit has been exceeded. The user program detects an updated count value.

Discrepancy limit [number of pulses]

The discrepancy limit is the difference in the number of pulses between the two counting channels. The permissible discrepancy is fixed to one pulse. Because a pulse consists of two edges, the detection of a third unequal edge triggers a counting discrepancy error and the diagnostic message "Counter discrepancy limit exceeded" is generated for both channels.

Discrepancy time limit

The time limit for discrepancy is the maximum time within which, after a pulse edge is detected on one input signal (DI_0 or DI_4), a corresponding edge must be detected on the opposite input signal (DI_4 or DI_0). The discrepancy time is measured for each individual unequal edge.

If an edge does not match after the set discrepancy time has expired, e.g. due to a wire break in a sensor cable, a discrepancy error is detected and the diagnostic message "Discrepancy error" is generated for both channels.

High counting limit

You limit the counting range by specifying the high counting limit. When the current count value exceeds the high counting limit, an overflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the high counting limit is exceeded. The current count value is then set to the start value +1 or the low counting limit +1, depending on the parameter assignment. The high counting limit must be greater than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is 2000000000.

Low counting limit

You limit the counting range by specifying the low counting limit. If the current count value falls below the low counting limit, an underflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the low counting limit is undershot. The current count value is then set to the start value -1 or the high counting limit -1, depending on the parameter assignment. The low counting limit must be lower than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is -2000000000.

Start value

You determine the count value at the beginning of the counting by configuring the start value. The current count value is reset to the start value in the following situations:

- After startup
- After parameter download
- After reset
- When the counting limit is exceeded, if configured

The start value must be a value between the high and low counting limit. The permissible range is between -2000000000 and 2000000000. The default setting is 0.

Counting value change reported

Determines when the count value is updated. This parameter is always set to "When present on a single channel". This results in an update being triggered as soon as a "single" rising edge on the primary channel DI_0 or a "single" falling edge on the secondary channel DI_4 is detected. In this context, "single" means that it is not a matching edge. A matching edge is an edge that coincides with an opposite edge already detected on the other channel.

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- Manual
- Automatic

5.2.3.4 Parameters for gate, reset and direction control

Gate, reset and direction control

Specifies the source for gate, reset, and direction control.

You can select the following options for the gate or direction control:

- "Software"
- "Hardware"

You can choose the following options for the reset control:

- "Software"
- "Software or Hardware"

The default setting is "Software".

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

5.2.3.5 Parameters for gate, reset and direction hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 25).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 26).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 27).

Discrepancy time

For more information, see section Discrepancy time (Page 27).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 28).

Input delay

For more information, see section Input delay (Page 29).

5.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Counter" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 1-455 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The counter only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Counter" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 1-456 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved
IB x + 2	Count value							
IB x + 3								

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 4	Count value							
IB x + 5								
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved
IB x + 7	Reserved		Value status of underflow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset controlled by SW	Gate controlled by SW	Reserved

Table 1-457 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

5.2.5 Assignment of the control interface counter

The safety program can influence the behavior of the module in "Counter" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 1-458 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

Explanations

Table 1-459 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control whether the software gate is open, and thus counting is activated. • 0: SW gate closed, counting stopped • 1: SW gate open, counting possible
QB x + 0	2	SW reset control	Use this bit to reset the current value to the configured start value. • 0: No action • 1: Resets the counter to the start value and clears all counter errors present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The counter is set to the "Start value" and any error status present on the channels of the counter is cleared.
QB x + 0	3	SW direction control	Use this bit to specify the counting direction. • 0: Counting direction up • 1: Counting direction down Changes in direction are only made when the gate is closed.
QB x + 0	4	Event reset	Use this bit to reset the following status bits in the feedback interface: • Underflow status • Overflow status As long as the "Reset event" bit is set to 1, the "Underflow status" and "Overflow status" bits are continuously reset.

5.2.6 Assignment of the feedback interface counter

In "Counter" operating mode, the safety program can receive actual values and status information via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 1-460 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved
IB x + 2	Count value							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 7	Reserved		Value status of under-flow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset con-trolled by SW	Gate con-trolled by SW	Reserved

Explanations

Table 1-461 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 0	2	HW reset signal	Only valid if the HW control is configured for the reset. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_2 and DI_6.
IB x + 0	3	HW direction signal	Only valid if the HW control is configured for the direction. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_3 and DI_7.
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received the gate control from either the SW control interface or the HW control and has responded as follows: • If the gate control is set to 1, the "Gate status" bit is also set to 1. The module begins monitoring the counter channel pair. • If the gate control is set to 0, the "Gate status" bit is also set to 0. Changes to the counter channel pair are ignored.
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the module sets the count value to the start value and clears the counter error states. The "Reset status" bit is set to 1. • If the reset control is set to 0, the "Reset status" bit is also set to 0. If both HW and SW control are used, both must be set to 0 to clear the status bit.
IB x + 1	3	Direction status	The "Direction status" bit indicates the counting direction. • 0: Counting direction is up • 1: Counting direction is down
IB x + 1	4	Overflow status	The "Overflow status" bit is always set when the current count value exceeds the configured "High counting limit". • 0: High counting limit not violated • 1: High counting limit was violated The overflow status bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the “Event reset” bit is set to 1.

Byte	Bit	Feedback bit/value	Description
IB x + 1	5	Underflow status	The "Underflow status" bit is always set when the current count value falls below the configured "Low counting limit". • 0: Low counting limit not violated • 1: Low counting limit was violated The "Underflow status" bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the "Event reset" bit is set to 1.
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Count value	The count value is a 32-bit signed integer value with a high limit of 2 billion and a low limit of -2 billion.
IB x + 6	1	HW gate value status	Contains the value status of the hardware control inputs in the event that gate is controlled by the hardware.
IB x + 6	2	HW reset value status	Contains the value status of the hardware control inputs in the event that reset is controlled by the hardware.
IB x + 6	3	HW direction value status	Contains the value status of the hardware control inputs in the event that direction is controlled by the hardware.
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	3	Value status of direction status	Contains the value status of direction status
IB x + 7	4	Value status of overflow status	Contains the value status of overflow status
IB x + 7	5	Value status of underflow status	Contains the value status of underflow status
IB x + 8	0	Value status of count value	Contains the value status of count value
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*
IB x + 9	3	Direction controlled by SW	Contains bit indicating whether direction is software-controlled.*
IB x + 9	4	Event reset controlled by SW	Contains bit indicating whether reset event is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the table "Address assignment by user data in the input range (Page 65)".

5.3 Use cases for Counter (as of firmware version V3.0.0)

⚠ WARNING

Make sure that the highest frequency occurring in the application does not exceed 500 Hz.

⚠ WARNING

Reinitialization after parameter download
When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.
The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

⚠ WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.
In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.
Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.
When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.
Details on this can be found in the application examples (Page 76).

Inputs for counter

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in a non-equivalent 1oo2 logic and are used as follows:

- DI_0 and DI_4 are used as counting channels.
- DI_1 and DI_5 are used optionally for HW gate control.
- DI_2 and DI_6 are used optionally for HW reset control.
- DI_3 and DI_7 are used optionally for HW direction control.

The process signals for the HW controls are provided by channels DI_1, DI_2 and DI_3.

The counter counts the number of relevant edges detected on both DI_0 and DI_4. The higher count value on relevant edges of both channels is output as the count value by the module.

Relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In "Counter" mode, the internal sensor supplies are permanently assigned to the inputs and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- VS_2 to DI_2 and VS_6 to DI_6 (activated if the HW reset control is configured)
- VS_3 to DI_3 and VS_7 to DI_7 (activated if the HW direction control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages

To avoid interference caused by high-energy surge voltages, you must observe the following restrictions when operating in "Counter" mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No restrictions

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 119) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 119) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Counter" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:

For the power supply, use a separate power supply unit that only supplies voltage to digital input modules F-DI 8x24VDC HF in "Counter" operating mode and the associated sensors.

WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the counter value.

Wiring diagram - Use case with external sensor supply

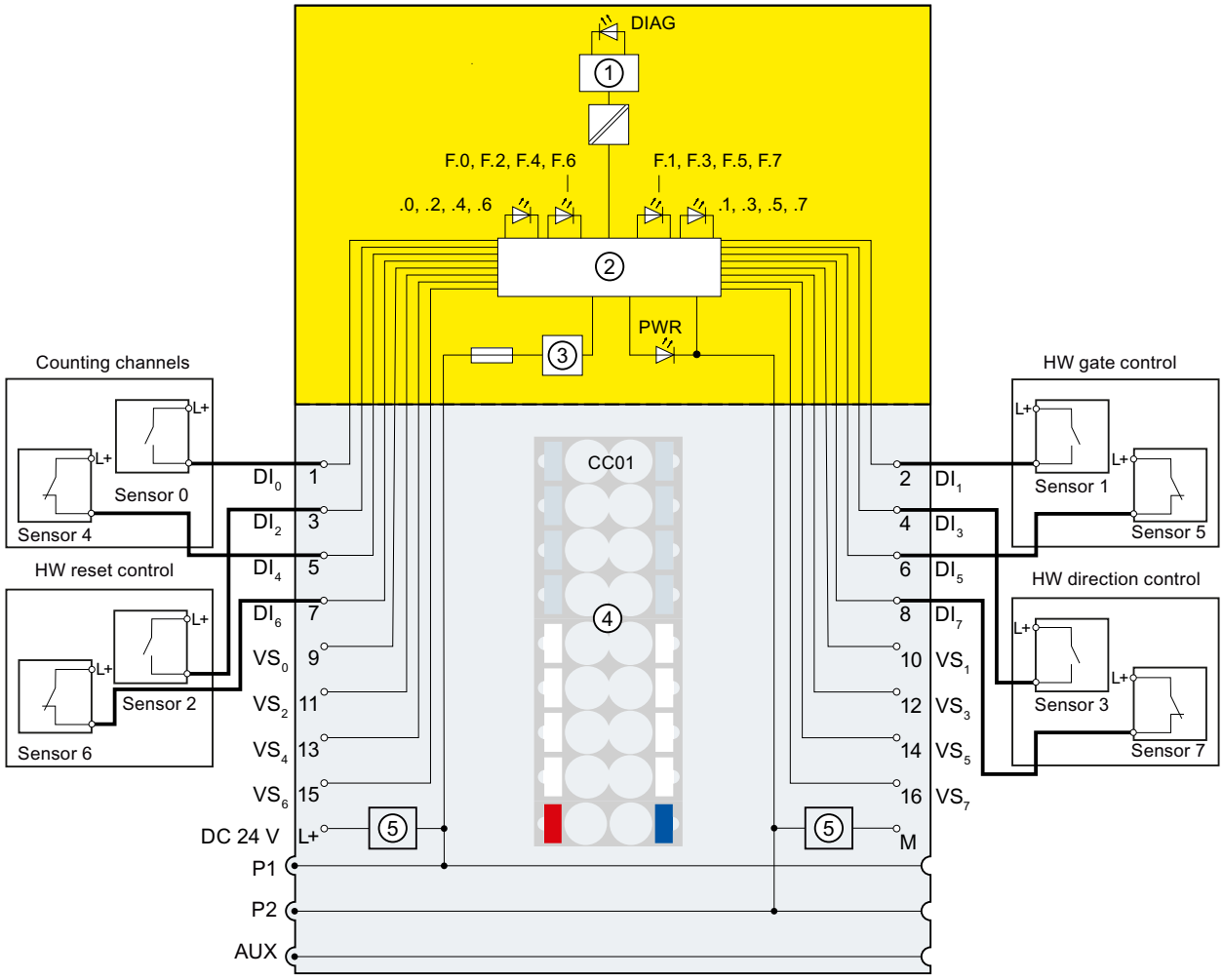


Figure 1-192 Use case with external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - Use case with internal sensor supply

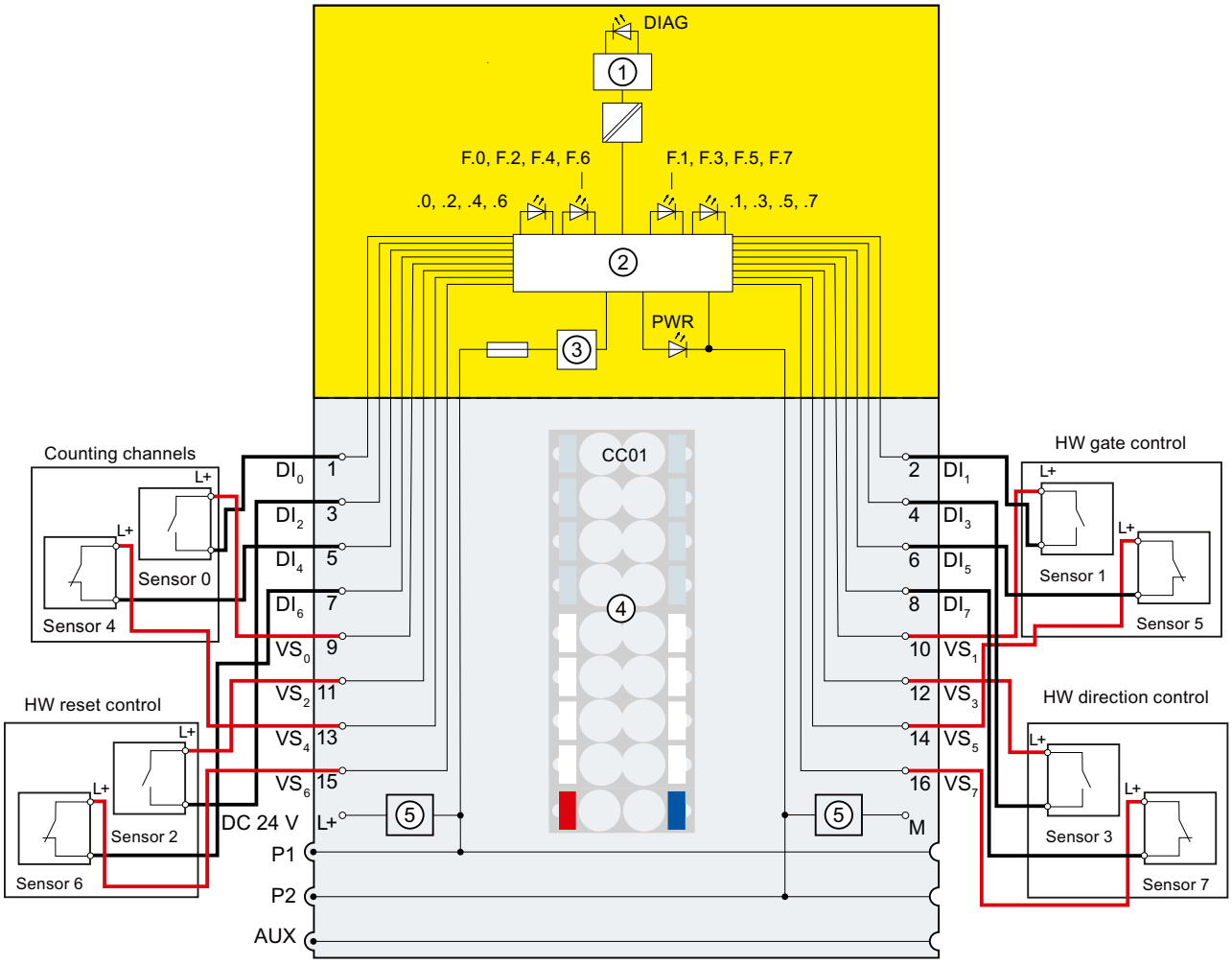


Figure 1-193 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 1-462 Error detection at counter inputs (DI_0 and DI_4)

Faults	Fault detection at counter inputs	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Counter discrepancy limit exceeded	Yes	Yes
Wire break	Yes*	Yes*

*) All these errors are detected based on the discrepancy. A discrepancy error is reported after the discrepancy time. Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

Table 1-463 Fault detection at HW inputs (DI_1, DI_2, DI_3, DI_5, DI_6 and DI_7)

Faults	Fault detection at HW control inputs	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

5.4 Application examples for counter mode

The following are two possible application examples for counter mode:

- Piece count
- Counting of continuous pulses

Piece count

In the illustrated example, the number of items transported on a conveyor belt is counted. The counting is performed via two sensors connected to DI_0 and DI_4.

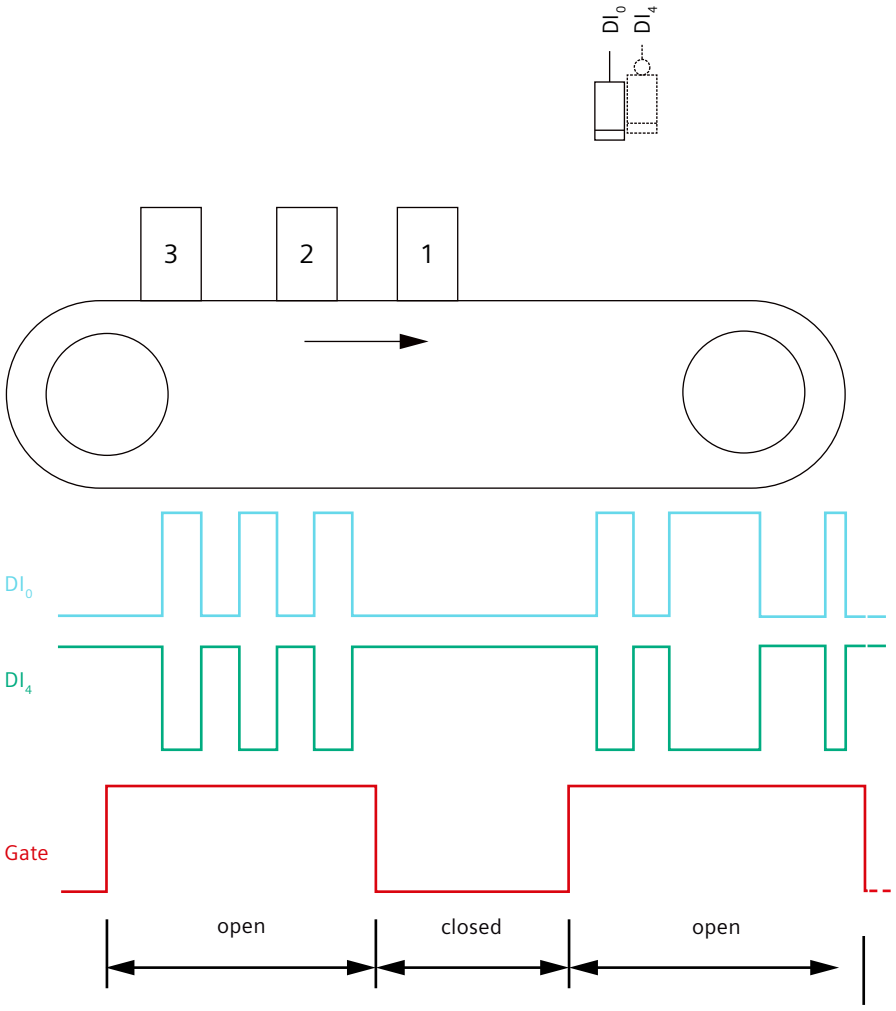


Figure 1-194 Piece count

The piece count refers to cases where an exact number of events is to be counted.

The piece count is defined by the following main characteristics:

- The signal change at the inputs occurs at an unpredictable time.
- The cycle duration and width of the pulses are variable.
- If the gate of the counter is open, the signal changes at the inputs can be stopped, paused, or resumed.
- This application example allows for an exact count value. (For details, see Rules and restrictions)

Rules and restrictions:

WARNING

In the time range 2*T_{cycle} before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.
In the time range 2*T_{cycle} before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.
Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.
When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" (DI_0 = 1, DI_4 = 0 or DI_0 = 0, DI_4 = 1). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

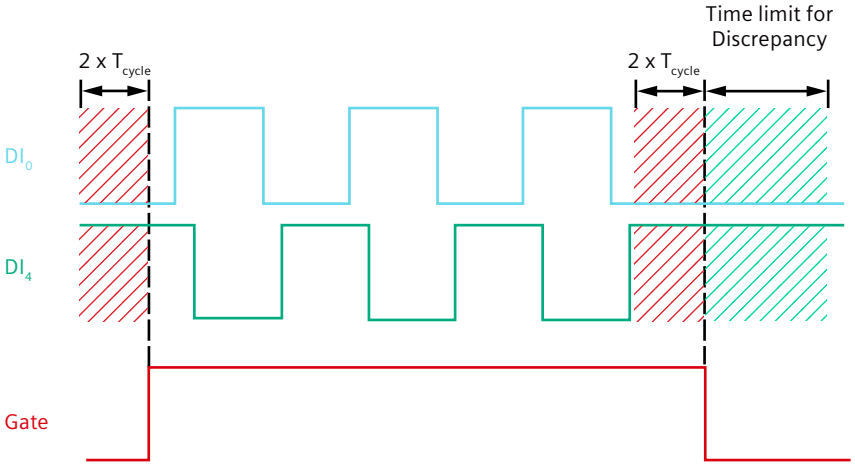


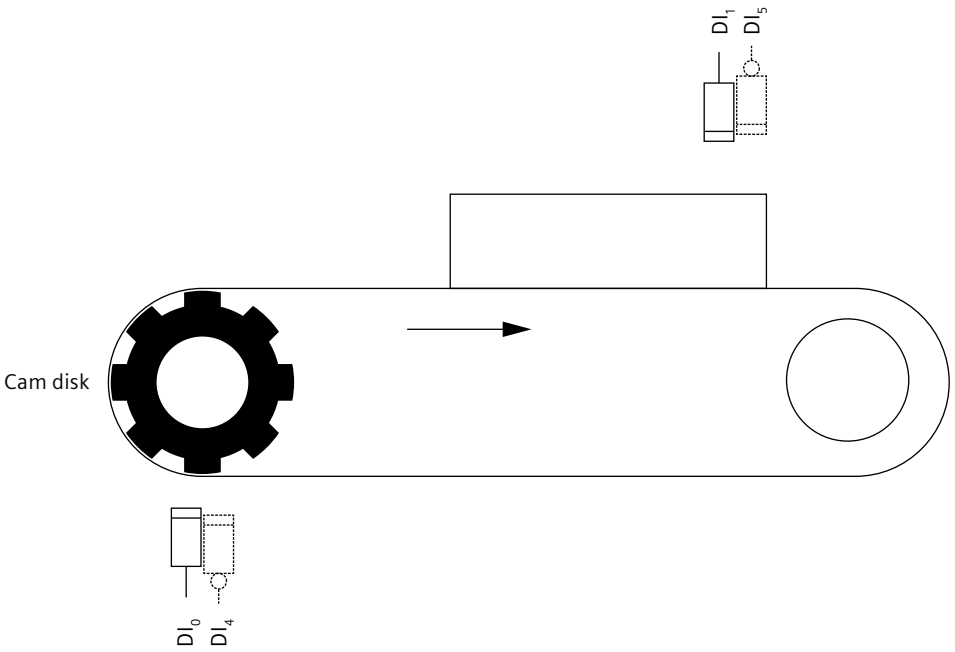
Figure 1-195 Leader and trailer

Counting of continuous pulses

In the illustrated example, the length of the item transported on a conveyor belt is determined.

The object is detected and the gate is controlled via sensors at digital inputs DI_1 and DI_5.

A cam disk is placed on the drive shaft of the conveyor belt. This is detected by sensors connected to DI_0 and DI_4. The length of the object can be inferred from the pulses counted by the sensors.



Counting continuous pulses refers to cases where recurring events are to be counted.

The counting of continuous pulses is defined by the following main characteristics:

- The signal change at the inputs occurs periodically.
- The maximum cycle duration of the pulses applied to the inputs depends on the "Discrepancy time limit" parameter.
- If the counter gate is open, the signal changes at the inputs **cannot** be stopped, paused, or resumed.
- This application example is suitable for applications that allow a tolerance-based count value. (For details, see Rules and restrictions)

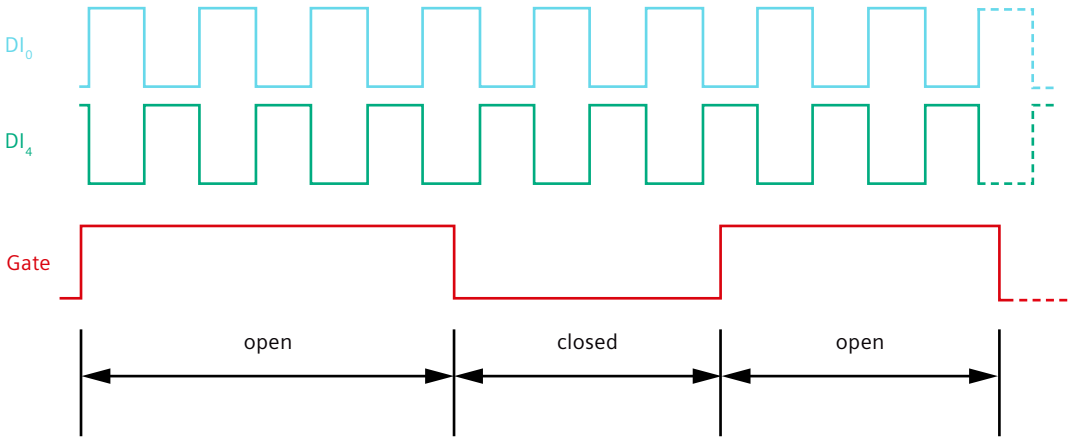


Figure 1-196 Counting of continuous pulses

Rules and restrictions:

- Ensure that the time assigned in the "Discrepancy time limit" parameter is longer than the longest time that the counter inputs are expected to remain unchanged (the longest gap between 2 edges). The figure below shows a continuous pulse pattern that alternates between three cycle durations: P1, P2, P3. The time assigned in the "Discrepancy time limit" parameter must be greater than T1. T1 is the largest distance between 2 edges.

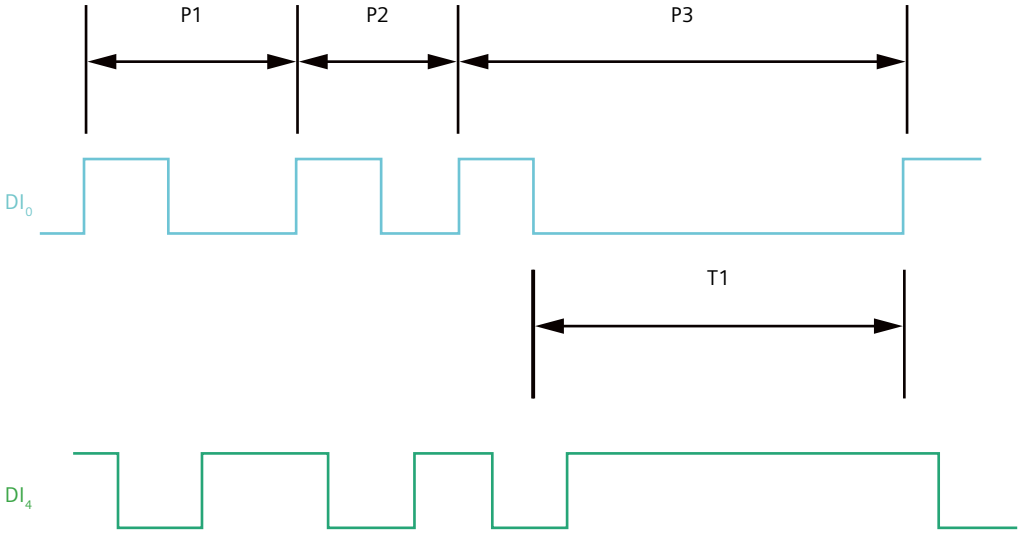


Figure 1-197 Pulse pattern

WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.
In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.
Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.
When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

Ensure that the continuous pulse pattern shown in the "Leader and trailer" figure is detected by inputs DI_0 and DI_4 for at least $2*T_{cycle}$ before the gate is opened. Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.
Ensure that, after the gate is closed, the continuous pulse pattern is detected by inputs DI_0 and DI_4 for at least the configured "Discrepancy time limit". Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

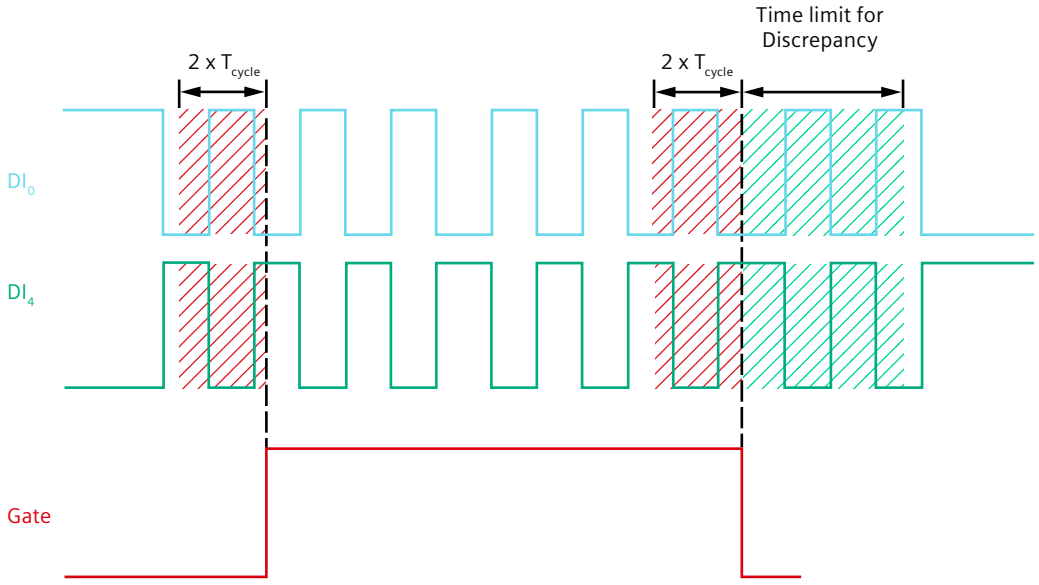


Figure 1-198 Leader and trailer

Standstill and Overspeed monitoring operating mode

6

6.1 Wiring

6.1.1 Pin assignment "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Table 1-464 Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE
The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE
Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

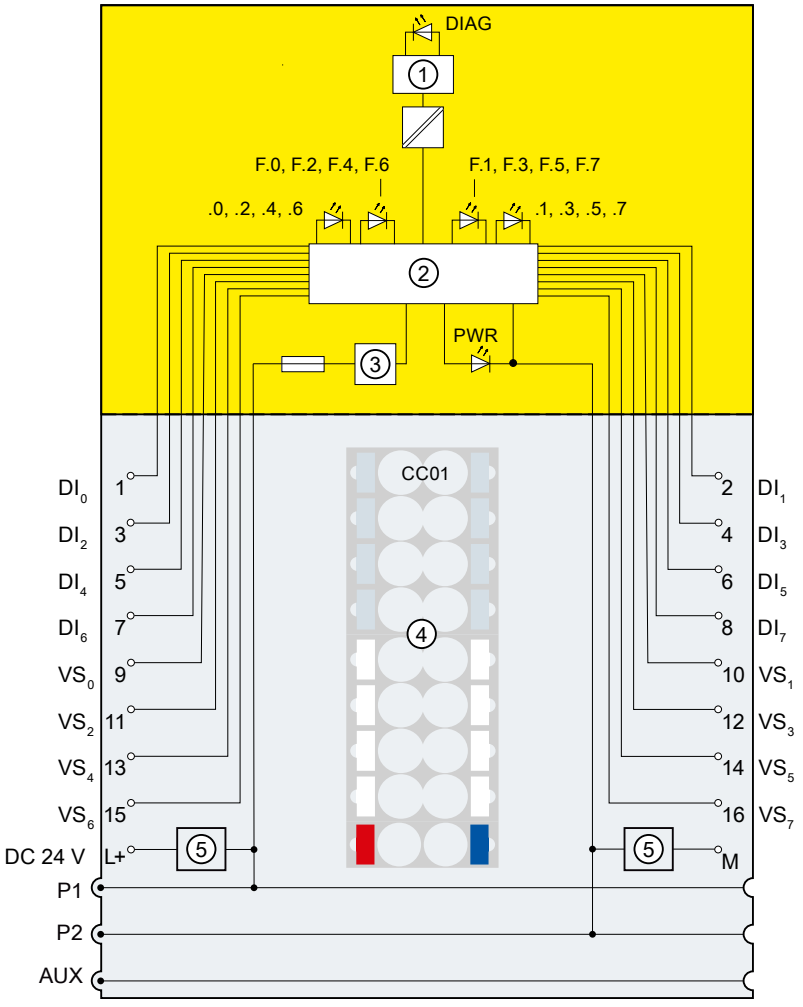
6.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.



①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 1-199 Block diagram

6.2 Parameters/address space

6.2.1 Standstill and overspeed monitoring

Function

Standstill and overspeed monitoring means the detection of periodically occurring pulse events. The module determines the number of pulses occurring in a defined time window and evaluates them.

Possible applications include:

- Monitoring for excessively high speed during rotation
- Monitoring of the standstill or runout of a rotational movement to its maximum residual speed

The standstill and overspeed monitoring is carried out by means of 1oo2 evaluation of the inputs DI_0 and DI_4. The following figure shows the required pulse pattern.

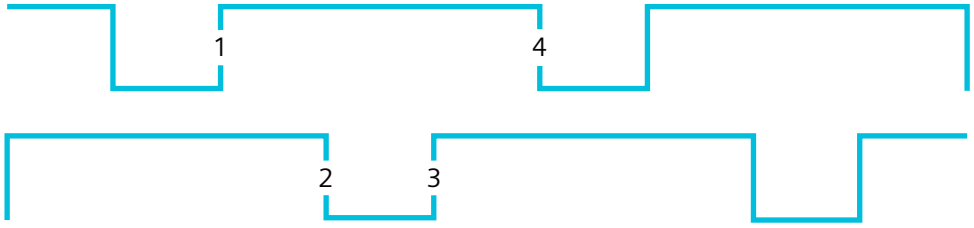
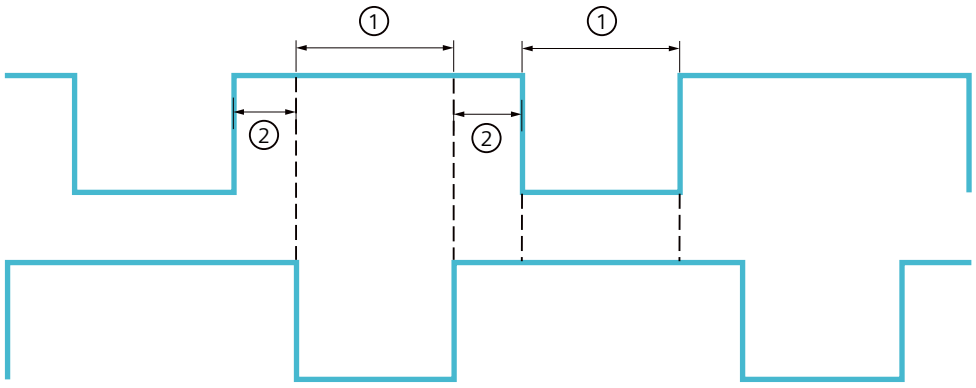


Figure 1-200 Pulse pattern

Between a rising edge (1) and falling edge (4) on the first channel, there must always be a falling edge (2) and a rising edge (3) on the second channel.

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.



① Minimum pulse duration of the "0" signal
② Minimum duration between edge changes = 330 µs

Figure 1-201 Minimum pulse length

Table 1-465 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

NOTE

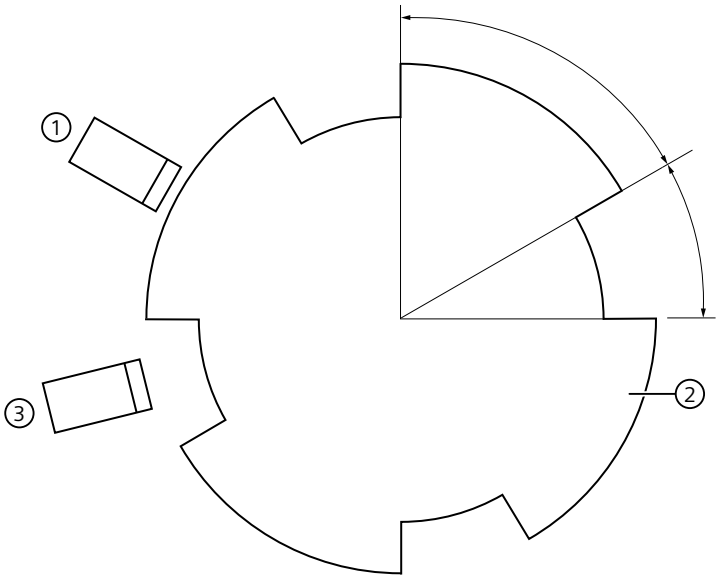
Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

⚠ WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the standstill and speed detection.

The pulse pattern requirements can be met with applications using a cam disk mounted on a motor shaft. For example, in the following figure in which the sensors are designed as normally open contacts:



① Sensor 1
② Cam disk
③ Sensor 2

Figure 1-202 Example of a pulse detection

With pulse detection, note the following:

- The segment that provides the "1" signal state is larger than the segment that represents the "0" signal state.
- You must position the sensors so that the signals on both sensors do not change at the same time and do not deliver the signal state "0" at the same time.
- After the logic of a sensor switches from 1 to 0, a minimum pulse duration of the "0" signal must be observed. During this entire duration, both sensors must constantly maintain their logic.

  Furthermore, a minimum duration of at least 330 µs must be between the edge changes. This period defines a phase in which both sensors must consistently keep logical 1 at the same time.
- After each logic change on either of the two sensors, a minimum pulse duration should elapse during which the logic on both sensors remains unchanged. See figure "Minimum pulse length" at the beginning of this section.

You define the properties of the standstill and overspeed monitoring with the functions described below.

Standstill monitoring counts the number of relevant edges.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of relevant edges in each monitoring window (at the end of the monitoring window):

- If the tolerant discrepancy evaluation method during standstill is configured, the highest counter reading of DI_0 and DI_4 is reported.
- If the tolerant discrepancy evaluation method during standstill is not configured, the counter reading of DI_0 is reported.

You can find additional information in the section "Use case standstill and overspeed monitoring (Page 100)".

Standstill monitoring

You set the standstill monitoring by selecting a standstill threshold and the duration of a monitoring window. The pulses per monitoring window are counted and compared to the standstill threshold at the end of each monitoring window. A standstill is reported if the number of pulses per monitoring window is less than or equal to the "Standstill threshold" parameter and remains less than or equal for the number of subsequent monitoring windows of "Standstill on-delay" + 1. The standstill is reported by the feedback interface by means of the "Standstill event status" bit. You can find more information under Feedback interface (Page 97).

If the number of input pulses per monitoring window exceeds the "Standstill threshold" parameter, the "Standstill event state" bit is set to "0".

Overspeed monitoring

You set the overspeed monitoring by selecting an overspeed threshold. The pulses per monitoring window are counted and compared to the overspeed threshold at the end of each monitoring window. Overspeed is detected as soon as the number of counted pulses is equal to or greater than the "Overspeed threshold". The overspeed is reported by the feedback interface using the "Overspeed event status" bit. You can find more information under Feedback interface (Page 97).

Reset control

The reset is triggered on the transition from logic 0 to logic 1. A reset clears all standstill and overspeed monitoring faults that are present on the channels. A reset is also necessary if a fault has occurred in the gate input channels. The reset function can only be executed if the standstill and overspeed monitoring is in fault status. If the reset is triggered with the gate open, counting begins immediately after the first monitoring window.

Gate control

Opening the hardware or software gate activates the standstill and overspeed monitoring.

You have two options to control the gate:

- Using the user program
- Via the digital inputs DI_1 and DI_5

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

Make sure that a valid pulse pattern is present at digital inputs DI_0 and DI_4 when the gate is opened. See the "Pulse pattern" figure at the beginning of this section.

When the gate is closed, the signal evaluation of the digital inputs DI_0 and DI_4 is not active.

If the reset is triggered with the gate open, counting begins immediately after the first monitoring window. You can find more information under Feedback interface.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

Discrepancy evaluation method

Standstill and overspeed monitoring allows you to choose by parameter assignment between a strict discrepancy evaluation method and a tolerant discrepancy evaluation method during standstill.

The differences in the discrepancy evaluation method are only applied if the standstill and overspeed monitoring is in the standstill state. This occurs when the number of pulses per monitoring window is lower than the configured "Standstill threshold".

- **Strict discrepancy evaluation method during standstill**

Each detected edge that deviates from the pulse pattern results in a discrepancy error. Use this discrepancy evaluation method to achieve maximum SIL3/Cat.4/PLe.

The parameter "Tolerant discrepancy evaluation method during standstill" is not activated.

- **Tolerant discrepancy evaluation method during standstill**

During standstill, a discrepancy error is only detected if the input signals DI_0 and DI_4 are at logical 0 at the same time. This can help when filtering jitter. To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring. Without cross-circuit proof wiring, you will achieve a maximum of SIL2/ Cat.3/Pld.

The parameter "Tolerant discrepancy evaluation method during standstill" is activated.

6.2.2 Parameters

The "Standstill and Overspeed monitoring" operating mode is only effective if the operating mode selection is configured as "Standstill and Overspeed monitoring".

Parameters for the "Standstill and Overspeed monitoring" operating mode

The following parameters are possible:

Table 1-466 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 1-467 Configurable standstill and overspeed monitoring parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Standstill and Overspeed monitoring - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair
Monitoring window duration	0.1 to 30 s	6 s	No	Channel pair
Overspeed threshold	2 to 14,400	7	No	Channel pair
Overspeed off-delay [number of monitoring windows]	1 to 127	1	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Standstill threshold	0 to 14,398	2	No	Channel pair
Standstill on-delay [number of monitoring windows]	1 to 127	1	No	Channel pair
Tolerant discrepancy evaluation method during standstill	• Not activated • Activated	Not activated	No	Channel pair
Gate control				
Gate controlled by	• Software • Hardware	Software	No	Module
Gate hardware control - Channel 1, 5				
Sensor evaluation	1oo2 evaluation, non-equivalent	1oo2 evaluation, non-equivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Reset control				
Reset controlled by	Software	Software (unchangeable)	No	Module

See also

Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 100)

6.2.3 Explanation of parameters

6.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.
The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

6.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Standstill and Overspeed monitoring" mode, the parameter must be set to "Passivate the channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs
When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

6.2.3.3 Standstill and overspeed monitoring parameters

Input delay

Input delay applied to the channels. See section Input delay (Page 29).

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- "Manual"
- "Automatic"

Monitoring window duration

Specifies the monitoring window duration in 0.1 s increments. You can set a range of 0.1 to 30 s. The default setting is 6 s.

Overspeed threshold

Determines the limit for overspeed detection in pulses per monitoring window. You can set a range from 2 to 14,400 pulses. To take the limit into account for normal operation, the set value must be at least 2 greater than the standstill threshold. The default setting is 7.

⚠ WARNING

When configuring the overspeed threshold, you need to consider the monitoring window duration and the input delay.
If the overspeed threshold cannot be reached, speed monitoring will not be performed correctly.
With the following formula, you must determine the maximum reachable value for the overspeed threshold:

*Maximum overspeed threshold = maximum frequency * monitoring window duration*

The value for the maximum frequency can be found in the following "Numerical values" table.

Table 1-468 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Overspeed off-delay [number of monitoring windows]

Determines how many consecutive monitoring windows without overspeed must be registered before the "Overspeed event status" bit is reset from 0 to 1. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Standstill threshold

Determines the limit for the standstill detection in pulses per monitoring window. You can set a range from 0 to 14,398 pulses. To take the limit into account for normal operation, the set value must be at least 2 lower than the overspeed limit. The default setting is 2.

⚠ WARNING

When configuring the standstill threshold, you need to consider the monitoring window duration and the input delay.
If the standstill threshold cannot be reached, standstill monitoring will not be performed correctly.
With the following formula, you must determine the maximum reachable value for the standstill threshold:

*Maximum standstill threshold = maximum frequency * monitoring window duration -2*

You must always set the value of the standstill threshold lower than the value of the overspeed threshold.
The value for the maximum frequency can be found in the following "Numerical values" table.

Table 1-469 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Standstill on-delay [number of monitoring windows]

Determines how many consecutive monitoring windows must detect a standstill before the standstill event status bit is set. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Tolerant discrepancy evaluation method during standstill

If you select this option, a tolerant discrepancy evaluation method is applied during the standstill. This can help when filtering jitter.

To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring.

6.2.3.4 Parameters for gate and reset control

Gate and reset control

Specifies the source for gate and reset control.

You can choose the following options for the gate control:

- "Software"
- "Hardware"

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

You can choose the following options for the reset control:

- "Software"

6.2.3.5 Parameters for gate hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 25).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 26).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 27).

Discrepancy time

For more information, see section Discrepancy time (Page 27).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 28).

Input delay

For more information, see section Input delay (Page 29).

6.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address ranges in the F-CPU:

Table 1-470 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The standstill and overspeed monitoring only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 1-471 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Over-speed event status	Reserved			Reset status	Gate status	First mon-itoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 7	Value status of standstill event status	Value status of overspeed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first monitoring window
IB x + 8	Reserved							Value status of the number of pulses per monitoring window
IB x + 9	Reserved					Reset controlled by SW	Gate controlled by SW	Reserved

Table 1-472 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

6.2.5 Assignment of the standstill and overspeed monitoring control interface

The safety program can influence the behavior of the module in "Standstill and Overspeed monitoring" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 1-473 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

Explanations

Table 1-474 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control when the software gate is opened and the standstill and overspeed monitoring is activated. • 0: The SW gate is closed and the standstill and overspeed monitoring is stopped. • 1: The SW gate is open and standstill and overspeed monitoring is enabled.
QB x + 0	2	SW reset control	Use this bit to clear all error statuses in the standstill and overspeed monitoring. • 0: No action • 1: Sets the number of pulses per monitoring window to 0 and clears all error states in the standstill monitoring that are present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The current number of pulses per monitoring window is set to 0 and any error status that is present on the channels of the standstill and overspeed monitoring is cleared.

6.2.6 Assignment of the standstill and overspeed monitoring feedback interface

The safety program can receive actual values and status information in "Standstill and Overspeed monitoring" operating mode via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 1-475 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Overspeed event status	Reserved			Reset status	Gate status	First monitoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 7	Value status of standstill event status	Value status of over-speed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first monitoring window
IB x + 8	Reserved							Value status of the number of pulses per monitoring window
IB x + 9	Reserved					Reset controlled by SW	Gate controlled by SW	Reserved

Explanations

Table 1-476 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 1	0	First monitoring window	The "First monitoring window" bit indicates whether the current monitoring window is the first after a new gate open command was received. • 0: The current monitoring window is not the first after a gate open command. Therefore, normal measured data can be expected. This bit enables the control system to identify the first monitoring window after gate opening. In this first window, the data may not be valid yet. In this way, the control system can distinguish the first window with an error from the subsequent regular monitoring windows. This allows you to distinguish between an actual error and the expected initial state during the first monitoring window. The first monitoring window should be handled by the user program accordingly before the actual measured values can be received. • 1: The current monitoring window is the first after a new gate open command. In the sampling phase, the standstill value status during the first monitoring window is 0 because there is no valid measurement data available to report.
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received and responded to the gate control from either the SW control interface or the HW control: • 1: Gate opened. Standstill and overspeed monitoring active. • 0: Gate closed Changes to the counting channel pair for standstill and overspeed monitoring are ignored.
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the "Reset status" bit is set to 1 and the module deletes the error states for standstill and overspeed monitoring. • If the reset control is set to 0, the "Reset status" bit is also set to 0.

Byte	Bit	Feedback bit/value	Description
IB x + 1	6	Overspeed event status	The "Overspeed event status" bit indicates the status of an overspeed detection. • 0: Overspeed detected • 1: No overspeed The bit is set to "0" if the pulse count within a monitoring window is greater than or equal to the configured "Overspeed threshold". The bit is automatically reset to "1" when both of the following conditions are met: • The number of pulses is below the "Overspeed threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Overspeed off-delay".
IB x + 1	7	Standstill event status	The "Standstill event status" bit indicates the status of a detected standstill. • 0: No standstill detected • 1: Standstill detected The bit is set to "1" if both of the following conditions are met: • The pulse count within a monitoring window is less than or equal to the configured "Standstill threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Standstill on-delay". The bit is automatically reset to "0" as soon as the pulse count exceeds the defined "Standstill threshold".
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 6	1	Value status of HW gate signal	Contains the value status of the hardware control channel pair in the event that the gate is controlled by the hardware.
IB x + 7	0	Value status of first monitoring window	Contains the value status of first monitoring window
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	6	Value status of overspeed event status	Contains the value status of overspeed event status
IB x + 7	7	Value status of standstill event status	Contains the value status of standstill event status
IB x + 8	0	Value status of the number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the above table "Assignment of the feedback interface".

6.3 Standstill and overspeed monitoring use cases (as of firmware version V3.0.0)

⚠ WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated
To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

⚠ WARNING

Make sure that the highest possible frequency does not exceed 480 Hz in the application.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 1-477 Conditions for achieving SIL/Cat./PL

Discrepancy evaluation	Wiring requirements	Achievable SIL/Cat./PL
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill deactivated)	None	3 / 4 / e
	Cross-circuit proof wiring	3 / 4 / e
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill activated)	None	2 / 3 / d
	Cross-circuit proof wiring	3 / 4 / e

Inputs for standstill and overspeed monitoring

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in 1oo2 equivalent logic for the standstill and overspeed monitoring counter channels and in 1oo2 non-equivalent logic for the hardware gate control channels:

- DI_0 and DI_4 are used as channels for the standstill and overspeed monitoring.
- DI_1 and DI_5 are used optionally for HW gate control.

The process signal for the hardware control is provided via channel DI_1.

Strict discrepancy evaluation method during standstill
If the strict discrepancy evaluation method is used during standstill, only input DI_0 counts.

If the speed or overspeed is detected, only input DI_0 counts.

Tolerant discrepancy evaluation method during standstill
If the tolerant discrepancy evaluation method during standstill is used, both DI_0 and DI_4 count, and the highest value of both (DI_0, DI_4) is used.

The tolerant discrepancy evaluation method for normal speed and overspeed is identical to the strict discrepancy evaluation method, which means that only DI_0 is counted.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of pulses in each monitoring window (at the end of the monitoring window).

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In "Standstill and Overspeed monitoring" mode, the internal sensor supplies are permanently switched on, permanently assigned to the inputs, and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages
To avoid interference due to high-energy surge voltages, you need to consider the following restrictions in "Standstill and Overspeed monitoring" operating mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:
No additional restrictions apply.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:
For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 119) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.
The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:
For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 119) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.
The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Standstill and Overspeed monitoring" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:
No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:
For the power supply, use a separate power supply unit that only supplies voltage in "Standstill and Overspeed monitoring" operating mode to F-DI 8x24VDC HF digital input modules and their associated sensors.

⚠ WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the number of pulses per monitoring window.

Wiring diagram - Use case with external sensor supply

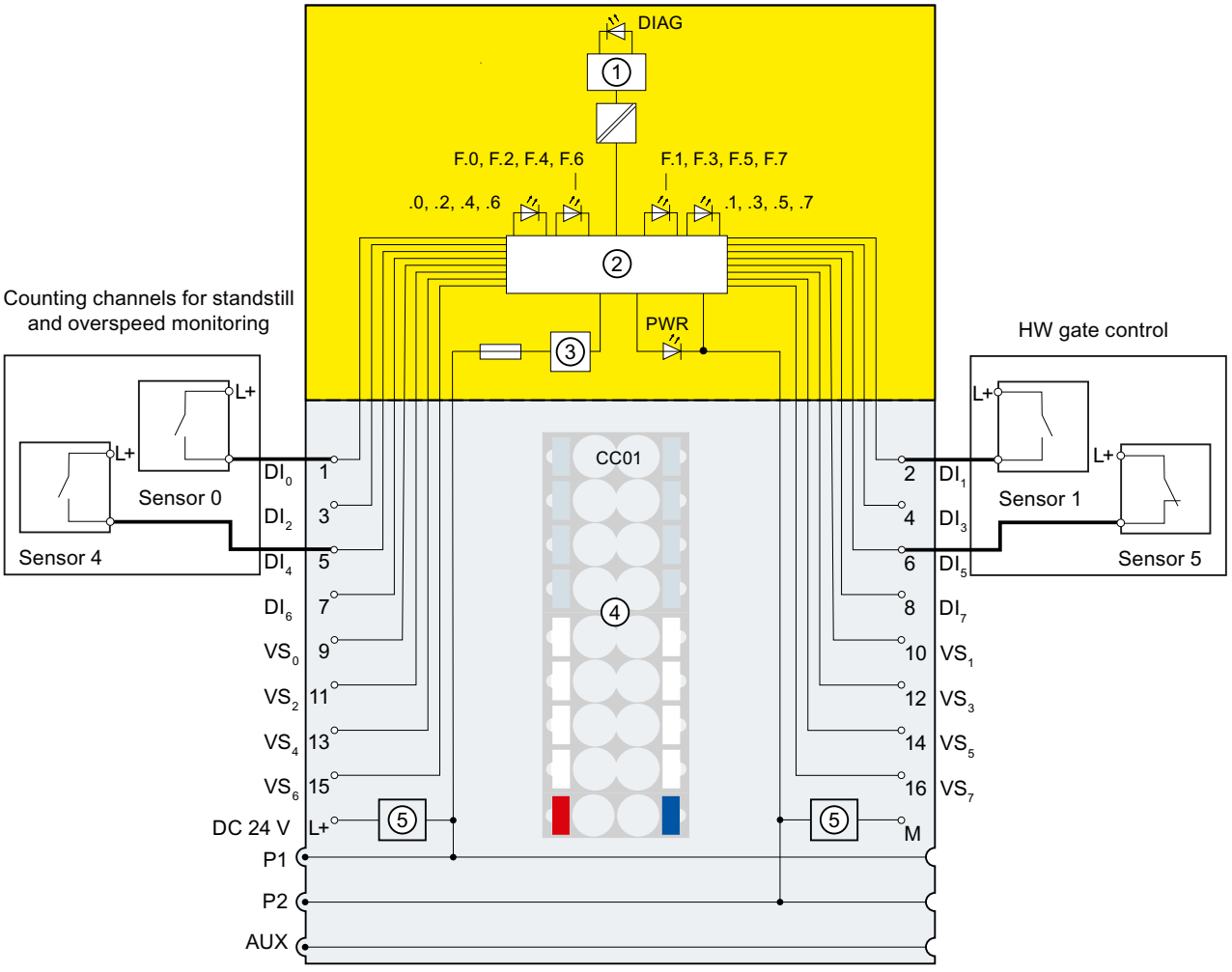


Figure 1-203 Use case with external sensor supply

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated
To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Wiring diagram - Use case with internal sensor supply

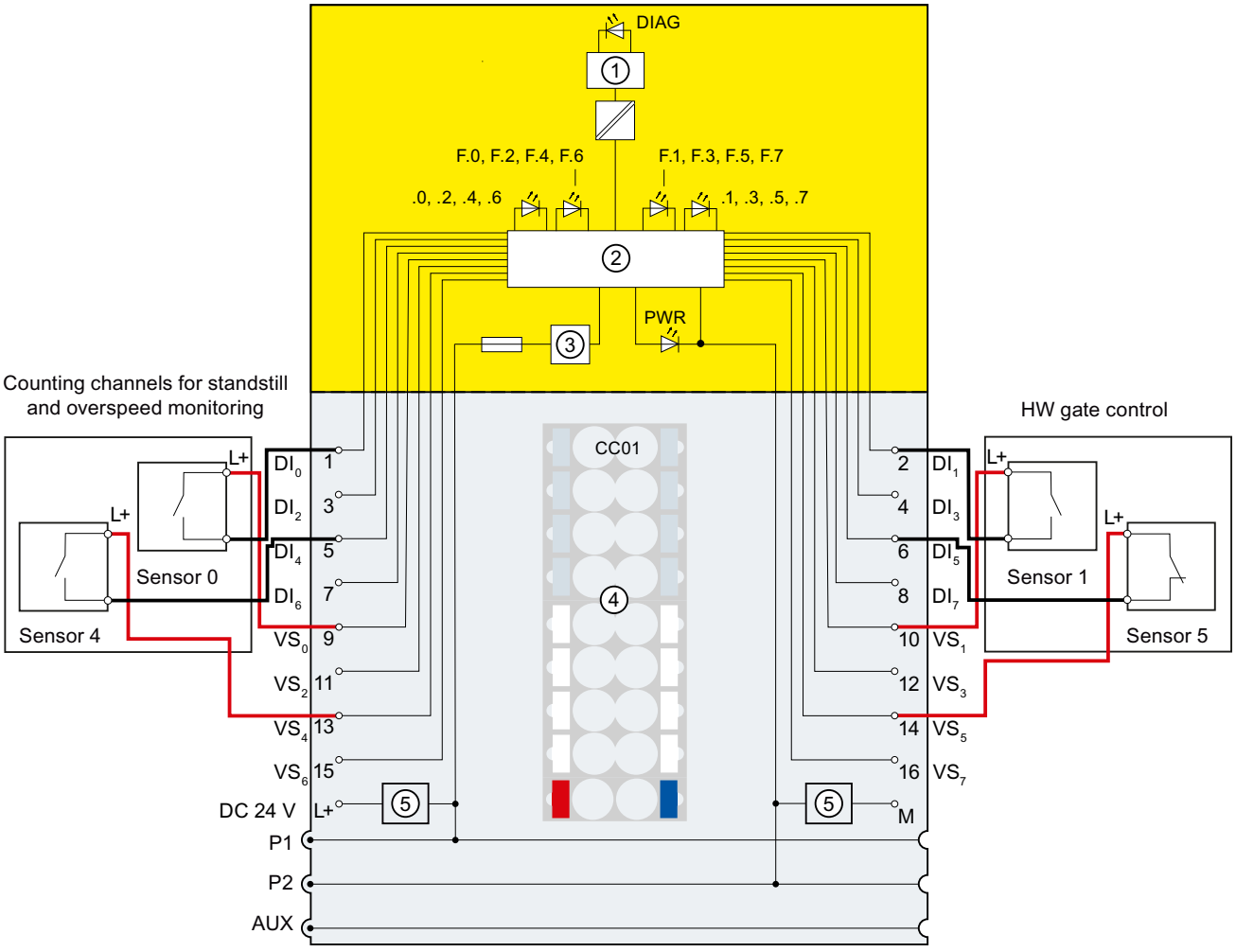


Figure 1-204 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

⚠ WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated
To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 1-478 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI

Table 1-479 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Fault detection

Table 1-480 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	No	No
Short-circuit with other channel pairs or with other sensor supplies	No	No
Short-circuit with L+ to DI_0 or DI_4	No	No
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI

Table 1-481 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

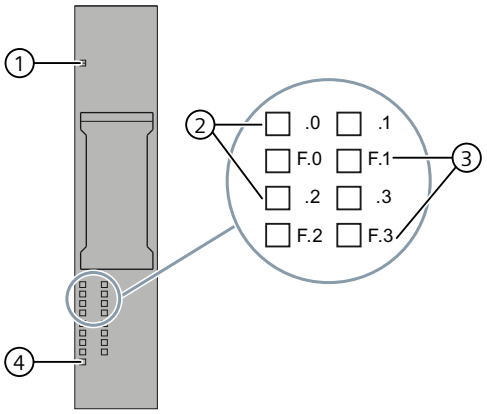
Interrupts/diagnostic messages

7

7.1 Status and error display

LED display

The following figure shows you the LED display of the F-DI 8x24VDC HF.



① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 1-205 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 112).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 1-482 DIAG LED fault display

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation at F-CPUs S7-1200/1500: At least one channel waits for a user acknowledgement.
Flashing	• Operation at F-CPUs S7-1200/1500: After a module fault, the F-module waits for a user acknowledgement. • Operation at F-CPUs S7-300/400: The F-module waits for a user acknowledgement.

Channel status/channel fault LED

Table 1-483 Status display of the LED channel status/channel fault

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		At least one channel waits for a user acknowledgement.

Channel status/DIAG/channel fault LED

Table 1-484 Status display of the LED channel status/DIAG/channel fault

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the PROFIsafe address of the configuration or there is a module-wide error. See section Interrupts (Page 110)
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 1-485 Status display of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ not present
■ On	Supply voltage L+ present

7.2 Interrupts

Introduction

The fail-safe digital input module F-DI 8×24VDC HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 112).

The following list provides you with an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledgment of a diagnostic message, eliminate the respective error and validate your safety function. Proceed as described in section Diagnostic messages (Page 112) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Parameter error
- Supply voltage missing
- Communication fault
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F parameter set incorrect
- CRC1 fault
- Device-specific diagnostics information, see manual
- Inconsistent iParameter (iParCRC error)
- F_Block_ID not supported

- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Acknowledge required to enable channel(s) - as channel error(s) are remedied.
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostic queue overflow
- F-address memory not accessible
- No valid F-address available
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- Wire break
- Discrepancy failure, channel status 0/0
- Discrepancy failure, channel status 0/1
- Discrepancy failure, channel status 1/0
- Discrepancy failure, channel status 1/1
- Input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to ground
- Sensor signal flutters
- Frequency too high
- Discrepancy error
- Input shorted to P
- Channel passivated
- Counter discrepancy limit exceeded

7.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

NOTE

If you are using a GSDML file for configuring the F-module, other error codes will be supplied. In this case you must multiply the listed error numbers by 0x40 (e.g. 0x05 * 0x40 = 0x140). However, the text in the CPU diagnostic buffer corresponds to the text of the diagnostic interrupt as listed in the table below.

Table 1-486 Diagnostic messages of the F-DI 8x24VDC HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 119)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_H	Possible causes: • There is an interrupted cable between the module and sensor. • The channel is not connected (open).	Establish a cable connection.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	• Correct the parameter assignment. • Check whether a coding element is available.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the BaseUnit • Check BaseUnit type
Communication fault	13_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.
Mismatch of safety destination address (F_Dest_Add)	40_H	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Safety destination address not valid (F_Dest_Add)	41_H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Safety source address not valid (F_Source_Add)	42_H	The PROFIsafe driver has detected an invalid F-source address.	

Diagnostic message	Fault code	Meaning	Remedy
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The PROFIsafe driver has detected an invalid watchdog time.	Check the parameter assignment of the PROFIsafe driver.
Parameter F_SIL exceeds SIL from specific device application	44_H	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47_H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameter (iParCRC error)	$4B_H$	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment of the PROFIsafe driver.
F_Block_ID not supported	$4C_H$	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between F-CPU and F-module is interrupted. • Impermissibly high electromagnetic interference is present. • An error has occurred during the sign-of-life monitoring.	• Check the communication link between the F-module and the F-CPU. • Eliminate the cause of the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Make sure that your communication is operating correctly.
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	$4F_H$	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.
Watchdog tripped	103_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostic queue overflow	$13E_H$	Overflow of the diagnostic memory. Not all pending diagnostics could be sent. This error can result in deactivation of the module up to switching on/off of the power supply.	Eliminate the previously reported error.

Diagnostic message	Fault code	Meaning	Remedy
Discrepancy failure, channel status 0/0	300_H	The discrepancy time set for 1oo2 evaluation was exceeded. Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short-circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring. You must eliminate the occurred error within 100 hours if no short-circuit test has been configured for the corresponding sensor supply.
Discrepancy failure, channel status 0/1	301_H		
Discrepancy failure, channel status 1/0	302_H		
Discrepancy failure, channel status 1/1	303_H		
Input signal not recorded unique	305_H	An error occurred during the plausibility check of the input signal between the processors. Possible causes: • The input signal is faulty. For example, through an impermissibly high electromagnetic interference. • There is a high-frequency input signal. For example, through reciprocal interference of the sensors, or the signal lies above the sampling frequency of the input signal. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • The sensor/switch bounces.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • There is a short-circuit of the internal sensor supply with L+. • There is a short-circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short-circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.
Overload or internal sensor supply short-circuit to ground	307_H	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short-circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
F-address memory not accessible	$30D_H$	F-source address placed in the electronic coding element and F-destination address cannot be accessed.	Check whether the coding element is available. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is stored in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between setpoint and actual configuration of the plant	• Perform the assignment of the PROFIsafe address during initial commissioning or deliberate parameter changes. • Check the consistency between the setpoint and actual configuration.

Diagnostic message	Fault code	Meaning	Remedy
Sensor signal flutters	310_H	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor/switch is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Frequency too high	311_H	The switching frequency of the sensor is too high. For counter as well as standstill and overspeed monitoring: This error can be detected even when the gate signal is closed.	Reduce the switching frequency of the sensor.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 119))
Discrepancy error	314_H	The discrepancy time set for 1oo2 evaluation was exceeded. The error message is output for channel n+4. Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring: This error indicates that the edges on the two channels do not match: • For counter, the edges were not matched within the configured discrepancy time. • For counter, a gate start was triggered while an unmatched edge was unresolved. • During standstill and overspeed monitoring, an out-of-sequence edge was detected using the strict discrepancy evaluation method during standstill. • During standstill and overspeed monitoring with either of the two discrepancy evaluation methods, both signals are logical 0 at the same time.	Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring: Determine and resolve the cause for the discrepancy error and then reset the counter or standstill and overspeed monitoring with the reset control.
Input shorted to P	$31C_H$	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	321_H	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	322_H	Possible causes: • The supply voltage is too low. • Wrong BaseUnit	• Check the supply voltage. • Use a BaseUnit of the type A0.

Diagnostic message	Fault code	Meaning	Remedy
Channel passivated	$32B_H$	Possible causes: • The high or low counting limit of the counter was violated twice without acknowledgment. • An error occurred on a hardware control channel pair.	Check the diagnostic buffer for errors that may have occurred in the hardware control channels. Resolve all existing errors and then reset the counter or the standstill monitoring with the reset control.
F-module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. Removing and inserting the module or POWER OFF – POWER ON necessary. • If the F-module cannot be put into operation anymore, consider a replacement.
Counter discrepancy limit exceeded	334_H	The counter discrepancy limit between the two channels of the counter has exceeded the permissible limit of 1.	Determine and resolve the cause for the discrepancy error and then reset the counter with the reset control.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

With subsequent voltage recovery (level must be within the specified value range for at least 1 minute (see Technical specifications (Page 119): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short-circuit to the sensor supply

When internal sensor supply is configured and short-circuit test is deactivated, short-circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is configured and short-circuit test is enabled, short-circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Behavior of the safety mat evaluation in case of cross circuit/short-circuit to the sensor supply or the digital input

With configured safety mat evaluation, short-circuits with L+, short-circuits with M and cross circuits to another channel are detected with configured safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the short-circuit/cross circuit lights up.

Behavior of the safety mat evaluation after wire break of the sensor supply cable or the cable of the digital input

With configured safety mat evaluation, the wire break is detected on all cables used for the connection of the safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the wire break lights up.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short-circuit test and the sensor power supply. For this reason, tables on fault detection for the applications are presented under:

Applications for inputs (Page 32)
Use cases for Counter (as of firmware version V3.0.0) (Page 70)
Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 100)

Detection of a cross circuit is not ensured in mixed operation between a channel with safety mat and a channel with 1oo1 or 1oo2 configuration.

Generally applicable information on diagnostics

For information on diagnostics which apply to all F-modules (e.g. reading out the diagnostic functions, passivation of channels), refer to the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

7.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by all errors.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of inputs and outputs for the value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in the following sections:

Address space (Page 31) of the "Digital inputs" operating mode

Address space (Page 65) of the "Counter" operating mode

Address space (Page 95) of the "Standstill and Overspeed monitoring" operating mode

Reference

A detailed description of the evaluation and processing of the value status can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

8

Technical specifications of F-DI 8×24VDC HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6BA01-0CA0/td?dl=en).

Article number	6ES7136-6BA01-0CA0
General information	
Product type designation	F-DI 8x24VDC HF
Firmware version	V3.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	SIMATIC Safety V20 or higher with HSP 0484
• STEP 7 configurable/integrated from version	as 6ES7136-6BA00-0CA0
• PROFINET from GSD version/GSD revision	GSDML V2.45
Operating mode	
• DI	Yes
• Counter	Yes; pulse counting, standstill and speed monitoring
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption, max.	40 mA; without load
Encoder supply	
Number of outputs	8
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes; Electronic (response threshold 0.7 A to 1.8 A)
• Output current per channel, max.	300 mA

Article number	6ES7136-6BA01-0CA0
• Output current per module, max.	800 mA; Total current of all encoders
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	7 byte; S7-300/400F CPU, 6 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	Yes; P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Digital input functions, parameterizable	
• Counter	Yes
– Number, max.	1
– Counting frequency, max.	500 Hz
– Counting direction up/down	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5 V
• for signal "1"	+15 to +30 V
Input current	
• for signal "1", typ.	3.7 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes
– at "0" to "1", min.	0.4 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.4 ms
– at "1" to "0", max.	20 ms
for technological functions	
– parameterizable	No
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	500 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No

Article number	6ES7136-6BA01-0CA0
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 2.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	29 g

Dimension drawing

See the Equipment Manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

Response times

A

Introduction

The next section shows the response times of the digital input module F-DI 8×24VDC HF. The response times of the digital input module F-DI 8×24VDC HF are included in the calculation of the response time of the F-system. To do this, use the SIMATIC STEP7 response time table (https://support.industry.siemens.com/cs/ww/en/view/93839056).

WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Times required for the calculation

- Maximum cycle time: T_{cycle} = 8.0 ms
- Max. acknowledgement time (device acknowledgement time): T_{DAT} = 16 ms

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo1 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T1 + T2

T1 = Time for short-circuit test

T2 = Startup time of sensor after short-circuit test

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo2 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay+ Discrepancy time*

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + max (T1p + T2p, T1s + T2s) + Discrepancy time*

*) Is omitted for discrepancy behavior "Supply value 0"

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

The discrepancy time is included in the calculation of the maximum response time (T_{WCDT}) and can therefore be set to 0 in the SIMATIC STEP7 response time table.

Maximum response time to external short-circuits (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = Input delay + T_{cycle} + (n * T_{cycle}) + Sum[x=0...7](Tsx)

Tsx summation term:

(T1x + T2x) < T_{cycle} → Tsx = T_{cycle}

(T1x + T2x) >= T_{cycle} → Tsx = max (T1x, T_{cycle}) + T2x

For deactivated sensor supplies or sensor supplies with deactivated short-circuit test, the value 0 has to be used in the formula for Tsx.

x = Sensor supply

T1x = Time for short-circuit test

T2x = Startup time of sensor after short-circuit test

n = Number of sensor supplies with activated short-circuit test

Below you will find two examples for calculating the maximum response time to external short-circuits on a F-DI 8×24VDC HF depending on the parameter assignment.

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
1	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
2	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
3	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
4	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
5	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
6	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
7	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Example calculation: (4.2 ms + 4.2 ms) >= 8.0 ms→ Ts = max (4.2 ms, 8.0 ms) + 4.2 ms = 12.2 ms

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	0.4	Enable	0.5	0.5	8.0	YES	8.0	5334.8
1	0.8	Enable	4.2	10	8.0	NO	18.0	5335.2
2	1.6	Enable	20	4.2	8.0	NO	24.2	5336.0
3	3.2	Enable	100	100	8.0	NO	200	5337.6
4	0.4	Disable	-	-	8.0	-	-	- *)
5	0.8	Enable	4.2	4.2	8.0	NO	12.2	5335.2
6	1.6	Enable	500	500	8.0	NO	1000	5336.0
7	3.2	Enable	2000	2000	8.0	NO	4000	5337.6

*) External short-circuits are not detected with a deactivated short-circuit test.

Example calculation channel 1: (4.2 ms +10 ms) >= 8.0 ms → Ts = max(4.2 ms, 8.0 ms) + 10 ms = 18.0 ms

Maximum response time for discrepancy error for 1oo2 evaluation (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = 2 * T_{cycle} + Input delay + 2 * max (T1p + T2p, T1s + T2s) + Discrepancy time

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

Maximum response time with no faults (Worst Case Delay Time, WCDT) for safety mat evaluation

When the safety mat is activated (the contact is closed), the maximum response time is 17.6 ms.

Maximum response time in the case of fault (One Fault Delay Time, OFDT) for safety mat evaluation

If a safety mat evaluation is only configured on one channel pair, the maximum response time in case of a fault is 25.6 ms.

If a safety mat evaluation is configured on 2 to 4 channel pairs, the maximum response time in case of a fault is 33.6 ms.

Maximum response time with no faults (Worst Case Delay Time, WCDT) for counter

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

Maximum response time to discrepancy error for counter (One Fault Delay Time, OFDT)

Maximum response time (T_{OFDT}) = 3 * T_{cycle} + Input delay + T1w

T1w = Discrepancy time limit (maximum permissible value is 30,000 ms).

Maximum response time with no faults (Worst Case Delay Time, WCDT) for standstill and overspeed monitoring

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T2w * 1.002

T2w = Monitoring window duration (maximum permissible value is 30,000 ms).

Maximum response time to discrepancy error for standstill and overspeed monitoring (One Fault Delay Time, OFDT)

To define the worst case failure response time for standstill and overspeed monitoring, the following assumptions need to be made:

- An event must occur that makes the failure noticeable. This implies a deviation from the expected pulse sequence. This event is defined as failure event.
- A type of motion must activate the sensor to trigger an event.

The failure reaction indicates the time between the occurrence of the failure event and the occurrence of a discrepancy on the backplane bus. To detect the discrepancy and pass it on to the backplane bus, 2 * T_{cycle} + Input delay are required.

SIEMENS

SIMATIC

ET 200SP
Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)

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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that affect the system in general are described in the system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to both the CPUs of the S7-1200/1500 automation system and CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in annex 1 of the report on the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

⚠ WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.
You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.
Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=24471&lc=en-WW)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary

and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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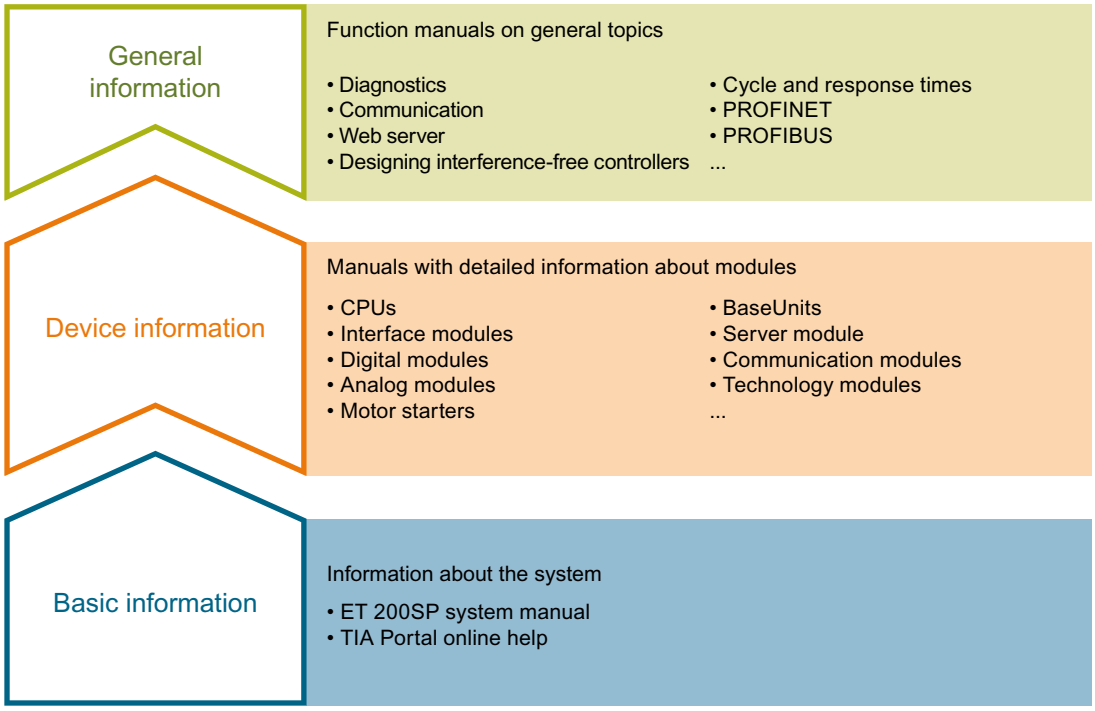
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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information
The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information
Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information
The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

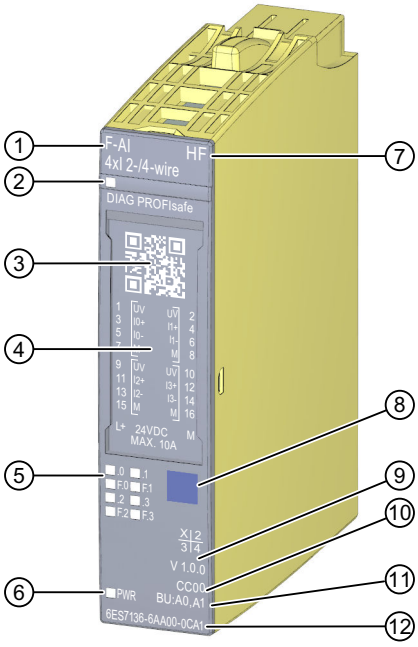
2

2.1 Properties

Article number

6ES7136-6AA00-0CA1

View of the module



①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 1-206 View of the F-AI 4xI 0(4)..20mA 2-/4-wire HF module

Properties

The module has the following technical properties:

- Fail-safe module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 4 analog inputs with electrical isolation between channels and the backplane bus (up to SIL3/Cat.4/PLd)
- Measuring ranges: 0..20 mA and 4..20 mA
- Resolution: 16 bits including sign
- Short circuit-proof power supply for 2-wire or 4-wire transmitter
- Supply voltage L+
- External sensor supply possible
- Assignable diagnostics
- Diagnostics display (DIAG, red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel- and module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Value status

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires.
The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic messages (Page 48).

NOTE

Cyclic reading of I&M data
Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector
- Electronic coding element as spare part (article number 6ES7193-6EF00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Connecting

3

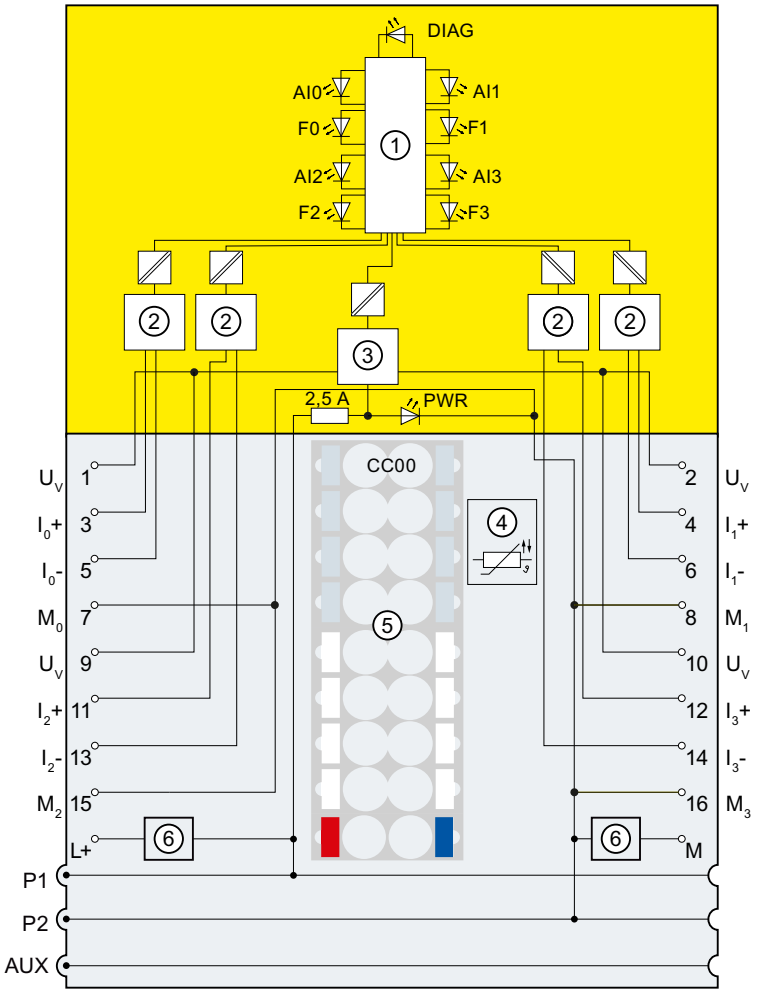
3.1 Wiring and block diagram

This section provides the block diagram of the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module with the terminal assignment.

You can find additional information about wiring BaseUnits in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Block diagram

The following figure shows the block diagram of the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module on the BaseUnit BU type A0/A1.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground to channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
I_n+	Current input positive, channel n	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n-	Current input negative, channel n	F0, F1, F2, F3	Channel fault LED (red)
		PWR	Power LED (green)

Figure 1-207 Block diagram

Sensor supply

⚠ WARNING

Voltage dips and voltage fluctuations of the voltage supply are not buffered by the F-module and, thus, affect the sensor supply.
This can cause the measured value to be false and must be taken into account when determining the safety function.
To ensure that the sensor functions problem-free, we recommend one of the following options:

- You can avoid voltage dips by using a voltage supply according to the NAMUR recommendation NE 21.

or

- Use a transducer with an appropriate battery backup or diagnostics.

Recommendation: Internal sensor supply

You are strongly advised to use the short circuit-proof internal sensor supply of the F-module. This internal sensor supply is monitored and its status is indicated by the Fn LED. The input is also protected in the event of short-circuits in the wiring or at the sensor.

NOTE

The internal sensor supply is switched off in case of a short circuit to ground or during power-up in the event of short circuit to L+.
The sensor supply is also switched off at input currents > 35 mA.
A check is made approximately 1 minute later to determine if the error has gone.

NOTE

Behavior of process values and diagnostics evaluation
Sensor startup during module startup:
After the internal sensor supply is activated, the evaluation of wire break and underflow diagnostics is suppressed for 3 seconds. During this time, the module makes the secure process data 0 available at all channels. This suppresses a possible wire break or underflow diagnostics caused by the sensor startup. If the sensor startup is not yet complete after the 3 seconds have elapsed, it is possible that the module might detect wire break or underflow and passivate the affected channel. In this case, the channel fault must be acknowledged during startup.
Sensor startup during operation:
If a sensor startup takes place during operation, e.g. the sensor supply is reactivated after a short-circuit, all analog values are invalid and wire break or underflow diagnostics can occur on the sensors connected to the internal sensor supply.

External/internal sensor supply

The figures in section "Applications of the F-I/O module (Page 34)" show how you can supply power to the sensors via an external sensor supply (for example, from another module).

⚠ WARNING

If there is a short-circuit from L+ to Mn+, the input resistors could be destroyed, depending on the selected interconnection type.
You can avoid this problem through proper wiring and use of the internal sensor supply.
When an external sensor supply is used, other suitable measures are necessary to protect the input resistors (e.g. external fast 50 mA fuse in the input circuit of the F-module).

⚠ WARNING

External sensor supply
If you use an external sensor supply, you need to take into consideration the voltage dips and voltage fluctuations when determining the safety function.
To ensure that the sensor functions problem-free, we recommend one of the following options:

- Use a transducer with an appropriate battery backup or diagnostics.
  or
- Use a **redundant** external sensor supply
  or
- **Monitor** the external sensor supply for undervoltage/overvoltage, including shutdown of the sensor supply in the event of a fault (single channel for SIL2; two-channel for SIL3).

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 1-487 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Current	0 to 20 mA (2-wire and 4-wire transducer) 4 to 20 mA (2-wire and 4-wire transducer)	16 bits including sign 16 bits including sign

You can find the tables of the measuring ranges as well as overflow, overrange, etc. in the Appendix Representation of analog values (Page 60).

4.2 Parameters

Parameters for F-AI 4xI 0(4)..20mA 2-/4-wire HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 34).

The following parameters are possible:

Table 1-488 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	depends on parameter assignment of F-CPU	No	Module
F-destination address	1 to 65534	suggested by F-system	No	Module
F-parameter signature (without address)	0 to 65535	calculated by F-system	No	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	suggested by F-system	No	Module
F-I/O DB name	—	suggested by F-system	No	Module
AI parameters				
Interference frequency suppression	• 50 Hz • 60 Hz	50 Hz	No	Module
Channel parameters:				
Channel n				
Sensor evaluation	• 1oo1 evaluation (max. SIL3/Cat.3/PLd) • 1oo2 evaluation (max. SIL3/Cat.4/PLe)	1oo1 evaluation (max. SIL3/Cat.3/PLd)	No	Channel
Standard value	• MIN • MAX	MIN	No	Channel
Discrepancy time *	100 to 30000 ms	100 ms	No	Channel
Tolerance window %, absolute	2.0 to 20.0%	5.0%	No	Channel
Tolerance window %, relative	2.0 to 20.0%	5.0%	No	Channel
Activated	• Disable • Enable	Enable	No	Channel
Channel fault acknowledgment	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Measuring range	• 0 to 20 mA • 4 to 20 mA	4 to 20 mA	No	Channel
Diagnostics: Wire break **	• Disable • Enable	Enable	No	Channel
Smoothing	• 1 • 2 • 4 • 8 • 16 • 32 • 64	1	No	Channel

* See formula under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23)

* Can only be set with 4 to 20 mA measuring range

4.3 Explanation of parameters

4.3.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Base for PROFIsafe addresses" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

4.3.2 Parameters of the channels

4.3.2.1 Interference frequency suppression

Here you set the interference frequency suppression for the line frequency:

- 50 Hz
- 60 Hz

You can find additional information on this in the Analog value processing function manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

4.3.2.2 Evaluation of the sensors

Overview

Here you select the type of sensor evaluation:

- "1oo1 evaluation (max. SIL3/Cat.3/PLd)"
- "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

If you do not want to measure with a channel or channel pair, disable the channel or the channel pair.

1oo1 evaluation (max. SIL3/Cat.3/PLd)

With the 1oo1 evaluation, there is one sensor, and it is connected to the F-module via a single channel.

1oo2 evaluation (max. SIL3/Cat.4/PLe)

With the 1oo2 evaluation, two input channels are occupied by:

- Two single-channel sensors
- One two-channel sensor

Note that in 1oo2 evaluation, two channels are combined into a channel pair.

Achievable safety class

Depending on the selected sensor evaluation, you achieve the following safety classes with a sensor that is qualified accordingly:

- SIL3/Cat.3/PLd for "1oo1 evaluation" or
- SIL3/Cat.4/PLe for "1oo2 evaluation"

See also

Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23)

4.3.2.3 Standard value

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can choose for each input channel pair which of the two F-CPU values is provided.

- "MIN": the lesser of the two values.
- "MAX": the greater of the two values.

During a discrepancy between the two input channels, the last valid standard value prior to the occurrence of the discrepancy is made available to the F-CPU.

4.3.2.4 Discrepancy time

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the discrepancy time for each channel pair here in milliseconds.

The discrepancy time does not start until the standard value is outside the assigned tolerance window (relative or absolute). If the two redundant input channels of the channel pair differ by more than the specified tolerance and for longer than the specified discrepancy time but no longer than the duration of the maximum response time, the F-module detects a discrepancy error and triggers a diagnostic interrupt. If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.

You can find additional information about configuring the discrepancy analysis under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.3.2.5 Tolerance window %, absolute

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for the channel pair. You specify the tolerance window as a percentage of the full-scale value. The reference value is the full-scale value, i.e. 20 mA. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

For more information regarding setting the tolerance window, refer to Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

Example

You have assigned the following:

- The "Tolerance window % absolute" 10%
- The measuring range 0..20 mA
- A discrepancy time of 100 ms

The input channels may differ from the configured discrepancy time (100 ms) up to the max. reaction time for a time window with a difference of more than 2 mA.

See also

Discrepancy time (Page 21)

4.3.2.6 Tolerance window %, relative

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for each channel pair. You specify the tolerance window as a percentage of the assigned standard value. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

The two parameters "Tolerance window % absolute" and "Tolerance window % relative" are combined. The "Tolerance window % absolute" parameter is decisive in case of low process values.

For more information regarding setting the tolerance window, refer to Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

Example

You have assigned the following:

- The "tolerance window % relative" is set at 10%
- A measuring range of 0 to 20 mA
- A discrepancy time of 200 ms
- A unit value of 20 mA

The input channels may differ from the configured discrepancy time (200 ms) up to the max. reaction time for a time window with a difference of more than 2 mA.

See also

Discrepancy time (Page 21)

4.3.2.7 Parameter assignment of discrepancy analysis for 1oo2 evaluation

Operating principle of discrepancy analysis

A discrepancy analysis is performed with a configured 1oo2 evaluation. **Smoothed** process values are used for the discrepancy analysis.

An assignable tolerance window is formed around the process value that represents the instantaneous standard value (value that is signaled to the F-CPU).

The tolerance window is formed relative to the process value or as an absolute value relative to the measuring range end value. Relative and absolute tolerance windows are combined.

If the process value does not represent the standard value at an instant and is within the tolerance window, **no** discrepancy exists.

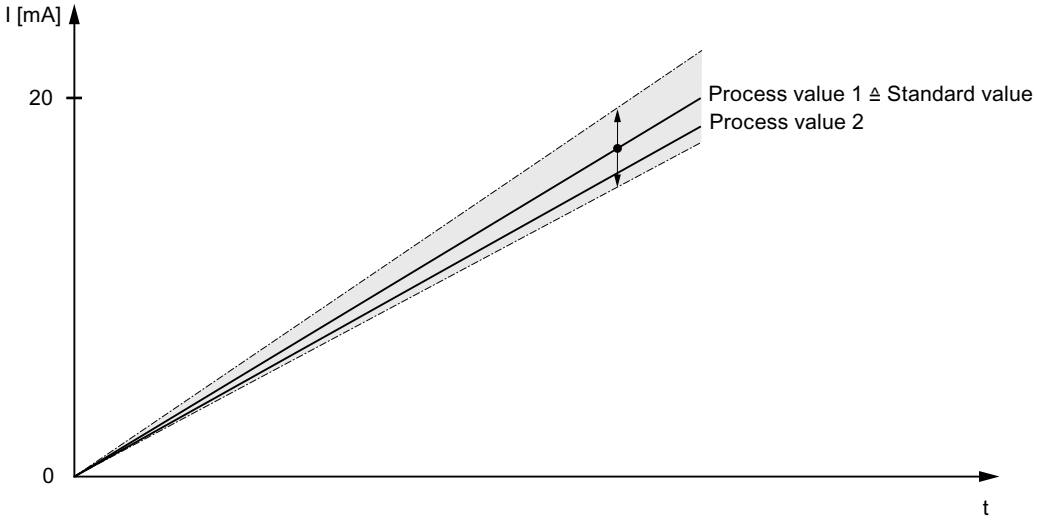


Figure 1-208 Example of a relative tolerance window *without* discrepancy (parameter assignment: standard value = MAX)

If the process value does not represent the standard value at an instant but is outside the tolerance window, a discrepancy exists.

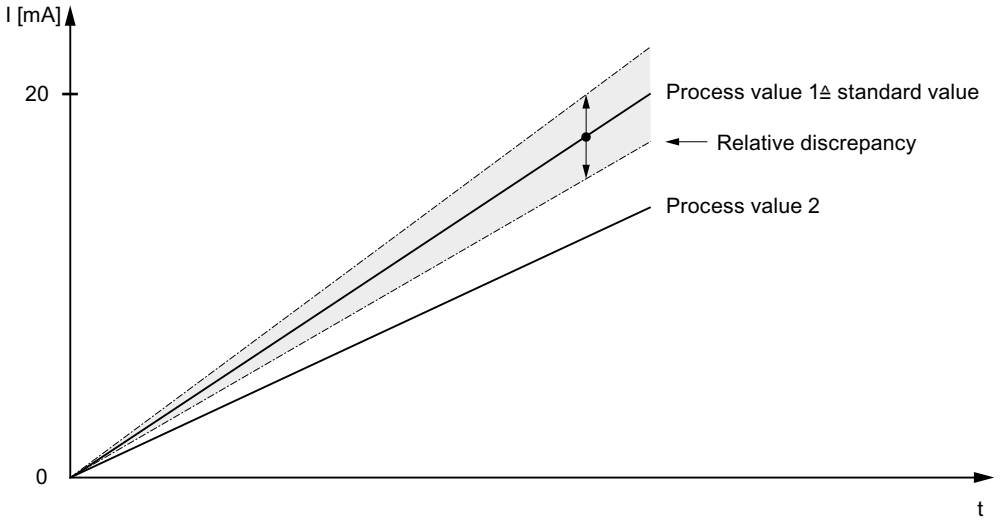


Figure 1-209 Example of a relative tolerance window *with* discrepancy (parameter assignment: standard value = MAX)

The assigned discrepancy time starts as soon as a discrepancy is detected. The discrepancy time runs as long as the discrepancy exists.

- During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.

  If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.
- There is no valid old value after startup. If the discrepancy is detected during this time, $7FFF_H$ is output for S7-300/400 F-CPUs or 0 is output for S7-1200/1500 F-CPUs and the discrepancy time is started.

  If there is no longer a discrepancy between the input channels when the discrepancy time expires, the standard value is output.

If the discrepancy time has expired, an error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the STEP 7 Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Configuring the discrepancy analysis parameters

The following four parameters for the discrepancy analysis are assigned for each channel pair:

- Discrepancy time
- Standard value
- Tolerance window %, absolute
- Tolerance window %, relative

"Discrepancy time" parameter

If the following is true, the F-module detects a discrepancy error:

- The process value that does not represent the standard value is outside the configured tolerance window.
- Lasts longer than the configured discrepancy time.
- Lasts at maximum the duration of the maximum response time.

In the case of a discrepancy error, the F-module triggers a diagnostic interrupt and sets the process value to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. The discrepancy time is reset if the standard value lies within the tolerance window again.

In the PII, the substitute value 0 is set for the safety program.

You calculate the maximum discrepancy time that is permitted in the respective application using the following formula:

Discrepancy time = Maximum response time (in case of discrepancy error) – 2 × Conversion cycle time × Smoothing – 2 × Conversion cycle time

NOTE

You calculate the discrepancy time by using the values from section Discrepancy time (Page 58) in the above equation.

You can assign the discrepancy time for each channel pair.

"Standard value" parameter

You can select which of the two values is to be signaled to the F-CPU for each input channel pair. During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.

- "MIN": The lower of the two values is signaled to the F-CPU as the standard value.
- "MAX": The higher of the two values is signaled to the F-CPU as the standard value.

"Tolerance window %, absolute" parameter

You can calculate the absolute tolerance window using the following formula:

$$T_{abs} = \frac{|\Delta I_{abs}|}{I_{ME} - I_{MA}} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta I_{abs} = \pm \frac{(I_{ME} - I_{MA}) \times T_{abs}}{100} \ [mA]$$

With

- I_{ME} = 20 mA (full-scale value)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA (start-of-scale value)
- I_{MA} = 4 mA for measuring range 4 ... 20 mA (start-of-scale value)
- T_{abs} = Tolerance in %
- ΔI_{abs} = Maximum deviation of current (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, absolute" parameter for each channel pair.

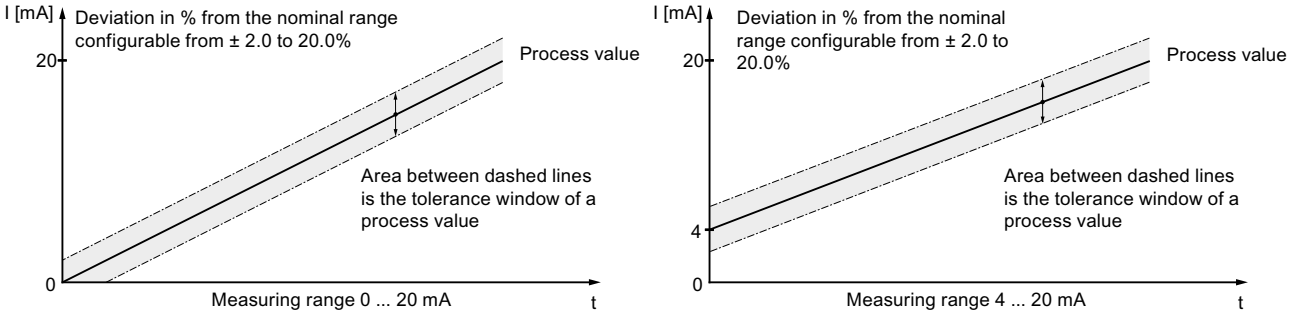


Figure 1-210 Absolute deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

"Tolerance window %, relative" parameter

The tolerance window is calculated as a percentage of the **smoothed** process value that represents the MIN or MAX value (depending on the parameter assignment of the standard value) in this instant.

You can calculate the relative tolerance window using the following formula:

$$T_{rel} = \frac{\left| \Delta I_{rel} \right|}{\left| I_{EW} - I_{MA} \right|} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta I_{rel} = \pm \frac{\left| I_{EW} - I_{MA} \right| \times T_{rel}}{100} \ [mA]$$

With

- I_{EW} = Process standard value (min./max.)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA
- I_{MA} = 4 mA for measuring range 4 ... 20 mA
- T_{rel} = Tolerance in %
- ΔI_{rel} = Maximum deviation of current (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, relative" parameter for each channel pair.

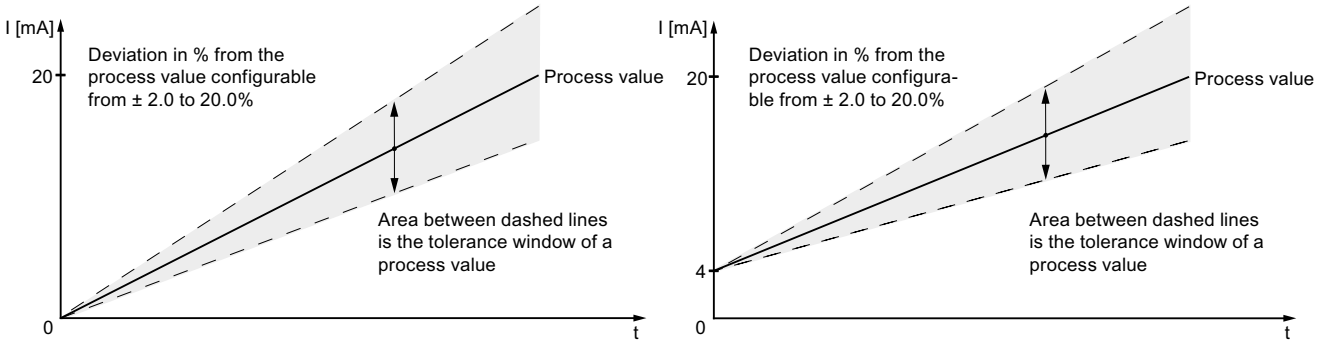


Figure 1-211 Relative deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

Combination of the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters

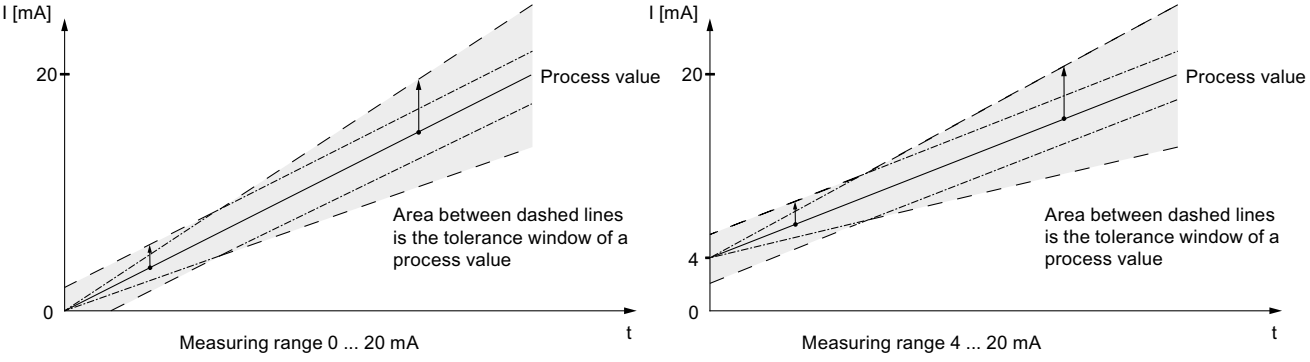
You can combine the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters as needed. The combined tolerance window (shown in gray in the figure below) is the maximum of T_{rel} and T_{abs}.

$T = MAX \{ T_{rel}, T_{abs} \}$

$\Delta I = MAX \{ \Delta I_{rel}, \Delta I_{abs} \}$

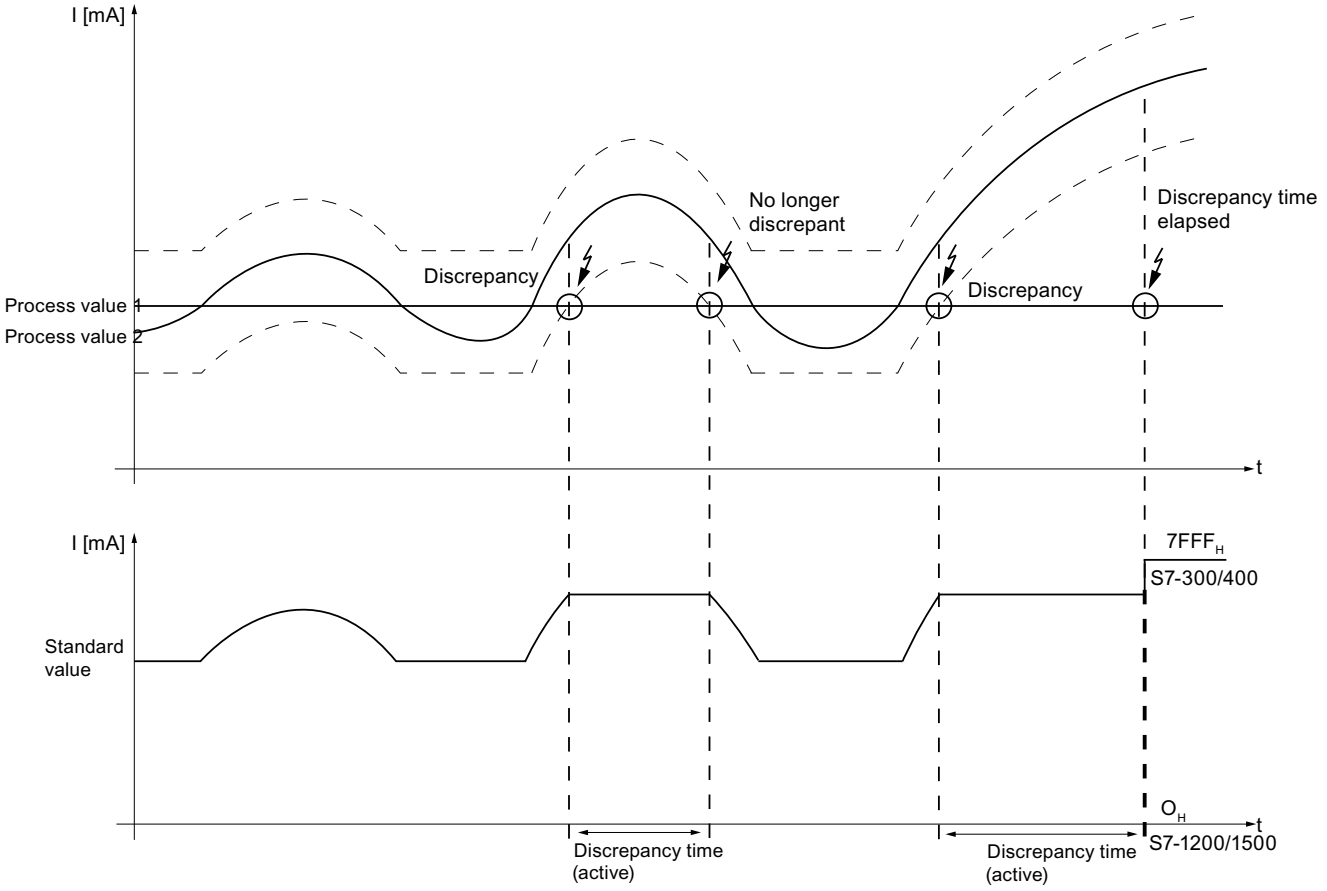
With

- T = Tolerance, in %
- ΔI = Maximum deviation of current (+/-)



Example

The following diagrams show you the behavior of the discrepancy evaluation when standard value = MAX.



The upper of the two diagrams shows you the characteristic curve of the two process values. The dashed line represents the absolute tolerance range configured in this example.

The lower of the two diagrams shows you the standard value signaled to the F-CPU.

In this example, on the first occurrence of a discrepancy, process value 1 is **within** the tolerance range again **before** expiration of the discrepancy time. This means the discrepancy error is not signaled.

In this example, on the second occurrence of a discrepancy, process value 1 is **outside** the tolerance range when the discrepancy time expires. As a result, a discrepancy error is signaled with 7FFF$_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs after expiration of the discrepancy time. In the PII, the substitute value 0 is set for the safety program.

See also

Discrepancy time (Page 21)
Tolerance window %, absolute (Page 22)
Tolerance window %, relative (Page 22)

4.3.2.8 Activated

If you select this check box, the corresponding channel is enabled for signal processing.

You can deactivate an unused channel with this parameter.

If you deactivate unused channels, the response time of the F-module is reduced.

4.3.2.9 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module can be operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.3.2.10 Measuring range

You select the measuring range for the channel with this parameter:

- 0 to 20 mA
- 4 to 20 mA

4.3.2.11 Diagnostics: Wire break

Function

Here you activate wire break detection for a configured measuring range of 4 to 20 mA.

With an assigned measuring range of 4 to 20 mA:

- With assigned wire break diagnostics and currents < 3.6 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without configured wire break and currents diagnostics < 0.4444 mA detects "underflow" and triggers a diagnostic interrupt in the F-CPU.

With an assigned measuring range of 0 to 20 mA, the wire break diagnostics is permanently set by default. With currents < 0.4442 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.

If you do not need a channel, deactivate the channel. Then, a wire break is not detected.

4.3.2.12 Smoothing

Using smoothing

Smoothing of analog values provides a stabilized analog signal for further processing. Smoothed values are always used for discrepancy analysis.

⚠ WARNING

The smoothing takes place as a result of averaging over the selected number of most recently converted analog values of a channel, e.g. 64.
The mean value generation causes a discrepancy to be delayed with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)". You can find an example below.

Smoothing principle

The measured values are smoothed by a digital filter. Smoothing is achieved by the F-module forming the mean of a number of converted (digitized) analog values determined by the "Smoothing" parameter.

You assign smoothing in 7 levels (1, 2, 4, 8, 16, 32, 64 conversion cycles). The level determines the number of analog signals that are averaged. If smoothing = 1 is configured, the smoothing is deactivated.

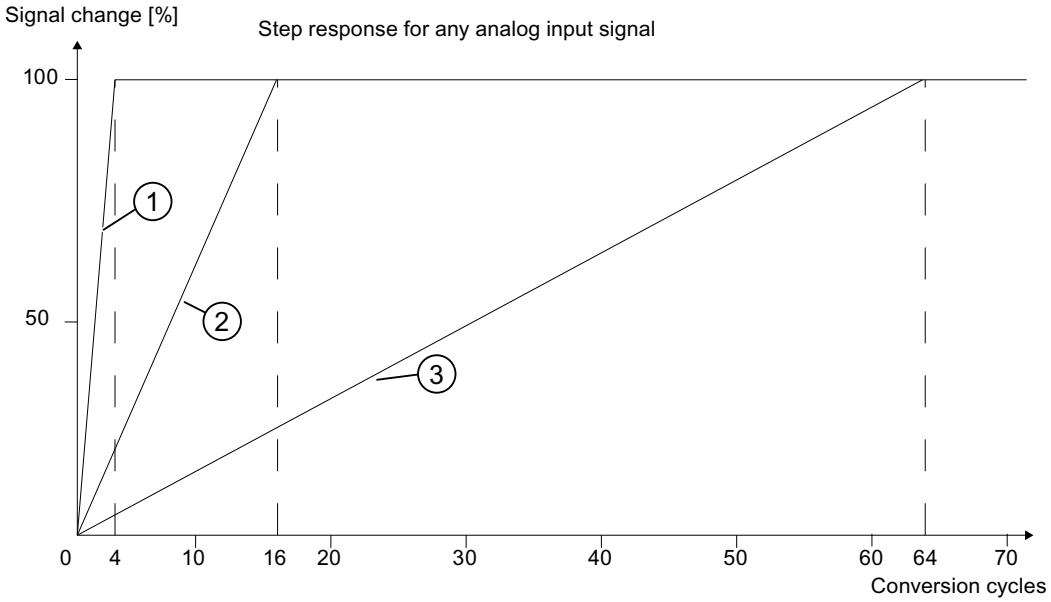
A higher smoothing provides a more stable analog value, and prolongs the time it takes to apply a smoothed analog signal following a unit step. You can find an example below.

NOTE

Smoothing is reset after startup, short circuit, wire break or another channel fault. If, for example, smoothing with 16 conversion cycles is assigned and all channels are active, it takes up to 2000 ms until the process value is signaled with a configured interference frequency suppression of 50 Hz.
Until the first valid process value, the F-module signals for the channel $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.
If a discrepancy occurs, measuring and smoothing continues and is not restarted.

Example

The figure below shows the number of conversion cycles, depending on the smoothing setting, after which the analog value is completely smoothed and available in the case of a unit step. The figure applies to all signal changes at the analog input.



① Smoothing - 4 conversion cycles
② Smoothing - 16 conversion cycles
③ Smoothing - 64 conversion cycles

Example: Effect of smoothing on the maximum response time for a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)" in case of error

If an error (One Fault Delay Time, OFDT) occurred with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you calculate the maximum response time according to the following formula:

Maximum response time (in case of discrepancy error) = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

Example: One channel pair connected and configured (activated), interference frequency 50 Hz, smoothing = 16 conversion cycles, discrepancy time = 2000 ms, conversion cycle time calculated with the formula from section Response times (Page 58):

Max. response time (in case of discrepancy error) = 2 × 70 ms × 16 + 2000 ms + 2 × 70 ms = 4380 ms

If a discrepancy exists between the two input channels, it can take 4380 ms until the F-module signals a discrepancy error to the F-CPU.

If the discrepancy time expires, an error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

4.4 Address space

Address assignment for the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF

The analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF occupies the following address areas in the F-CPU:

Table 1-489 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 12	QB x + 0 to x + 3
S7-1200/1500 F-CPUs	IB x + 0 to x + 13	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF

The user data occupy the following addresses in the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF out of all the assigned addresses in the F-CPU:

Table 1-490 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/2)							
IB x + 1								
IB x + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/3)							
IB x + 3								
IB x + 4	Input value at channel 2							
IB x + 5								
IB x + 6	Input value at channel 3							
IB x + 7								
IB x + 8	—	—	—	—	Value status* for AI_3	Value status* for AI_2	Value status* for AI_1	Value status* for AI_0

* Only S7-1200/1500 F-CPUs

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

You achieve SIL3/Cat.4/PLe with the following applications.

The wiring is performed on the suitable BaseUnit. Additional information is available in the Connecting section in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

5.1 Application 1: Safety mode SIL3/Cat.3/PLd with 2-wire transducer

Introduction

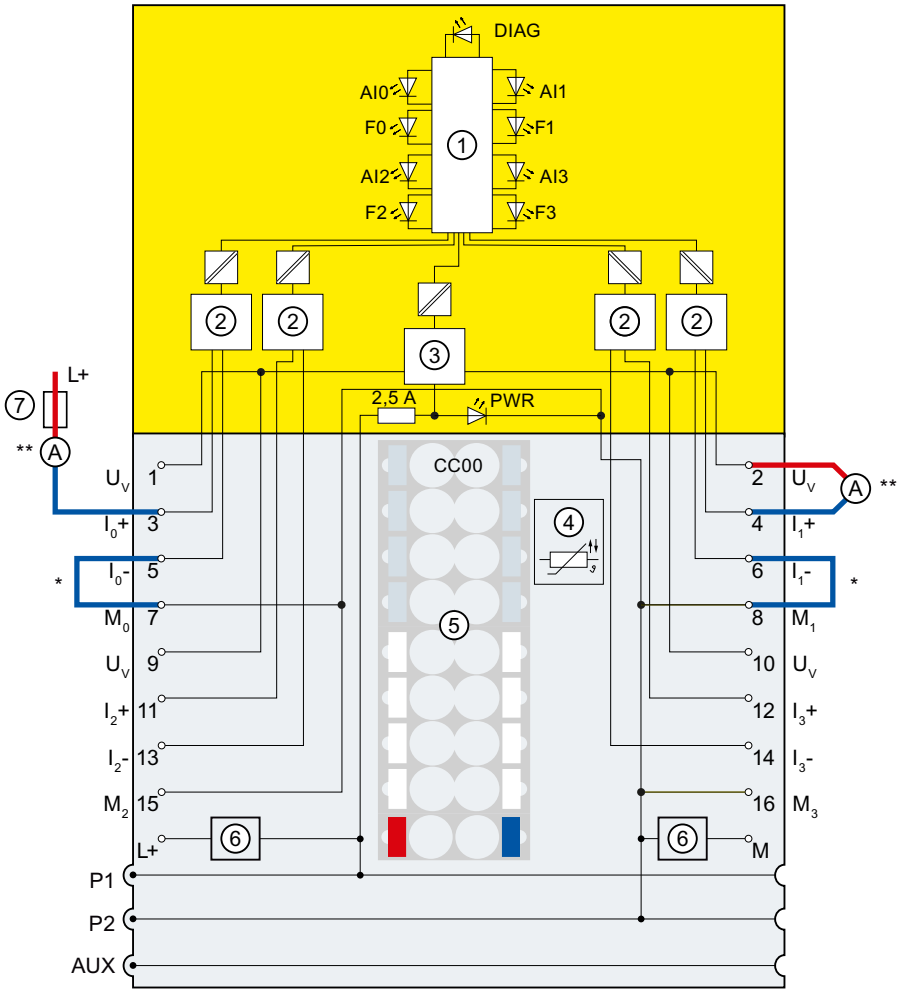
Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 1: Safety mode SIL3/Cat.3/PLd, 1oo1 (1v1) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 48)".

Current measurement 0/4 to 20 mA, 2-wire transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)

I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Create the bridge directly at the terminal connection.	**	Measuring transducer

Figure 1-212 1oo1 evaluation

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 1

Table 1-491 Parameters for application 1 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 ... 20 mA • 4 ... 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.2 Application 2: Safety mode SIL3/Cat.4/PLe with 2-wire transducer

Introduction

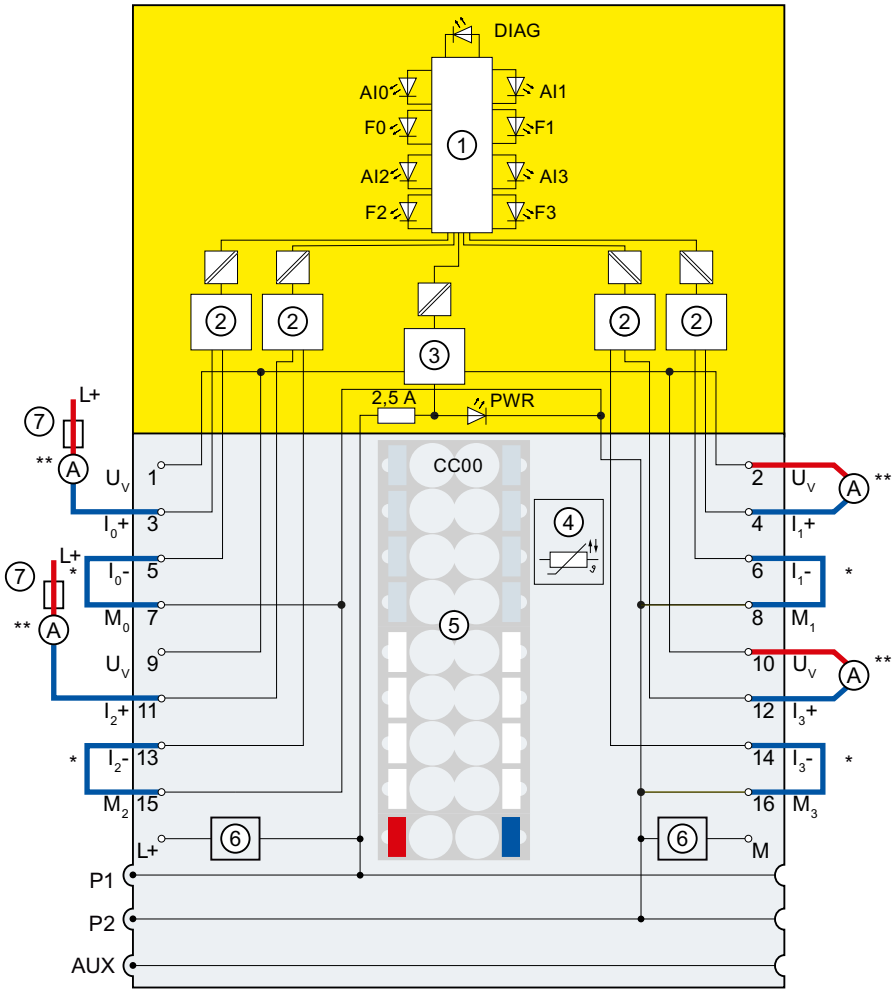
Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- application 2: Safety mode SIL3/Cat.4/PLe, 1oo2 (2v2) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 48)".

Current measurement 0/4 to 20 mA, 2-wire transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)

I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Create the bridge directly at the terminal connection.	**	Measuring transducer

Figure 1-213 1oo2 evaluation

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified, two-channel sensor or two qualified single-channel sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 2

Table 1-492 Parameters for application 2 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.3 Application 3: Safety mode SIL3/Cat.3/PLd with 4-wire transducer

Introduction

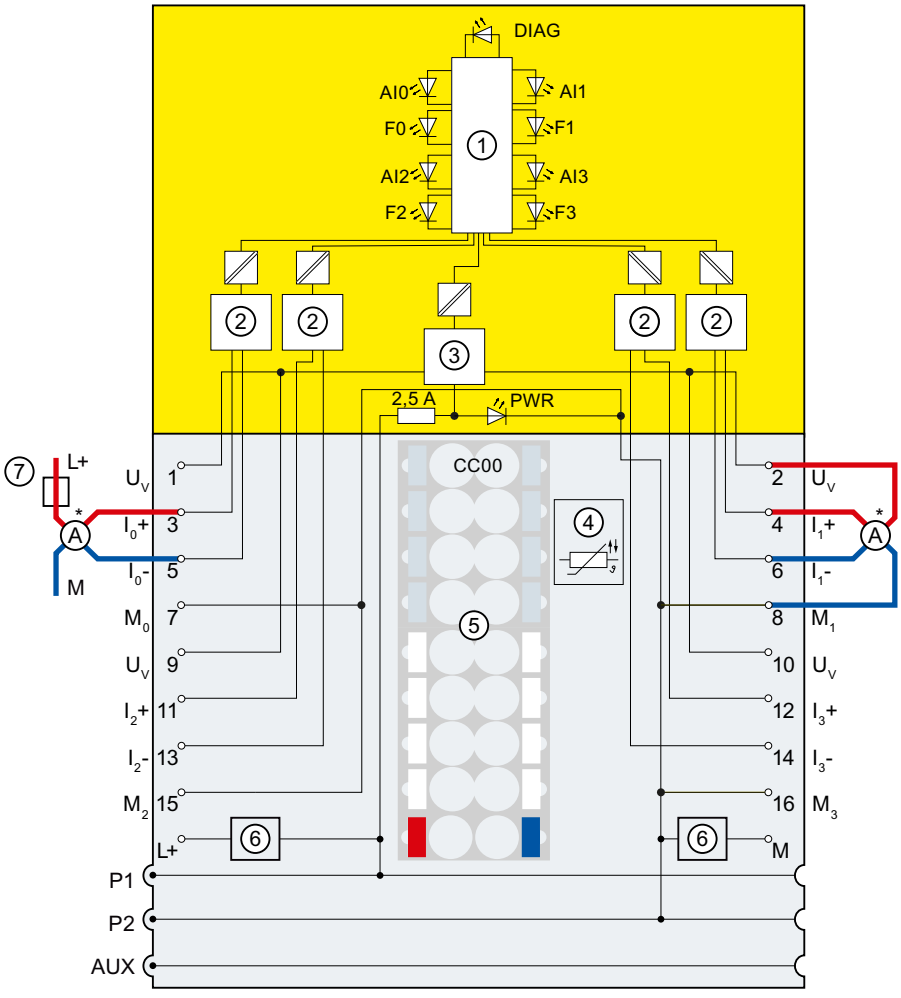
Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 3: Safety mode SIL3/Cat.3/PLd, 1oo1 (1v1) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 48)".

Current measurement 0/4 to 20 mA, 4-wire transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 1-214 1oo1 evaluation

⚠ WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 3

Table 1-493 Parameters for application 3 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.4 Application 4: Safety mode SIL3/Cat.4/PLe with 4-wire transducer

Introduction

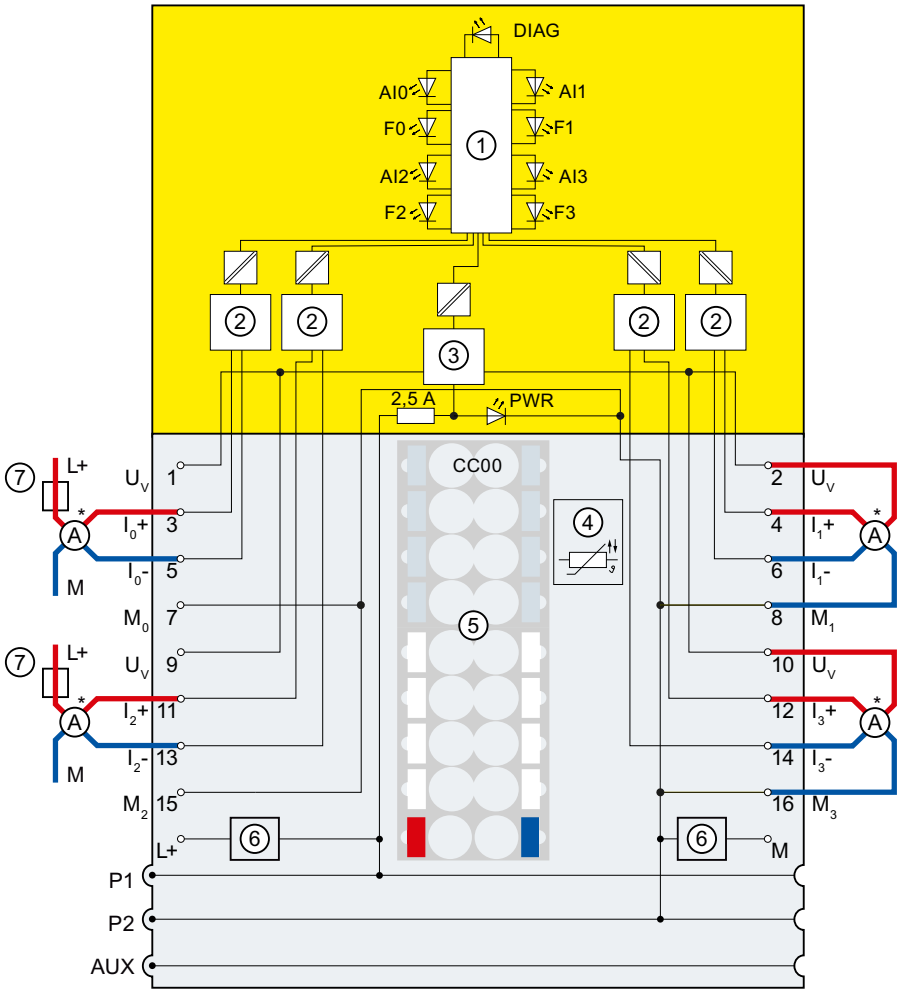
Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire for

- application 4: Safety mode SIL3/Cat.4/PLe, 1oo2 (2v2) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 48)".

Current measurement 0/4 to 20 mA, 4-wire transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 1-215 1oo2 evaluation

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use suitably qualified sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 4

Table 1-494 Parameters for application 4 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)

Parameters	Range of values in safety mode
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

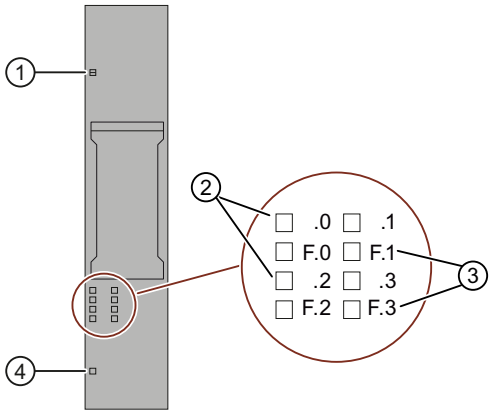
Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-AI 4xI 0(4)..20mA 2-/4-wire HF.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 1-216 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostic messages (Page 48).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 1-495 Error display of the LED DIAG

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for a user acknowledgment.
Flashing	• Operation in S7-1200/1500 F-CPUs: The F-module is waiting for a user acknowledgment after a module fault. • Operation in S7-300/400 F-CPUs: The F-module is waiting for a user acknowledgment.

Channel status/channel fault LED

Table 1-496 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or supply voltage L+ missing.
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
Alternately flashing		At least one channel is waiting for a user acknowledgment.

Channel status/DIAG/channel fault LED

Table 1-497 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address.
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address.

PWR LED

Table 1-498 Status display of LED PWR

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 48).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 48)

Scope of diagnostic interrupt: F-module

- Overtemperature
- Parameter error
- Supply voltage missing
- Channel/component temporarily not available
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog timer value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F-parameter set incorrectly
- CRC1 fault
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported

- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (monitoring time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostics memory overflow
- Channel failure acknowledgment
- F-address memory not accessible
- No valid F-address available
- Diagnostics memory overflow
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- Channel/component not available

Scope of diagnostic interrupt: Channel

- Diagnostics: Wire break (can only be configured for measuring range 4..20mA)
- High limit exceeded
- Low limit violated
- Safety-related switch off
- Internal supply voltage of the module failed
- Common mode error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Discrepancy error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Read back failure
- ADC error
- Fault in test circuit

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 1-499 Diagnostic messages of the F-AI 4xI 0(4)..20mA 2-/4-wire HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	The F-module measured an excessively high temperature.	Operate the F-module within the specified temperature range (see Technical specifications (Page 53)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_H	Possible causes: • A cable to the sensor is broken. • Fault at the external circuit • Defective sensor • Wrong sensor type set in the parameters • Input channel not used • Measurement resistance too high	Check the possible causes and eliminate the fault.
High limit exceeded	7_H	The measured value exceeds the measuring range.	Check the interaction between the module and the sensor.
Low limit violated	8_H	The measured input value is below a measuring range.	Check the interaction between the module and the sensor.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Safety-related switch off	19_H	For safety purposes, channel was switched off due to an error on another channel. Possible causes: • Short circuit is present.	• Correct the process wiring.
Channel/component temporarily not available	$1F_H$	Possible causes: • Internal fault in the F-module • Firmware update error	• Replace the F-module. • Repeat the firmware update.

Diagnostic message	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The F-module detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The F-module detected an invalid F-destination address.	
Safety source address not valid (F_Source_Add)	42_H	The F-module detected a different F-source address.	
Safety watchdog timer value is 0 ms (F_WD_Time)	43_H	The F-module detected an invalid safety watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The F-module detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The F-module detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	46_H	The F-module detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The F-module detected inconsistent F-parameters.	
Transmission error: Inconsistent data (CRC error)	$4D_H$	The F-module detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Electromagnetic interference has exceeded limits. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Inconsistent iParameters (iParCRC error)	51_H	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	52_H	The F-module detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Timeout (monitoring time 1 or 2 expired)	54_H	The F-module detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	100_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Watchdog tripped	103_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Internal supply voltage of the module failed	104_H	Internal voltage is too low.	Replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Common mode error	118_H	Voltage between two input channels is too high.	Correct the input wiring.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for the F-module. Note any error messages. • Use only firmware versions released for this F-module.
Diagnostics memory overflow	$13E_H$	Overflow of the diagnostics memory. It was not possible to send all pending diagnostics. This error can lead to deactivation of the F-module and even to switch off/on of the supply voltage.	Remedy the cause of the diagnostics surge.
Analog input signal not recorded unique	304_H	Measured values from the sensor are not plausible. Possible causes: • Increased EMC • F-module defective	Check the interaction between the F-module and the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • Short-circuit of internal sensor supply to P	Check the process wiring.
Overload or internal sensor supply short-circuit to M	307_H	• The internal sensor supply is overloaded. • Missing or insufficient supply voltage L+.	• Eliminate the short-circuit in the process wiring. • Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Channel failure acknowledgment	$30B_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
No valid F-address available	$30D_H$	The F-source address and F-destination address stored in the electronic coding element cannot be accessed.	Verify that the coding element is present. Replace the coding element, if necessary.
F-address memory not accessible	$30E_H$	No valid PROFIsafe address is saved in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between target and actual configuration of the plant.	• In the case of initial commissioning or deliberate parameter change, assign the PROFIsafe address. • Check the consistency of the target and actual configuration.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 53))
Discrepancy error	314_H	The discrepancy time set for 1oo2 operation has been exceeded. Possible causes of the discrepancy error: • Incorrect parameter assignment • Wire break in the sensor's supply cable	Check the discrepancy time, the sensors and the cabling.
Read back failure	$31E_H$	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Auxiliary voltage too high	321_H	The supply voltage is too high.	Check the supply voltage and then test the safety application.

Diagnostic message	Fault code	Meaning	Remedy
Auxiliary voltage too low	322_H	The supply voltage is too low.	Check the supply voltage and then test the safety application.
ADC error	331_H	Internal error during analog-digital conversion. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Fault in test connection	332_H	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute (see Technical specifications (Page 53): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and fault display, the F-module provides information about the validity of each analog input signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is the binary additional information of an analog input signal. The value status is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the analog input signal.

The value status is affected by all faults.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors, you can only access the low order channel in the safety program, e.g. channel 0.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 32).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

7.1 Technical specifications

Technical specifications of the F-AI 4xI 0(4)..20mA 2-/4-wire HF

Article number	6ES7136-6AA00-0CA1
General information	
Product type designation	F-AI 4xI 0(4) ... 20 mA 2/4-wire HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 with HSP 203
CiR – Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	0.38 A
Current consumption, max.	0.4 A
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes
• Output current, max.	300 mA; total current of all encoders/channels
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	14 byte; S7-300/400F CPU, 13 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte

Article number	**6ES7136-6AA00-0CA1**
Hardware configuration	
Automatic encoding	
• Electronic coding element type F	Yes
Analog inputs	
Number of analog inputs	4
• For current measurement	4
permissible input current for current input (destruction limit), max.	35 mA
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
• Input resistance (0 to 20 mA)	125 Ω
• 4 mA to 20 mA	Yes
• Input resistance (4 mA to 20 mA)	125 Ω
Cable length	
• shielded, max.	1 000 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	20 / 16,667
• Interference voltage suppression for interference frequency f1 in Hz	50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	7
• parameterizable	Yes
• Step: None	Yes; 1x conversion cycle time
• Step: low	Yes; 2x / 4x conversion cycle time
• Step: Medium	Yes; 8x / 16x conversion cycle time
• Step: High	Yes; 32x / 64x conversion cycle time
Encoder	
Connection of signal encoders	
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1 %
Temperature error (relative to input range), (+/-)	0.023 %/K
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.1 %

Article number	6ES7136-6AA00-0CA1
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	2 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.1 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
• Common mode interference, min.	70 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes, "Alarms/diagnostic messages" section in the manual
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; Measuring range 4 to 20 mA only
• Short-circuit	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; Red LED
• for module diagnostics	Yes; Green/red LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3

Article number	6ES7136-6AA00-0CA1
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 5.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Operational limit in complete temperature range

⚠ WARNING

When designing the safety function, you must take into account the information "Operational limit in complete temperature range" for the entire mission time.

Temperature characteristic values

NOTE

When the ambient temperature exceeds 55 °C, you must only apply a maximum total current of 3 A to an adjacent F-DQ 4x24VDC/2A PM HF.

Dimension drawing

See ET 200SP BaseUnits manual

See also

ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Response times

A

Introduction

You will find the response times of the F-AI 4xI 0(4)..20mA 2-/4-wire HF below. The response times are included in the calculation of the F-system response time.

Definition of response time for fail-safe analog inputs

The response time results from the number of channels/channel pairs, the response time per channel/channel pair, the basic response time and the configured smoothing.

Times required for the calculation

- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 20 ms
- Basic response time: 20 ms
- Response time per channel
  - At 50 Hz: 25 ms
  - At 60 Hz: 22 ms

Conversion cycle time = basic response time + (N × response time per channel)

(N = number of active channels)

The conversion cycle time is the time in which all activated channels are processed/converted once.

Typical response time

You can calculate the typical response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF using the following formula:

Typical response time = Conversion cycle time × Smoothing

Max. response time (worst case delay time, WCDT)

You can calculate the maximum response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF (worst case delay time, WCDT) using the following formula:

Max. response time = 2 × Conversion cycle time × Smoothing

Response time in the case of a fault (one fault delay time, OFDT)

You can calculate the response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF (one fault delay time, OFDT) as follows:

- According to the following formula if a discrepancy error is present:

  Typical response time = Conversion cycle time × Smoothing + Discrepancy time + Conversion cycle time

  Maximum response time = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time
- According to the following formula if a channel fault is present:

  Typical response time = Conversion cycle time

  Max. response time = 2 × Conversion cycle time

This means that, for OFDT, the time on occurrence of a discrepancy error should be taken with parameter assignment "1oo2 evaluation (max. SIL3/Kat.4/PLe)" and the time on occurrence of a channel fault should be taken with parameter assignment "1oo1 evaluation (max. SIL3/Kat.3/PLd)".

Representation of analog values

B

In this section we are presenting the analog values for all measuring ranges that you can use with the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module.

Measured value resolution

The analog values are shown as fixed-point number in two's complement.

The resolutions shown here are 16 bits including sign.

Table 1-500 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of analog values

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 1-501 Current measuring range 0 to 20 mA

Values		Current measuring range	Range
Dec.	Hex.	0 to 20 mA	
32512	$7F00_H$	> 23.518 mA	Overflow[2]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	23.518 mA . . 20.0007 mA	Overrange
27648 . . 614	$6C00_H$ . . 266_H	20 mA . . 0.4442 mA	Nominal range
613 . . 1 0	265_H . . 1_H 0_H	< 0.4442 mA . . 723.4 nA 0 mA	Wire break[1]

1 The F-module signals a wire break, $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 In *STEP 7 Safety*, the fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) in the PII for the safety program.

Table 1-502 Current measuring range 4 to 20 mA

Values		Current measuring range	Range	
Dec.	**Hex.**		**Diagnostics wire break: No**	**Diagnostics wire break: Yes**
32512	$7F00_H$	> 22.814 mA	Overflow[2]	Overflow[2]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	22.814 mA . . 20.0006 mA	Overrange	Overrange
27648 . . 1 0	$6C00_H$ . . 1_H 0_H	20 mA . . 4 mA + 578.7 nA 4 mA	Nominal range	Nominal range
-1 . . -691	$FFFF_H$ . . $FD4D_H$	3.9994 mA . . 3.6 mA	Underrange	Underrange
-692 . . -6144	$FD4C_H$ . . $E800_H$	< 3.6 mA . . 0.4444 mA		Wire break[1]
-6145	$E7FF_H$	< 0.4444 mA	Underflow[2]	

1 The F-module signals a wire break, $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 In *STEP 7 Safety*, the substitute value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

SIEMENS

SIMATIC

ET 200SP
Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that affect the system in general are described in the system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to both the CPUs of the S7-1200/1500 automation system and CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

PII: Process image inputs (analog value).

Analog value: Process value available to the customer in the user program (PII).

Analog signal: Sensor signal at the input terminal.

Measured value: Digital analog signal for internal processing / evaluation.

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in annex 1 of the report on the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

⚠ WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.
You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.
Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/24471)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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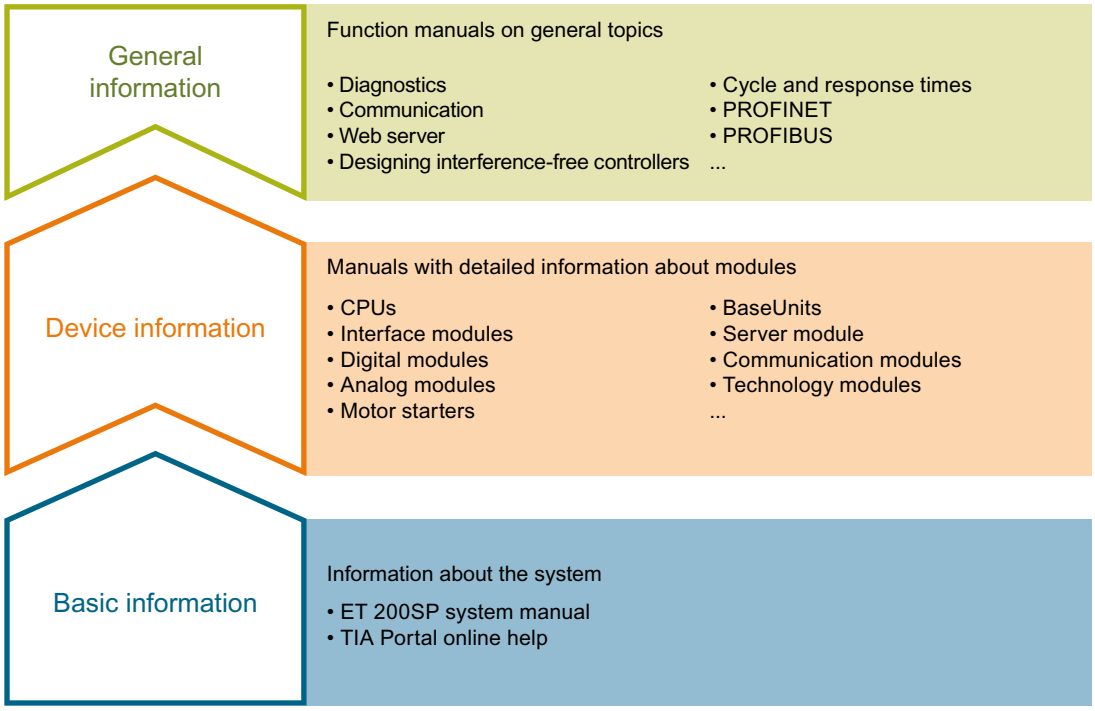
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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information
The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information
Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information
The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules
- Support for the following processes of the fail-safe CPUs:
  - Program update
  - Restore from a backup file
  - Reset to factory settings
  - Memory reset

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a quick test of the wiring and the module configuration of a plant, including fail-safe digital inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

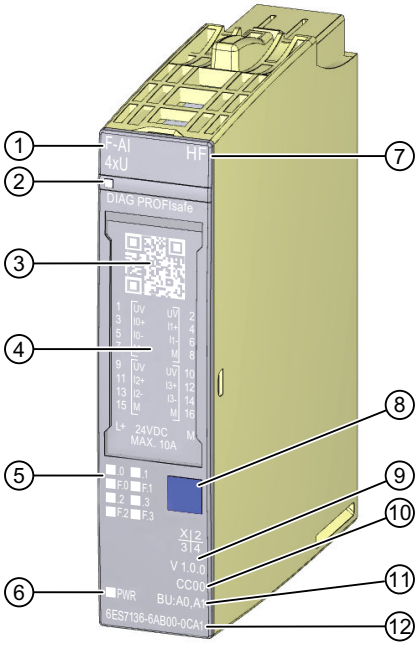
2

2.1 Properties

Article number

6ES7136-6AB00-0CA1

View of the module



①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 1-217 View of the F-AI 4xU 0..10V HF module

Properties

The module has the following technical properties:

- Fail-safe analog input module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 4 analog inputs with electrical isolation between channels and the backplane bus (up to SIL3/Cat.4/PLd)
- 1oo2 evaluation with configurable tolerance window and discrepancy
- Measuring range: 0 ... 10 V
- Resolution: 16 bits including sign
- Short-circuit-proof power supply
- Supply voltage L+
- External sensor supply possible
- Internal sensor supply U_V
- Configurable wire break diagnostics
- Diagnostics display (DIAG, red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g. high limit exceeded, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel- and module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Value status

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires.
The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic messages (Page 46).

NOTE

Cyclic reading of I&M data
Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector
- Electronic coding element type H as spare part (article number 6ES7193-6EH00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The following fail-safe modules need an electronic coding element type F (white):

- F-AI 4xI (0)4..20mA HF (6ES7136-6AA00-0CA1)
- F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)
- F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)
- F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)
- F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

The following fail-safe modules need an electronic coding element type H (gray):

- F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

Connecting

3

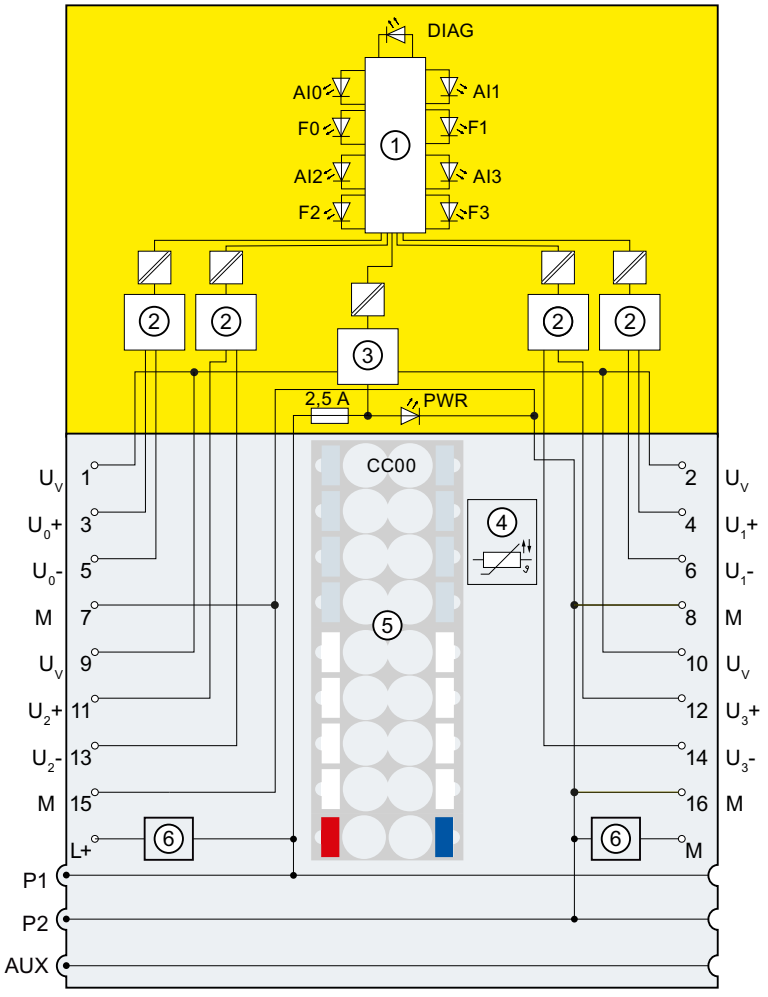
3.1 Wiring and block diagram

This section provides the block diagram of the F-AI 4xU 0..10V HF analog input module with the terminal assignment.

You can find additional information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the block diagram of the F-AI 4xU 0..10V HF analog input module on the BaseUnit BU type A0/A1.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 1-218 Block diagram

Sensor supply

⚠ WARNING

Voltage dips and voltage fluctuations of the voltage supply are not buffered by the F-module and, thus, affect the sensor supply.
This can cause the measured value to be falsified and must be taken into account when determining the safety function.
To ensure that the sensor functions without problems, we recommend one of the following options:

- You can avoid voltage dips by using a voltage supply according to the NAMUR recommendation NE 21.

or

- Use a transducer with an appropriate battery backup or diagnostics.

Recommendation: Internal sensor supply

You are strongly advised to use the short-circuit-proof internal sensor supply of the F-module. This internal sensor supply is monitored and its status is indicated by the respective error LED. The input is also protected in the event of short-circuits in the wiring or at the sensor.

NOTE

The internal sensor supply is switched off in case of a short circuit to ground or during power-up in the event of short circuit to L+.
A check is made approximately 1 minute later to determine if the error has gone.

NOTE

Behavior of process values and diagnostics evaluation

Sensor startup during module startup:

After the internal sensor supply is activated, the "Wire break" and "Low limit violated" diagnostics is suppressed for 3 seconds to prevent passivation of the respective channel by the sensor startup. During this time, the module makes the secure process data 0 available at all channels. If the sensor startup is not completed in time, passivation will occur that must subsequently be acknowledged.

Sensor startup during operation:

If a sensor startup takes place during operation, e.g. the sensor supply is reactivated after a short-circuit, all analog values are invalid and wire break or underflow diagnostics can occur on the sensors connected to the internal sensor supply.

External/internal sensor supply

The figures in section "Applications of the F-I/O module (Page 33)" show how you can supply power to the sensors via an external sensor supply (for example, from another module).

⚠ WARNING

External sensor supply

If you use an external sensor supply, you need to take voltage dips and voltage fluctuations into consideration for the safety function.

To ensure that the sensor functions without problems, we recommend one of the following options:

- Use a transducer with an appropriate battery backup or diagnostics.
  or
- Use a **redundant** external sensor supply
  or
- **Monitor** the external sensor supply for undervoltage/overvoltage, including shutdown of the sensor supply in the event of a fault (single channel for SIL2; two-channel for SIL3).

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 1-503 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Voltage	0 ... 10 V	16 bits including sign

You can find the table of the measuring ranges as well as overflow, overrange, etc. in the Appendix Representation of analog values (Page 57).

4.2 Parameters

Parameters for F-AI 4xU 0..10V HF

⚠ WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 33).

The following parameters are possible:

Table 1-504 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 ... 65535 ms	150 ms	No	Module
F-source address	1 ... 65534	Depends on parameter assignment of F-CPU	No	Module
F-destination address	1 ... 65534	Suggested by F-system	No	Module
F-parameter signature (without addresses)	0 ... 65535	Calculated by F-system	No	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Suggested by F-system	No	Module
F-I/O DB name	—	Suggested by F-system	No	Module
AI parameters				
Interference frequency suppression	• 50 Hz • 60 Hz	50 Hz	No	Module
Channel parameters:				
Channel n				
Sensor evaluation	• 1oo1 evaluation (max. SIL2/Cat.3/PLd) • 1oo2 evaluation (max. SIL3/Cat.4/PLe)	1oo1 evaluation (max. SIL2/Cat.3/PLd)	No	Channel
Standard value	• MIN • MAX	MIN	No	Channel
Discrepancy time *	100 ... 30000 ms	100 ms	No	Channel
Tolerance window %, absolute	2.0 ... 20.0%	5.0%	No	Channel
Tolerance window %, relative	2.0 ... 20.0%	5.0%	No	Channel
Activated	• Disable • Enable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Measuring range	0 ... 10 V	0 ... 10 V	No	Channel
Diagnostics: Wire break	• Disable • Enable	Enable	No	Channel
Smoothing	• 1 • 2 • 4 • 8 • 16 • 32 • 64	1	No	Channel

* See formula under Discrepancy analysis with 1oo2 evaluation (Page 22)

4.3 Explanation of parameters

4.3.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Central F-source address" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

4.3.2 Parameters of the channels

4.3.2.1 Interference frequency suppression

Here you set the interference frequency suppression for the line frequency:

- 50 Hz
- 60 Hz

For more information, refer to the Analog value processing Function Manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

4.3.2.2 Sensor evaluation

Overview

Here you select the type of sensor evaluation:

- "1oo1 evaluation (max. SIL2/Cat.3/PLd)"
- "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

If you do not want to measure with a channel or channel pair, disable the channel or the channel pair. If you deactivate unused channels, the response time of the F-module is reduced.

1oo1 evaluation (max. SIL2/Cat.3/PLd)

With the 1oo1 evaluation, there is one sensor, and it is connected to the F-module via a single channel.

1oo2 evaluation (max. SIL3/Cat.4/PLe)

With the 1oo2 evaluation, two input channels are occupied by:

- Two single-channel sensors
- One two-channel sensor

Note that in 1oo2 evaluation, two channels are combined into a channel pair.

Achievable safety level

Depending on the selected sensor evaluation, you achieve the following safety classes with a sensor that is qualified accordingly:

- SIL2/Cat.3/PLd for "1oo1 evaluation"
- SIL3/Cat.4/PLe for "1oo2 evaluation"

See also

Discrepancy analysis with 1oo2 evaluation (Page 22)

4.3.2.3 Standard value

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", two channels are considered to be a channel pair. You can select from two measured values in this case, which is provided by the F-CPU as analog value:

- "MIN": the lesser of the two values.
- "MAX": the greater of the two values.

During a discrepancy between the two input channels, the last valid standard value prior to the occurrence of the discrepancy is made available to the F-CPU.

4.3.2.4 Discrepancy time

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the discrepancy time for each channel pair here in milliseconds.

The discrepancy time does not start until the standard value is outside the assigned tolerance window (relative or absolute). If the two redundant input channels of the channel pair differ by more than the specified tolerance and for longer than the specified discrepancy time but no longer than the duration of the maximum response time, the F-module detects a discrepancy error and triggers a diagnostic interrupt. If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is restarted when a new discrepancy is detected.

You can find additional information about configuring the discrepancy analysis under Discrepancy analysis with 1oo2 evaluation (Page 22).

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3.2.5 Tolerance window %, absolute

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for the channel pair. You specify the tolerance window as a percentage of the full-scale value. The reference value is the maximum full-scale value, i.e. 10 V. The entered value is rounded to one decimal place.

If the two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

For more information regarding setting the tolerance window, refer to Discrepancy analysis with 1oo2 evaluation (Page 22).

Example

You have assigned the following:

- The "Tolerance window % absolute" at 10%
- The measuring range 0 V ... 10 V
- A discrepancy time of 100 ms

The input channels may differ from the configured discrepancy time (100 ms) up to the max. response time for a time window with a difference of more than 1 V.

See also

Discrepancy time (Page 20)

4.3.2.6 Tolerance window %, relative

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for each channel pair. You specify the tolerance window as a percentage of the assigned standard value. The entered value is rounded to one decimal place.

If the two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

The two parameters "Tolerance window % absolute" and "Tolerance window % relative" are combined. The "Tolerance window % absolute" parameter is decisive in case of low process values.

For more information regarding setting the tolerance window, refer to Discrepancy analysis with 1oo2 evaluation (Page 22).

Example

You have assigned the following:

- The "tolerance window % relative" at 10%
- The measuring range 0 V ... 10 V
- A discrepancy time of 200 ms

The analog signals may differ for a time window of set discrepancy time (200 ms) up to the maximum reaction time. If your measured values are 9 V and 10 V, a difference in the measured values up to 1 V is tolerated for the MAX standard value. If you configure the MIN standard value, only a difference of up to 0.9 V is tolerated. If the tolerated difference is exceeded, the module signals a diagnostics.

See also

Discrepancy time (Page 20)

4.3.2.7 Discrepancy analysis with 1oo2 evaluation

Operating principle of discrepancy analysis

A discrepancy analysis is performed with a configured 1oo2 evaluation. **Smoothed** process values are used for the discrepancy analysis.

An assignable tolerance window is formed around the process value that represents the instantaneous standard value (value that is signaled to the F-CPU).

The tolerance window is formed relative to the process value as well as an absolute value relative to the full-scale value.

If the process value does not represent the standard value at an instant and is within the tolerance window, **no** discrepancy exists.

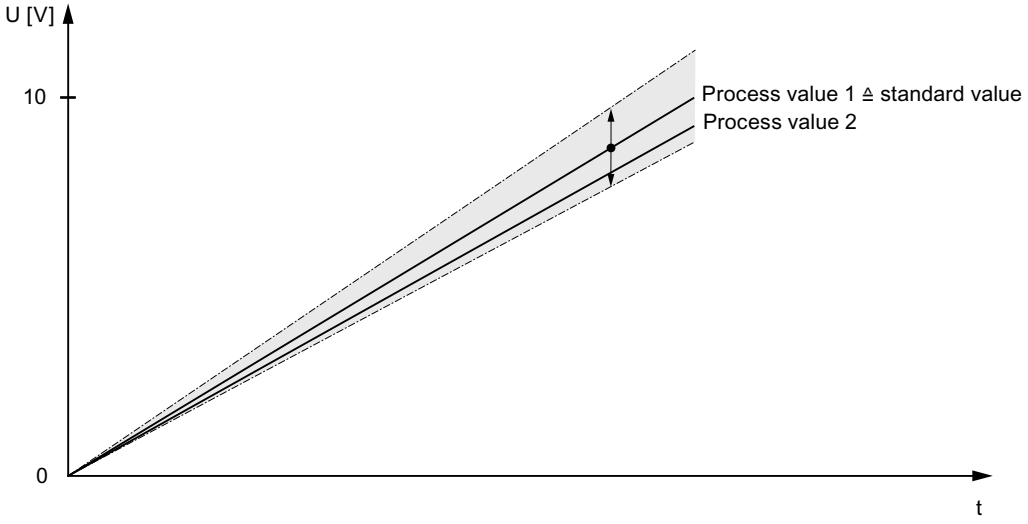


Figure 1-219 Example of a relative tolerance window *without* discrepancy (parameter assignment: standard value = MAX)

If the process value does not represent the standard value at an instant but is outside the tolerance window, a discrepancy exists.

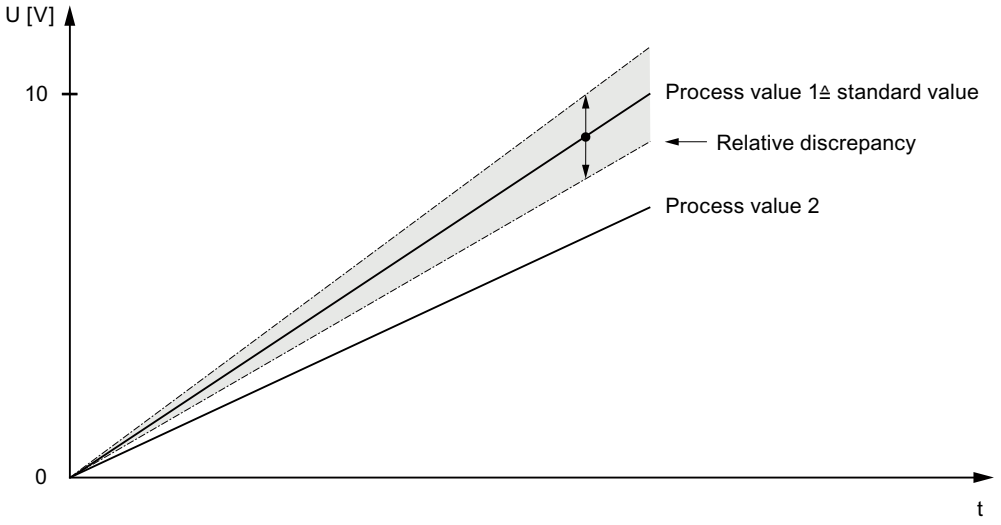


Figure 1-220 Example of a relative tolerance window *with* discrepancy (parameter assignment: standard value = MAX)

The assigned discrepancy time starts as soon as a discrepancy is detected.

- During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.
- There is no valid old value after startup from an error or after Off/On of the power supply. During this time, the process value $7FFF_H$ is output for the S7-300/400 F-CPUs and the process value 0 for S7-1200/1500 F-CPUs until a smoothed process value is available once again (see section Smoothing (Page 20)). If a discrepancy of the smoothed process value is now determined, the configured discrepancy time starts running.
- If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the standard value is output. With a new discrepancy, the discrepancy time measurement starts again.

If the discrepancy time has expired with an existing discrepancy, a discrepancy error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the STEP 7 Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Configuring the discrepancy analysis parameters

The following four parameters for the discrepancy analysis are assigned for each channel pair:

- Discrepancy time
- Standard value
- Tolerance window %, absolute
- Tolerance window %, relative

"Discrepancy time" parameter

When all criteria are met, the F-module triggers a discrepancy error:

- The process value that does not represent the standard value is outside the configured tolerance window.
- Lasts longer than the configured discrepancy time.
- Lasts at maximum the duration of the maximum response time.

In the case of a discrepancy error, the F-module triggers a diagnostic interrupt and sets the process value to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. The discrepancy time is reset if the standard value lies within the tolerance window again.

In the PII, the substitute value 0 is set for the safety program.

You calculate the maximum discrepancy time that is permitted in the respective application using the following formula:

Discrepancy time = Maximum response time (in case of discrepancy error) – 2 × Conversion cycle time × Smoothing – 2 × Conversion cycle time

NOTE

You calculate the discrepancy time by using the values from section Response times (Page 55) in the above equation.

You can assign the discrepancy time for each channel pair.

"Standard value" parameter

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", two channels are considered to be a channel pair. You can select from two measured values in this case, which is provided by the F-CPU as analog value:

- "MIN": The lower of the two values is signaled to the F-CPU as the standard value.
- "MAX": The higher of the two values is signaled to the F-CPU as the standard value.

"Tolerance window %, absolute" parameter

You can calculate the absolute tolerance window using the following formula:

$$T_{abs} = \frac{|\Delta U_{abs}|}{U_{ME} - U_{MA}} \times 100 \ [\%]$$

You can calculate the maximum absolute deviation of the voltage of the full-scale value using the following formula:

$$\Delta U_{abs} = \pm \frac{(U_{ME} - U_{MA}) \times T_{abs}}{100} \ [V]$$

With the following parameters:

- U_{ME} = 10 V (full-scale value)
- U_{MA} = 0 V for measuring range 0 V ... 10 V (start-of-scale value)
- T_{abs} = absolute tolerance in %
- ΔU_{abs} = Maximum absolute deviation of the voltage from the full-scale value (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, absolute" parameter for each channel pair.

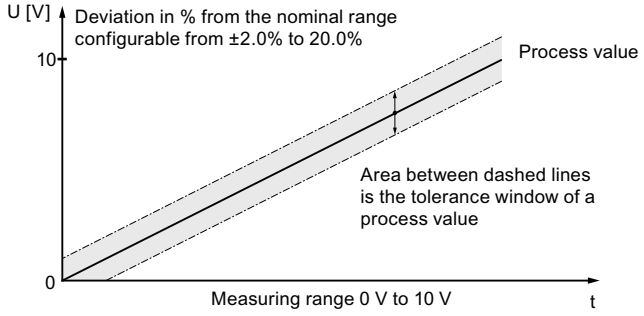


Figure 1-221 Absolute deviation in % from the nominal range for measuring range of 0 V to 10 V

"Tolerance window %, relative" parameter

The tolerance window is calculated as a percentage of the **smoothed** process value that represents the MIN or MAX value (depending on the parameter assignment of the standard value).

You can calculate the relative tolerance window using the following formula:

$$T_{rel} = \frac{|\Delta U_{rel}|}{|U_{EW} - U_{MA}|} \times 100 \ [\%]$$

You can calculate the maximum relative deviation of the voltage of the measured value using the following formula:

$$\Delta U_{rel} = \pm \frac{|U_{EW} - U_{MA}| \times T_{rel}}{100} [V]$$

With the following parameters:

- U_{EW} = Process standard value (min./max.)
- U_{MA} = 0 V for measuring range 0 V ... 10 V (start-of-scale value)
- T_{rel} = Relative tolerance in %
- ΔU_{rel} = Maximum relative deviation of the voltage from the measured value (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, relative" parameter for each channel pair.

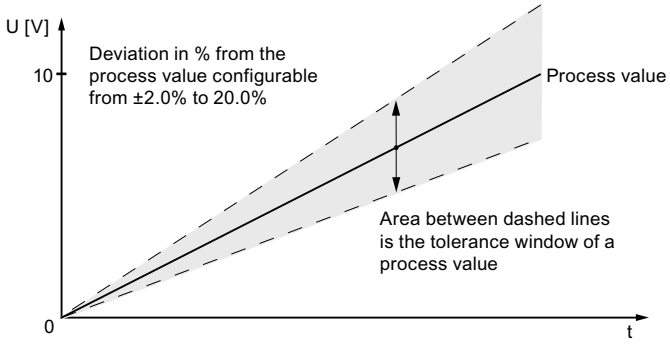


Figure 1-222 Relative deviation in % from the nominal range for measuring range of 0 V to 10 V

Combination of the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters

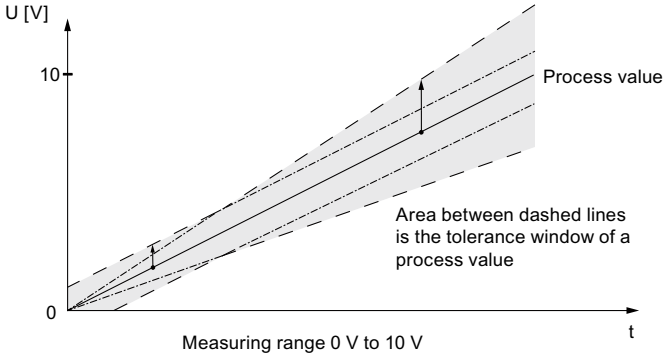
You can combine the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters as needed. The combined tolerance window (shown in gray in the figure below) is the maximum of T_{rel} and T_{abs}.

$T = MAX \{ T_{rel}, T_{abs} \}$

$\Delta U = MAX \{ \Delta U_{rel}, \Delta U_{abs} \}$

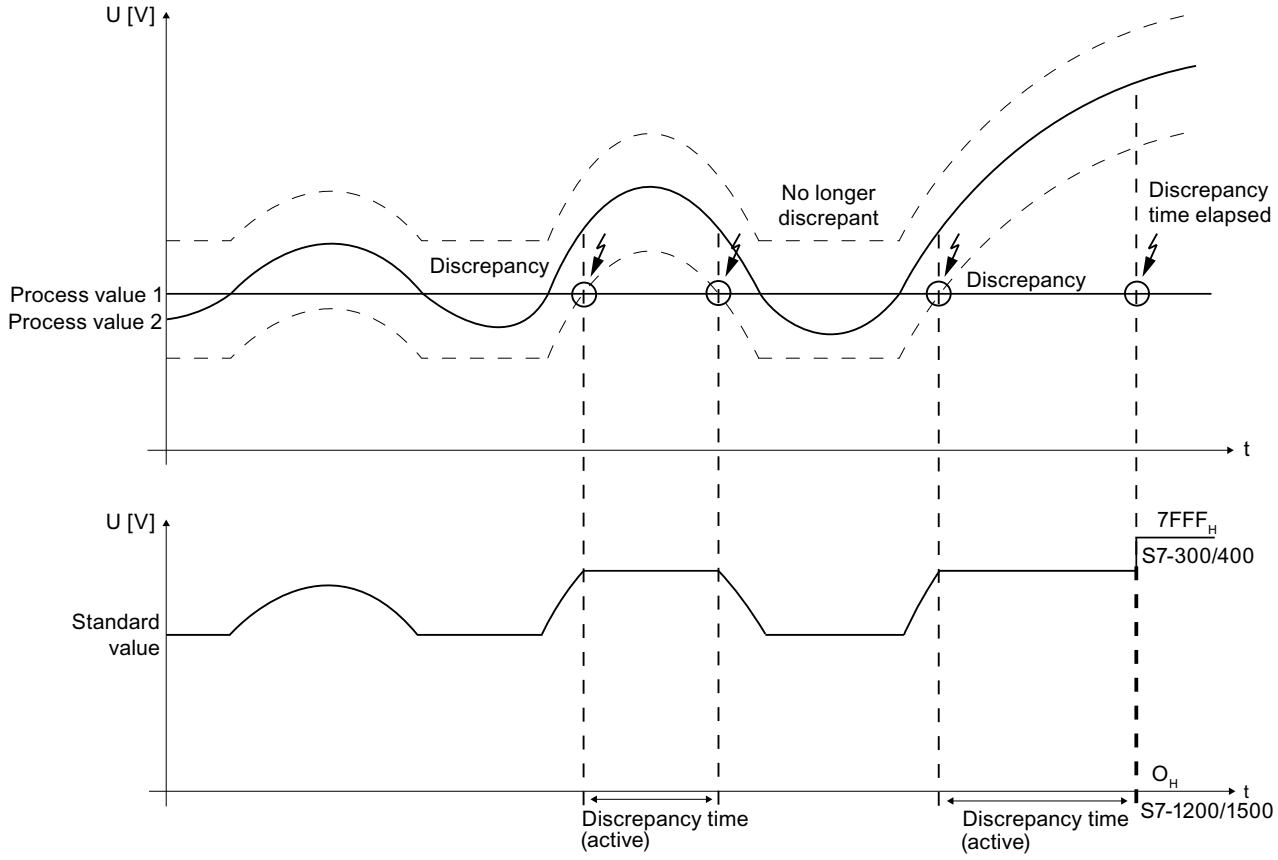
With:

- T = Tolerance, in %
- ΔU = maximum deviation of the voltage (+/-)



Example

The following diagrams show you the behavior of the discrepancy evaluation when standard value = MAX.



The upper of the two diagrams shows the characteristic curve of the two process values. The dashed line represents the absolute tolerance range configured in this example.

The lower of the two diagrams shows the standard value signaled to the F-CPU.

In this example, on the first occurrence of a discrepancy, process value 1 is **within** the tolerance range again **before** expiration of the discrepancy time. This means the discrepancy error is not signaled.

In this example, on the second occurrence of a discrepancy, process value 1 is **outside** the tolerance range when the discrepancy time expires. As a result, a discrepancy error is signaled with $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs after expiration of the discrepancy time. In the PII, the substitute value 0 is set for the safety program.

See also

Tolerance window %, absolute (Page 21)
Tolerance window %, relative (Page 21)
Smoothing (Page 29)

4.3.2.8 Activated

If you select this check box, the corresponding channel is enabled for signal processing.
You can deactivate an unused channel with this parameter.
If you deactivate unused channels, the response time of the F-module is reduced.

4.3.2.9 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs
The parameter is only relevant if the F-module can be operated on an S7-1200/1500 F-CPU.
The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".
The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs
The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.
For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3.2.10 Measuring range

The parameter shows the measuring range for the channel:

- 0 ... 10 V

4.3.2.11 Diagnostics: Wire break

Function

Here you activate the wire break detection. No smoothed measured values are used for the wire break diagnostics.
With a measuring range of 0 V to 10 V:

- With configured wire break diagnostics and voltages < 1 V, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without configured wire break diagnostics and voltages < 0.2962 V, an "underflow" is detected and a diagnostic interrupt is triggered in the F-CPU.

For performance reasons, an unused channel should be disabled. There is no wire break detection for a disabled channel.

4.3.2.12 Smoothing

Smoothing principle

The measured values are smoothed by a digital filter. Smoothing is achieved by the F-module forming the sliding mean of a number of converted (digitized) analog values determined by the "Smoothing" parameter.

You assign smoothing in 7 levels (1, 2, 4, 8, 16, 32, 64 conversion cycles). The level determines the number of analog signals converted last that are averaged. If smoothing = 1 is configured, the smoothing is deactivated.

The higher the smoothing you select, the more stable the smoothed analog value of the converted analog signal, and the longer the time it takes until the smoothed analog signal is available as analog value following a unit step. You can find an example below.

For more information on the analog value, refer to the Analog value processing Function Manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

NOTE

Smoothing is recalculated after startup, short circuit, wire break or any other channel fault. If, for example, smoothing is configured with 16 conversion cycles, all channels are activated and the configured frequency suppression is 50 Hz, it can take up to 2000 ms until the valid process value is signaled.
Until the first valid process value, the F-module signals $7FFF_H$ for the channel on S7-300/400 F-CPUs or 0 on S7-1200/1500 F-CPUs.
The calculation of the smoothing is not interrupted in case of a discrepancy.

Using smoothing

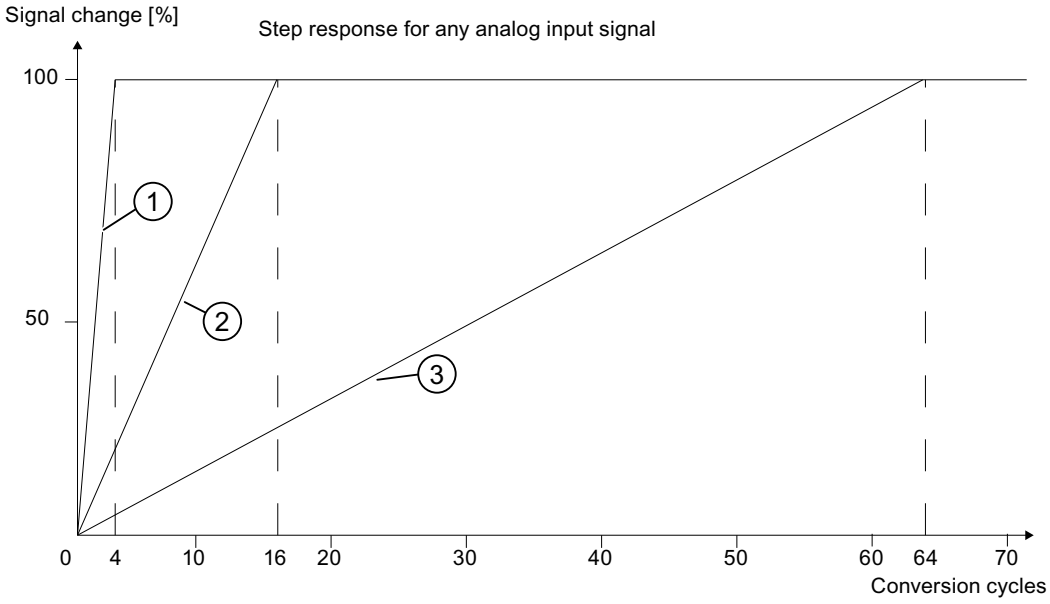
Smoothing of analog values provides a stabilized analog signal for further processing. Smoothed values are always used for discrepancy analysis.

⚠ WARNING

The smoothing takes place as a result of mean value generation over the selected number of most recently converted analog values of a channel, e.g. 64.
The mean value generation causes a discrepancy to be delayed with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)". You can find an example below.

Example

The figure below shows the number of conversion cycles, depending on the set smoothing, after which the analog value is completely available following a unit step. The figure applies to all signal changes at the analog input.



① Smoothing - 4 conversion cycles
② Smoothing - 16 conversion cycles
③ Smoothing - 64 conversion cycles

Example: Effect of smoothing on the maximum response time for a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)" in case of error

If an error (One Fault Delay Time, OFDT) occurred with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you calculate the maximum response time according to the following formula:

Maximum response time (in case of discrepancy error) = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

In this example, one channel pair is connected and configured (activated), interference frequency 50 Hz, smoothing = 16 conversion cycles, discrepancy time = 2000 ms, conversion cycle time calculated with the formula from section Response times (Page 55):

Max. response time (in case of discrepancy error) = 2 × 70 ms × 16 + 2000 ms + 2 × 70 ms = 4380 ms

If a discrepancy exists between the two input channels, it can take 4380 ms until the F-module detects a discrepancy error. This error is then signaled to the F-CPU.

If the discrepancy time has expired, a discrepancy error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

4.4 Address space

Address assignment of the F-AI 4xU 0..10V HF analog input module

The analog input module F-AI 4xU 0..10V HF occupies the following address ranges in the F-CPU:

Table 1-505 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 12	QB x + 0 to x + 3
S7-1200/1500 F-CPUs	IB x + 0 to x + 13	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of the F-AI 4xU 0..10V HF analog input module

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the F-AI 4xU 0..10V HF analog input module:

Table 1-506 User data address assignment in the input range

Byte in the F-CPU	Occupied bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/2)							
IB x + 1								
IB x + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/3)							
IB x + 3								
IB x + 4	Input value at channel 2							
IB x + 5								
IB x + 6	Input value at channel 3							
IB x + 7								
IB x + 8	—	—	—	—	Value status* for AI_3	Value status* for AI_2	Value status* for AI_1	Value status* for AI_0

* Only S7-1200/1500 F-CPUs

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Applications of the F-I/O module

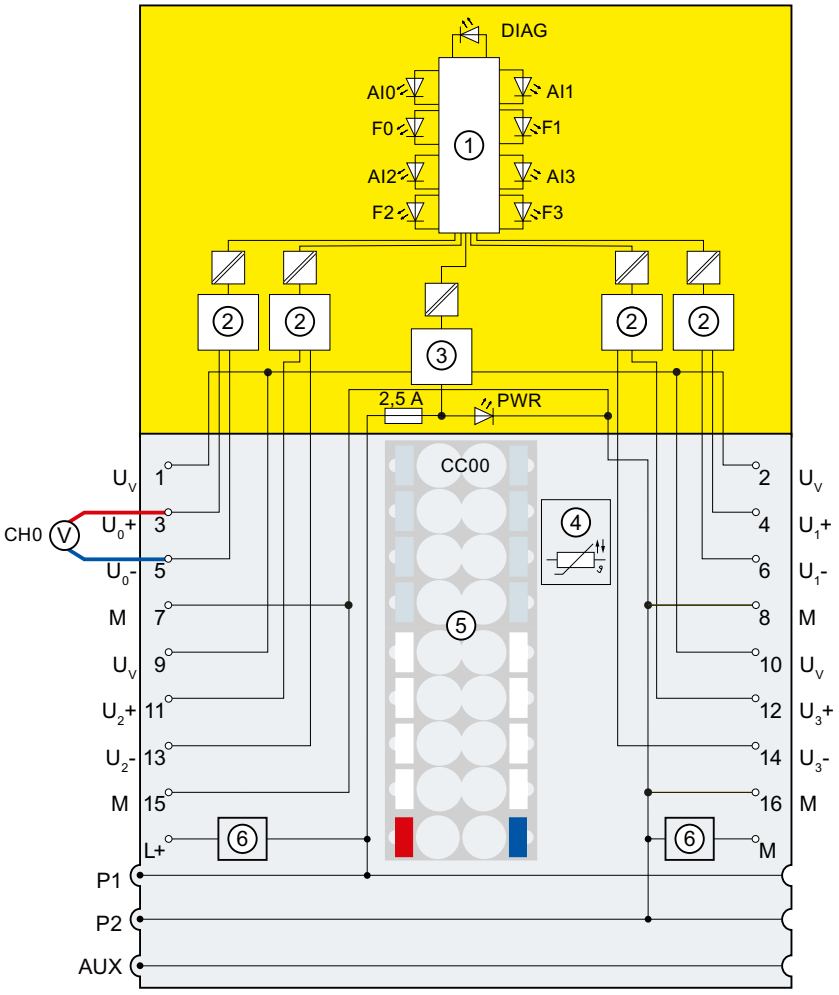
5

The wiring is performed on a suitable BaseUnit. Additional information is available in the Connecting section in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

5.1 Application 1: Safety mode SIL2/Cat.3/PLd with two-wire connection, 1oo1 evaluation

Voltage measurement from 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 1-223 1oo1 evaluation

⚠ WARNING

To achieve SIL2/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

⚠ WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.
For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

Assignable parameters for application 1

Table 1-507 Parameters for application 1 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL2/Cat.3/PLd)

Parameters	Range of values in safety mode
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

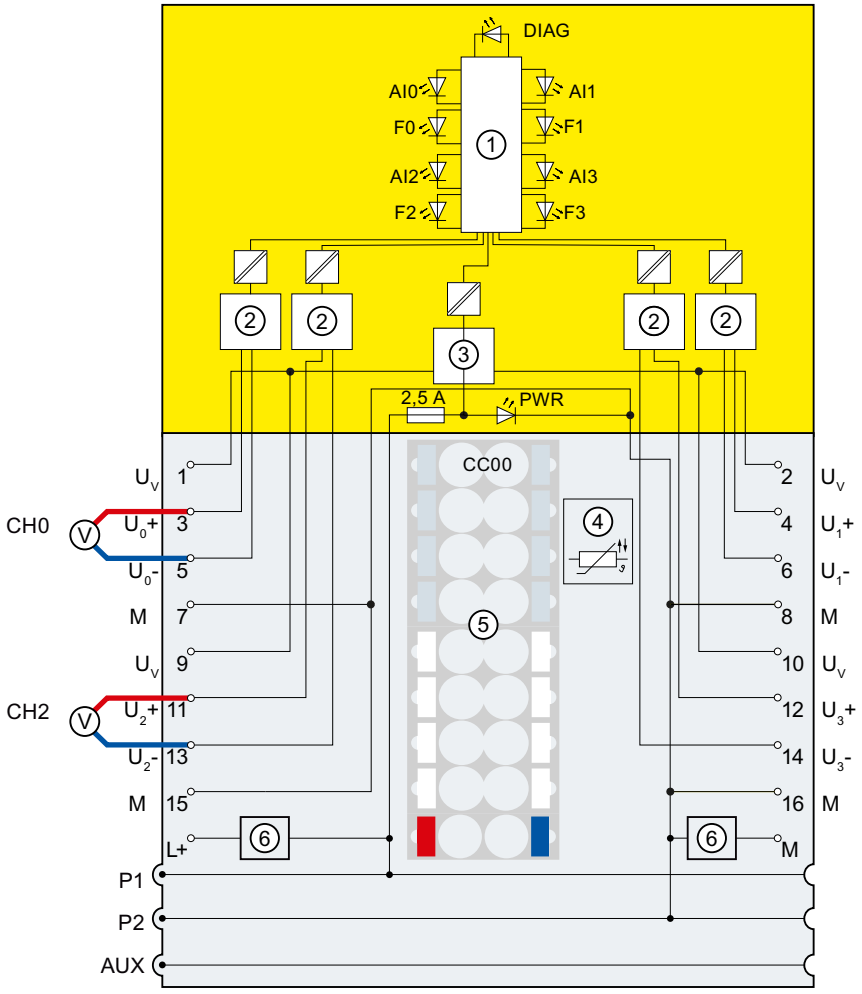
See also

Diagnostic messages (Page 46)

5.2 Application 2: Safety mode SIL3/Cat.4/PLe with two-wire connection, 1oo2 evaluation

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 1-224 1oo2 evaluation

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified, two-channel sensor or two qualified single-channel sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 2

Table 1-508 Parameters for application 2 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 ... 30000 ms
Tolerance window %, absolute	2.0 ... 20.0%
Tolerance window %, relative	2.0 ... 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

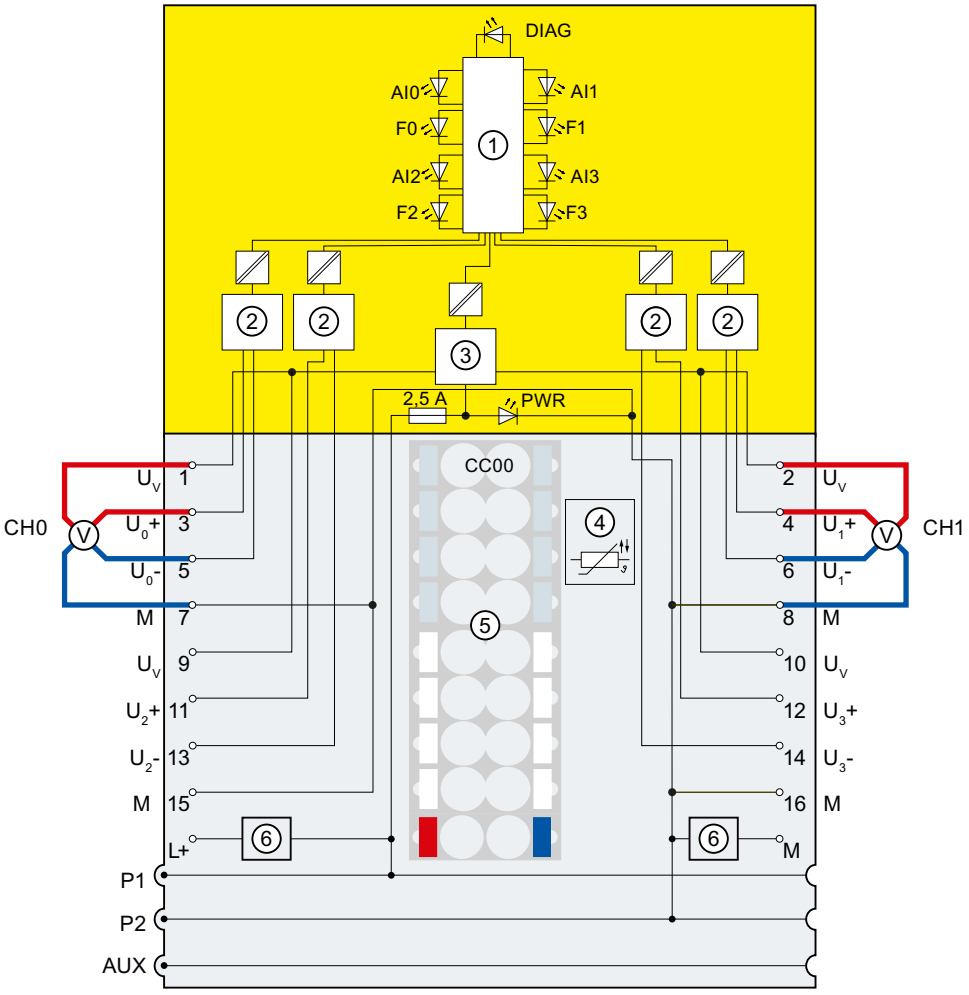
See also

Diagnostic messages (Page 46)

5.3 Application 3: Safety mode SIL2/Cat.3/PLd with four-wire connection, 1oo1 evaluation

Voltage measurement 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 1-225 1oo1 evaluation

⚠ WARNING

To achieve SIL2/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

⚠ WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.
For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

Assignable parameters for application 3

Table 1-509 Parameters for application 3 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL2/Cat.3/PLd)
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

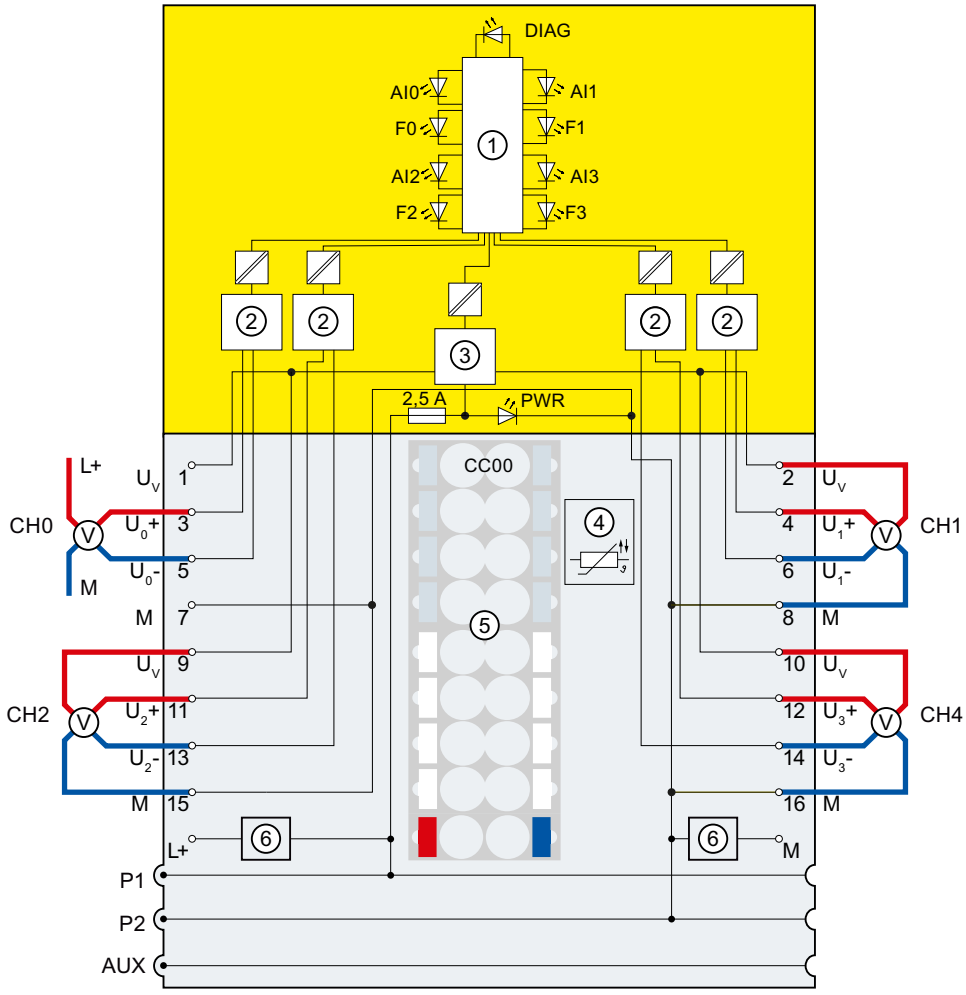
See also

Diagnostic messages (Page 46)

5.4 Application 4: Safety mode SIL3/Cat.4/PLe with four-wire connection, 1oo2 evaluation

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 1-226 1oo2 evaluation

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use suitably qualified sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 4

Table 1-510 Parameters for application 4 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 ... 30000 ms
Tolerance window %, absolute	2.0 ... 20.0%
Tolerance window %, relative	2.0 ... 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

See also

Diagnostic messages (Page 46)

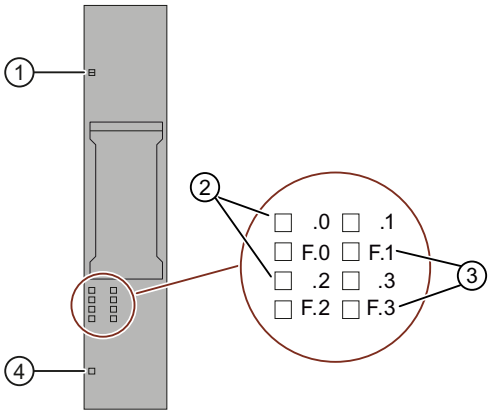
Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-AI 4xU 0..10V HF.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 1-227 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostic messages (Page 46).

WARNING

The DIAG LED and the channel status and channel fault LEDs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 1-511 Error display of the LED DIAG

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation with S7-1200/1500 F-CPUs: At least one channel is waiting for a user acknowledgment.
Flashing	• Operation with S7-1200/1500 F-CPUs: The F-module is waiting for a user acknowledgment after a module fault. • Operation with S7-300/400 F-CPUs: The F-module is waiting for a user acknowledgment.

Channel status/channel fault LED

Table 1-512 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or supply voltage L+ missing.
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
Alternately flashing		At least one channel is waiting for a user acknowledgment.

Channel status/DIAG/channel fault LED

Table 1-513 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address or there is a module-wide error. See section Alarms (Page 44).
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address.

PWR LED

Table 1-514 Status display of LED PWR

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe analog input module F-AI 4xU 0..10V HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 46).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging a diagnostic message, remedy the respective fault and check your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 46)

Module-wide diagnostic interrupts:

- Overtemperature
- Undertemperature
- Parameter error
- Supply voltage missing
- Channel/component temporarily not available
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog timer value is 0 ms (F_WD_Time)
- Parameter F_CRC_Length does not match the generated values
- Version of F-parameter set incorrectly
- CRC1 fault
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)

- Transmission error: Timeout (monitoring time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostics memory overflow
- Acknowledgement required to activate the channel as soon as the channel faults are remedied.
- F-address memory not accessible
- No valid F-address available
- Supply voltage too high
- Supply voltage too low
- Channel/component not available

Channel-wide diagnostic alarms

- Wire break
- High limit exceeded
- Low limit violated
- Safety-related switch off
- Internal supply voltage of the module failed
- Common mode error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Discrepancy error
- Read back failure
- ADC error
- Fault in test circuit

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module information).

Once the fault is eliminated, the F-module must be reintegrated in the safety program with manual acknowledgment. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Table 1-515 Diagnostic alarms of the F-AI 4xU 0..10V HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 51)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_H	Possible causes: • A cable to the sensor is broken. • Fault at the external circuit • Defective sensor • Wrong sensor type set in the parameters • Input channel not used	Check the possible causes and eliminate the fault.
High limit exceeded	7_H	The measured value exceeds the measuring range.	Check the interaction between the module and the sensor.
Low limit violated	8_H	The measured value is below the measuring range.	Check the interaction between the module and the sensor.
Parameter error	10_H	The parameter error can be: • The F-module cannot use the parameters (unknown, invalid combination, etc.).	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Safety-related switchoff	19_H	For safety purposes, the channel was switched off due to an error on another channel. Possible causes: • A short-circuit of the sensor supply to ground is present.	• Correct the process wiring.
Channel/component temporarily not available	$1F_H$	Possible causes: • Internal fault in the F-module • The firmware version of the F-module is inconsistent.	• Replace the F-module. • Repeat the firmware update.

Diagnostic message	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The F-module detected a different F-destination address.	• Check the parameter assignment of the F-parameters and the assigned PROFIsafe address of the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The F-module detected an invalid F-destination address.	
Safety source address not valid (F_Source_Add)	42_H	The F-module detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The F-module detected an invalid safety watchdog time.	
Parameter F_CRC_Length does not match the generated values	45_H	The F-module detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The F-module detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The F-module detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	$4B_H$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The F-module detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transfer error: Inconsistent data (CRC error)	$4D_H$	The F-module detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Electromagnetic interference has exceeded limits. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transfer error: Timeout (monitoring time 1 or 2 expired)	$4E_H$	The F-module detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Check the components that are involved in the communication.
Acknowledgement required to activate the channel as soon as the channel faults are remedied.	$4F_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
Module is defective	100_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Watchdog tripped	103_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Internal supply voltage fault	104_H	Internal power supply of the module failed.	Replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Common mode error	118_H	Voltage between two input channels is too high.	Correct the input wiring.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This results in the F-module not being ready for operation.	• Perform a firmware update for the F-module. Note any error messages. • Use only firmware versions released for this F-module.
Analog input signal not recorded unique	304_H	Measured values from the sensor are not plausible. Possible causes: • Increased EMC • F-module defective	Check the interaction between the F-module and the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • Short-circuit of internal sensor supply to P	Check the process wiring.
Overload or internal sensor supply short-circuit to M	307_H	• The internal sensor supply is overloaded. • Missing or insufficient supply voltage L+.	• Eliminate the short-circuit in the process wiring. • Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
F-address memory not accessible	$30D_H$	The F-source address and F-destination address stored in the electronic coding element cannot be accessed.	Verify that the coding element is present. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is saved in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between target and actual configuration of the plant.	• In the case of initial commissioning or deliberate parameter change, assign the PROFIsafe address. • Check the consistency of the target and actual configuration.
Undertemperature	312_H	The F-module has fallen below its specified temperature range.	Operate the F-module within the specified temperature range (see Technical specifications (Page 51))
Discrepancy error	314_H	The discrepancy time set for 1oo2 operation has been exceeded. Possible causes of the discrepancy error: • Unsuitable parameter assignment • One of the two sensors is defective	Check the discrepancy time, the sensors and their cabling.
Read back failure	$31E_H$	The F-module has detected an internal error through the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Supply voltage too high	321_H	The supply voltage L+ is too high.	Check the supply voltage L+ and then test the safety application.
Supply voltage too low	322_H	The supply voltage L+ is too low.	Check the supply voltage L+ and then test the safety application.
ADC error	331_H	Internal error during analog-digital conversion. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Fault in test connection	332_H	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value range for at least 1 minute (see Technical specifications (Page 51): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and fault display, the F-module provides information about the validity of each analog input signal – the value status. The value status is entered in the process image along with the input signal.

Value status for F-modules

The value status is a binary additional information of an input signal. The value status is entered in the process image inputs (PII) at the same time as the process signal. It provides information about the validity of the input signal.

The value status is affected by all faults.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors, you can only access the low order channel in the safety program, e.g. channel 0, channel pair 0/2.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image inputs. You can find the assignment in section Address space (Page 31).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

7

7.1 Technical specifications

Technical specifications of the F-AI 4xU 0..10V HF

Article number	6ES7136-6AB00-0CA1
General information	
Product type designation	F-AI 4XU 0..10V HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V16 with HSP 308
Operating mode	
• cyclic measurement	Yes
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	0.38 A
Current consumption, max.	0.4 A
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes
• Output current, max.	300 mA; total current of all encoders/channels
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	2 W

Article number	6ES7136-6AB00-0CA1
Address area	
Address space per module	
• Inputs	14 byte; S7-300/400F CPU, 13 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type H	Yes
Analog inputs	
Number of analog inputs	4
• For voltage measurement	4
permissible input voltage for voltage input (destruction limit), max.	35 V
Input ranges (rated values), voltages	
• 0 to +10 V	Yes
– Input resistance (0 to 10 V)	16 kΩ
Cable length	
• shielded, max.	200 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	20 / 16,667
• Interference voltage suppression for interference frequency f1 in Hz	50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	7
• parameterizable	Yes
• Step: None	Yes; 1x conversion cycle time
• Step: low	Yes; 2x / 4x conversion cycle time
• Step: Medium	Yes; 8x / 16x conversion cycle time
• Step: High	Yes; 32x / 64x conversion cycle time
• Average value filter	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1 %
Temperature error (relative to input range), (+/-)	0.023 %/K
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.1 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	2 %

Article number	6ES7136-6AB00-0CA1
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.1 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	70 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; Green/red LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 5.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h

Article number	6ES7136-6AB00-0CA1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Operational limit in complete temperature range

WARNING

When designing the safety function, you must take into account the information "Operational limit in complete temperature range" for the entire mission time.

Temperature characteristic values

NOTE

When the ambient temperature exceeds 55 °C, you must only apply a maximum total current of 3 A to an adjacent F-DQ 4x24VDC/2A PM HF.

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

You will find the response times of the F-AI 4xU 0..10V HF below. The response times are included in the calculation of the F-system response time.

Definition of response time for fail-safe analog inputs

The response time results from the number of channels/channel pairs, the response time per channel/channel pair, the basic response time and the configured smoothing.

Times required for the calculation

- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 20 ms
- Basic response time: 20 ms
- Response time per channel
  - At 50 Hz: 25 ms
  - At 60 Hz: 22 ms

Conversion cycle time = basic response time + (N × response time per channel)

(N = number of active channels)

The conversion cycle time is the time in which all activated channels are processed/converted once.

Typical response time

You can calculate the typical response time of the F-AI 4xU 0..10V HF using the following formula:

Typical response time = Conversion cycle time × Smoothing

Maximum response time (worst case delay time, WCDT)

You can calculate the maximum response time of F-AI 4xU 0..10V HF (worst case delay time, WCDT) using the following formula:

Maximum response time = 2 × Conversion cycle time × Smoothing

Response time in the case of a fault (one fault delay time, OFDT)

You can calculate the response time of the F-AI 4xU 0..10V HF (one fault delay time, OFDT) as follows:

- According to the following formula if a discrepancy error is present:

  Typical response time = Conversion cycle time × Smoothing + Discrepancy time + Conversion cycle time

  Maximum response time = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time
- According to the following formula if a channel fault is present:

  Typical response time = Conversion cycle time

  Max. response time = 2 × Conversion cycle time

This means that, for OFDT, the time on occurrence of a discrepancy error should be taken with parameter assignment "1oo2 evaluation (max. SIL3/Cat.4/PLe)" and the time on occurrence of a channel fault should be taken with parameter assignment "1oo1 evaluation (max. SIL2/Cat.3/PLd)".

Representation of analog values

B

In this section we are presenting the analog values for all measuring ranges that you can use with the F-AI 4xU 0..10V HF analog input module.

Measured value resolution

The analog values are shown as fixed-point number in two's complement.

The resolutions shown here are 16 bits including sign.

Table 1-516 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of analog values

The following tables list the decimal and hexadecimal values (codes) of the voltage measuring range 0 V to 10 V.

Table 1-517 Voltage measuring range 0 V to 10 V

Values		Voltage measuring range	Range	
Dec.	Hex.		Diagnostics wire break: No	Diagnostics wire break: Yes
32512	$7F00_H$	> 11.759 V	Overflow[1]	Overflow[1]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	11.759 V . . 10 V + 361.69 µV	Overrange	Overrange
27648 . . 2765	$6C00_H$ . . 0ACD	10 V . . 1 V (1.0000723 V)	Nominal range	Nominal range
2764 . . 819	0ACC . . 0333	< 1 V (1.0000723 V) . . 0.2962240 V		Wire break[1]
818 . . 1 0	0332 . . 1 0	< 0.2962240 V . . 361.69 µV 0 V	Underflow[2]	

1 The F-module signals a "Wire break" or "High limit violated", $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 The F-module signals a "Low limit violated", 8000_H for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

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SIMATIC

ET 200SP
Digital Output Module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB01-0CA0)

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Introduction

1

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. You can find functions that generally relate to the ET 200SP system in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Important note for maintaining the operational safety of your plant

NOTE

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log onto Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)
     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:
     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

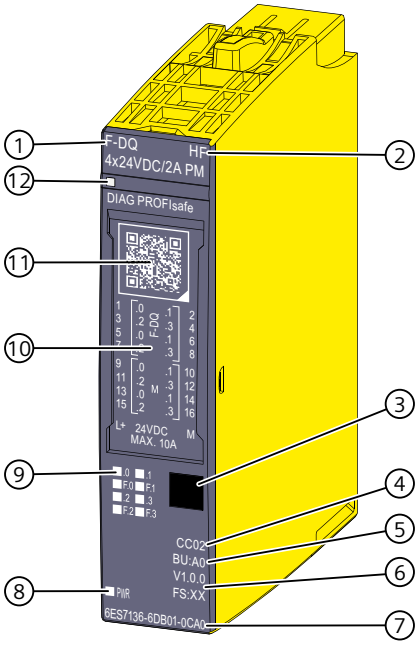
3

3.1 Properties

Article number

6ES7136-6DB01-0CA0

View of the module



①	Module type and name	⑦	Article number
②	Function class	⑧	LED for supply voltage
③	Color coding module type	⑨	LEDs for channel status
④	Color code for selecting the color-coded labels	⑩	Wiring diagram
⑤	BU type	⑪	QR code for identification link
⑥	Firmware and function version	⑫	LED for diagnostics

Figure 1-228 View of the F-DQ 4×24VDC/2A PM HF module

Properties

The module has the following technical properties:

- Fail-safe digital module
- PROFIsafe
- PROFIsafe address type 2
- 4 outputs, PM switching (SIL3/Cat.4/PLe)
- Supply voltage L+
- Output current per output 2 A
- Source output (PM switching)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostic display (DIAG red/green LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Diagnostics e.g. short-circuit/wire break, channel by channel
- Channel-based or module-based passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data
- "Keep last valid value" parameter

⚠ WARNING

If you have configured the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB00-0CA0) in a plant, but have inserted the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB01-0CA0) instead, the information from the equipment manual of the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB00-0CA0) continues to apply.

⚠ WARNING

The safety parameters in the technical specifications apply for a service life of 20 years and a repair time of 100 hours. If repair is not possible within 100 hours, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours have elapsed. The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic messages (Page 46).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as replacement part (article number 6ES7193-6EF00-1AA0)

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs
If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.
Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.
One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.
The required measures are standardized for plants with product standards.
For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Use in safety mode with the "Keep last valid value" setting

With the "Keep last valid value" setting for the "Behavior at loss of communication" parameter, you can only use the F-DQ 4×24VDC/2A PM HF I/O module in compliance with the EN 54-2 standard.

NOTE

If the "Behavior at loss of communication" parameter is set to "Keep last valid value", it cannot be used in accordance with the standards for machine safety (IEC 61508, ISO 13849-1).

Connecting

4

4.1 Wiring and schematic circuit diagram

This section includes the schematic circuit diagram of the digital output module F-DQ 4×24VDC/2A PM HF with the terminal assignment.

You can find information on wiring the BaseUnit in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

General terminal assignment

Table 1-518 Terminal assignment for F-DQ 4×24VDC/2A PM HF

Pin assignment for F-DQ 4×24VDC/2A PM HF (6ES7136-6DB01-0CA0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DQ-P_0	**2**	DQ-P_1	• DQ-P_n: Output signal, channel n, P-switching • DQ-M_n: Chassis ground for output signal, channel n, M-switching	A0	 CC02 6ES7193-6CP02-2MA0
3	DQ-P_2	**4**	DQ-P_3			
5	DQ-P_0	**6**	DQ-P_1			
7	DQ-P_2	**8**	DQ-P_3			
9	DQ-M_0	**10**	DQ-M_1			
11	DQ-M_2	**12**	DQ-M_3			
13	DQ-M_0	**14**	DQ-M_1			
15	DQ-M_2	**16**	DQ-M_3			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types, can be identified by the last two digits of the article number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

The fuse integrated in the BaseUnit type A1 can be triggered for the digital output module, rendering the terminals unusable.

Make sure that you only use digital modules with the BaseUnit type A0 during commissioning.

Switching non-floating loads

If the following two conditions are met, a short-circuit is detected by the F-DQ 4×24VDC/2A PM HF:

- When loads are switched from the F-DQ 4×24VDC/2A PM HF that have a connection between chassis ground and ground. For example to improve the EMC properties.
- When chassis ground and ground are connected on the supplying power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection.

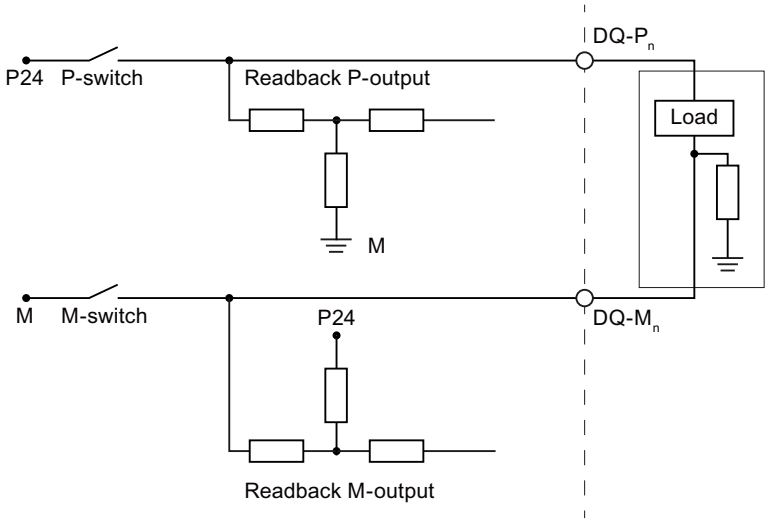


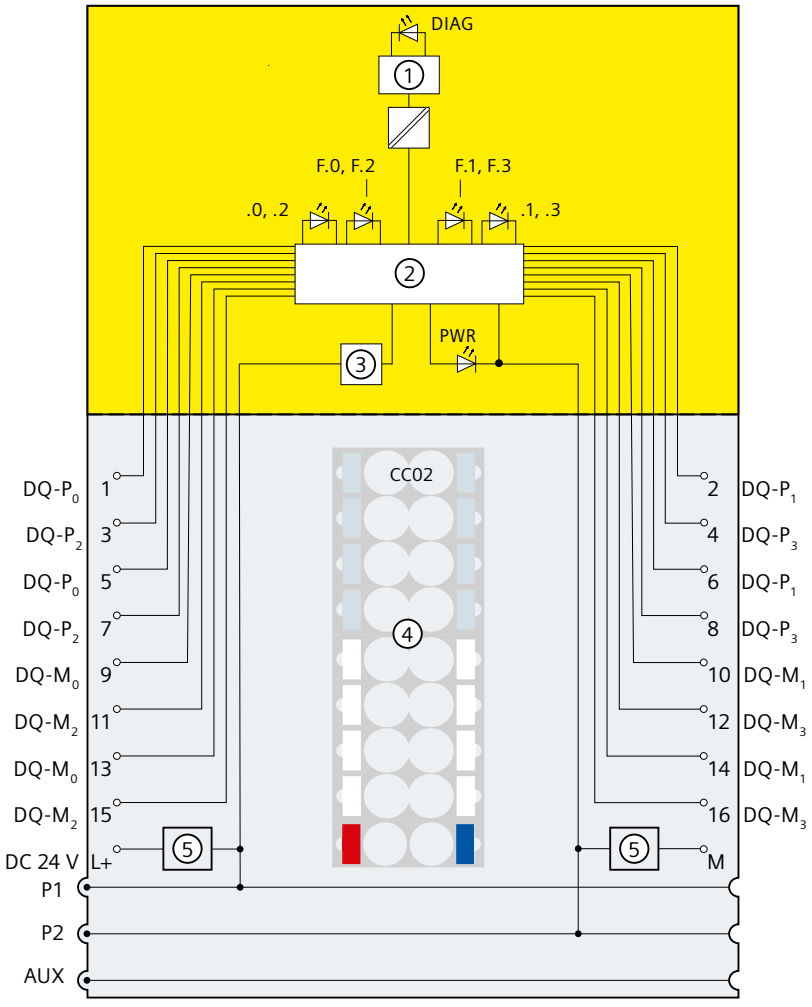
Figure 1-229 Switching of grounded loads (resistance between chassis and ground)

Alternatively, you can use the following modules:

- F-DQ 8x24VDC/0.5A PP HF
- The F-PM-E 24VDC/8A PPM ST power module for which the output is configured as PP switching

Schematic circuit diagram

The following figure shows the pin assignment of the digital output module F-DQ 4×24VDC/2A PM HF on the BaseUnit BU type A0.



①	Backplane bus interface	DQ-P_n	Output signal, channel n, P-switching
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DQ-M_n	Chassis ground for output signal, channel n, M-switching
④	Color-coded label with color code CC02 (optional)	DIAG	Error or diagnostics LED (green, red)
⑤	Filter connection supply voltage (only when light-colored BaseUnit is present)	0.0 to 0.3	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.3	Channel fault LED (red)
M	Chassis ground supply voltage	PWR	Power LED (green)

Figure 1-230 Schematic circuit diagram of the F-DQ 4×24VDC/2A PM HF

Parameters/address space

5

5.1 Parameters

Parameters for F-DQ 4×24VDC/2A PM HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 36).

The following parameters are possible:

Table 1-519 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (with addresses)	0 to 65535	Is calculated by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	• Passivate entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB-number	—	Is proposed by the F-system	No	Module
F-I/O DB-name	—	Is proposed by the F-system	No	Module
DQ parameters:				
Maximum test period	• 100 s • 1000 s	1000 s	No	Module

*) When the "Enable Dynamic Read Back" parameter is enabled.

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Behavior at loss of communication	• Apply substitute value "0" • Keep last valid value	Apply substitute value "0"	No	Module
Disable Dark Test (max. SIL2, CAT3, PLd)	• Disable • Enable	Disable	No	Module
Disable Dark Test for 48 hours	• Disable • Enable	Disable	No	Module
Enable Dynamic Read Back	• Disable • Enable	Disable	No	Module
Channel parameters:				
Channel n				
Activated	• Disable • Enable	Enable	No	Channel
Max. readback time, dark test and switch-off test	• 0.6 to 400.0 ms • 0.6 to 20.0 ms *	1.0 ms	No	Channel
Max. readback time switch-on test	0.6 to 5.0 ms	0.6 ms	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter "Reintegration after channel fault".	Manual	No	Channel
Activated light test	• Disable • Enable	Disable	No	Channel
Diagnosis: Wire break	• Disable • Enable	Disable	No	Channel

*) When the "Enable Dynamic Read Back" parameter is enabled.

5.2 Explanation of parameters

5.2.1 F-parameters

5.2.1.1 PROFIsafe address

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

5.2.1.2 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

5.2.1.3 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use on S7-1200/1500 F-CPUs
When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

5.2.2 DQ parameters

5.2.2.1 Maximal test period

With this parameter, you specify the time within which the light, dark and switch on tests (complete bit pattern test) should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test time is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

5.2.2.2 Behavior at loss of communication

Defines the reaction of the digital output in the event of CPU STOP or communication failure between the F-module and CPU.

- Apply substitute value "0"
- Keep last valid value

Behavior of the I/O module depending on the "Behavior at loss of communication" parameter.

With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, the I/O module is only compliant with EN 54-2.

Options:

- Safety mode (SIL3)
- Safety mode (EN 54)

You can find more information on the behavior of the I/O module depending on the "Behavior at loss of communication" parameter in the section "Reaction of the output module with the "Keep last valid value" setting (Page 23)".

5.2.2.3 Reaction of the output module with the "Keep last valid value" setting

Behavior of I/O module

Depending on the "Behavior at loss of communication" parameter, the digital output module complies with the following standards:

Table 1-520 Conformity to standards

Setting of the "Behavior at loss of communication" parameter	
"Apply substitute value "0""	**"Keep last valid value"**
In conformance with all standards mentioned in the certificates. You will find the certificates on the Internet at: • Certificate for S7 F/FH Systems (https://support.industry.siemens.com/cs/ww/en/ps/14362/cert)	Only compliant with EN 54-2

NOTE

To provide the substitute value, it is necessary to supply the interface module with voltage.

Applications

Typical applications for safety mode with the "Keep last valid value" setting are:

- Ventilation systems
- Smoke flaps

Reactions to faults

NOTE
Observe the appropriate standards for the installation.

NOTE
With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, only the EN 54-2 standards are met.
The last valid value is supplied when the following communication failures/interruptions occur:

- STOP of the F-CPU (interruption of the PROFIsafe communication)
- Breakdown of PROFIsafe communication
  - Following CRC errors
  - Disconnection of the PROFINET connection
  - Monitoring time of data frames exceeded
- Error in the safety program of the F-CPU
- Error in the PROFIsafe protocol

After resumption of the PROFIsafe communication, the current process value is output again.
The safe state "0" is assumed at the output of the digital output module when the following faults occur:

- Channel fault
- Module fault

If a channel fault occurs in connection with S7 F/FH systems, the last valid value of all error-free channels is held after a STOP-RUN transition of the F-CPU until the channels are re-integrated in the safety program. If the parameter "Behavior after channel fault" is set to "Passivate entire module", you need to eliminate the channel fault before you can reintegrate the channels in the safety program.

5.2.2.4 Disable Dark Test (max. SIL2, CAT3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive or a process value change of a digital input with very short input delay.

A capacitive load that does not correspond to the load curves (see section Switching capacitive loads (Page 56)) can lead to passivation of the output during a process value change, switch-on test or light test despite the dark test being disabled.

The "Enable Dynamic Read Back" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Disable Dark Test (max. SIL2, CAT3, PLd)" parameter.

They achieve max. SIL2/Cat.3/PLd with disabled dark test.

For disabled dark test:

⚠ WARNING

SIL2/Cat.3/PLd requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. The "0" signal must have a duration of at least 2 seconds. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

⚠ WARNING

When you use the function "Disable Dark Test", cross-circuits between channels with "1" signal are not detected. If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated. Also take into consideration the respective requirements of your product standards regarding error detection time.

5.2.2.5 Disable Dark Test for 48 hours

This option allows you to suppress the dark test.

To suppress dark test pulses, you must ensure that all channels together carry the 0-signal once within the 48 hours. This suspends the dark test for a further 48 hours.

If this condition is not fulfilled, all dark test pulses will be applied anyway on all channels after expiration of this time. With 0-signal channels, the test pulses of light test continue to occur.

The "Enable Dynamic Read Back" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Disable Dark Test (max. SIL2, CAT3, PLd)" parameter.

If the following condition is met, the dark test is permanently suppressed:

- Before the 48 hours have elapsed, all channels together have a 0 signal.

⚠ WARNING

If a fault caused by short-circuits (cross-circuits) is detected when the safety function is requested (switching off of the output), not only is this output passivated but all outputs are switched off and the module is passivated. This is necessary because no complete bit pattern test is performed within 48 hours and therefore an undetected accumulation of errors cannot be ruled out.
Observe the respective requirements of your product standards with regard to the error discovery time.

If you enable the "Disable Dark Test for 48 hours" parameter, all channels use the values set for channel 0 for the "Max. readback time switch-on test/dark test" parameter.

5.2.2.6 Enable Dynamic Read Back

To avoid an undesired reaction of the actuator to a dark test, you have the option of dynamizing the dark test of the output of the F-module.

The dynamic readback function ends the dark test as soon as the readback signal of the dark test has been validly detected.

- The "Disable Dark Test (max. SIL2, CAT3, PLd)" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Enable Dynamic Read Back" parameter.
- The value range of the "Max. readback time, dark test and switch-off test" parameter is limited to a range between 0.6 and 20 ms.

⚠ WARNING

If the "Enable Dynamic Read Back" function is used, cross-circuits between 1-signal channels are not detected.
If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated.
Also take into consideration the respective requirements of your product standards regarding error detection time.

5.2.3 Parameters of the channels

5.2.3.1 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

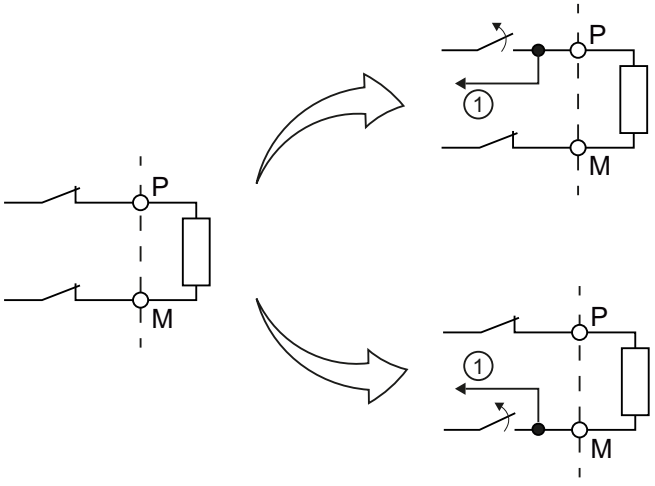
5.2.3.2 Max. readback time, dark test and switch-off test

Function

Dark tests are switch-off tests with bit pattern test.

For "Disable dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1-231 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the max. readback time, dark test and switch-off test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher max. readback time, dark test and switch-off test increases the response time of the F-module.

⚠ WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured max. readback time, dark test and switch-off test) Hz cannot be detected (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"

Because the fault response time is extended by the max. readback time, dark test and switch-off test, we recommend that you set the max. readback time, dark test and switch-off test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads (Page 56).

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the max. readback time, dark test and switch-off test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification, use the process value "1" with a minimum duration that corresponds to the "Maximum test time" parameter.
- If the output channel is passivated sporadically, set a higher value for the max. readback time, dark test and switch-off test.
- If the output channel is passivated, the max. readback time, dark test and switch-off test is too small for a connected capacitive load. The discharge cannot take place within the configured max. readback time, dark test and switch-off test. Increase the max. readback time, dark test and switch-off test.

If you have set the max. readback time, dark test and switch-off test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

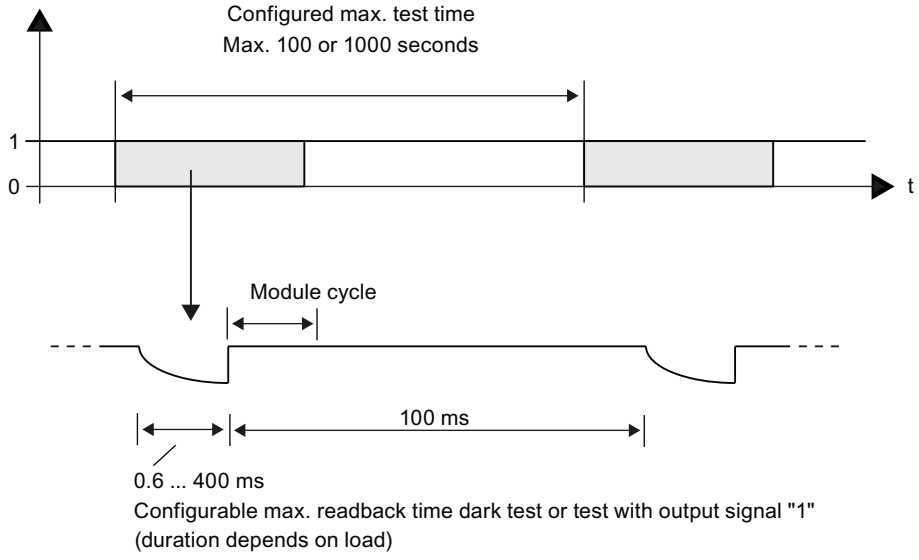


Figure 1-232 Test pulses of the dark test

The interval between two test pulses amounts to at least 100 ms.

NOTE

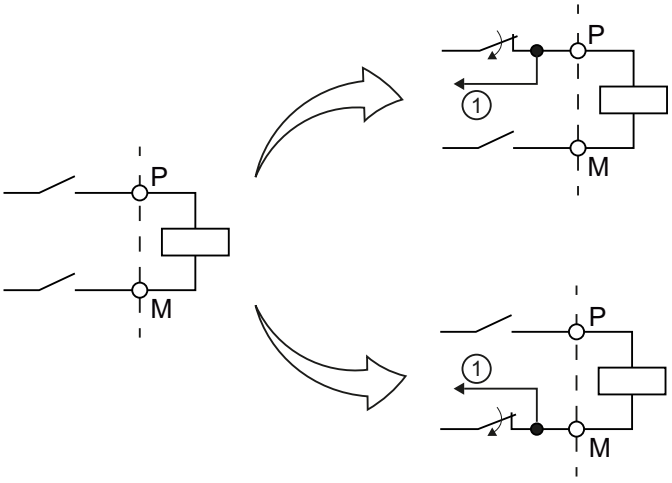
Note that the test pulses can be T_{diff} longer than the set test time.
T_{diff} = max (150 µs, min (10% of the set test time, 300 µs))

5.2.3.3 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.



① Readback

Figure 1-233 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 56).

If the capacitance of the actuator is not known, you may have to determine the required value for the readback time switch-on test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time is too small for a connected capacitive load. The charge of the capacitive load cannot take place during the configured readback time. Increase the readback time.

If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

5.2.3.4 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module is operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatic: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

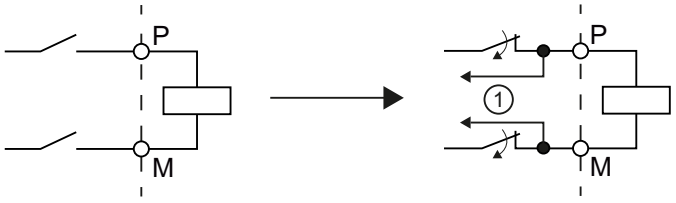
For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

5.2.3.5 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output. Wire break is only detected with a 0 signal at the output if the "Diagnosis: Wire break" parameter is activated in addition to the "Activated light test" parameter.

For a light test, a test signal is switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.



① Readback

Figure 1-234 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

With bad readback signals, the signal is always present at the output channel for the configured readback time.

If a wire break or overload is detected after the maximum readback time has elapsed, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

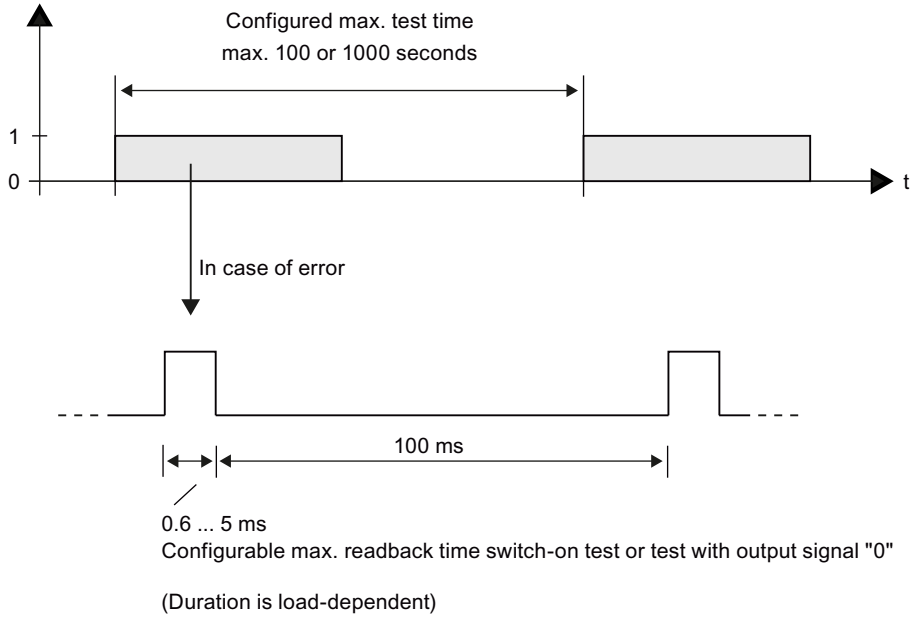


Figure 1-235 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test time per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 100 ms. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

5.2.3.6 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

To detect a wire break with a "0" output signal, you must also enable the light test.

5.3 Address space

Address assignment of the digital output module F-DQ 4×24VDC/2A PM HF

The digital output module F-DQ 4×24VDC/2A PM HF occupies the following address areas in the F-CPU:

Table 1-521 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In input range**	**In output range**
F-CPUs S7-300/400	IB x + 0 to x + 4	QB x + 0 to x + 4
F-CPUs S7-1200/1500	IB x + 0 to x + 5	QB x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 4×24VDC/2A PM HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 4×24VDC/2A PM HF:

Table 1-522 Address assignment through user data

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0
QB x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

You can find detailed information on F-I/O access in the SIMATIC Safety – Configuration and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

See also

Value status (Page 49)

Applications of the F-I/O module

6

6.1 Applications of the F-DQ 4x24VDC/2A PM HF

You achieve SIL3/Cat.4/PLe with the following applications.
The wiring is performed on a suitable BaseUnit (Page 16).

6.2 Application: Wiring a load to each digital output

Each of the four fail-safe digital output consists of a P-switch DQ-P_n and an M-switch DQ-M_n. You connect the load between the P-switch and the M-switch. The two switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

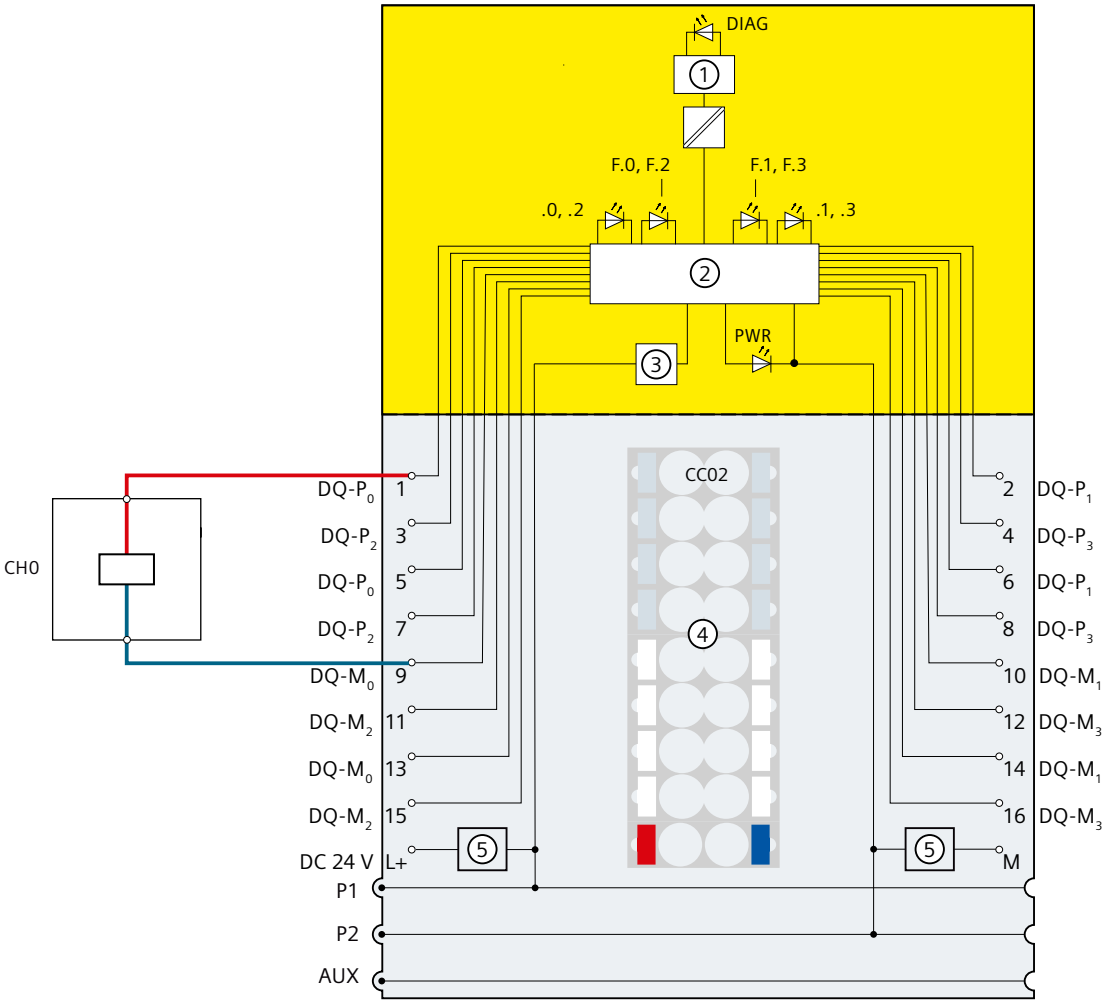


Figure 1-236 Wiring diagram for 1 relay each at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

6.3 Application: Connection of loads to L+ and M at each digital output

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

- Same reference potential
- The normally open contacts of the two relays must be connected in series.

This configuration achieves SIL3/Cat.4/PLe (process status readback required).

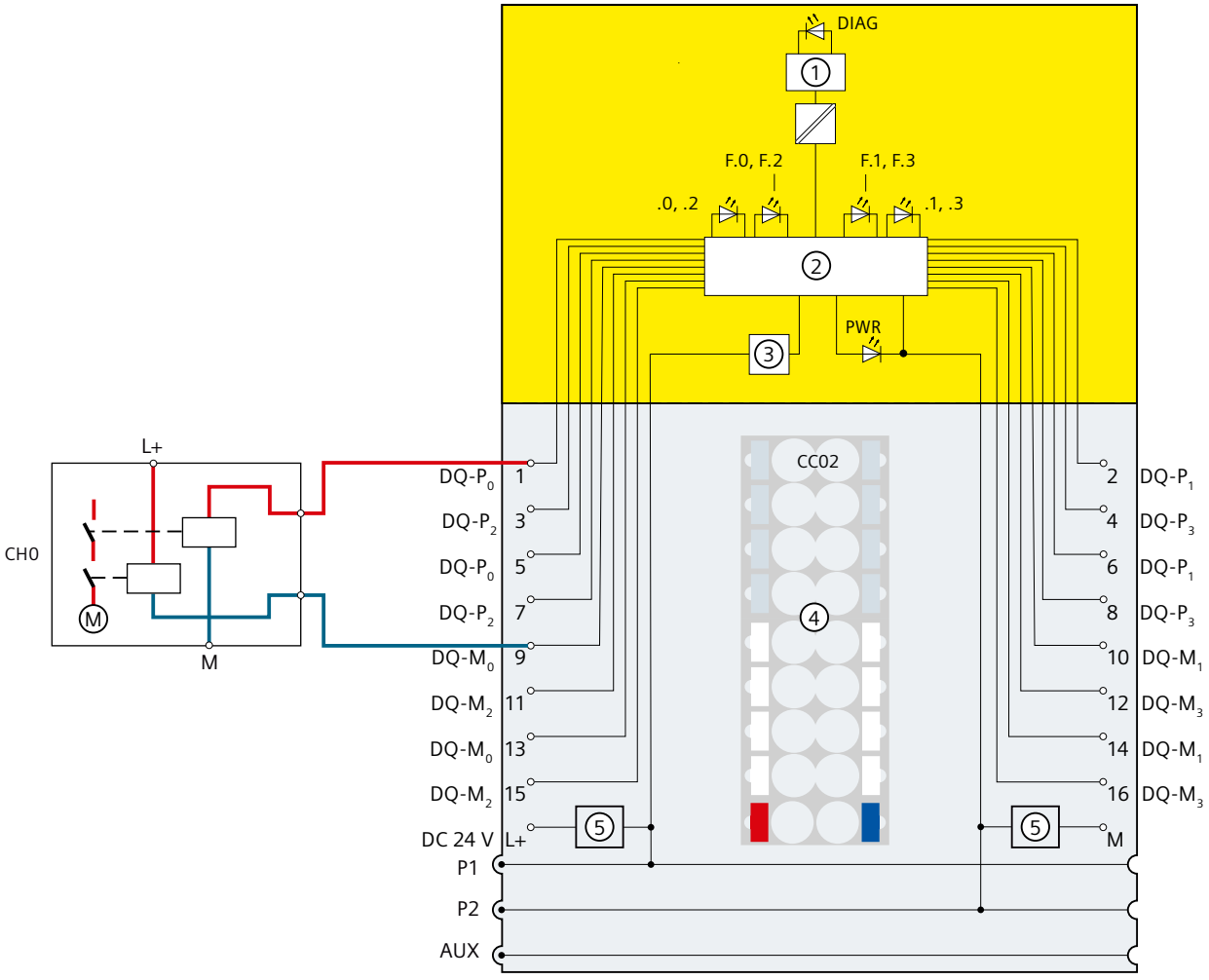


Figure 1-237 Wiring diagram for connecting 2 relays each to 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

WARNING

When two relays are connected to one digital output, as shown in the figure above, the "wire break" and "overload" faults are detected only at the P-switch of the output (not at the M-switch).

⚠ WARNING

With a cross circuit between P-switch and M-switch of the output, the module detects the fault and switches off the output. But the actuator is still supplied with power due to the external fault.
To avoid cross-circuits between P- and M-switches of a fail-safe digital output, you need to lay the cables for connecting the relays to the P- and M-switch in such a way that they are protected against cross-circuits, for example as separately sheathed cables or in separate cable ducts.

NOTE

The digital output module F-DQ 4×24VDC/2A PM HF performs a bit pattern test depending on the parameter assignment. For this, the module outputs up to 5 ms pulses depending on the parameter assignment. This test (switch-on test) is run with a time offset between the P-switch and M-switch to prevent the actuator from being activated. This pulse may cause the corresponding relay to operated, which may reduce its service life.
We therefore recommend adhering to the wiring scheme described below.

6.4 Application: Wiring two loads in parallel to each digital output

To protect against cross-circuits between P-switch and M-switch in fail-safe digital outputs, we recommend the following wiring scheme. This circuit achieves SIL3/Cat.4/PLe.

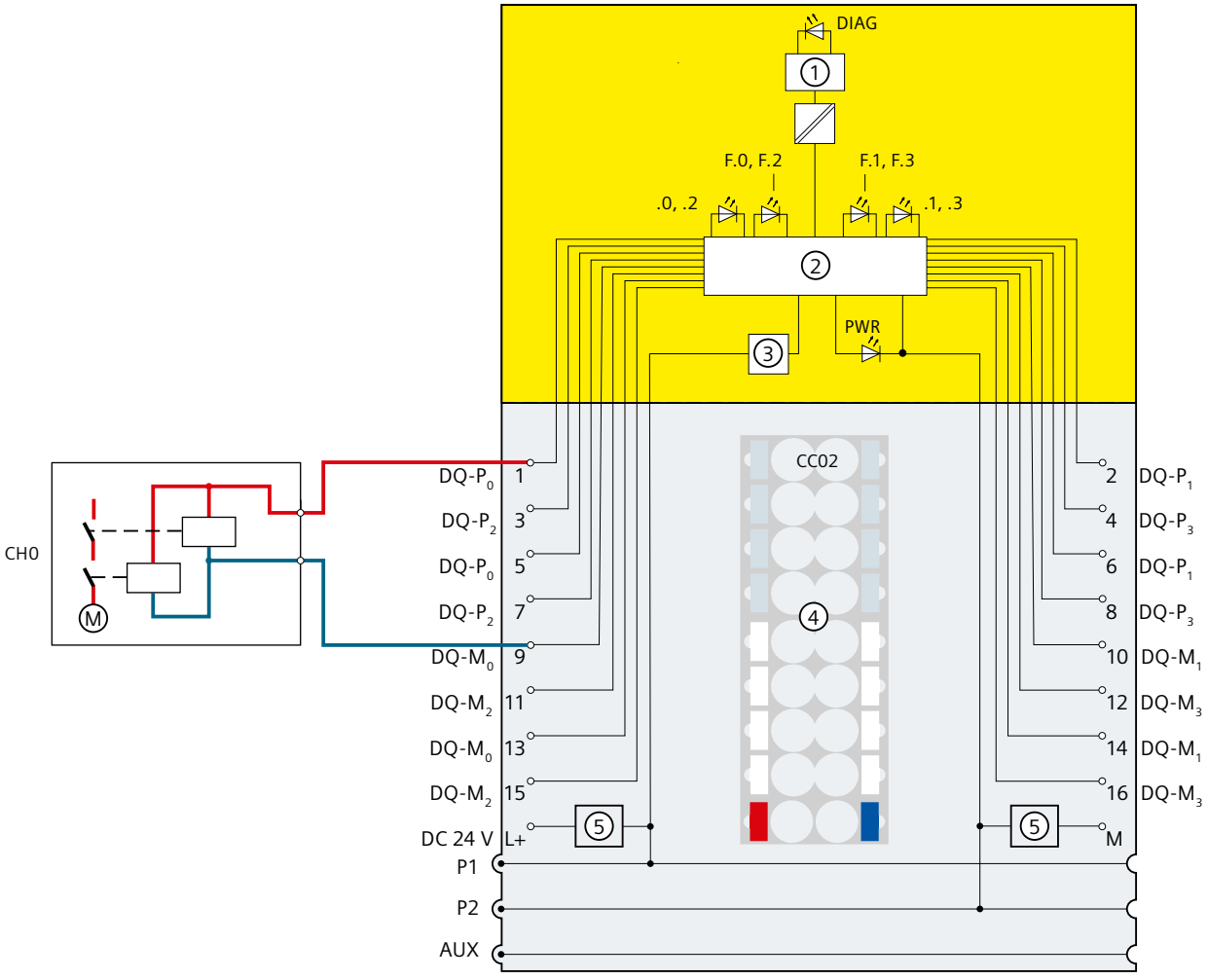


Figure 1-238 Wiring diagram for 2 relays each parallel at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

NOTE

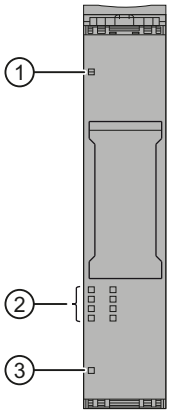
With a parallel connection of two relays on one digital output (as shown above) the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnostics is not safety-related.

Interrupts/diagnostic messages

7

7.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green), channel fault (red)
③ PWR (green)

Figure 1-239 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 46).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 1-523 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

DIAG LED

Table 1-524 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	Module parameters configured and module diagnostics
Flashing	Module waits for user acknowledgment

Channel status/channel fault LED

Table 1-525 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 1-526 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

7.2 Interrupts

Introduction

The F-DQ 4x24VDC/2A PM HF fail-safe digital output module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 46).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Proceed as described in section Diagnostic messages (Page 46) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Parameter error
- Supply voltage missing
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F parameter set incorrect
- CRC1 fault
- Device-specific diagnostics information, see manual
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Channel failure acknowledgment
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostic queue overflow
- F-address memory not accessible
- No valid F-address available
- Undertemperature
- Auxiliary voltage too high

- Auxiliary voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- Wire break
- Safety-related shutdown
- Short-circuit to L+
- Short-circuit to ground
- Frequency too high
- Output defective
- Readback failure
- Overload

7.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

NOTE

You can connect multiple actuators per output
The diagnostics of the actuators influence each other in the case of multiple wiring.
This means:

- A wire break is only signaled if both actuators are affected.
- A single short-circuit affects both actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

Table 1-527 Diagnostic messages of the F-DQ 4×24VDC/2A PM HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 51)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_H	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open).	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Operate the F-module within the specified supply voltage range. • Check BaseUnit type
Safety-related shutdown	19_H	The channel was switched off for safety reasons due to an error on another channel. Possible causes: • There is a short-circuit. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark and light test).
Mismatch of safety destination address (F_Dest_Add)	40_H	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Safety destination address not valid (F_Dest_Add)	41_H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Safety source address not valid (F_Source_Add)	42_H	The PROFIsafe driver has detected an invalid F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The PROFIsafe driver has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47_H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameters (iParCRC error)	$4B_H$	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between F-CPU and F-module is interrupted. • Impermissibly high electromagnetic interference is present. • An error has occurred during the sign-of-life monitoring.	• Check the communication connection between the F-module and the F-CPU. • Eliminate the cause of the electromagnetic interference. • POWER OFF - ON of the station • Reassign the configuration and parameter assignments to the F-module (the station).
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	Check the parameter assignment. Make sure that your communication is operating correctly.
Channel failure acknowledgment	$4F_H$	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.
Watchdog tripped	103_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put into operation anymore, consider a replacement.
Short-circuit to L+	105_H	Short circuit to L+ can mean: • The output cable is short-circuited to L+. • There is a short circuit between two output channels. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).

Diagnostic message	Fault code	Meaning	Remedy
Short-circuit to ground	106_H	Short circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • There is a short circuit between two output channels. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostic queue overflow	$13E_H$	Overflow of the diagnostics memory. Not all pending diagnostics could be sent. This error can result in deactivation of the module up to switching on/off of the supply voltage.	Eliminate the previously reported error.
F-address memory not accessible	$30D_H$	F-source address placed in the coding element and F-destination address cannot be accessed.	Check whether the coding element is available or replace it.
No valid F-address available	$30E_H$	No valid PROFIsafe address is stored in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between setpoint and actual configuration of the plant.	• Perform the assignment of the PROFIsafe address during initial commissioning or deliberate parameter changes. • Check the consistency between the setpoint and actual configuration.
Frequency too high	311_H	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency (see Technical specifications (Page 51)).
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 51))
Output defective	$31D_H$	The F-module has detected an internal error. Possible causes: • The capacitive load is too high. • Short circuit to L+ or M • The F-module is defective	• Increase the test times (dark, light, switch-on tests). • Check the wiring. • Replace the F-module.
Readback failure	$31E_H$	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The capacitive load is too high. • The F-module is defective.	• Increase the test times (dark, light, switch-on tests). • If the error persists, replace the F-module.
Overload	320_H	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists. • The capacitive load is too high.	Check the process wiring.

Diagnostic message	Fault code	Meaning	Remedy
Auxiliary voltage too high	321_H	The supply voltage is too high.	Check the supply voltage.
Auxiliary voltage too low	322_H	The supply voltage is too low.	Check the supply voltage.
F-module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. Pulling and plugging the module or POWER OFF – POWER ON is necessary. • If the F-module cannot be put into operation anymore, consider a replacement.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute (see Technical specifications (Page 51) Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

For information on diagnostics which apply to all fail-safe modules (e.g. for reading out the diagnostic functions, passivation of channels), refer to the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

7.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 34).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

8

Technical specifications of F-DQ 4×24VDC/2A PM HF

The following table lists the technical specifications on the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6DB01-0CA0/td?dl=en).

Article number	6ES7136-6DB01-0CA0
General information	
Product type designation	F-DQ 4x24VDC/2A PM HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 with HSP / V21
• PROFINET from GSD version/GSD revision	GSDML V2.45
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption (rated value)	30 mA; without load
Current consumption, max.	21 mA; From the backplane bus
output voltage / header	
Rated value (DC)	24 V
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	3 W
Address area	
Address space per module	
• Inputs	6 byte; S7-300/400F CPU, 5 byte
• Outputs	6 byte; S7-300/400F CPU, 5 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes

Article number	6ES7136-6DB01-0CA0
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	4
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	> 3.3 A
Open-circuit detection	Yes
• Response threshold, typ.	8 mA
Overload protection	Yes
• Response threshold, typ.	3 A
Limitation of inductive shutdown voltage to	sourcing output: -39 V DC in relation to 2M, sinking output: +47 V DC in relation to 2M
Controlling a digital input	Yes; digital output, according to IEC 61131-2, type 2
Switching capacity of the outputs	
• with resistive load, max.	2 A
• on lamp load, max.	10 W
Load resistance range	
• lower limit	12 Ω
• upper limit	2 000 Ω
Output voltage	
• for signal "1", min.	24 V; L+ (-0.5 V)
Output current	
• for signal "1" rated value	2 A
• for signal "0" residual current, max.	0.5 mA
Switching frequency	
• with resistive load, max.	30 Hz; Symmetrical
• with inductive load, max.	0.1 Hz; according to IEC 60947-5-1, DC-13, symmetrical
• with capacitive load, max.	30 Hz; observe chapter "Switching of capacitive loads" in the manual
• on lamp load, max.	10 Hz; Symmetrical
Total current of the outputs	
• Current per channel, max.	2 A; note derating data in the manual
• Current per module, max.	6 A; note derating data in the manual
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	500 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnostics indication LED	
• RUN LED	Yes; green LED

Article number	6ES7136-6DB01-0CA0
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL2	< 2.00E-04
– Low demand mode: PFDavg in accordance with SIL3	< 2.00E-05
– High demand/continuous mode: PFH in accordance with SIL2	< 1.00E-08 1/h
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Temperature characteristic values

Mounting position	Maximum temperature	Total current across all channels
Horizontal	40 °C	6 A
	50 °C	5 A
	60 °C	4 A
Vertical	50 °C	4 A

NOTE

Due to the small size of output modules with higher loads, pay attention to the heat development between adjacent modules. If overtemperature occurs in an output module exposed to an elevated load, shutdown may result and reduce the plant availability. If you fully load an output module, the average total current of the modules directly adjacent to it should not exceed 75% of the values listed in the technical specifications. If you load directly adjacent modules with their maximum total current, reduce the maximum total current of the output module by 1 A (e.g., for horizontal installation up to 60 °C → total current of 3 A across all channels).

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

The reaction time of the digital output module F-DQ 4×24VDC/2A PM HF is specified below. The reaction times of the digital output module F-DQ 4×24VDC/2A PM HF are included in the calculation of the reaction time of the F-system.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

- Maximum cycle time: T_{cycle} = 5 ms
- Max. acknowledgment time (device acknowledgment time): T_{DAT} = 31 ms

You configure the dark test time (Readback time, T_{rb}) and switch-on time (Readback time switch-on test, T_{rb_swon}) in STEP 7.

Definition of maximum reaction time in an error-free scenario (worst case delay time, WCDT)

The maximum reaction time (T_{WCDT}) for fail-safe digital outputs in the error-free case is as follows:

Max. reaction time (T_{WCDT}) = 2 × T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time)

Definition of maximum reaction time if there is a fault/error (one fault delay time, OFDT)

Max. reaction time (T_{OFDT}) = 2 × T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time)

Maximum reaction time when a channel fault is detected by bit pattern test

Max. reaction time (T_{WCDT}) = 2 ×T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time) + configured test time

Mode of operation: Disable Dark Test for 48 hours - enabled

It can take up to a process value change 0-1 on the corresponding channel before a channel fault is detected. Note the restrictions in the section Disable Dark Test for 48 hours (Page 25).

Switching of loads

B

B.1 Connecting capacitive loads

If a digital output module F-DQ 4×24VDC/2A PM HF is connected to loads that require little current and have a capacitance, a short-circuit or overload may be detected. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trend shown in the diagram below represents the correlation between load impedance and maximum switched load capacitance at a supply voltage of 24 V DC.

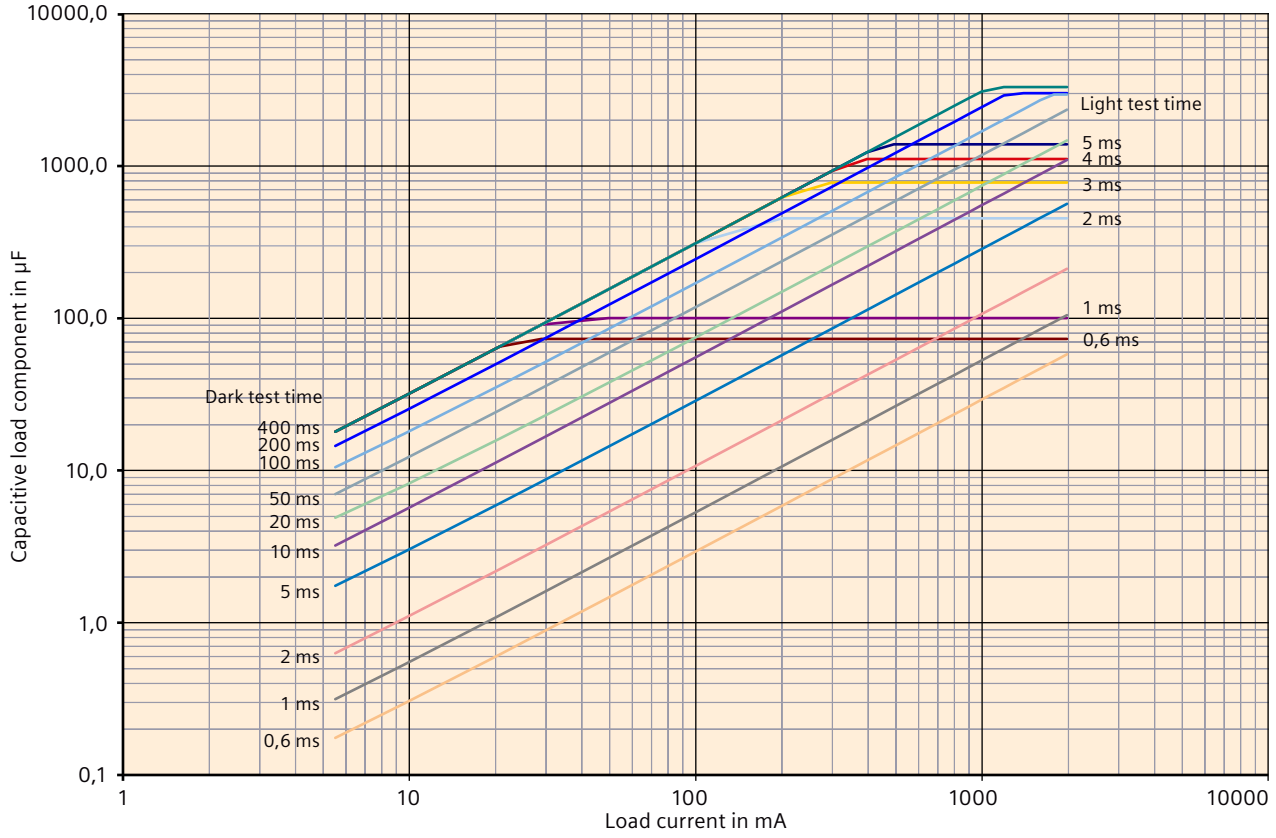


Figure 1-240 Switching of capacitive loads for digital output module F-DQ 4×24VDC/2A PM HF depending on the configured dark and light test time

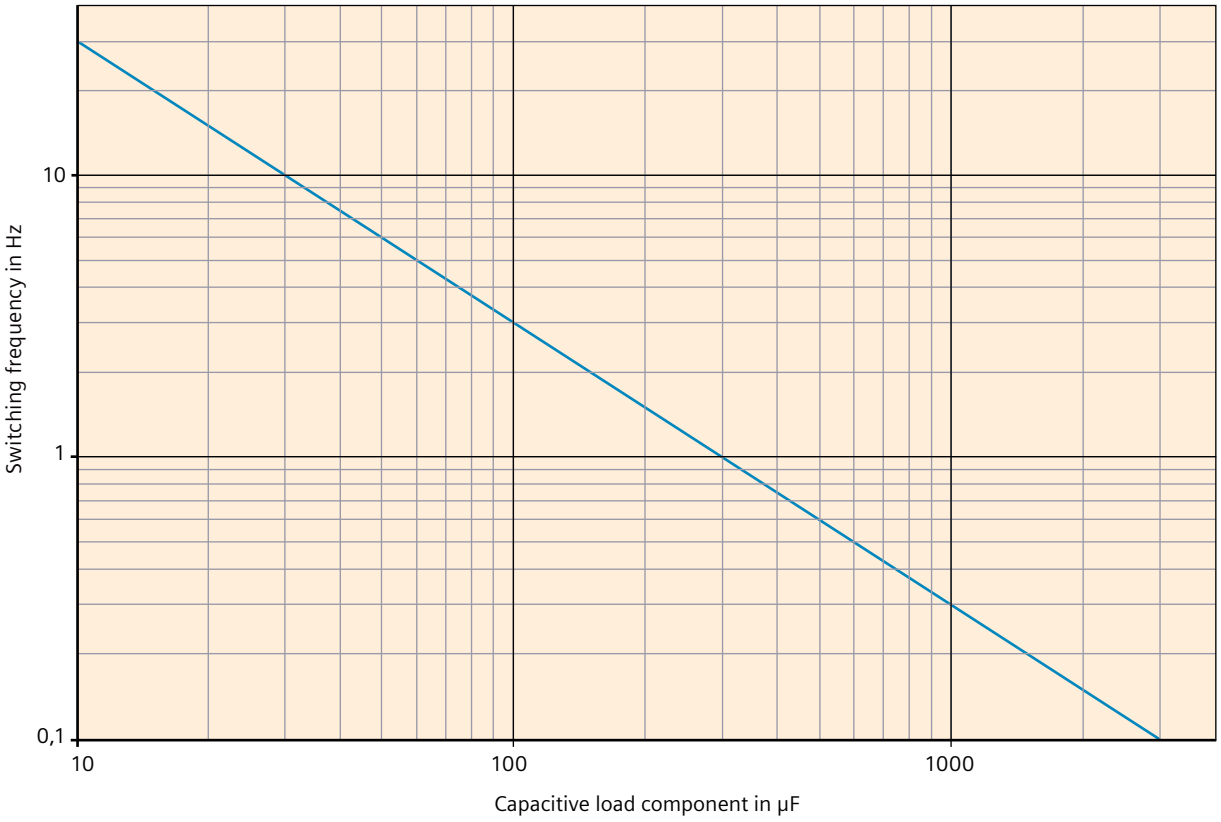


Figure 1-241 Maximum switching frequency depending on the capacity of the load

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

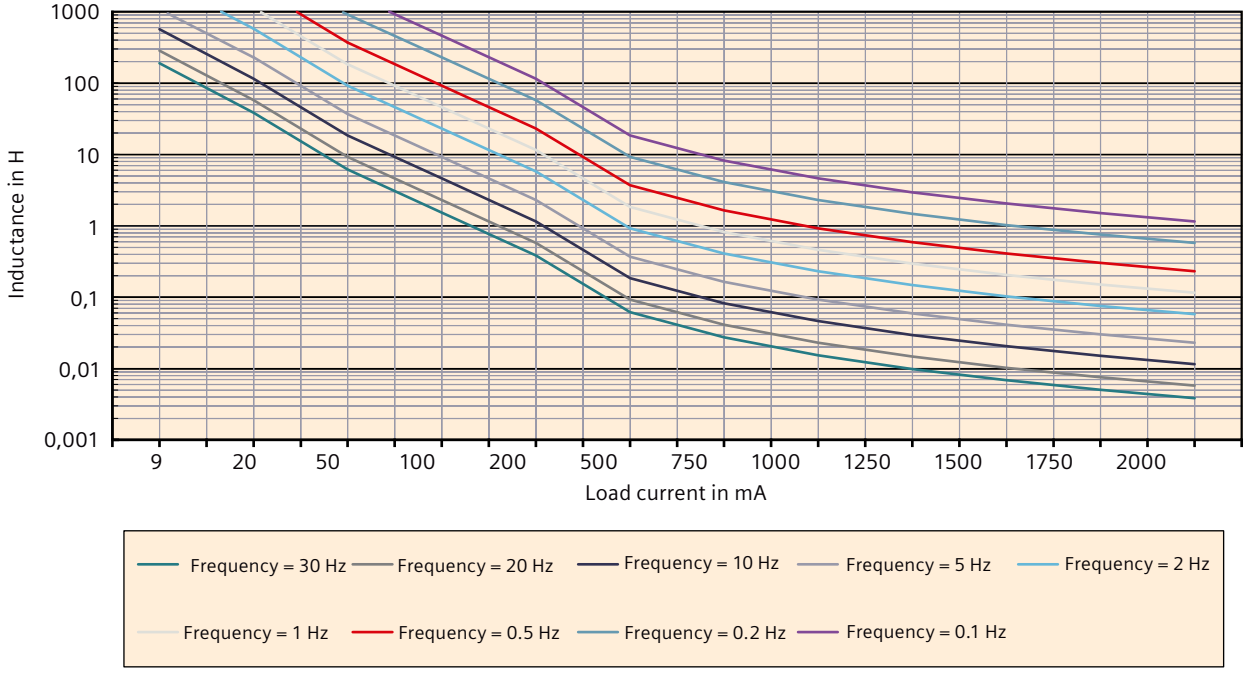


Figure 1-242 Switching of inductive loads for the digital output module F-DQ 4x24VDC/2A PM HF depending on load current and switching frequency

SIEMENS

SIMATIC

ET 200SP
Digital output module F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

Equipment Manual

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12/2022
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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that affect the system in general are described in this system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used below, it refers to the central processing units of the S7-1200/1500 automation system and the S7-300/S7-400 automation systems of the previous generation and to CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

PII: Process image input.

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in Annex 1 of the report to the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

⚠ WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.
You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.
Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- S7-1500 Software Controller (https://support.industry.siemens.com/cs/us/en/ps/13912)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/24471)

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are

available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

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ET 200SP documentation guide

1

1.1 Information classes ET 200SP



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Product overview

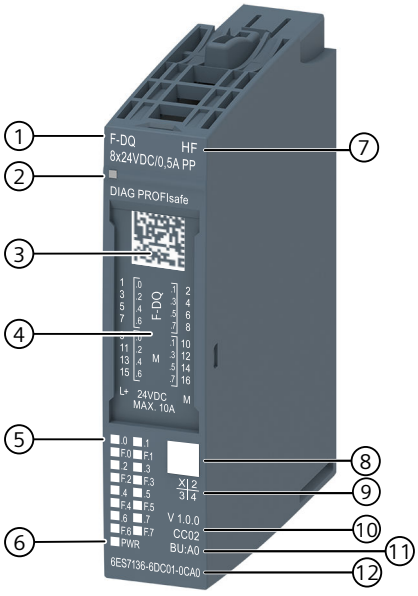
2

2.1 Properties

Article number

6ES7136-6DC00-0CA0

View of the module



① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Connection diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color identification module type
⑨ Function and firmware version
⑩ Color code to select the color identification labels
⑪ Article number

Figure 1-243 View of the module F-DQ 8x24VDC/0.5A PP HF

Properties

The module has the following technical characteristics:

- Fail-safe digital module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 8 outputs, PP-switching (SIL3/Cat.4/PLe)
- Supply voltage L+
- Output current 0.5 A per output
- Sourcing output (PP-switching)
- Suitable for solenoid valves, DC contactors and signal lamps
- Direct interconnection to inputs of an F-DI possible
- Diagnostics display (DIAG red/green LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel-specific or module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data (V1.0.1 and higher)

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours elapse. The module switches off independently after the 100 hours have expired. Follow the repair procedure described in section Diagnostics alarms (Page 43).

NOTE

Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

The following accessory must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as spare part (article number 6ES7193-6EF00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs
If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus put the F-system in a dangerous state.
Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.
One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.
The required measures are standardized for plants with product standards.
For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Connecting

3

3.1 Wiring and block diagram

This section provides the block diagram of the F-DQ 8×24VDC/0.5A PP HF F-module with the terminal assignment.

You can find information about the various connection options and their configuration in the section Applications of the F-I/O module (Page 27) or Parameters/address space (Page 18).

You can find more information about wiring the BaseUnit in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

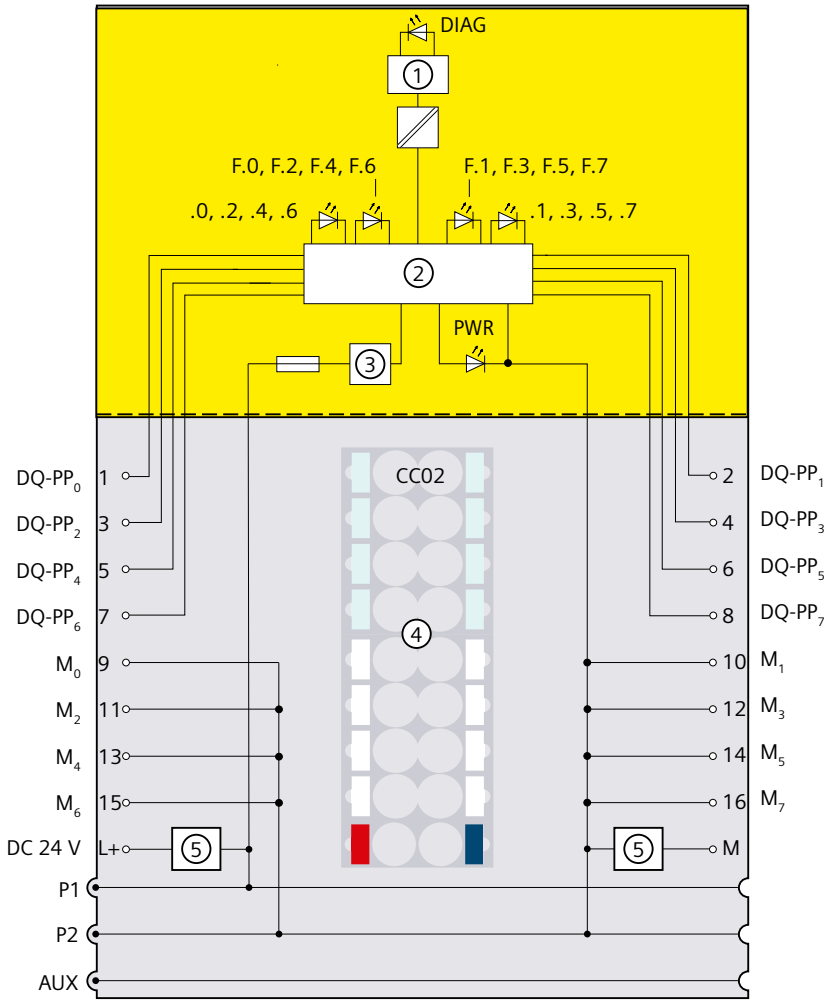
The load group of the F-module must begin with a light-colored BaseUnit. Keep this in mind as well during configuration.

NOTE

Make sure that you only use the digital output module with BaseUnit type A0 during commissioning.

Block diagram

The following figure shows the terminal assignment of the F-DQ 8×24VDC/0.5A PP HF digital output module on BaseUnit BU type A0.



①	Backplane bus interface	M_n	Ground for connection of actuator of channel n.
②	Output electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	$DQ\text{-}PP_n$	Output bit n, channel n, PP-switching (sourcing output)
④	Color-coded label with color code CC02 (optional)	DIAG	LED error of diagnostics (green, red)
⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	LED channel status (green)
24 VDC	Supply voltage L+ (feed for light-colored BaseUnit only)	F.0 to F.7	LED channel error (red)
M	Supply voltage ground	PWR	LED Power (green)

Figure 1-244 Block diagram

Parameters/address space

4

4.1 Parameters

Parameters for F-DQ 8x24VDC/0.5A PP HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 27).

The following parameters are possible:

Table 1-528 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Dependent on parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Suggested by F-system	No	Module
F-parameter signature (without addresses)	0 to 65535	Calculated by F-system	No	Module
Behavior after channel faults	• Passivate the entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Suggested by F-system	No	Module
F-I/O DB name	—	Suggested by F-system	No	Module
DQ parameters:				
Maximum test period	• 100 s • 1000 s	1000 s	No	Module
Disable dark test for 48 hours	• Disable • Enable	Disable	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Channel parameters:				
Channel n				
Activated	• Enable	Enable	No	Channel
Max. readback time light test / dark test	• 0.8 / 1.0 ms • 3.0 / 5.0 ms	0.8 / 1.0 ms	No	Channel
Activated light test	• Enable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

4.2.1.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address with the "Central F-source address" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses assigned in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

4.2.1.2 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

4.2.1.3 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use in S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use in S7-1500 F-CPUs
When using the fail-safe module in S7-1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.2 Parameters of the channels

4.2.2.1 Maximum test period

With this parameter, you specify the time within which the light, dark tests (complete bit pattern test) should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test period is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

4.2.2.2 Disable dark test for 48 hours

This option allows you to suppress the dark test.

To suppress dark test pulses, you must ensure that all channels together carry the 0-signal once within the 48 hours. If this condition is not fulfilled, all dark test pulses will be applied anyway on all channels after expiration of this time.

With 0-signal channels, the test pulses of light test continue to occur.

⚠ WARNING

When you use the function "Disable dark test for 48 hours", cross-circuits between channels with 1-signal are not detected.
If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated.
Also take into consideration the respective requirements of your product standards regarding error detection time.

When you activate the parameter "Disable dark test for 48 hours", all channels use the values set for channel 0 for the parameter "Max. readback time light test / dark test".

4.2.2.3 Activated

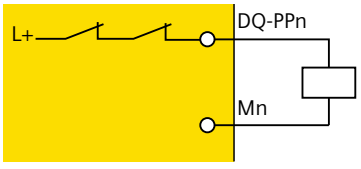
The channel is always activated for this F-module.

4.2.2.4 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel has the 1-signal. This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1-245 Functional principle of the dark test (PP switching)

This parameter allows you to set the time for the readback.

If the expected signals could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the reaction time of the F-module.

⚠ WARNING

Through the configured dark test time, short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured dark test time) Hz cannot be recognized (50:50 sampling ratio).
Short-circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short-circuit detection (cross-circuit) with 1-signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you only use the large readback time dark test if the output channel would be passivated with the small readback time.

In case of the "Connecting a load per digital output" (Page 28) application, see the warnings and notes in the section describing the application.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 54).

Setting readback time dark test with unknown actuator capacity

If the capacity of the actuator is not known, it may be necessary for you to set the larger readback time. This may also be necessary due to component variation in the

actuator or external influences.

Proceed as follows:

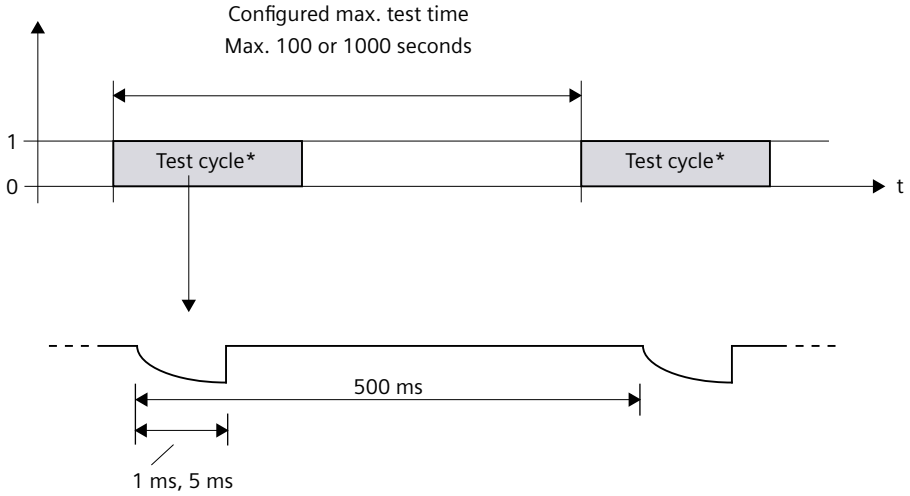
- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use a 1-signal with a minimum duration that corresponds to the "Maximum test period".
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

Test pulses of the dark test

The interval between two test pulses is 500 ms.



* Output of test pulses only during test cycle.

Figure 1-246 Test pulses of the dark test

NOTE

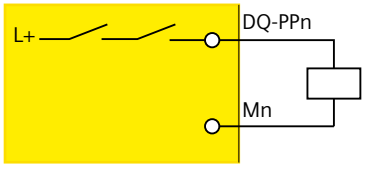
If the dark test detects an error, the affected channel is switched off with the error message "Short circuit to L+", all the other channels with the error message "Safety-related shutoff".

4.2.2.5 Max. readback time light test

Function

Short-circuit is detected with a 0-signal at the output.

For a light test, a test signal is switched to the output channel while the output channel has the 0-signal. The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.



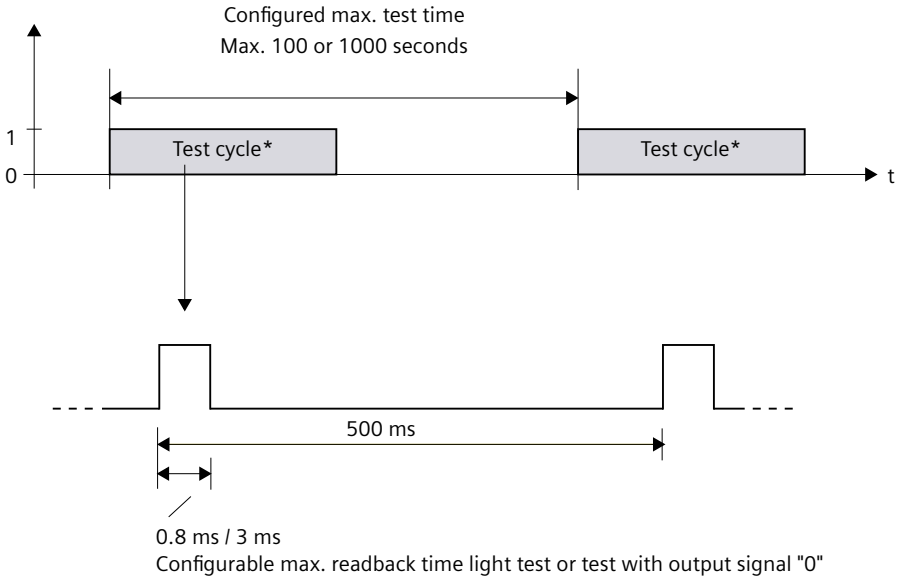
① Readback

Figure 1-247 Functional principle of the light test

If the signal was not read back correctly once the maximum readback time light test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time light test for the light test increases the reaction time of the F-module.

Test pulses of the light test



* Output of test pulses only during test cycle.

Figure 1-248 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test period per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 500 ms. If the fault is still present, the maximum test period is automatically reduced to 60 seconds and a diagnostics alarm is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.2.6 Activated light test

The light test is always enabled for this F-module.

4.2.2.7 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs
This parameter is only relevant if the fail-safe module is operated on an S7-1500 F-CPU, and can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel should react to a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs
The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. There you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3 Address space

Address assignment of the digital output module F-DQ 8x24VDC/0.5A PP HF

The digital output module F-DQ 8x24VDC/0.5A PP HF occupies the following address areas in the F-CPU:

Table 1-529 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 4	QB x + 0 to x + 4
S7-1200/1500 F-CPUs	IB x + 0 to x + 5	QB x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 8x24VDC/0.5A PP HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 8x24VDC/0.5A PP HF:

Table 1-530 Address assignment of user data **in the input range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Value status DQ_7	Value status DQ_6	Value status DQ_5	Value status DQ_4	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

Table 1-531 Address assignment of user data **in the output range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB x + 0	DQ_7	DQ_6	DQ_5	DQ_4	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

Applications of the F-I/O module

5

You achieve SIL3/Cat.4/PLe with the following applications.

You carry out the wiring on the appropriate BaseUnit. For more on this, see Connecting section in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

5.1 Installation of the ground line between the power supply and the BaseUnit

Interconnection	Achievable fail-safe performance characteristics	
	Single ground line	Redundant ground line
Connection of the load to the M_n terminal of the BaseUnit	SIL3/Cat.4/PLe	Not required
Connection of the load to the ground of the BaseUnit	SIL3/Cat.3/PLd	SIL3/Cat.4/PLe

In case of redundant installation of the ground line between the power supply and the BaseUnits, the ground connection to the BaseUnits must be installed as follows:

- When the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF is installed on a dark-colored BaseUnit, terminal M of this dark-colored BaseUnit must be additionally connected to the ground of the power supply.
- When the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF is installed on a light-colored BaseUnit, terminal M of the dark-colored BaseUnit installed to the right of the light-colored BaseUnit must be additionally connected to the ground of the power supply.

WARNING

When connecting the load to the ground of the power supply, you must run two ground lines between the power supply and the BaseUnits for safety reasons to achieve SIL3/Cat.4/PLe. Otherwise, the maximum residual current at signal "0" (specified in the technical specifications) cannot be maintained if a single ground line is interrupted.

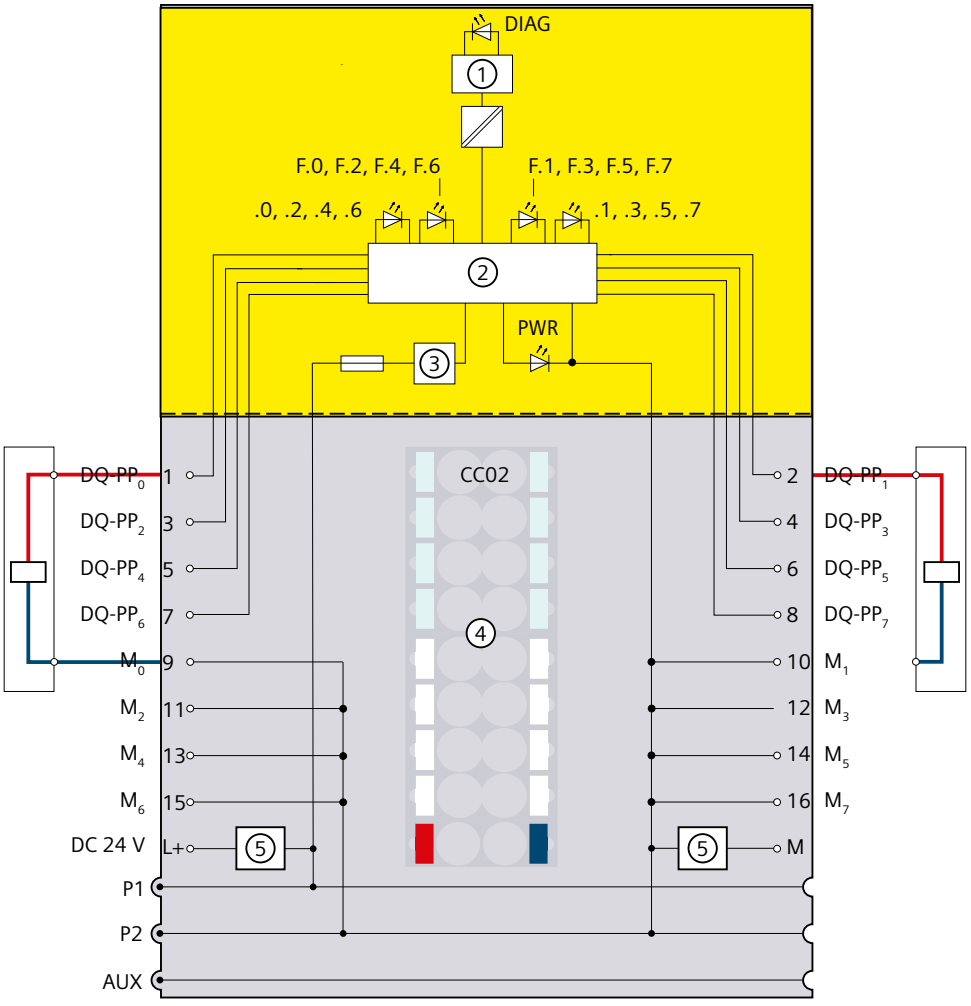
See also

Connecting (Page 16)

5.2 Application: Wiring a load to each digital output

Each of the 8 fail-safe digital outputs consists of two P-switches, which form a PP-switch DQ-PP$_n$. You connect the load between the sourcing output DQ-PP$_n$ and ground. The ground may be the internal ground M$_n$ or an external ground. The two P-switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).



① Backplane bus interface
② Output electronics
③ Reverse polarity protection
④ Color-coded label with color code CC02 (optional)
⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 1-249 Wiring diagram for one relay each to a F-DQ of the digital output module F-DQ 8x24VDC/0.5A PP HF

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, a suitably-qualified actuator, e.g. in accordance with IEC 60947, is required.

⚠ WARNING

The actuator can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

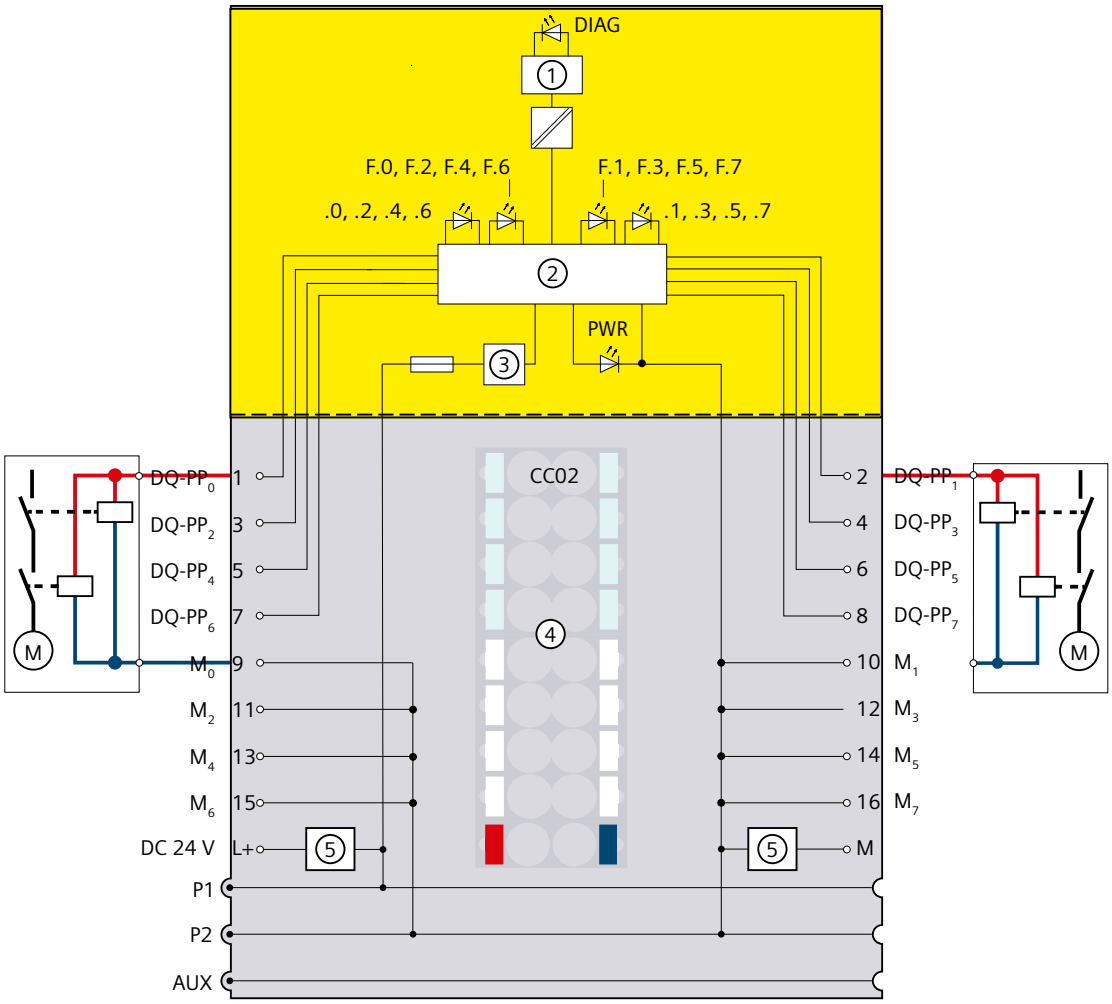
⚠ WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).
If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".
If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.3 Application: Wiring two loads in parallel to each digital output

The ground may be the internal ground M_n or an external ground. This circuit achieves SIL3/Cat.4/PLe.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).



① Backplane bus interface
② Output electronics
③ Reverse polarity protection
④ Color-coded label with color code CC02 (optional)
⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 1-250 Wiring diagram for two relays in parallel to a F-DQ of the digital output module F-DQ 8x24VDC/0.5A PP HF

⚠ WARNING

The actuator can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

⚠ WARNING

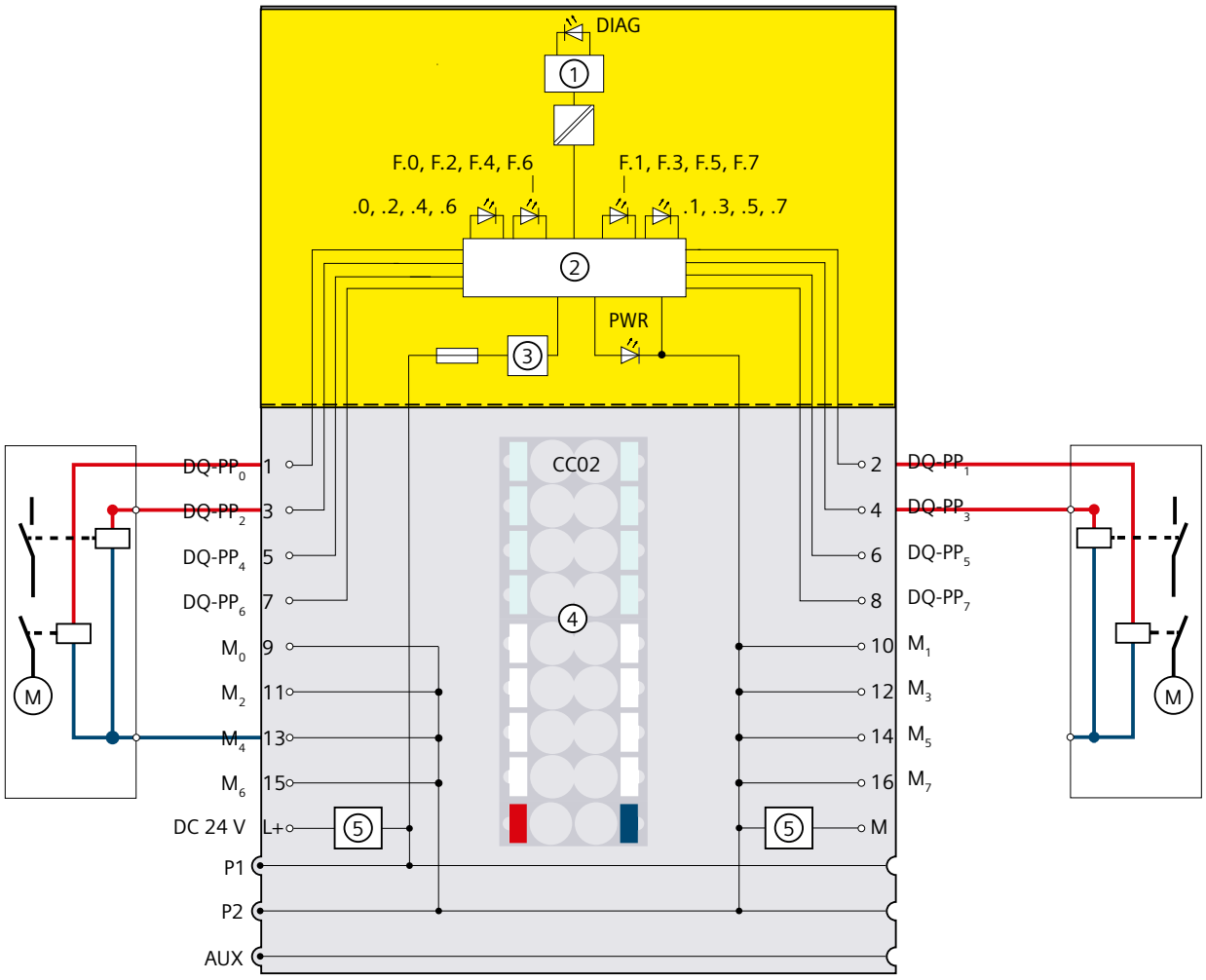
If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).
If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".
If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.4 Application: Two-channel actuator connection via 2 digital outputs

Electronic outputs

Safety-related electronic outputs are always implemented internally using two channels. As a result, each of these outputs can be used for applications up to SIL3 according to EN 62061 or Cat.4/PLe according to EN ISO 13849-1. The two outputs must have an identical configuration and be controlled simultaneously. Passivation must take place module-wide.

The ground may be the internal ground M_n or an external ground. This circuit achieves SIL3/Cat.4/PLe. To achieve SIL3/Cat.4/PLe, see section Installation of the ground line between the power supply and the BaseUnit (Page 27).



① Backplane bus interface

② Output electronics

③ Reverse polarity protection

④ Color-coded label with color code CC02 (optional)

⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 1-251 Wiring diagram for two relays in parallel to two F-DQs of the digital output module F-DQ 8x24VDC/0.5A PP HF

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, a suitably-qualified actuator, e.g. in accordance with IEC 60947, is required.

5.5 Application: Connection of a fail-safe digital input to each digital output

Each of the 8 fail-safe digital outputs can be connected to a fail-safe digital input of the type 1, 2 or 3 in accordance with IEC61131-2.

In this application, the input delay of the fail-safe digital input must be set so that the light test and the dark test of the fail-safe digital output do not impair the fail-safe digital input.

You can achieve SIL3/Cat.4/PLe with this circuit.

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified fail-safe digital input, e.g. ET 200SP F-DI 8x24VDC HF.

Input without ground return

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

If the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF and the fail-safe digital input module are supplied by different power supply units, the grounds of the two power supply units must be connected to each other.

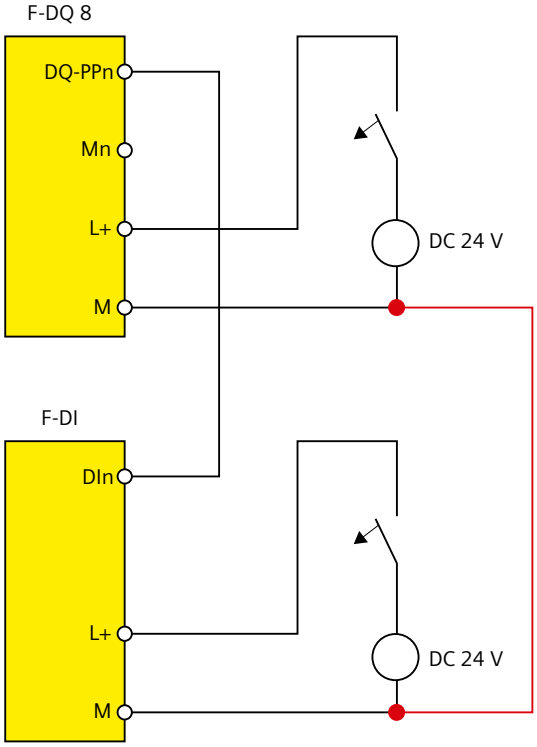


Figure 1-252 Wiring diagram of an output of the digital output module F-DQ 8x24VDC/0.5A PP HF with an input of a fail-safe digital input module (without ground return).

⚠ WARNING

To avoid an impermissible process value at the fail-safe digital input, the wiring must be installed so that an interruption of the connection between the ground of the fail-safe digital output module and the ground of the fail-safe digital input module can be excluded (e.g. redundant lines).

⚠ WARNING

In case of a cross-circuit between a positive potential (e.g. L+) and DQ-PP_n, a 1-signal is permanently present at the fail-safe digital input. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the fail-safe digital inputs in a cross-circuit-proof manner, for example, as separate, sheathed cables or in separate cable ducts.

⚠ WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).
If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".
If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

Input with ground return

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

In this application for potential-free, fail-safe digital inputs, the connection DI_n- of the fail-safe digital input is returned to the internal ground M_n of the fail-safe digital output module.

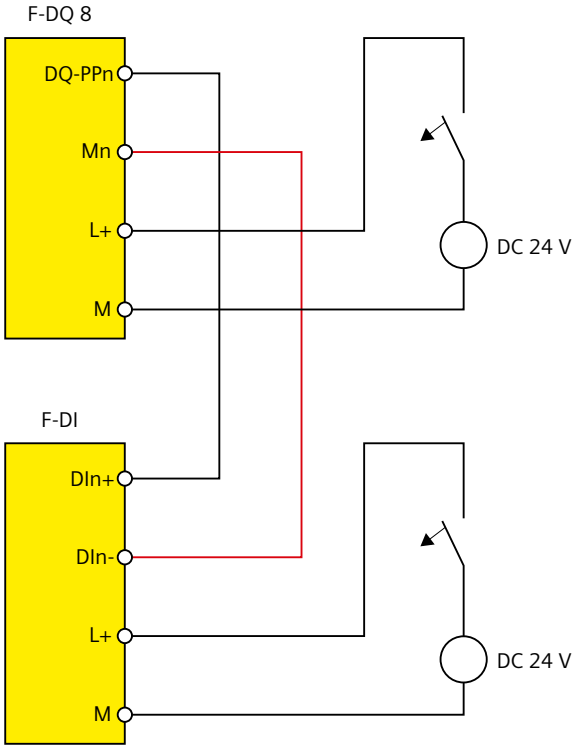


Figure 1-253 Wiring diagram of an output of the digital output module F-DQ 8x24VDC/0.5A PP HF with an input of a fail-safe digital input module (with ground return).

WARNING

In case of a cross-circuit between a positive potential (e.g. L+) and DQ-PP_n, a 1-signal is permanently present at the fail-safe digital input. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the fail-safe digital inputs in a cross-circuit-proof manner, for example, as separate, sheathed cables or in separate cable ducts.

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).
If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".
If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.6 Application: Connection of the ET 200SP digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

You can use any of the 8 fail-safe digital outputs to actuate one or more digital output modules F-RQ 1x24VDC/24..230VAC/5A.

Pay attention to the permitted current for the corresponding output channel and the total current over all outputs at the corresponding ambient temperature.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

For operation of the digital output module F-RQ 1x24VDC/24..230VAC/5A as of FS 04, use of the following readback times is required: Channel parameter Max. readback time light test/dark test with the default value "0.8 / 1.0 ms".

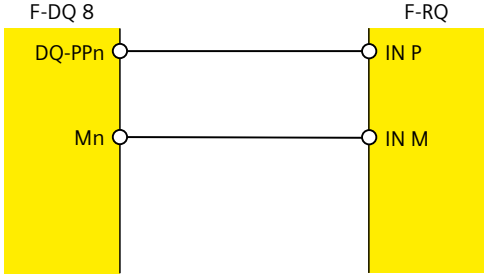


Figure 1-254 Wiring diagram

NOTE

The output signals "OUT P, OUT M" of the digital output module F-RQ 1x24VDC/24..230VAC/5A are looped through from "IN P, IN M" and should therefore be considered like the output signals of the F-DQ 8x24VDC/0.5A PP HF "DQ-PP_n, M_n". For this reason, please observe the wiring rules for the F-DQ 8x24VDC/0.5A PP HF.

⚠ WARNING

The digital output module F-RQ 1x24VDC/24..230VAC/5A can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the digital output modules F-RQ 1x24VDC/24..230VAC/5A in a cross-circuit-proof manner, e.g. as separate, sheathed cables or in separate cable ducts.

⚠ WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).
If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".
If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

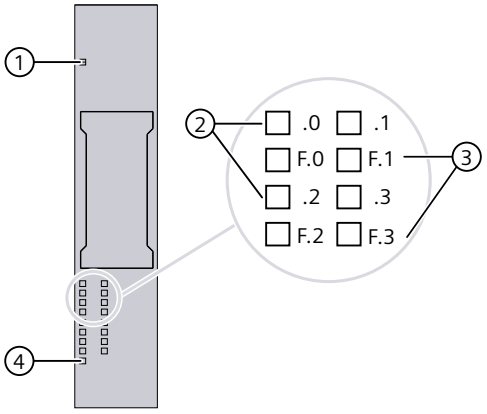
Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-DQ 8x24VDC/0.5A PP HF.



① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 1-255 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. You can find solutions for diagnostics alarms in section Diagnostics alarms (Page 43).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 1-532 Error display of the LED DIAG

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured

DIAG	Meaning
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for user acknowledgment.
Flashing	• Operation in S7-1200/1500 F-CPUs: The F-module expects user acknowledgment after a module error. • Operation in S7-300/400 F-CPUs: The F-module is waiting for user acknowledgment.

Channel status/channel fault LED

Table 1-533 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		• Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for user acknowledgment. • Operation in S7-300/400 F-CPUs: At least one channel is waiting for user acknowledgment.

Channel status/DIAG/channel fault LED

Table 1-534 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address or there is a module fault. See section Interrupts (Page 42).
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 1-535 Status display of LED PWR

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF supports diagnostic interrupts.

Diagnostic interrupts

The F-module generates a diagnostic interrupt for each diagnostics alarm described in section Diagnostics alarms (Page 43).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostics message, correct the respective fault and validate your safety function. In this case, follow the steps described in section Diagnostics alarms (Page 43).

Module-wide diagnostic interrupts

- Overtemperature
- Error
- Parameter error
- Supply voltage missing
- Safety-related shutoff
- Channel/component temporarily unavailable
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F-parameter set incorrectly
- CRC1 fault
- Save iParameter watchdog time exceeded
- Restore iParameter watchdog time exceeded
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- F-address memory not accessible

- Undertemperature
- Supply voltage too high
- Supply voltage too low

Channel-wide diagnostic interrupts

- Short-circuit to L+
- Short-circuit to ground
- Channel failure acknowledgment
- Frequency too high

6.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated for each diagnostics event and the F-module flashes the DIAG LED. You can read out the diagnostics alarm, for example, from the diagnostics buffer of the F-CPU. You can evaluate the error codes using the user program.

NOTE

You can connect several actuators per output.
If several actuators are connected to an output, the diagnostics of each actuator affects the other ones.
In other words, a single short-circuit affects multiple actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Table 1-536 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Fault code	Meaning	Solution
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 48)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Operate the F-module within the specified supply voltage range. • Check BaseUnit type

Diagnostics alarm	Fault code	Meaning	Solution
Safety-related shutoff	19_H	For safety purposes, channel was switched off due to an error on another channel. Possible causes: • A short-circuit exists. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light).
Channel/component temporarily unavailable	$1F_H$	The firmware version of the F-module is inconsistent.	Repeat the firmware update.
Mismatch of safety destination address (F_Dest_Add)	40_H	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The firmware of the F-module has detected an illegal different F-destination address.	Check the configuration/parameter assignment of the iPar server.
Safety source address not valid (F_Source_Add)	42_H	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	46_H	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The firmware of the F-module has detected inconsistent F-parameters.	
Save iParameter watchdog time exceeded	49_H	iPar server does not respond to "save IPar" within 4.4 minutes.	
Restore iParameter watchdog time exceeded	$4A_H$	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the configuration/parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	$4B_H$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The firmware of the F-module has detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference. • Power switched OFF and ON for station • Assign the configuration and parameter assignment to the F-module (of the station).

Diagnostics alarm	Fault code	Meaning	Solution
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	100_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner. • Wrong BaseUnit	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put back into operation, consider replacing it. • Use a BaseUnit of the type A0.
Watchdog tripped	103_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put back into operation, consider replacing it.
Short-circuit to L+	105_H	Short circuit to L+ can mean: • The output cable is short-circuited to L+. • The capacitive load between the channels is too high (for example, due to cable length or load current being too low). • There is a short circuit between two output channels. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light). • Pay attention to the warnings in Applications of the F-I/O module (Page 27).
Short-circuit to ground	106_H	Short-circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • The capacitive load is too high. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light). • Check the actuator.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Channel failure acknowledgment	$30B_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	$30D_H$	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Frequency too high	311_H	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency (see Technical specifications (Page 48))

Diagnostics alarm	Fault code	Meaning	Solution
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 48)) Once the temperature has increased and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Supply voltage too high	321_H	The supply voltage is too high.	Check the supply voltage and then test the safety application.
Supply voltage too low	322_H	• The supply voltage is too low. • EMC, wrong BaseUnit	Check the supply voltage and then test the safety application.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

A supply voltage that is too low is detected for voltages less than 17 V. A supply voltage that is too high is detected for voltages greater than 32 V.

When the voltage is then recovered (level must remain within the specified value range for at least 1 minute (see Technical specifications (Page 48): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostics alarm and the status and error display, the F-module provides information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is affected by a short-circuit and the plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 25).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

7

Technical specifications of F-DQ 8x24VDC/0.5A PP HF

The table below shows the technical specifications as of 12/2022. A data sheet with technical specifications updated on a daily basis can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6DC00-0CA0/td?dl=en).

Article number	6ES7136-6DC00-0CA0
General information	
Product type designation	F-DQ 8x24 V DC/0.5 A PP HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V14 SP1 with HSP 202
• STEP 7 configurable/integrated from version	V5.5 SP4 HF5
• PROFINET from GSD version/GSD revision	V2.31
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; From the backplane bus
output voltage / header	
Rated value (DC)	24 V
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	3 W
Address area	
Address space per module	
• Inputs	6 byte; 5 bytes non-RIOforFA; 6 bytes RIOforFA
• Outputs	6 byte; 5 bytes non-RIOforFA; 6 bytes RIOforFA

Article number	6ES7136-6DC00-0CA0
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	8
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	Min. 0.7 A
Open-circuit detection	No
Limitation of inductive shutdown voltage to	Typ. -39 V
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	2 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 000 Ω
Output voltage	
• for signal "1", min.	24 V; L+ (-0.5 V)
Output current	
• for signal "1" rated value	0.5 A
• for signal "0" residual current, max.	0.5 mA
Switching frequency	
• with resistive load, max.	30 Hz; Symmetrical
• with inductive load, max.	0.1 Hz; according to IEC 60947-5-1, DC-13, symmetrical
• with capacitive load, max.	2 Hz; Symmetrical
• on lamp load, max.	10 Hz; Symmetrical
Total current of the outputs	
• Current per channel, max.	0.5 A; note derating data in the manual
• Current per module, max.	3 A; note derating data in the manual
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	3 A
– up to 50 °C, max.	2.5 A
– up to 60 °C, max.	2 A
vertical installation	
– up to 50 °C, max.	2 A
Cable length	
• shielded, max.	100 m
• unshielded, max.	100 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	No

Article number	6ES7136-6DC00-0CA0
Alarms	
• Diagnostic alarm	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 6.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 2.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; with derating
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

You can find the reaction times of the F-DQ 8x24 V DC/0.5 A PP HF digital output module below. The reaction times of the F-DQ 8x24 V DC/0.5 A PP HF digital output module are included in the calculation of the F-system reaction time.

Use the SIMATIC STEP7 Reaction Time Table (https://support.industry.siemens.com/cs/ww/en/view/93839056) for this.

Definition of reaction time for fail-safe digital outputs

The reaction time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

- Max. cycle time: T_{cycle} = 8 ms
- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 16 ms

The maximum reaction time in the case of fault (One Fault Delay Time, OFDT) is equivalent to the maximum reaction time with no faults (Worst Case Delay Time, WCDT).

You assign the parameters for maximum readback time dark test (T_{rb}) and maximum readback time light test (T_{rb_lt}) in STEP 7 or the TIA Portal.

Operating mode: Disable dark test for 48 hours – disabled

Maximum reaction time with no faults (Worst Case Delay Time, WCDT)
$t <= 4 * T_{cycle}$

Maximum reaction time with detection of a channel fault by readback
$t <= 6 * T_{cycle} + T_{rb}$

Maximum reaction time with detection of a channel fault by bit pattern test
$t <= 2 * T_{cycle}$ + maximum test period

Operating mode: Disable dark test for 48 hours – enabled

Maximum reaction time with no faults (Worst Case Delay Time, WCDT)
$t <= 5 * T_{cycle} + T_{rb} + T_{rb_lt}$

Maximum reaction time with detection of a channel fault
A channel fault may not be detected until a 0-1 process value change takes place on the corresponding channel. Please note the restrictions detailed in section Disable dark test for 48 hours (Page 21)

Switching of loads

B

B.1 Connecting capacitive loads

If an F-DQ 8x24VDC/0.5A PP HF digital output module is interconnected with loads that have an excessive capacitance, this can lead to detection of a short-circuit. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trend shown in the diagram below represents the correlation between load current and maximum switchable load capacitance at a supply voltage of 24 V DC.

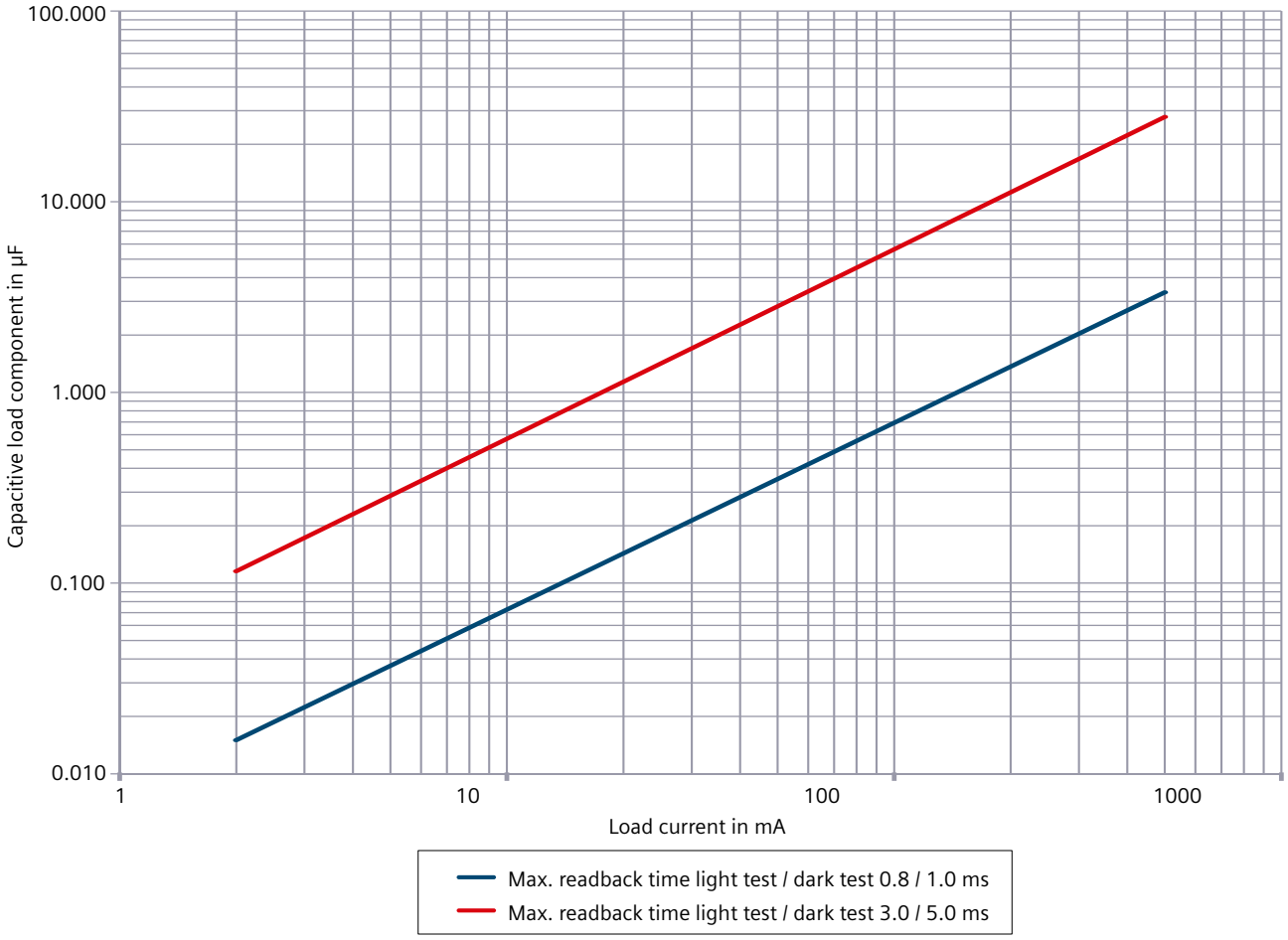


Figure 1-256 Switching of capacitive loads for the F-DQ 8x24VDC/0.5A PP HF digital output module depending on the configured max. readback time light test / dark test.

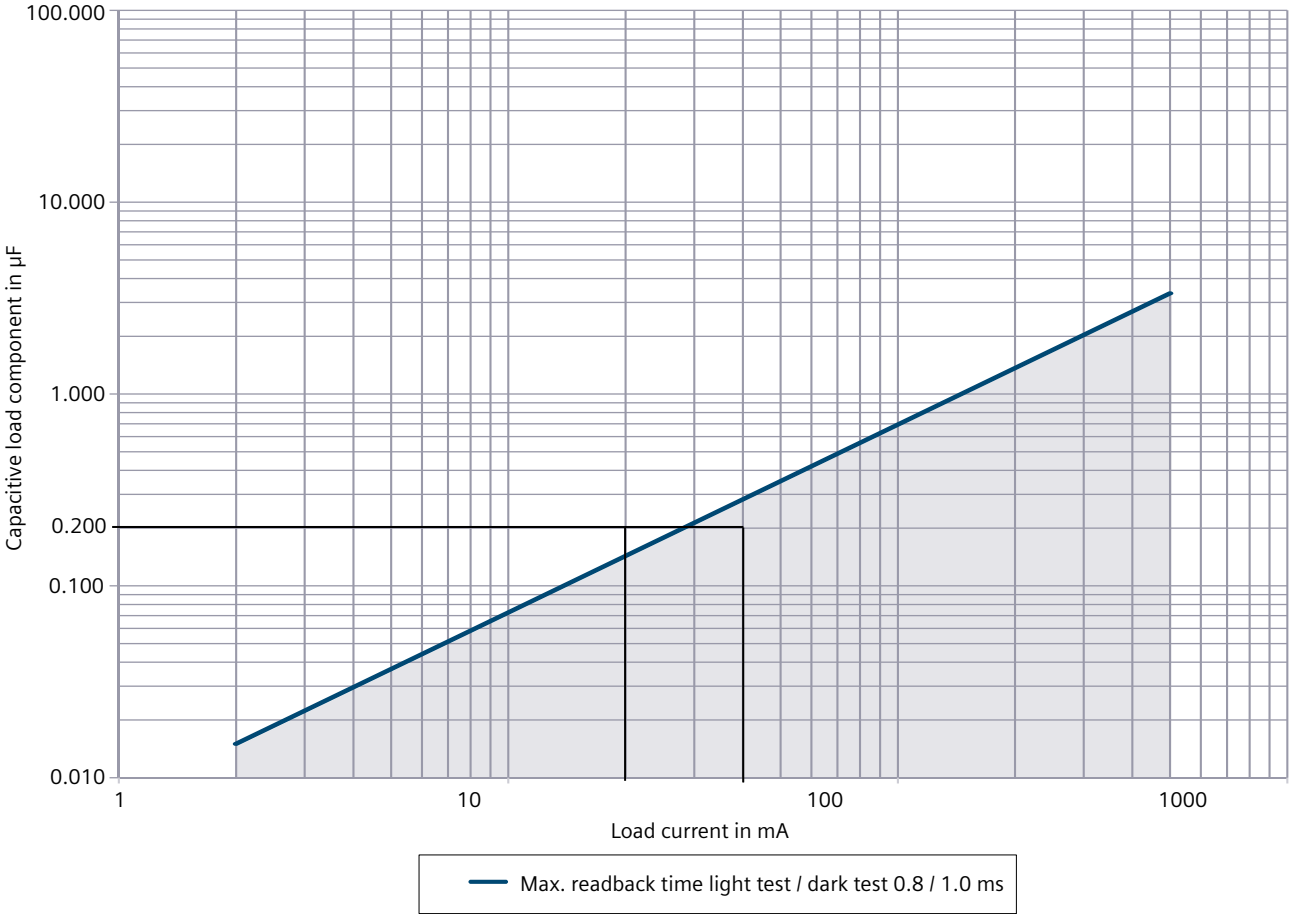
Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the trend, select an actuator with higher current consumption so that the new operating point is below the curve.

Example

You have configured a maximum readback time light test/dark test of "0.8 / 1.0 ms". You have set the load current to 20 mA and the capacity to 0.2 µF. The operating point is thus outside the range defined by the trend (gray background).

Solution: Select an actuator with higher current consumption. In this example, 40 mA. Alternatively, you can configure the parameter "Max. readback time light test / dark test" with "3.0 / 5.0 ms".



B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

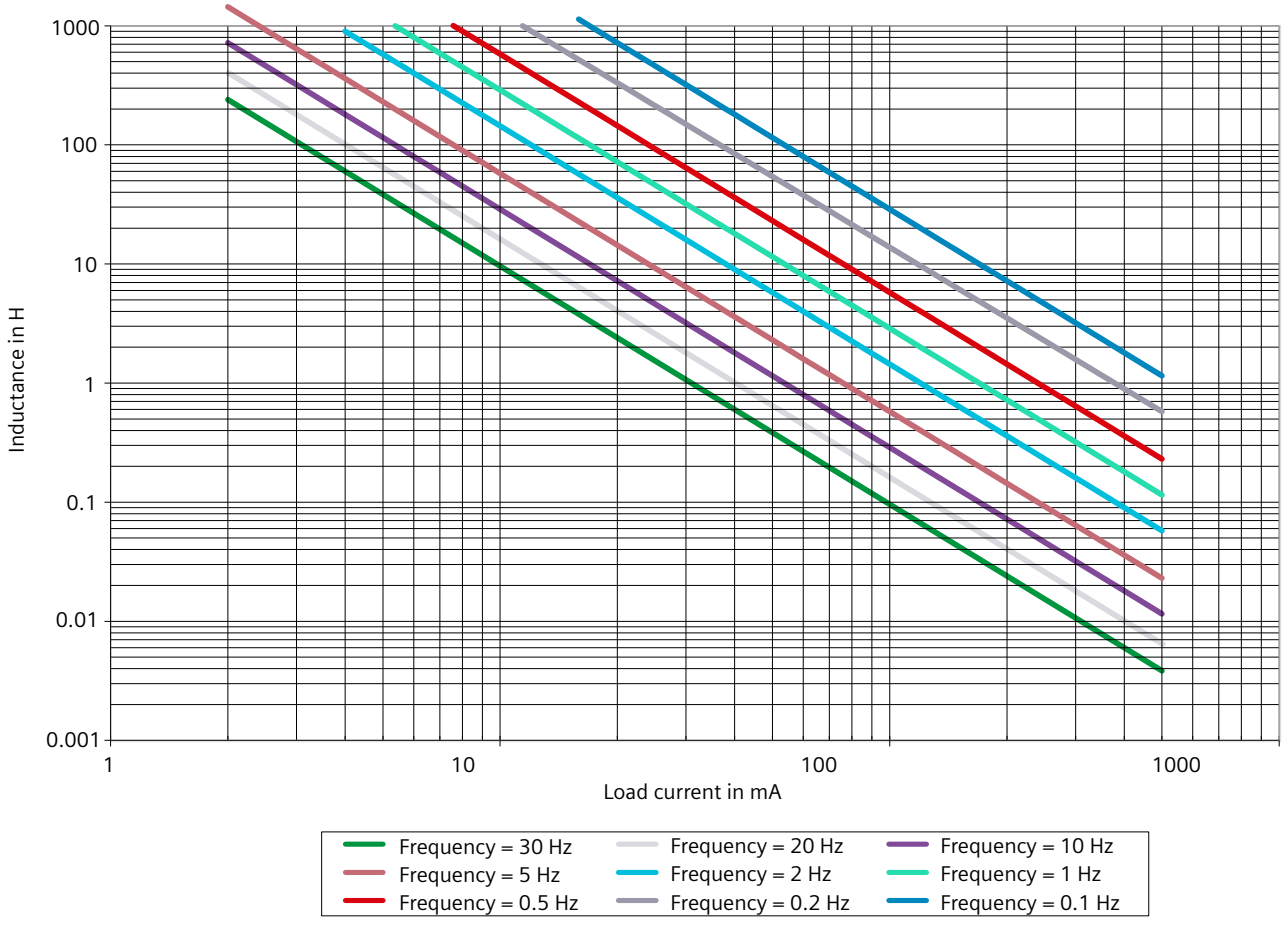


Figure 1-257 Switching of inductive loads for the F-DQ 8x24VDC/0.5A PP HF digital output module depending on the load current and switching frequency

SIEMENS

SIMATIC

ET 200SP
Digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

Equipment Manual

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Preface

Purpose of this documentation

This manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information in this manual and the system manual supports you when commissioning the ET 200SP system.

Conventions

Pay particular attention to notes highlighted as follows::

NOTE

A note contains important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to the documentation

1

1.1 Guide to the documentation for the digital output module F-RQ 1x24VDC/24..230VAC/5A

Introduction

The documentation of the SIMATIC products has a modular structure and includes topics relating to your automation system.

The complete documentation of the ET 200SP system consists of different modules made up of system manuals, function manuals and device manuals.

The STEP 7 (online help) information system supports you when configuring and programming your automation system.

Overview of the documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

The table below lists additional documents that complement this description of the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A and that are available on the Internet.

Table 1-537 Documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting up • Commissioning • Approvals • TÜV certificates
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment and verification right through to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/automation/service&support).

Please e-mail any queries you may have e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-RQ 1x24VDC/24..230VAC/5A

Article number

6ES7136-6RA00-0BF0

View of the module



Figure 1-258 View of the F-RQ 1x24VDC/24..230VAC/5A module

Properties

- Technical properties
  - Digital module with 1 relay output (2 isolated NO contacts)
  - Safety class SIL3/category 4/PLe can be achieved if the F-RQ module is controlled by a fail-safe output (for example F-module F-DQ 4x24VDC/2A PM HF)
  - Control voltage 24 VDC
  - Total current for both NO contacts 5 A max.
  - Isolated from control voltage
  - Suitable for solenoid valves, DC contactors and signal lamps
- Supported system functions
  - I&M identification data
  - Firmware update

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a service life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the module in question from the BaseUnit or switch off its supply voltage before 100 hours are up.

Accessories

The following components can be used with the module:

- Labeling strips
- Color identification labels
- Reference identification labels

Connecting up

3

3.1 Terminal assignment

General terminal assignment

Table 1-538 Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A

Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**	**Color identification label (terminals 1 to 16)**
1	RQ_{01}+ [13]	**2**	RQ_{01}- [14]	• RQ_n+, RQ_n-: Channel n • IN: Control input • OUT: Control input for loop-through	BU20-P8+A4-+0B	 CC42 6ES7193-6CP42-2MB0
3	RQ_{02}+ [23]	**4**	RQ_{02}- [24]			
5	—	**6**	—			
7	—	**8**	—			
9	IN P	**10**	OUT P			
11	IN M	**12**	OUT M			
13	AUX	**14**	AUX			
15	AUX	**16**	AUX			

3.2 Block diagram

Block diagram

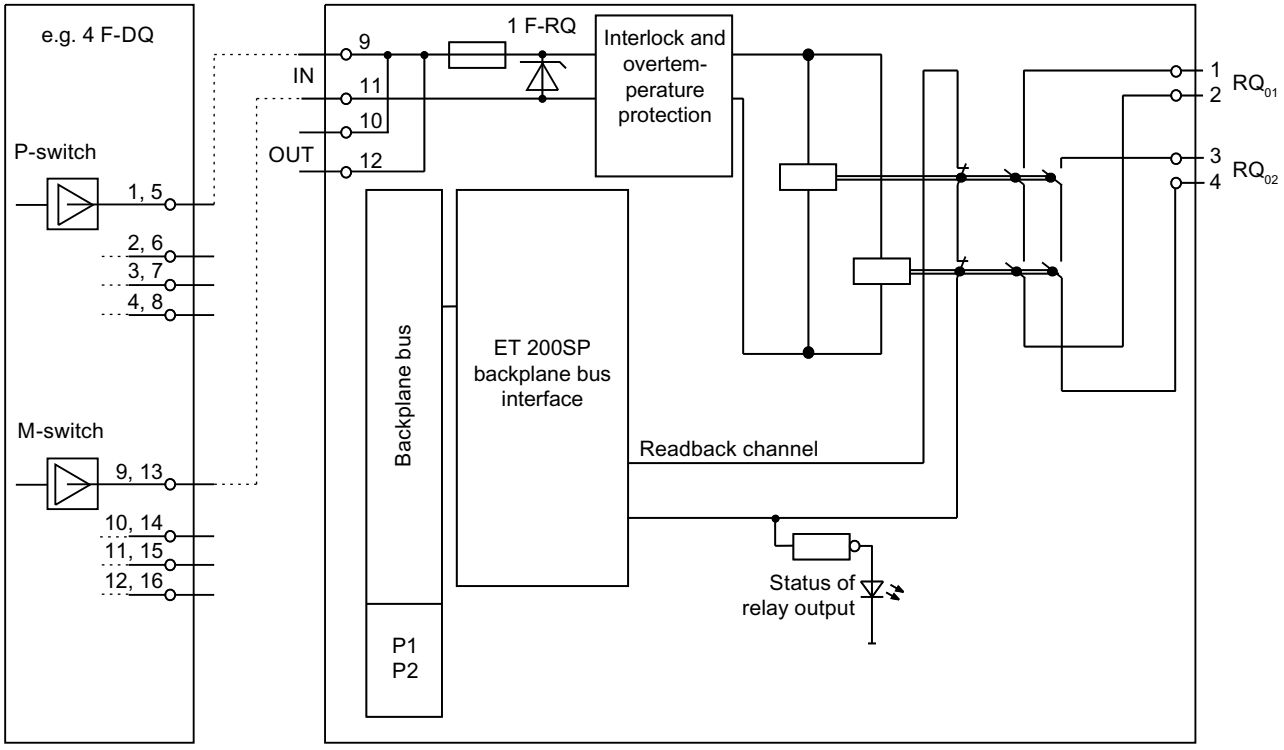


Figure 1-259 Block diagram F-RQ 1x24VDC/24..230VAC/5A

Addressing

4

4.1 Address space

Address assignment of the digital output module F-RQ 1x24VDC/24..230VAC/5A

The digital output module F-RQ 1x24VDC/24..230VAC/5A occupies the following address ranges in the F-CPU:

Table 1-539 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
in input range	**in output range**
x.0 and x.1	—

x = Module start address

Address assignment of the user data of the digital output module F-RQ 1x24VDC/24..230VAC/5A

Of the occupied addresses of the digital output module F-RQ 1x24VDC/24..230VAC/5A, the user data occupies the following addresses in the F-CPU:

Table 1-540 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-RQ module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	RQ_1 Inverted readback channel (corresponds to process signal at IN)	RQ_0 Readback channel

x = Module start address

The user data is in the standard process image of the inputs and is not transferred to the F-CPU in safety-related communication. The readback channel in the user program is therefore displayed as a non-failsafe variable.

NOTE

With migration projects from the ET 200S product family, note the following:
The readback channel RQ_0 (bit 0) allows direct interconnection with the FDBACK instruction (F-block F_FDBACK) to its FEEDBACK input without additional inversion.
The readback channel RQ_1 (bit 1) is inverted.

Additional information

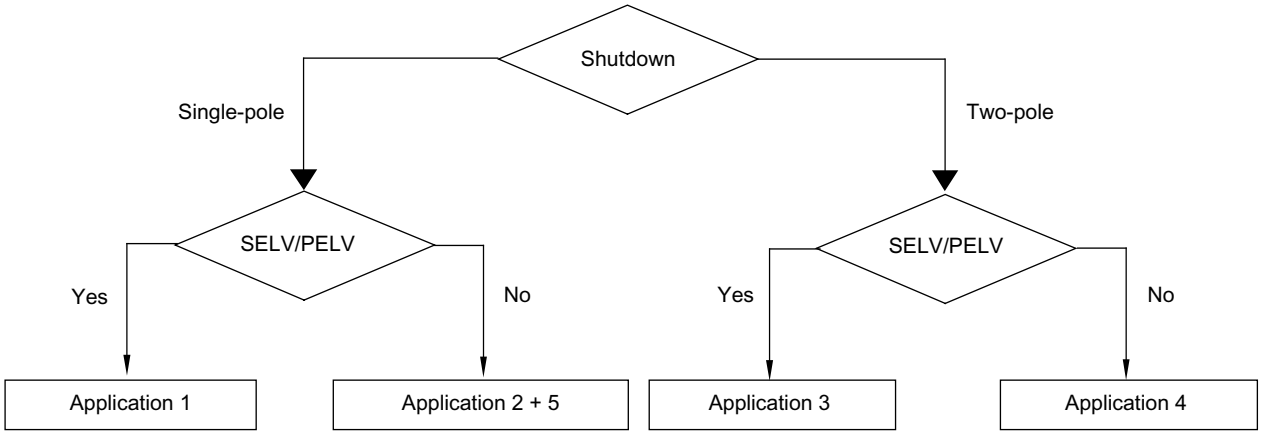
For detailed information about F-I/O access, refer to the SIMATIC Safety, Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications of the F-RQ 1x24VDC/24..230VAC/5A

You can achieve SIL3/category 4/PLe in the following applications if the activating F-module supports SIL3/category 4/PLe.



The wiring is carried out on the suitable BaseUnit (http://support.automation.siemens.com/WW/view/en/58532597/133300).

Wiring the 24 VDC power supply

Apply the 24 VDC control voltage to IN P (terminal 9) and IN M (terminal 11). The 24 VDC supply line is usually connected via a sourcing/sinking fail-safe output (e.g. digital output module F-DQ 4x24VDC/2A PM HF). Wire the P output (sourcing) of the F-DQ to the IN P of the F-RQ module and the M output (sinking)to the IN M of the F-RQ module.

As an alternative, you can also connect to a sourcing-sourcing fail-safe output. However, note that external short-circuits to P at the P input cannot be controlled. In this case, IN M would be connected directly to the control voltage ground.

NOTICE
Connecting the control voltage to the IN P and IN M inputs with the reverse polarity will destroy the F-module.

Wiring the load voltage and the load

The connectors of the relay output are electrically isolated NO contacts. This means that power must be supplied to these contacts from an external source. Connect the load supply (supply 1) and the load (load 1) in series to the RQ_{01} connectors (terminals 1;2). This ensures that the NO contacts of the relay interrupt the current flow of the power supply through the load. Due to the two relay contacts connected in series, the current flow can still be interrupted if one of the two relays has a fault..

The second circuit is independent of the first. They are logically interconnected by the common control. This means that the potential in the RQ_{02} (terminals 3;4), supply 2 and load 2 circuit may be different.

⚠ WARNING

If you connect a non-SELV/PELV power supply to one channel, you must not use the other channel.

Parameter assignment of the digital output module F-DQ 4x24VDC/2A PM HF

Assign the following parameters for the channel of the F-DQ 4x24VDC/2A PM HF digital output module to be activated:

Table 1-541 Parameter assignment

Parameter	
Max. readback time dark test	1 ms
Max. readback time switch on test	1 ms

As the relays are highly inductive, you have the option of activating "Diagnostics: wire break" *or* "enable light test".

5.2 Application 1: 2 loads, single-pole switch-off

Wiring diagram

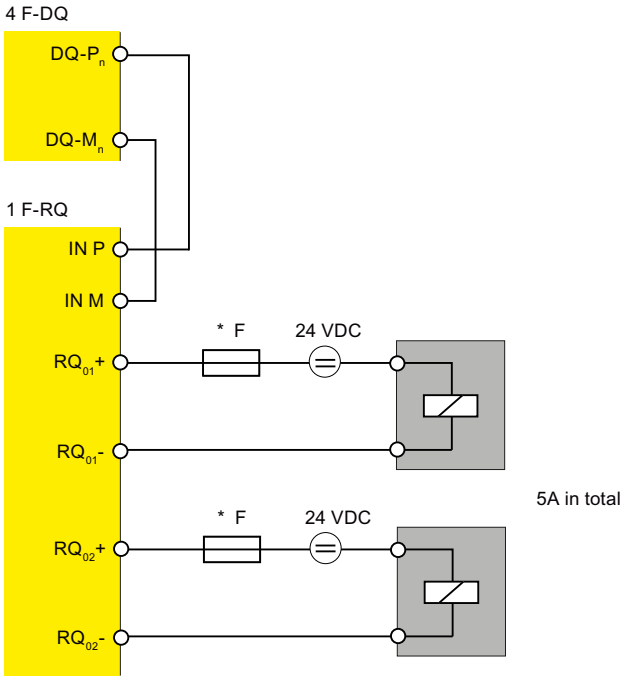


Figure 1-260 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

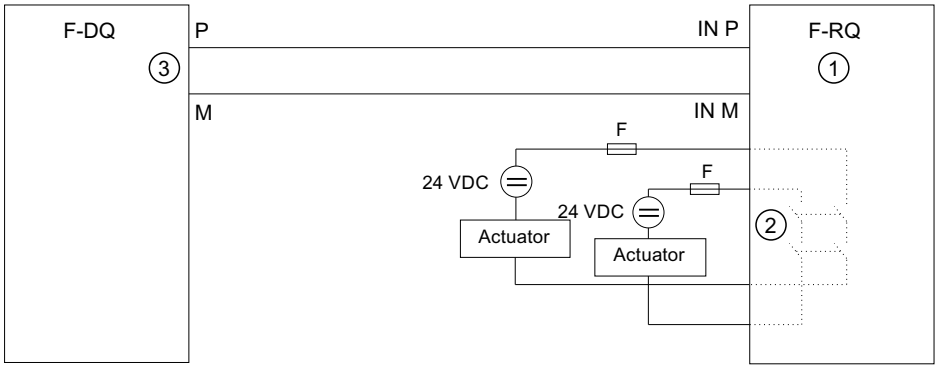
In this application, you can use one F-RQ module for single-pole switching of two loads with a total of 5A and one/two SELV/PELV power supplies.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.
Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 1-261 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.3 Application 2: 1 load, single-pole switch-off

Wiring diagram

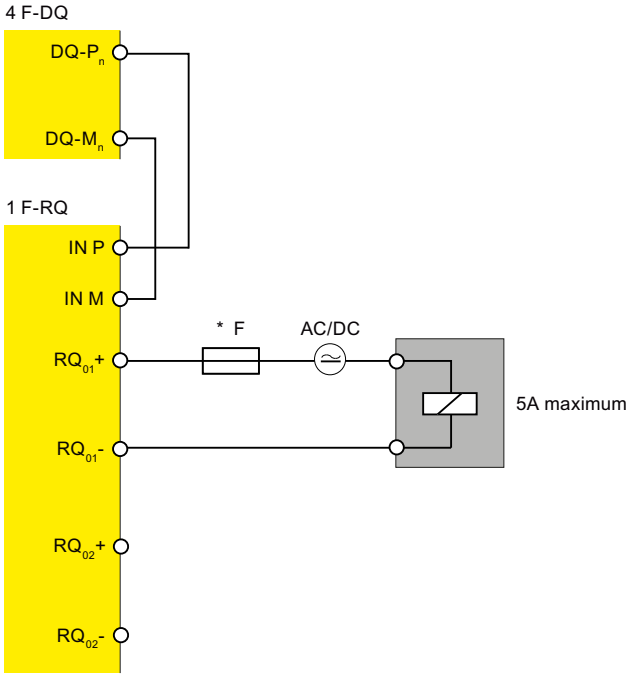


Figure 1-262 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

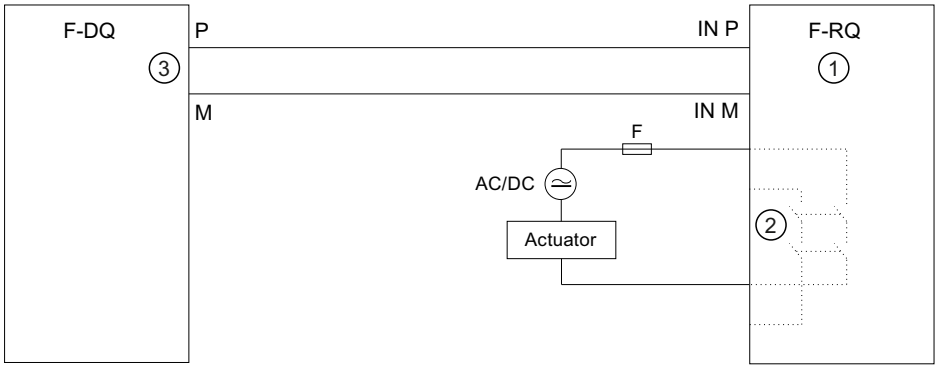
This application allows single-pole switching of one load with a total of 5A with one F-RQ module.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.
Please note that for applications in accordance with EN 50156-1, the specified rated current of the overcurrent protective device must be multiplied by the safety factor 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 1-263 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.
SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.
If a fault is detected during this function test, replace the F-RQ module.

5.4 Application 3: 1 load, two-pole switch-off with 1 F-RQ module

Wiring diagram

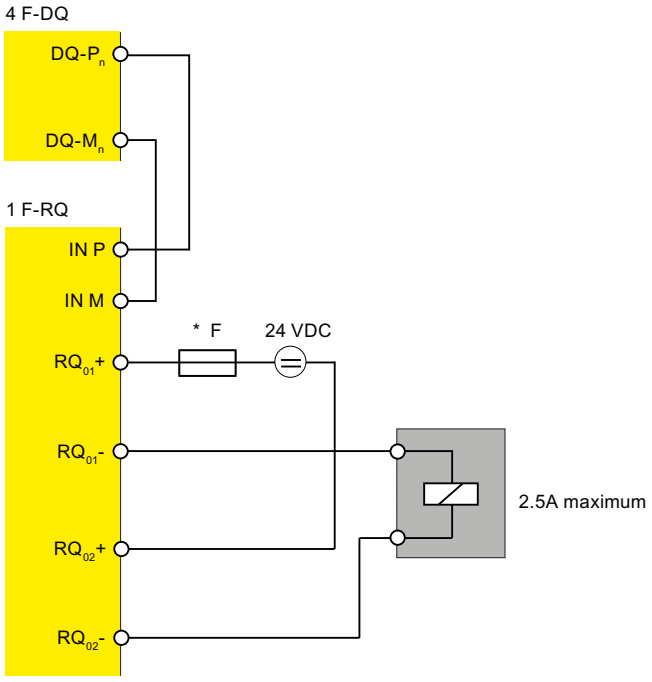


Figure 1-264 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

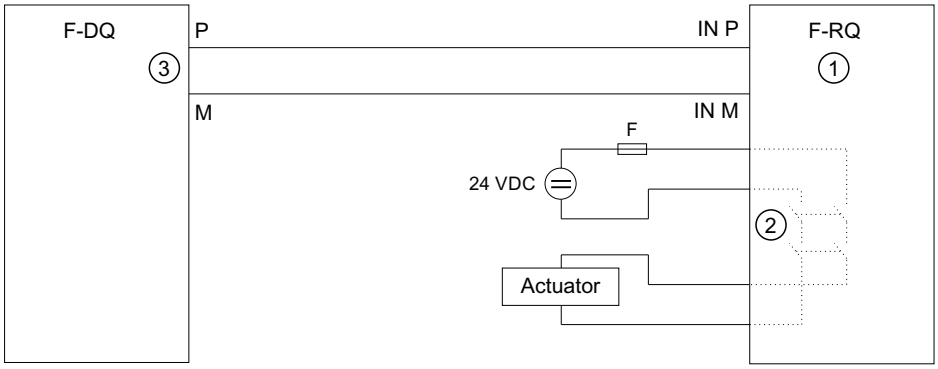
This application allows two-pole switching with one F-RQ module of one load with a maximum of 2.5A and an SELV/PELV power supply.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.
Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 1-265 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.
SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.
If a fault is detected during this function test, replace the F-RQ module.

5.5 Application 4: 1 load, two-pole switch-off with 2 F-RQ modules

Wiring diagram

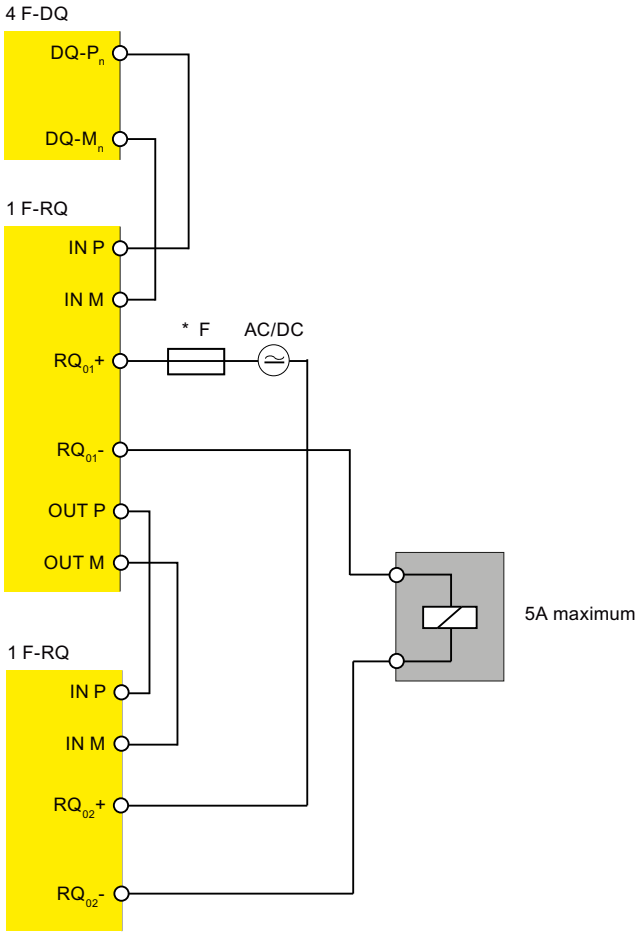


Figure 1-266 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

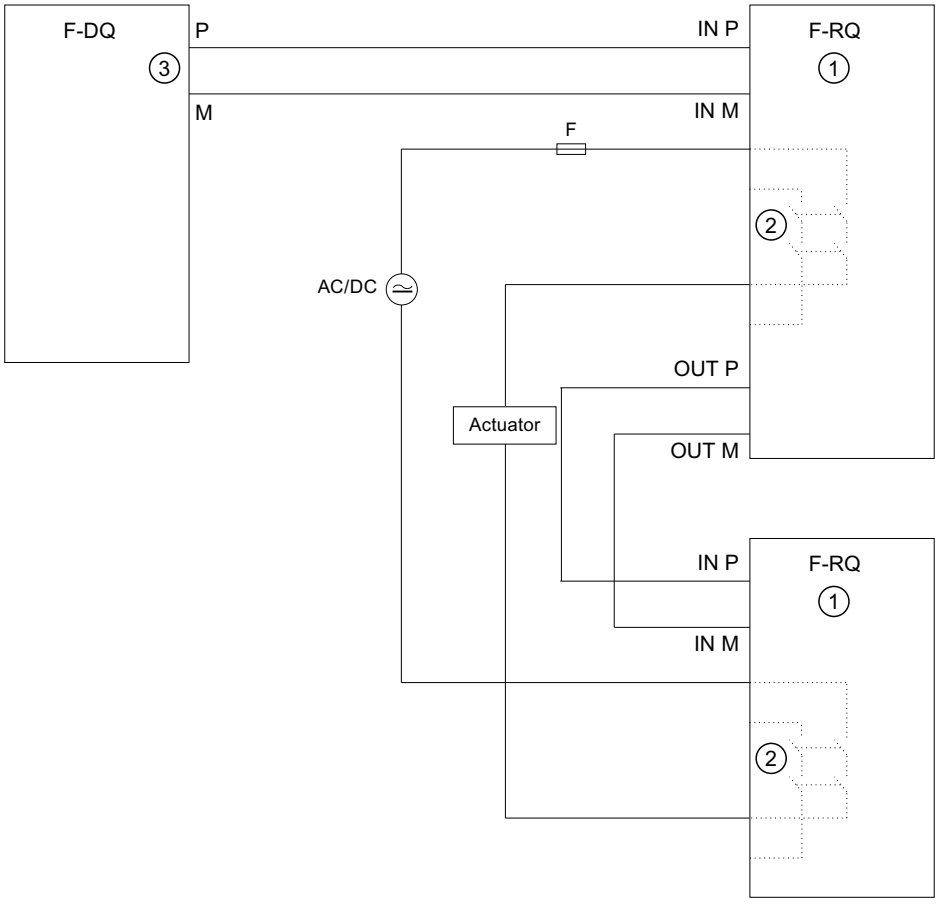
This application allows two-pole switching of one load with a max. of 5A with two F-RQ modules.

⚠ WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.
Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 1-267 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

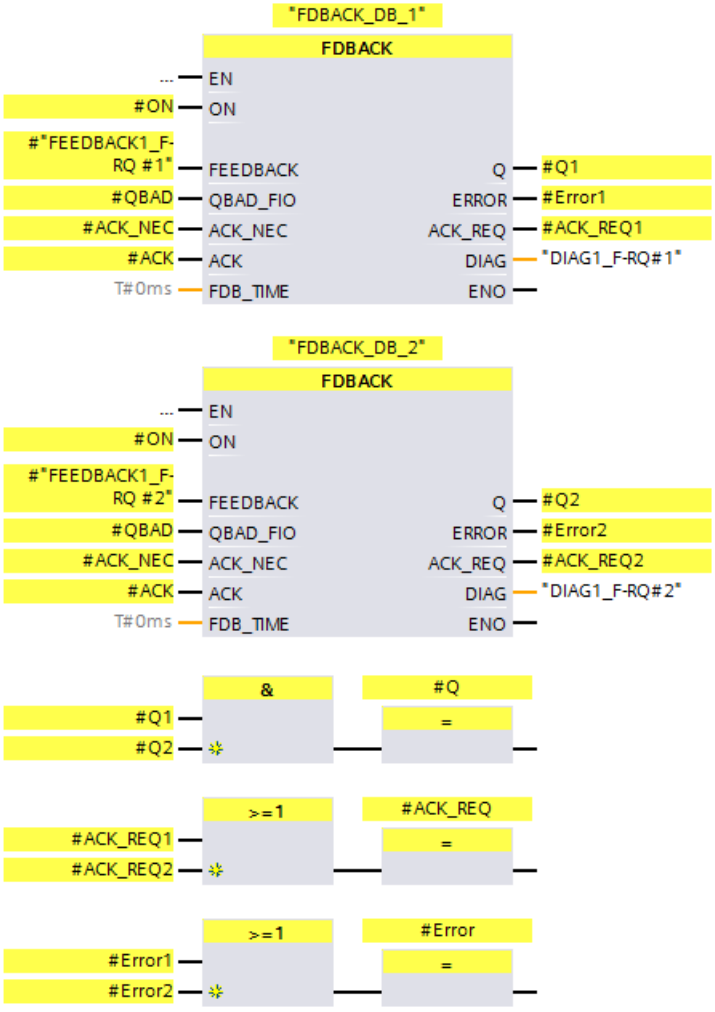
If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.
SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.
If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:



5.6 Application 5: 2 loads, single-pole switch-off with 2 F-RQ modules

Wiring diagram

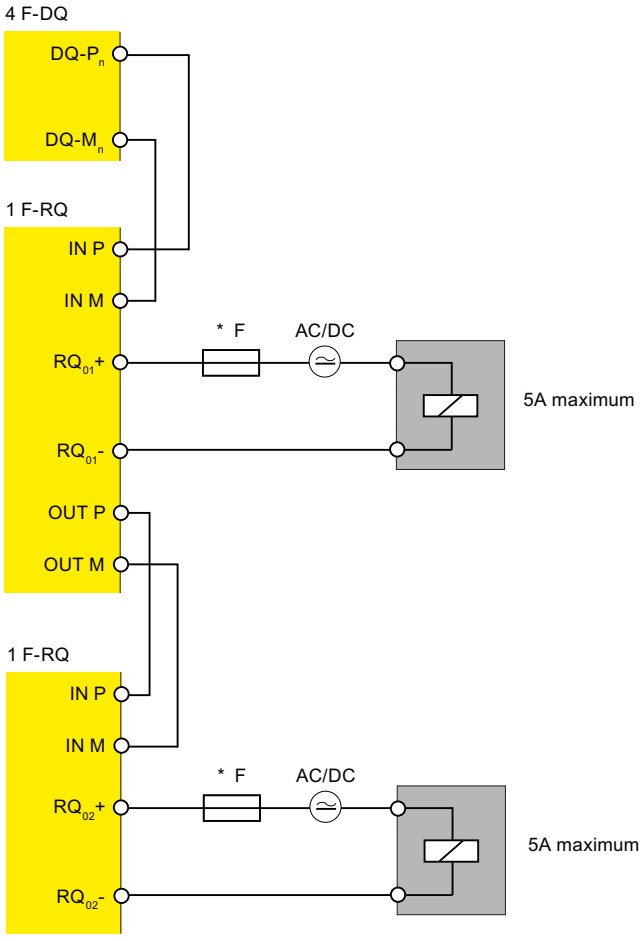


Figure 1-268 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

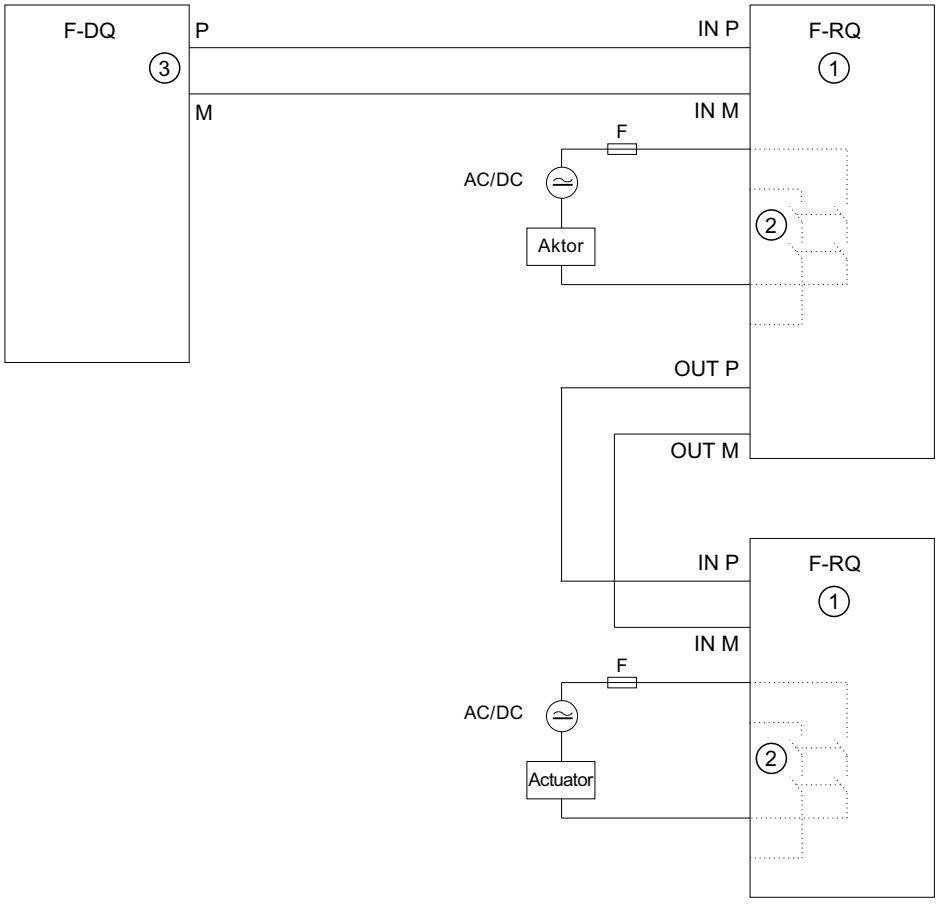
This application allows the single-pole switching of two loads with 5A each with two F-RQ modules. One power supply is not SELV/PELV.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.
Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).



① F-RQ with integrated FEEDBACK input
② Relay contacts for switching the load
③ Output Q

Figure 1-269 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

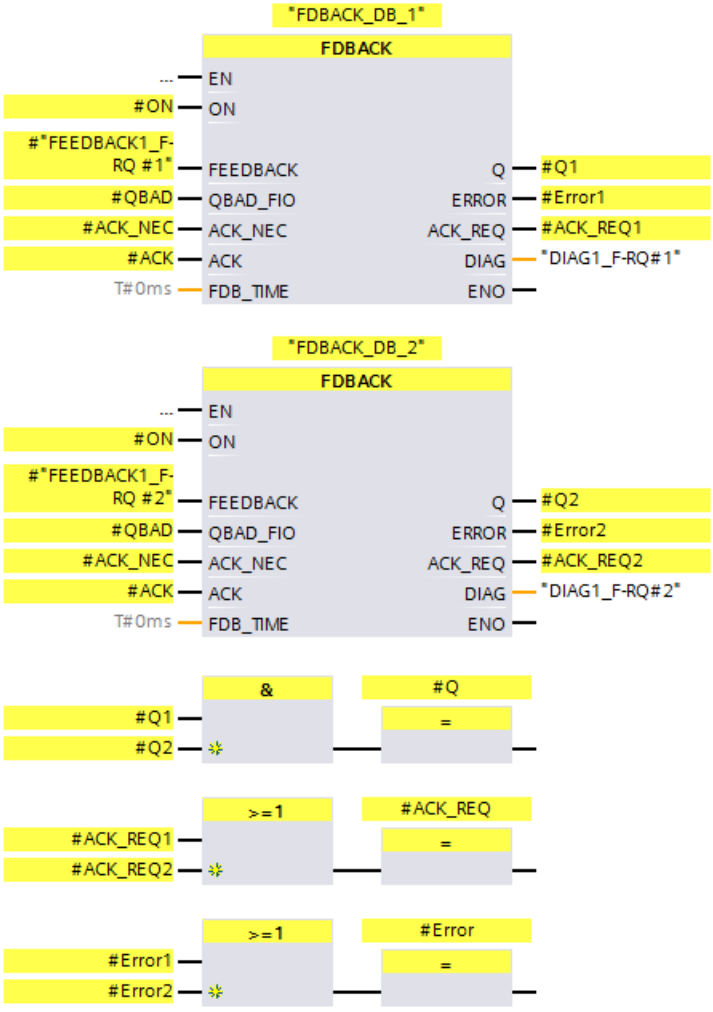
If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.
SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.
If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:

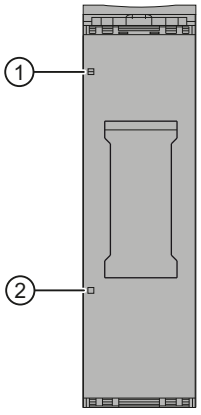


Status and error display

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green)

Figure 1-270 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays.

WARNING

The DIAG LED and the channel status LED of the output are not designed as safety-related LEDs and therefore must not be evaluated for safety-related activities.

DIAG LED

Table 1-542 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashing	Module parameters not set
■ On	Module parameters set and no module diagnostics

Channel status LED

Table 1-543 Meaning of the channel status LED

Status	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

Technical specifications

7

7.1 Technical specifications

Technical specifications of F-RQ 1×24VDC/24...230VAC/5A

	6ES7136-6RA00-0BF0
Product type designation	F-RQ 1x24VDC/24 ... 230VAC/5A
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V13
STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
Installation type/mounting	
Rail mounting possible	Yes; standard mounting rail
Supply voltage	
Type of supply voltage	24 VDC
Rated value (DC)	24 V; coil voltage
Low limit of permitted range (DC)	20.4 V
High limit of permitted range (DC)	28.8 V
Power	
Power consumption from the backplane bus	100 mW
Power loss	
Power loss, typ.	1 W
Address range	
Address space per module	
Input	1 byte
Digital outputs	
Number of outputs	1
Voltage induced on current interruption limited to	No
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	5 A
With lamp load, max.	25 W
Switching frequency	
With resistive load, max.	2 Hz
With inductive load, max.	0.1 Hz; see information in the manual

	6ES7136-6RA00-0BF0
With inductive load (to IEC 60947-5-1, DC13), max.	0.1 Hz
With inductive load (to IEC 60947-5-1, AC15), max.	2 Hz
Total current of the outputs (per module)	
Horizontal installation	
Up to 40 ℃, max.	5 A; note derating information in the manual
Up to 50 ℃, max.	4 A; note derating information in the manual
Up to 60 ℃, max.	3 A; note derating information in the manual
Vertical installation	
Up to 50 ℃, max.	3 A; note derating information in the manual
Relay outputs	
Number of relay outputs	1; 2 NO contacts
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	70 mA
External fuse for relay outputs	Yes, 6 A, see information in the manual
Relay approved acc. to UL 508	Yes; Pilot Duty B300 R300
Switching capacity of contacts	
With inductive load, max.	See additional description in the manual
With resistive load, max.	See additional description in the manual
Thermal continuous current, max.	5 A
Contact rating, min.	1 mA
Contact rating after exceeding 300 mA, min.	10 mA
Contact rating after exceeding 300 mA, max.	5 A
Rated switching voltage (DC)	24 V
Rated switching voltage (AC)	230 V
Length of cable	
Cable length, shielded, max.	500 m; for load contacts
Cable length unshielded, max.	300 m; for load contacts
Control cable (input), max.	10 m
Interrupts/diagnostics/status information	
Diagnostics messages	
Diagnostics	Yes, firmware update
Diagnostics display LED	
RUN LED	Yes; green/red DIAG LED
Channel status display	Yes; green LED
Electrical isolation	
Electrical isolation, channels	
Between channels	Yes; only with SELV / PELV
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between channels and backplane bus/supply voltage	250 VAC (reinforced insulation)
Between backplane bus and supply voltage	60 VAC/75 VDC

	6ES7136-6RA00-0BF0
Insulation	
Insulation test voltage	2545 VDC 2 s (routine test)
Overvoltage category	III
Tested with	
Between channels and backplane bus/supply voltage	2545 VDC 2s (routine test), surge voltage test 7200 VDC/5 positive and 5 negative pulses (type test)
Between backplane bus and supply voltage	707 VDC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
Category according to ISO 13849-1:2008	4
SIL according to IEC 61508:2010	SIL 3
Low demand (PFD) acc. to SIL2	<1.00E-04, proof test interval 1 year
Low demand (PFD) acc. to SIL3	<1.00E-05, proof test interval 1 month
High demand (PFH) acc. to SIL2	<1.00E-08 1/h, proof test interval 1 year
High demand (PFH) acc. to SIL3	<6.00E-09 1/h, proof test interval 1 month
Dimensions	
Width	20 mm
Weights	
Weight, approx.	56 g

Supplement to the technical specifications

Technical specifications	
Relay outputs	
Current consumption of relays (coil current of all relays), min.	20 mA
Permitted potential difference	
• Between NO contacts	75 VDC / 60 VAC
Insulation tested	
• Between the NO contacts	707 VDC (type test)

Derating

NOTE

As the modules are small, you need to monitor the heat build-up between adjacent modules if output modules are subject to high loads. A temperature rise in an output module exposed to a high load can result in shutdown and reduce plant availability. If the operating voltage > 25 VDC, the average total current of the modules directly adjacent should not exceed 50% of the levels listed in the technical specifications, and the ambient temperature should not exceed 50 °C.

If the ambient temperature exceeds 50 °C, supply voltage L+ must not exceed 25 VDC.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

7.2 Mechanical and climatic ambient conditions

In contrast to the specifications for mechanical environmental conditions and mechanical environmental conditions testing in the "Mechanical and climatic ambient conditions" section of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual, the following applies to this F-module:

Mechanical ambient conditions

The following table shows the mechanical ambient conditions in the form of sinusoidal vibrations.

Table 1-544 Mechanical ambient conditions

Frequency band	ET 200SP with BusAdapter BA 2×FC	ET 200SP with BusAdapter BA 2×RJ45/ BA 2xSCRJ
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude	
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration	

Tests of mechanical ambient conditions

The following table provides important information about the type and scope of the tests for ambient mechanical conditions.

Table 1-545 Tests of mechanical ambient conditions

Check for ...	Test standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sinus)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes

Check for ...	Test standard	Comment
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes

7.3 Switching capacity and service life of contacts

Switching capacity and service life of contacts

You can extend the service life beyond the value indicated in the tables below by installing an external protective circuit.

The tables below show the switching capacity and service life of the contacts.

Table 1-546 Switching capacity and service life of contacts with resistive load

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	5.0 A	350000
	3.0 A	500000
	2.0 A	750000
	1.0 A	1800000
	0.5 A	4000000
230 VAC	5.0 A	100000
	3.0 A	150000
	2.0 A	200000
	1.0 A	400000
	0.5 A	800000

Table 1-547 Switching capacity and service life of contacts **with inductive load according to IEC 947-5-1 DC 13/ AC15**

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	1.0 A	100000
	0.5 A	200000
230 VAC	1.0 A	200000
	0.5 A	350000

Table 1-548 B10d values

AC	750000
DC	10000000

Response times

A

A.1 Response times

Introduction

The section below shows the response times of the digital output module F-RQ 1x24VDC/24..230VAC/5A. The response times of digital output module F-RQ 1x24VDC/24..230VAC/5A are included in the calculation of the F-system response time.

Definition of response time for fail-safe relay outputs

The response time defines the interval between controlling by means of a fail-safe digital output module until the signal change at the relay output.

Maximum response time without errors

The maximum response time for fail-safe relay outputs when there are no errors is equal to:

Max. response time = 16 ms

Readback response time

The readback response time for fail-safe relay outputs is equal to:

Readback response time = 30 ms

Maximum response time until error detection

Max. response time = cycle time of the safety program + max. readback time of the FDBACK instruction + max. response time of the F-DQ module + max. response time of the F-RQ module + 12.8 ms

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SIMATIC

ET 200SP
Fail-safe Module F-CM AS-i Safety ST (3RK7136-6SC00-0BC1)

Equipment Manual

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03/2017
A5E03957059020A/RS-AB/002

Preface

Purpose of the documentation

This manual complements the ET 200SP distributed I/O system system manual. General functions of the ET 200SP are listed in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

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Documentation guide

1

Introduction

The following paragraph gives you an overview of the additional documentation you need to use the F-CM AS-i Safety ST.

Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

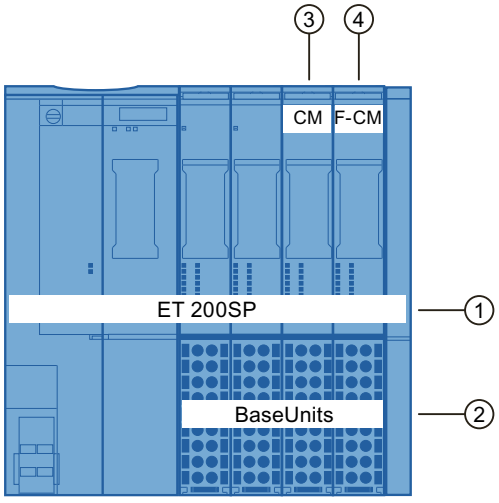


Figure 1-271 Example of a system structure

Table 1-549 Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

No.	Component	Documentation	Most important contents
①	System	Fail-safe modules: Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en) ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)	• Application planning • Installation • Connecting • Commissioning • Technical specifications
		Fail-safe system: Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en) Programming and Operating Manual SIMATIC Safety (http://support.automation.siemens.com/WW/view/en/54110126/0/en)	• Configuration • Programming

No.	Component	Documentation	Most important contents
②	BaseUnits	SIMATIC ET 200 SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)	• Connecting • Technical specifications
③	CM AS-i Master ST	Manual CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)	• Commissioning • Technical specifications
④	ET 200SP F-CM AS-i Safety ST fail-safe module	Device manual ET 200SP F-CM AS-i Safety ST fail-safe module (3RK7136-6SC00-0BC1)	• Installation • Connecting • Configuration

Safety instructions

2

Important safety instructions

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.
For operation in Pollution Degree 2 environment.

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.
When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or an enclosure. To comply with EU Directive 94/9 (ATEX 95), this enclosure must meet the requirements of at least IP54 according to EN 60529.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.
Wires must not be connected to the device or disconnected from the device within a flammable or combustible environment.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.
Do not disconnect live wires from the device if it cannot be ensured that an explosive atmosphere is not present in the environment.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.
Replacement of components may impair suitability for Class I, Division 2 or Zone 2.

⚠ WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.
Do not open the device when the supply voltage is switched on.

⚠ WARNING

Connection only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to an AS-i power supply unit that meets the conditions indicated in the Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

For this reason, you are only permitted to connect safety extra-low voltage (SELV) with limited power source (LPS) according to IEC 60950-1, EN 60950-1, VDE 0805-1 to the supply connections.

The supply of the device must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

Take measures to prevent transient overvoltages of more than 40% of the rated voltage. You can ensure this by using only AS-i power supply units that meet the requirements indicated in Section Terminal assignment (Page 20) in "Power supply units for AS-Interface". Transient overvoltages are not permitted to exceed 119 V under any circumstances. This will ensure compliance with an ATEX requirement.

⚠ CAUTION

Failure to observe this information may result in property damage and bodily injury

This device is only suitable for use in areas defined as Class I, Division 2, Groups A, B, C, and D and is not suitable for use in hazardous areas.

⚠ WARNING

To be operated by experienced users only

Improper operation may result in death, severe injury, and serious property damage. Users must be familiar with ASIsafe and the safety system used, e.g., SIMATIC, Distributed Safety, SIMATIC Safety Advanced.

Only an experienced user is permitted to teach the code sequences of safe AS-i slaves (organizational specification).

⚠ CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is only suitable for use in areas defined as Class I, Zone 2, Group IIC and in non-hazardous areas.

NOTICE

Checking parameters

Check that all parameters are correctly set before final acceptance.

NOTICE

Reaction to faults in fail-safe modules
If you are using the module in safety-critical applications, the PROFIsafe mechanism of passivation and reintegration is enabled and must be used.
Observe the information concerning passivation and other fault reactions in the documentation for the ET 200SP Distributed I/O System, see Section Documentation guide (Page 5).

NOTICE

Single-channel use of safe AS-i input slaves
The values in the PROFIsafe process image input have Safety Integrity Level SIL 3.
If two-channel interconnection is not used for a safe AS-i input slave, the application has a maximum safety integrity level of SIL 2 or less. The configuration tool / STEP 7 cannot detect this.
You must ensure that the signals are correctly processed in the safety application.

NOTICE

Ensure that the plant is functioning correctly in productive operation
Carry out a function test before the system goes into productive operation.

Important note for maintaining the operational safety of the system

NOTE

Newsletter containing information on product development and product features
Owners of systems with safety-related characteristics must ensure compliance with special operational safety requirements. Suppliers are required to comply with special product monitoring measures. For this reason, Siemens publishes a special newsletter containing information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective. A newsletter keeps you constantly up to date in this regard. A subscription to the newsletter is necessary so that you can make any needed changes to your system. To sign up for the newsletter, go to:
Internet (https://www.industry.siemens.com/newsletter)
Select "Service & Support" > "Industry Online Support" > "Automation Technology" > "AS-Interface". Select the "Update" entry type.

See also

References (Page 82)

Product overview

3

3.1 Properties of the F-CM AS-i Safety ST

Item number

3RK7136-6SC00-0BC1

View of the module



Figure 1-272 View of the F-CM AS-i Safety ST module

Use of the module

The F-CM AS-i Safety ST module is a communication module for use in the SIMATIC ET 200SP Distributed I/O System.

The F-CM AS-i Safety ST module features a 20 mm wide ET 200SP module housing. A BaseUnit (BU) is required for use in the ET 200SP. The F-CM AS-i Safety ST module can be plugged in to:

- BaseUnit Type C0
- BaseUnit Type C1

The F-CM AS-i Safety ST fail-safe communication module expands a standard AS-Interface network to include safety-related communication.

The F-CM AS-i Safety ST module reads the input states of safety-related AS-Interface input modules and provides these states to a fail-safe F-CPU for further evaluation.

In the opposite direction, the F-CM AS-i Safety ST module receives safe output states of an F-CPU and outputs them for control of safety-related outputs on AS-Interface.

The F-CM AS-i Safety ST fail-safe module supports safety-related applications up to SIL 3 according to EN 62061 or safety category up to PL e according to EN 13849-1. The input and

output values of the safety-related AS-i slaves are addressed using the safe cyclic process image. You need an F-CPU for safe processing.

The F-CM AS-i Safety ST module has no AS-i master functionality. For operation of the AS-i network, you need a CM AS-i Master ST module (3RK7137-6SA00-0BC1) or another AS-i master conforming to AS-i Specification V3.0.

You can plug several F-CM AS-i Safety ST modules into one SIMATIC ET 200SP station. An F-CM AS-i Safety ST occupies 16 input bytes and 8 output bytes in the I/O address space. The number of F-CM AS-i Safety ST modules that can be plugged in depends on:

- The maximum address space of the utilized interface module (IM) of the ET 200SP
- The amount of address space occupied by other modules

Up to five module combinations of CM AS-i Master ST (32 input bytes/32 output bytes) and F-CM AS-i Safety ST (16 input bytes/8 output bytes) can be plugged in to one SIMATIC ET 200SP station with standard interface module IM 155-6 PN ST having a maximum address space of 256 input bytes/256 output bytes. If other modules are present in the ET 200SP station, the available address space and the maximum number of AS-i modules are reduced.

In a SIMATIC ET 200SP station with High Feature Interface Module IM 155-6 PN HF and a maximum address space of 1 440 input bytes/1 440 output bytes, a correspondingly greater number of modules can be plugged in.

You can find additional information in ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

Properties

- Technical properties
  - Gateway between PROFIsafe and ASIsafe, without master functionality
  - Expands a standard AS-i network to include safety-related communication (ASIsafe)
  - Transfer of safety-related digital I/O values in the cyclic process image
  - Monitoring of up to 31 safety-related input slaves
  - Control of up to 16 safety-related AS-i output slaves or switch-off groups
  - Power supplied from the AS-i voltage
  - Use of various interconnection types (1oo1 and 1oo2) is possible
  - Input delay of 0 ms to 150 ms can be assigned for each channel
  - Startup test can be activated for each channel
  - Discrepancy monitoring can be configured for each channel
  - Sequence monitoring can be set for each channel
  - Channel-wise passivation
  - Test for 0 signal before reintegration
  - 8 LED displays for status and error diagnostics
- Supported functions
  - I&M identification data
  - PROFIsafe V2.4
  - Firmware update

NOTICE
Max. proof test interval When the proof test interval has expired, you must replace the device; see "Technical specifications (Page 74)".

- New properties as from FW V1.0.1
  As from product version 02, the module is shipped with FW V1.0.1 (or higher).
  - Extended functions (diagnostic texts)
  - New messages
  - New diagnostics data record 206

For more information, see Section "Parameterizing (Page 31)".

Accessories

The following components can be used with the module:

- Labeling strips
- Reference identification label

Ease of maintenance

The following features support maintenance:

- Code sequences are saved in the coding element. As a result, teaching of the code sequences does not have to be repeated after an F-CM AS-i Safety ST module is replaced.
- Use is automated to the greatest extent possible. This applies, in particular, to the teaching of the code sequences of safe AS-i slaves.
- An F-address that has already been assigned is stored in the coding element. This means that there is no need to repeat teaching-in after replacing the F-CM AS-i Safety ST module.
- The module/BaseUnit concept allows you to easily replace defective hardware. Remove the defective module from the rack and plug in the new module.

Further information can be found in the Section "Code sequences (Page 61)".

Certifications

More detailed information regarding certifications can be found in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

3.2 Operating modes of the F-CM AS-i Safety ST

3.2.1 Standard mode

Self test during device startup

After the AS-i voltage is switched on (PWR LED shows steady green light), the F-CM AS-i Safety ST module performs a comprehensive self-test. During this test, all LEDs are lit for approximately 3 seconds. Exception: the "DIAG" LED is controlled directly by the ET 200SP backplane bus and indicates the communication status for the ET 200SP system.

Checking of the F-address

After the self-test, the module checks the F-address. If no valid F-address is available, the "DIAG" and "PROFIsafe" LEDs flash red (the status LED flashes green). You must then assign the F-address, see Section "F-parameters (Page 33).

Downloading of the module parameters

The F-CM AS-i Safety ST then begins to read in code sequences of the safe AS-i slaves on the connected AS-i bus. At the same time, the module downloads the module parameters that were stored in the PLC CPU. The module parameters can only be downloaded when the operating voltage is applied to the interface module of the ET 200SP and the parameters have been made available by the PLC CPU during startup of the ET 200SP station.

The "Status" LED flashes green until the module parameters are completely downloaded or the PLC CPU is in STOP state, or the PLC communication is interrupted.

Cyclic data exchange of safe input/output data

When a valid set of module parameters has been downloaded and the PLC CPU is in "RUN" state, the safe input/output data is evaluated according the parameter assignment and exchanged with the PLC CPU.

The PROFIsafe protocol is used for the data exchange.

The "Status" LED is lit green during cyclic data exchange.

If the F-CM AS-i Safety ST module starts cyclic data exchange directly after startup, but communication cannot yet be established on the AS-i bus, the F-CM AS-i Safety ST module supplies the substitute value "0" in the input image. Passivation is delayed by a maximum of 30 s in this case. As a result, communication can start on the AS-i bus within this time window without passivation. After this time window, the input/output channels are passivated if there is no AS-i communication.

3.2.2 Error statuses

NOTE

Statuses not considered to be errors

The F-CM AS-i Safety ST module does not consider the following statuses to be errors, i.e. no alarm and no passivation is triggered:

- Waiting for start-up test
- Input/output with value = 0 in the process image without error condition, e.g. normal opening of the input contacts by pressing an emergency stop button or opening a protective door.

Diagnostic information can be read out in the user program using data records. For information, please refer to Section "Data records for diagnostics (Page 45)".

3.2.2.1 Serious device fault

Description

Examples of conditions that trigger a serious device fault are:

- Fault in the electronics
- Repeated synchronization error

You can read the following pattern on the LEDs:

Table 1-550 LED display for a serious device fault

LED	Display
"Status"	☐ "Off"
"Error"	■ Red "On"
"CFG"	■ Red "On"
"PSF"	■ Red "On"

In the event of a serious device fault, communication with the F-CM AS-i Safety ST module, e.g., reading a data record, is not possible. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

1. Switch off the module.
2. Wait for the module to cool down, if necessary.
3. Switch on the device again.
4. If the error persists after the module is switched on, the module must be replaced.

3.2.2.2 Device fault

Description

Examples of conditions that trigger a device fault are:

- Device fault (e.g. sporadic synchronization error, see also DS92)
- Configuration error (e.g. problem with contact to backplane bus, coding plug missing, see also DS92)

You can read the following pattern on the LEDs:

Table 1-551 LED display for device faults

LED	Display
"Status"	☐ "Off"
"Error"	✳ Red "flashes"
"CFG"	☐ "Off"
"PSF"	☐ "Off"

In the event of a device fault of this type, communication with the F-CM AS-i Safety ST module is only possible. e.g., for reading out additional diagnostic information via data records. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

- Make sure that the station is properly grounded.
- Check whether the coding element is present or replace it if necessary.
- Plug the module into the BaseUnit in an untwisted position.

Switch off the module. If the error persists after the module is switched on and no external error cause can be found, the module must be replaced.

3.2.2.3 Process signal error

Description

Examples of conditions that trigger a process signal error are:

- Discrepancy error at the inputs of a safe AS-i input slave
- Sequence error at the inputs of a safe AS-i input slave
- Sporadic code sequence error (from FW V1.0.1), e.g. fault caused by EMC in the input circuit
- Code sequence error at a safe AS-i input slave, e.g. due to cross-circuit at the inputs
- Failure of a safe AS-i input slave

You can read the following pattern on the LEDs:

Table 1-552 LED display for discrepancy error or sequence error

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	□ "Off"
"PSF"	✲ Red "flashes"

Table 1-553 LED display for code sequence errors (e.g. due to cross-circuit) or for slave failure

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	✲ Red "flashes"
"PSF"	✲ Flashes red if the CPU is in RUN "off" if the CPU is in STOP.

In the event of a process signal error, the F-CM AS-i Safety ST module remains in cyclic data exchange. Only at the safe input slave involved in each case is the substitute value "0" processed and the channel passivated. After the cause of the error has been eliminated, the channel can be reintegrated via the safety program.

The "PSF" LED goes out only after all channels have been reintegrated.

The "DIAG" LED switches from flashing red to green as soon as all errors that led to a passivation of the individual channels have been cleared.

Communication with the F-CM AS-i Safety ST module is possible, for example, for reading out additional diagnostic information via data records.

Response to code sequence errors

- **Sporadic code sequence error**
  Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
  Behavior as from firmware V1.0.1:
  - Sporadic code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The resetting to the substitute value 0 takes place without any delay.
  - Diagnostic alarm is triggered (after a short delay, in order to distinguish between sporadic code sequence errors and general code sequence errors).
  - **Response to FW V1.0.0**

  - No message as diagnostic alarm in FW V1.0.0 and no passivation of the channel.
  - Safety input bit of the channel is reset to substitute value 0 without a delay and automatically switches to the process value 0 or 1 if there is no interference to the code sequence.

- **Code sequence error (general)**
  Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the fail-safe input module.
  Behavior (identical for firmware V1.0.0 and V1.0.1 or higher):
  - Code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The reset to the substitute value 0 takes place without a delay, while the diagnostic alarm is triggered after a short delay (delay necessary in order to distinguish between sporadic code sequence errors and general code sequence errors).

3.2.2.4 Parameter assignment error

Description

In the event of invalid configuration data, the cyclic data exchange will not start.
You can read the following pattern on the LEDs:

Table 1-554 LED display for parameter assignment errors

LED	Display
"Status"	✳ Green "flashing"
"Error"	☐ "Off"
"CFG"	☐ "Off"
"PSF"	✳ Red "flashes"

1. Check the hardware configuration in *STEP 7*.
2. Perform a compilation.
3. Download the configuration data to the PLC CPU.

3.3 Firmware update

Performing a firmware update

Information about updating the firmware can be found in the ET 200SP System Manual.

NOTE

Noting the firmware version
After a firmware update, mark the current firmware version on the housing of the F-CM AS-i Safety ST.

NOTE

Requirement for the firmware update
Always perform the firmware update of the F-CM AS-i Safety ST in a separate ET 200SP rack. Ensure that no other modules besides the interface module (IM), the F-CM AS-i Safety ST, and the terminating server module are located in the ET 200SP rack.
During the firmware update of the F-CM AS-i Safety ST module, the associated CPU must be in the STOP operating state. To do this, switch the CPU to the STOP state before starting the firmware update.

NOTE

If the FW V1.0.0 is replaced by another FW version, then an intermediate step is necessary. If you would like to replace a higher FW version with FW version V1.0.0, then this intermediate step is also necessary.
As an intermediate step, the Bootloader Version (B1.0.0) of the firmware must be loaded before the actual firmware V1.x.x.

NOTICE

Observe references to the download page for executing the firmware change Failure to do so can result in the destruction of the device.
The firmware versions are made available in the Online Support:
Online Support (https://support.industry.siemens.com/cs/ww/en/view/109743655)

NOTICE

Checking the firmware version for F-permission
Before using a new firmware version, check whether it is permitted for use in the respective module.
The permissible firmware version is specified in the appendices of the F-CM AS-i Safety ST Safety certificate.

See also:

Certificate for failsafe module F-CM AS-i Safety ST (3RK7136-6SC00-0BC1) (https://support.industry.siemens.com/cs/ww/en/view/90477145)

Certificate for ET 200SP modules (http://support.automation.siemens.com/WW/view/en/49368678/134200)

Handling of the F-address and the code sequences

NOTE

Saving of the F-address in the coding element
During a firmware update, the F-address that is saved in the coding element is retained. Observe the information in the description of the firmware version.

NOTE

Saving of the code sequences in the coding element
During a firmware update, the ASIsafe code sequences that are saved in the coding element are retained. Observe the information in the description of the firmware version.

LED behavior during a firmware update

During a firmware update, the LEDs exhibit the following behavior:

- "DIAG" LED flashes red.
- "ADDR" LED flashes green.
- "PWR" LED lights up green.
- The rest of the LEDs are Off.

NOTE

Supply voltage during a firmware update
The AS-i voltage and the supply voltage of the ET 200SP station must not be switched off during a firmware update.

On successful completion of a firmware update, the module performs a hot restart. It is not necessary to switch off the voltage.

After the restart, the LEDs indicate the status of the F-CM AS-i Safety ST same as after a device startup.

If the firmware update cannot be completed, switch the AS-i voltage off and back on again and repeat the firmware update.

See also

Error statuses (Page 14)

Connection

4

4.1 Terminal assignment

Requirement

For connecting, you require a BaseUnit:

- Type C1 (dark BaseUnit, e.g., item number 6ES7193-6BP20-0BC1)
- Type C0 (light BaseUnit, e.g., item number 6ES7193-6BP20-0DC0)

Note that, within a BaseUnit group for AS-i consisting of light and dark BaseUnits, only the AS-i modules CM AS-i Master ST and F-CM AS-i Safety ST may be combined. Other module types of the ET 200SP must always be separated from the BaseUnit group for AS-i using light BaseUnits.

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition
Connect the BaseUnit only to AS-i power supply units that meet the requirements given in Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

Variants

Use with light BaseUnit Type C0
If the F-CM AS-i Safety ST module is connected to an AS-i network whose AS-i master is located outside the ET 200SP station, use the light BaseUnit Type C0.

If the AS-i master is located within the ET 200SP station, you can also use the light BaseUnit. However, you must wire the AS-i network explicitly using the connecting terminals.

The light BaseUnit Type C0 has no internal connection to the module plugged in on the left.

Use with dark BaseUnit Type C1
If you are using a combination of CM AS-i Master ST and F-CM AS-i Safety ST on the same AS-i network, use the dark BaseUnit. In this case, plug the CM AS-i Master ST module into a light BaseUnit Type C0. Next to it on the right, plug the F-CM AS-i Safety ST module into a dark BaseUnit Type C1.

In this case, connect the AS-i network to the light BaseUnit. The dark BaseUnit does not have to be connected to the AS-i network because the connection is made automatically via the BaseUnit group.

In contrast to other BaseUnit types, for the BaseUnits Type C0 and Type C1, the P1 and P2 busbars of the BaseUnit are electrically isolated from the front panel connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-). An electrical connection is made in each case via the plugged-in CM AS-i Master ST module or F-CM AS-i Safety ST module.

The AS-i voltage connected to the light BaseUnit Type C0 is applied through the plugged CM AS-i Master ST module to the busbars. The busbars of the BaseUnit group are connected-through. The F-CM AS-i Safety ST module is supplied with AS-i voltage via the busbars of the dark BaseUnit Type C1. It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload in the modules.

If you want to maintain the voltage supply of the F-CM AS-i Safety ST module when the CM AS-i Master ST module is unplugged from the light BaseUnit, you can wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and the dark BaseUnit Type C1.

Grouping of a light BaseUnit Type C0 with several dark BaseUnits Type C1
The use of a single F-CM AS-i Safety ST module on an AS-i network is generally sufficient. If several F-CM AS-i Safety ST modules are being used on an AS-i network by means of series connected dark BaseUnits Type C1, you must wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and a dark BaseUnit Type C1. This will prevent an overload of the modules. A current draw from the dark BaseUnit is not allowed. Additional information about this can be found in "Use with dark BaseUnit Type C1".

General terminal assignment

Table 1-555 Terminal assignment of the F-CM AS-i Safety ST

Terminal	Assignment	Description
1	TEACH1	Connection of the "TEACH" button (optional) See Section Code sequences (Page 61).
2	TEACH2	
3	RES	Reserved
4	RES	Reserved
5	RES	Reserved
6	RES	Reserved
1L, 2L[1)]	ASI+	Dark BaseUnit Type C1: optional connection of the AS-i cable, positive polarity Light BaseUnit Type C0: connection of the AS-i cable, positive polarity
1N, 2N [1)]	ASI-	Dark BaseUnit Type C1: optional connection of the AS-i cable, negative polarity Light BaseUnit Type C0: connection of the AS-i cable, negative polarity

1) The terminals are connected through in the BaseUnit.

Connecting an external "TEACH" button

You can connect a "TEACH" button to the "TEACH1" and "TEACH2" terminals of the F-CM AS-i Safety ST module. The "TEACH" button enables the transfer of code sequences of the connected safe AS-i input slaves. This function is activated by closing the button contact on the TEACH1 and TEACH2 terminals.

The maximum cable length between the terminal and "TEACH" button is 0.5 m.

Use two wires routed in parallel for connecting the button (not included in the scope of delivery).

Additional rules and instructions for operating the ET 200SP with fail-safe modules

Observe generally the information in Section "Connecting" in the following documentation:

- Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
- Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)

The conditions for connecting sensors and actuators to the modules of the ET 200SP also apply generally to the connecting of sensors and actuators to the slaves and modules of the AS-i network.

In addition, the information in the documentation of the AS-i component applies.

Ensure that all components of the AS-i network are connected in such a way that the voltage applied to the safety-related AS-i modules is limited to a maximum of 40 V.

The ET 200SP modules CM AS-i Master ST and F-CM AS-i Safety ST have internal safe electrical isolation from the backplane bus of the ET 200SP.

Power supply units for AS-Interface

A connected power supply unit must have the following properties:

- Rated output voltage 30 V DC (AS-Interface Standard) or 24 V DC (AS-i Power24V)
- PELV/SELV (Protective/Safety Extra-Low Voltage) standard
- Residual ripple < 250 mVpp
- Limiting of output voltage to a maximum of 40 V in the event of a fault, including a second fault.

The Siemens power supply units for AS-Interface meet these requirements. For additional information, refer to the operating instructions of the power supply unit.

Use an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit that meets the above-indicated requirements and an AS-i data decoupling unit.

In the following text, the expression "AS-i power supply unit" stands, unless described otherwise, for an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit and an AS-i data decoupling unit.

When AS-i Power24V is used, there are limitations on the cable length (max. 50 m AS-i cable) and usability of AS-i components and connected sensors/actuators due to the reduced voltage.

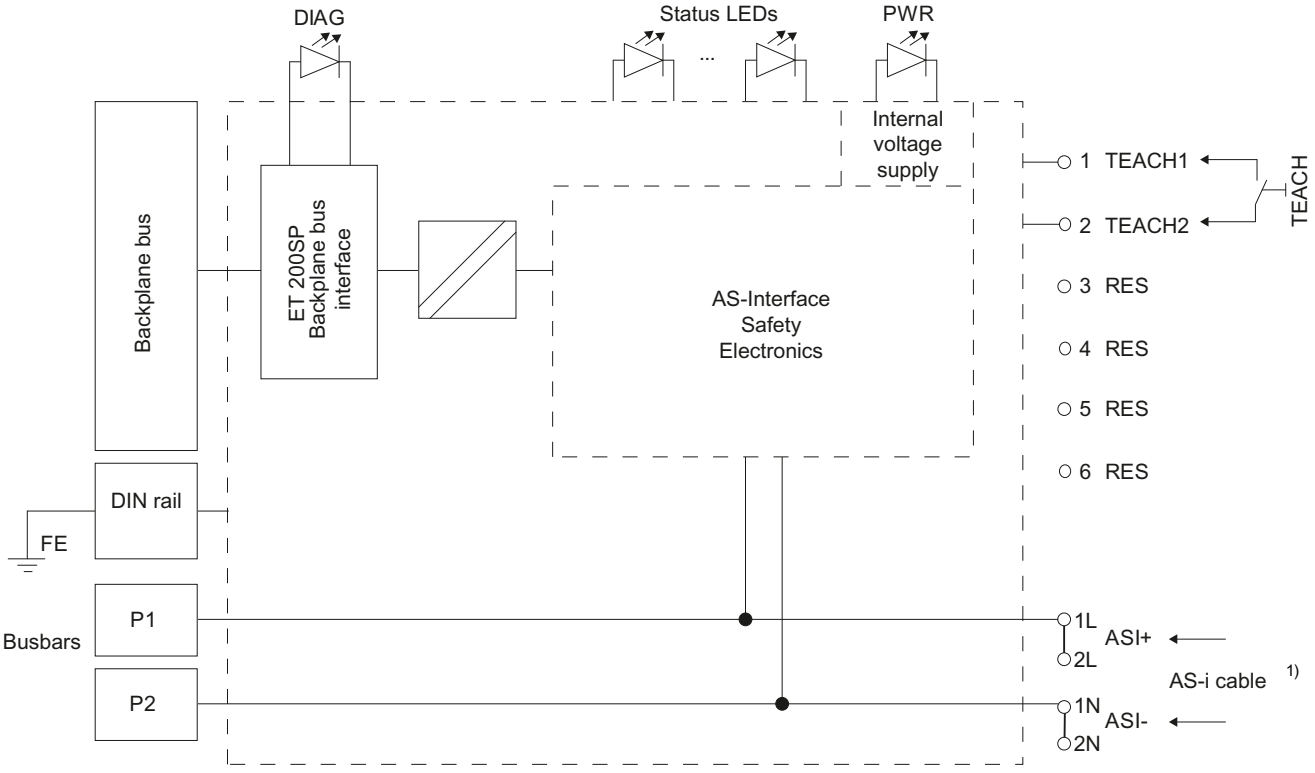
Use a PELV / SELV power supply when operating the F-CM AS-i Safety ST module on PROFIsafe.

Additional notes:

- AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
- FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)

4.2 Schematic circuit diagram

Schematic circuit diagram



1) AS-i cable: Connection not applicable for dark BaseUnit

Figure 1-273 Schematic diagram of F-CM AS-i Safety ST

Connection to busbars

Requirement:

- An AS-i power supply unit is connected to the light BaseUnit Type C0 of the BaseUnit group.
- A CM AS-i Master ST module is plugged into the light BaseUnit.

If you plug an F-CM AS-i Safety ST module into a dark BaseUnit Type C1, the F-CM AS-i Safety ST module will be automatically supplied with AS-i voltage via the busbars.

It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L, 2L (ASI+) and 1N, 2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload of the modules.

Note the additional explanations in Section Terminal assignment (Page 20).

Configuring

5

5.1 Configuring the F-CM AS-i Safety ST

Notes on configuration

You configure the ET 200SP station and its F-CM AS-i Safety ST module and assign their parameters with *STEP 7*.

There is currently no provision for configuration via a GSD file, because the GSD configuration procedure does not permit safety-related parameter assignment (according to PROFIsafe Specification V2.4).

NOTE

F-CM AS-i Safety ST in the hardware catalog of *STEP 7*

If the F-CM AS-i Safety ST module is not listed in the hardware catalog of *STEP 7* , you will need a "Hardware Support Package". This HSP can be obtained from the Internet using the corresponding function in *STEP 7*.

NOTE

Operation under S7 F systems is not approved.

NOTE

The data exchange with "F-DX-MOD" is not supported.

Software for configuration of the F-CM AS-i Safety ST

Configuration software	Requirements	Installation information
STEP 7 (classic) V5.5 SP3 HF4 or higher with Distributed Safety	Hardware Support Package HSP 2093[1)] Internet	Online Help for *STEP 7*
STEP 7 (classic) V5.5 SP4 or higher with Distributed Safety		
STEP 7 (TIA Portal) V13 or higher with Safety Advanced	Hardware Support Package HSP 70[1)] Internet (http://support.automation.siemens.com/WW/view/en/29156492/133100)	
STEP 7 (TIA Portal) V14 or higher with Safety Advanced / Basic		

1) Download optional, if not already contained in the hardware catalog

NOTE

Observe the online help on *STEP 7*.

The "S7 F-Configuration Pack" can be found on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).

Procedure

1. Assign the parameters of the F-CM AS-i Safety ST module according to your safety application.
2. Configure the AS-i Master in such a way that it includes all AS-i slaves in the communication – including the control addresses for safe AS-i outputs that are activated in the F-CM AS-i Safety ST module.
3. Download the hardware configuration to the PLC-CPU.
4. Assign the associated F-address to the F-CM AS-i Safety ST module.
5. Start the teaching and transferring of the code sequences of the safe AS-i input slaves.
6. Create the safety program in the F-CPU.
7. Test your application.

Information concerning these steps can be found in the following sections and in the manuals of the utilized devices.

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage
Observe instructions in the programming and operating manuals

Observe the instructions in the manuals.

- Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

See also

HSP WinCC "classic" (http://support.automation.siemens.com/WW/view/en/23183356)

5.2 Safety-related communication with AS-Interface

5.2.1 Operating principle of code sequences of safe AS-i slaves

For realization of safety-related communication, each safe AS-i input slave sends a code sequence over the AS-i bus. To prevent a mix-up of the AS-i input slaves on an AS-i bus, each AS-i input slave sends a different code sequence. The code sequences are permanently stored in the AS-i input slave.

The F-CM AS-i Safety ST module checks every code sequence for correct data content. Depending on the result of the evaluation, the module sets the the safe input image.

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

You will find more information about teaching code sequences, and the LED behavior, in Section "Code sequences (Page 61)".

You can find a description of the individual parameters in the Section "Process signal errors (Page 15)".

5.2.2 Operating principle of the safe AS-i outputs

Safety-related communication for safe AS-i outputs also uses code sequences. However, they have a different data structure compared to the code sequences of safe AS-i input slaves. The code sequences for safe AS-i outputs do not have to be taught and transferred.

For the function of a safe AS-i output, you need the following components:

- A control unit
- An evaluation unit

Control unit

The control unit outputs safety-related IN or OUT control commands to the AS-i bus. The control unit is integrated in the F-CM AS-i Safety ST module. The control unit assumes an active position in the communication. It acts like an AS-i slave and has an AS-i address that must be called by the AS-i master. The values in the output data of the AS-i master are not relevant in this case. The F-CM AS-i Safety ST module inserts the safety-related control data into the communication data.

Besides controlling the OFF state according to specification, a control unit can control up to four different output switching states: F-OUT 1, F-OUT 2, F-OUT 3, and F-OUT 4. The F-CM AS-i Safety ST module, however, makes available only the output switching state F-OUT 1, i.e., The OFF and ON states are controlled.

In addition to the switching states, a control unit can send out two different auxiliary signals: AUX1 and AUX2. You can use these auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, the AUX1 and AUX2 signals are mapped in the safe process image output. The auxiliary signals are not safety-related signals, however. During control by the safety program, the F-CM AS-i Safety ST module sends a sequence from each auxiliary signal one after the other on the AS-i bus. Up to 16 different control units can be activated in the F-CM AS-i Safety ST module. The control units are managed in the F-CM AS-i Safety ST module as switching group 0 to switching group 15.

If you want to use more than 16 different control units, you can plug two F-CM AS-i Safety ST modules into the ET 200SP station.

Observe the information on the bus configuration in Section AS-i bus configuration with multiple F-CM AS-i Safety ST modules (Page 28).

NOTICE
Uniqueness of the AS-i address on the AS-i bus Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

Evaluation unit

The evaluation unit reads the safety-related control commands ON or OFF on the AS-i bus and passes corresponding switching commands, e.g., to switching contacts. In case of error, e.g., communication error on the AS-i bus, the evaluation unit switches off. The evaluation unit is integrated in the safe AS-i output module to which, for example, drive contactor coils are connected. The evaluation unit behaves as a passive unit in the AS-i communication. The master does not detect the evaluation unit and does not call it. The evaluation unit monitors the communication of the AS-i address of the control unit and reacts to its safety-related control signals.

You set the AS-i address (see Section "Control unit") the evaluation unit is to monitor.

You can set multiple evaluation units to the same address so that a control unit can control multiple safe output modules simultaneously.

NOTICE
Bus cycle time for safe AS-i outputs An evaluation unit requires a minimum AS-i bus cycle time. Ensure that at least 5 AS-i addresses are present on the AS-i bus. Otherwise, the control unit goes to error state. When A/B slaves are used, at least 5 different numerical AS-i addresses must be present. That is, a combination of slave addresses 1A and 1B count as 1 numerical address. The F-CM AS-i Safety ST module does not have a monitoring function for this configuration rule.

5.3 AS-i bus configuration with multiple F-CM AS-i Safety ST modules

The F-CM AS-i Safety ST module generates an additional physical bus load on the AS-i cable.

To avoid faults due to too low levels of the communication signals on the AS-i cable, the entire bus load on the AS-i cable must not exceed a maximum value.

The following rules apply to the determination of the physical bus load on the AS-i cable:

Device type	Bus load value
Slave with A/B address	0.5
Slave with standard address	1.0
F-CM AS-i Safety ST module	2.5
Maximum value as sum of all devices	35.0

Determine the total bus load by adding the bus load values of the components connected to the AS-i cable. You do not have to include the standard AS-i master and AS-i power supply unit system components when calculating the bus load.

To avoid disturbances, the maximum bus load must not exceed the value 35.

The bus load value of the F-CM AS-i Safety ST module remains unchanged if switching groups are activated in the F-CM AS-i Safety ST module for control of safe outputs. In other words, the internally generated AS-i addresses do not influence the bus load value.

If you connect additional components, e.g., an MSS 3RK3 modular safety system, to the AS-i cable, you must take into consideration the bus load values of these components. For more detailed information, refer to the relevant manual.

When a repeater is used, this yields multiple cable segments for which the bus load can be determined separately.

The following configuration examples result from the table:

- In a fully expanded AS-Interface network configuration (with 31 slaves with standard address), you can install 1 F-CM AS-i Safety ST module.
- In an AS-Interface network configuration with 30 slaves with standard address, you can install 2 F-CM AS-i Safety ST modules.

5.4 Configuring with STEP 7 (classic)

With *STEP 7* (classic) the F-CM AS-i Safety ST module is configured independently of the configuration of further ET 200SP modules, e.g. CM AS-i Master ST.

If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM AS-i Safety ST module, then this configuration error is not recognized when compiling the configuration. The F-CM module does not report that the slave cannot be detected until operation is in progress or code sequences are being read.

5.5 Configuring with the TIA Portal

TIA Portal V13 SP1

With TIA Portal V13 SP1, an F-CM AS-i Safety module can only be configured in combination with an AS-i master, necessitating the configuration of the AS-i slaves in STEP 7.

The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.

The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.

TIA Portal V14 or higher

From TIA Portal V14 onwards, an F-CM AS-i Safety module can be configured:

- In combination with an AS-i Master, necessitating the configuration of the AS-i slaves in STEP 7. The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.
  The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.
- Regardless of an AS-i master, i.e. no configuration of the AS-i slaves in STEP 7 is required. In this case, the parameters of the AS-i input slaves are set in the properties window of the F-CM AS-i Safety ST module.

In the case of safe inputs/outputs, the "Configuration status" output field in the properties of the F-CM reports whether the configuration of the F-CM is compatible with the configuration of the connected AS-i subnet. If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM module, then the compilation of the configuration is nevertheless still possible. During operation or when reading the code sequences, however, the F-CM module reports that the slave cannot be detected.

The affected input address is passivated.

Configuration of safe AS-i outputs

The F-CM module contains a control unit for the safe AS-i outputs, see Section "Functional principle of the safe AS-i outputs (Page 26)".

TIA Portal V13 SP1

When configuring with TIA Portal V13 SP1, this control unit is not visible in the network view on the AS-Interface subnet of the AS-i master. The configuration of the F-CM module, however, is always combined with the AS-i master.

TIA Portal V14 or higher

In TIA Portal V14 or higher, the control unit must additionally be configured as a virtual slave on the AS-i subnet of the master, in the event that the AS-i slaves are configured in STEP 7.

A virtual slave is inserted automatically if a safe AS-i output is activated in the properties of the F-CM module and the F-CM module is already linked with the AS-i subnet. If necessary, by using the "Add AS-i Slave to AS-i network" button, the virtual slave can be inserted in the properties of the F-CM module under "Safe outputs". If no AS-i subnet is connected to the F-CM when the "Add AS-i slave to AS-i network" button is actuated, a subnet is automatically inserted.
The virtual slave can be managed like any other slave on the subnet, which means that all AS-i slave addresses existing in the AS-i subnet are visible. The virtual slave can be deleted if the control of the safe AS-i output is no longer required.

If necessary, the virtual slave can also be inserted straight from the hardware catalog (3RK7136-6SC00-0BC1F-DQ) into the subnet of the master.

NOTE

The virtual slave 3RK7136-6SC00-0BC1F-DQ is not a hardware module that is connected to the AS-i cable, but only a tool for the configuration of the AS-i master. The AS-i address assigned to the virtual slave 3RK7136-6SC00-0BC1F-DQ is emulated in the F-CM AS-i Safety module as soon as the corresponding safe output is activated in the properties of the F-CM.

If the AS-i master is engineered without configuring the AS-i slaves in STEP 7, i.e. either configuration of the AS-i slaves via the "SET" button or via the control panel in the TIA Portal, then the secure outputs in the F-CM must be configured and must have been loaded into the station before the configuration of the AS-i slaves is read into the master by means of the "SET" button or via the control panel in the TIA Portal.

Assigning parameters / Setting the address space 6

6.1 Parameters

List of parameters

Table 1-556 F-parameters

Parameter	Value range	Default setting	Parameter reassignment in RUN	Scope
F-monitoring time (ms)	1 ... 65534 ms	150 ms	No	F-CM AS-i Safety ST
F-source address	1 ... 65534	Assigned by the F-system	No	F-CM AS-i Safety ST
F-destination address	1 ... 65534	Is suggested by the F-system	No	F-CM AS-i Safety ST

For information on the F-parameters and the assignment of the F-address, refer to the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

Table 1-557 Potential group / AS-i network

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
BaseUnit with AS-i voltage supply	Potential group: The AS-i network of the left module (dark BaseUnit) is used New potential group: New AS-i network (light BaseUnit)	The AS-i network of the left module (dark BaseUnit) is used	No	F-CM AS-i Safety ST

Table 1-558 Module parameters: Behavior after channel faults

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Behavior after channel faults	Passivate the channel (setting cannot be changed).	Passivate the channel	-	F-CM AS-i Safety ST

Safe inputs
Up to 31 safe AS-i input slaves are monitored. Open the settings for each required AS-i address. Activate the input monitoring and assign the parameters.

Table 1-559 Module parameters: Safe inputs, AS-i address 1 to 31

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate input monitoring	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
I address	Output field, value is calculated automatically	-	No	Channel / safe AS-i input slave
Input delay (ms)	0 ms, 50 ms ... 150 ms[1)]	0 ms	No	Channel / safe AS-i input slave
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent	1oo2 evaluation	No	Channel / safe AS-i input slave
Startup test	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy monitoring	• Disable • Enable	• "Disable" if 1oo1 evaluation • "Enable" if 1oo2 evaluation	No	Channel / safe AS-i input slave
Discrepancy behavior	Supply "0" value[2)]	Supply "0" value	-	Channel / safe AS-i input slave
Discrepancy time infinite	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy time (ms)	0 ms ... 60 000 ms	500 ms	No	Channel / safe AS-i input slave
Sequence monitoring	• Deactivated • In ascending order (input 1 before input 2 at HIGH state) • In descending order (input 2 before input 1 at HIGH state)	Deactivated	No	Channel / safe AS-i input slave
Reintegration after discrepancy error	Test 0 signal necessary on both channels[2)]	Test 0 signal necessary on both channels	-	F-CM AS-i Safety ST
Configuration status	-	-	-	(read-only)

1) In increments of 10 ms

2) The setting cannot be changed.

Safe outputs
You can activate up to 16 safe AS-i switching groups Open the settings for each required switching group. Activate the output control and set the associated AS-i address.

Table 1-560 Safe outputs: Switching group 0 to 15

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate output control	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
AS-i address	1 ... 31		No	Channel / safe AS-i output slave
AS-i address switching output	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
AS-i address error acknowledgement	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
Configuration status	-	-	-	(read-only)

You will find additional information in the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

6.2 Explanation of the parameters

6.2.1 F-parameters

Specify F-destination address for F-I/O of the PROFIsafe address type 2

The F-destination address of F-I/O of the PROFIsafe address type 2 is automatically assigned for every F-CPU.

F-source address

With the parameter "Central F-source address" you specify the F-source address for the F-I/O of the PROFIsafe address type 2 assigned to this F-CPU. The F-source address must be unique throughout the network.

NOTE
A change to the parameter "Central F-source address" results in a modification to the safety program when it is recompiled. A new acceptance may therefore be required, as this centrally modifies the F-source address of all F-I/O devices of address type 2 retrospectively.

See also

S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)
SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)

6.2.2 Potential group / AS-i network

Here, you set:

- The BaseUnit you are using.
- How the F-CM AS-i Safety ST I/O module is connected to the AS-i network.

The module can be connected to the AS-i cable by external wiring or automatically via the module plugged in on the left.

- Enable new AS-i network (light BaseUnit)
- Use AS-i network of the left module (dark BaseUnit)

BaseUnit with voltage supply

Enable new AS-i network (light BaseUnit)
Select this option if the module is plugged into a light BaseUnit.

Connect the module to the AS-i cable (ASI+ / ASI-) via the BaseUnit. The module is supplied with voltage from the AS-i cable. Connect the AS-i cable to an AS-i power supply unit or to a combination of a data decoupling unit and a suitable power supply unit.

There is no module-internal connection of the AS-i cable to the module plugged in on the left.

With TIA Portal or with STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (normally: CM AS-i Master ST).

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition
Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 20), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

Use AS-i network of the left module (dark BaseUnit)
Select this option if the module is plugged into the dark BaseUnit.

The module inserted on the left must be a CM AS-i Master ST module (normal situation) or another F-CM AS-i Safety ST module (special case).

The module is connected to the AS-i cable of the module plugged in on the left and supplied with voltage via the module-internal connection.

The module-internal connection is designed only for supplying power to the F-CM AS-i Safety ST I/O module. If several dark BaseUnits are connected in series, a direct connection of the dark BaseUnits to the AS-i cable using external wiring is additionally recommended.

Supplying power to AS-i modules, e.g., AS-i slaves, via the terminals of the dark BaseUnit is not permitted.

With TIA Portal, the F-CM AS-i Safety ST module uses the same AS-Interface subnet as the module inserted on the left (normally: CM AS-i Master ST).

With STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (as a rule: CM AS-i Master ST).

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 20), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

6.2.3 Module parameters - General

Behavior after channel faults

This parameter is permanently set to "Passivate the channel".

After channel faults have occurred, only the faulty PROFIsafe channels are passivated. The PROFIsafe channel corresponds to the safe input and output address in the process image.

6.2.4 Module parameters - Safe inputs

Configuration status

A valid evaluation is only possible if a compatible safe AS-i slave is actively operating on the network.

Input monitoring where there is a missing safe input or a missing AS-i slave causes a passivation of the input address. If no configuration of the slaves is saved in the STEP 7 project, the settings of the AS-i master must ensure that the connected compatible safe AS-i slave is actively operating, for example, using the "SET" button of the master.

Input monitoring activated

With activation of the input monitoring, you activate the corresponding AS-i slave as an input channel for signal processing in the safety program. The AS-i address must be assigned to a safe AS-i input slave.

When the input monitoring is activated, the value of the input channel is calculated based on the input states of the assigned safe AS-i input slave and the evaluation conditions specified by the parameter assignment. If a fault occurs, the substitute value "0" is transferred and the channel is passivated.

If input monitoring is deactivated, the substitute value "0" is transferred. The channel is not passivated.

If required, the AS-i slave can be monitored by another evaluation module, e.g., by another F-CM AS-i Safety ST module, the 3RK3 Modular Safety System. This applies both when input monitoring is deactivated and when it is activated.

NOTE

Call of the AS-i slave
The AS-i slave must be called by the AS-i master. Set up the configuration of the AS-i master in such a way that the communication of the AS-i master with the AS-i address functions properly.

NOTE

Slave profile
A safe AS-i input slave has the slave profile (IO.ID) = 0.B or 7.B.

I address

The input bit address of the input channel for the signal processing in the safety program is indicated here. It is calculated automatically from the start of the inputs entered on the "Addresses" tab.

Input delay

To suppress coupled-in interference or brief switching pulses, you can set an input delay for each AS-i slave. This will suppress interference pulses whose pulse time is less than the set input delay, in ms. The input delay applies to both channels of the channel pair of the AS-i slave.

NOTE

Time of fault suppression shortened by up to 75 ms
It can take 15 AS-i cycles until the valid code sequence is detected. As a result, the time of the fault suppression is shortened by up to 75 ms compared to the set value.

A long input delay suppresses longer interference pulses but results in a longer response time.

Range of values:	0 to 150 ms
Default	0 ms

The values 0, 50 to 150 ms can be selected in 10 ms increments.

The input delay time acts in addition to the system response time. Suppressed interference pulses are not visible in the safety program.

Evaluation of the sensors

This parameter specifies how the connected sensors are to be evaluated.

1oo1 evaluation
In 1oo1 evaluation, the sensor exists once and is connected to the first input of the safe AS-i slave via a single channel. You jumper the second input of the AS-i slave. Instead of the jumper, you can also connect another single-channel sensor to the second input. Only when both inputs supply an ON signal does the F-CM AS-i Safety ST module transfer the "1" value to the safety program (the two inputs are ANDed).

The individual states of the two inputs of the AS-i slave are not visible in the safety program.

A discrepancy analysis is not performed in 1oo1 evaluation.

1oo2 evaluation, equivalent
In 1oo2 (2v2) evaluation, equivalent, both inputs of the safe AS-i slave are occupied by one two-channel sensor or by two single-channel sensors. The two single-channel sensors then belong together functionally as a pair.

The input signals are compared internally for equivalence. The two inputs of the AS-i slave are combined to form a channel pair.

A discrepancy analysis is possible in 1oo2 evaluation, equivalent.

Discrepancy analysis

If you are using a two-channel sensor or two single-channel sensors that acquire the same physical process variable, the sensors will, for example, respond with a delay due to the limited accuracy of their arrangement to each other. For fail-safe inputs, the discrepancy analysis for equivalence is used to infer errors from the time characteristic of two signals of the same functionality. For two associated input signals, if different levels are detected after the input delay time has expired, the discrepancy analysis is started. A check is made to determine if the difference has disappeared after expiration of an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error.

Startup test

If the "Startup test" parameter is activated, after startup of the channel or after a cross-circuit error (code sequence error), the value transferred to the safety program is kept at the substitute value "0" until the connected sensor has been correctly actuated at least once. Afterwards, the value of the input channel is calculated according to the set functionality.

The actuation of the sensor is defined to mean that both inputs of the safe AS-i slave must supply an ON signal, e.g., both switching contacts of the sensor are closed. Then, they must supply an OFF signal, e.g., switching contacts open. Finally, an ON signal must be supplied again, e.g., switching contacts closed. During the sensor actuation phase, none of the following errors may occur:

- Discrepancy error
- Sequence error
- Cross-circuit error (code sequence error)

After reintegration is complete, you must perform a startup test. For this purpose, you actuate the sensor to be monitored once.

A discrepancy error or a sequence monitoring error does not trigger a new startup test.

Discrepancy monitoring

If the discrepancy monitoring is activated, a discrepancy analysis is performed. This is the normal setting for 1oo2 evaluation, equivalent, in order to achieve high error uncovering.

You can deactivate the discrepancy monitoring for special situations. This corresponds in principle to 1oo1 evaluation of sensors. Check whether the lower error uncovering is sufficient for the required safety level. You may possibly use a sensor with integrated error uncovering. If required, you can activate the sequence monitoring.

When 1oo2 evaluation of the sensors is set, discrepancies in signal states between input 1 and input 2 are monitored.

When discrepancy monitoring is activated, the discrepancy time starts to elapse as soon as a difference is detected between the signal on input 1 and the signal on input 2. If the set discrepancy time is exceeded and the difference continues to exist, a discrepancy error is triggered.

Before switch-on, the signal value 0 must be present at both inputs, even when a discrepancy error has not occurred or the discrepancy time has not been set to "infinite".

If the "Evaluation of the sensors" parameter has been assigned with 1oo1, discrepancy monitoring is not performed.

Discrepancy behavior

This parameter is permanently set to "Supply 0 value".

The discrepancy behavior determines the value that is made available to the safety program in the F-CPU during the discrepancy, i.e., while the discrepancy time is running.

After expiration of the set input delay time, once an "OFF" signal is detected at one of the two input channels of the channel pair involved, this parameter setting causes the value "0" to be provided to the safety program in the F-CPU. This setting does not affect the sensor-actuator response time as a result of the discrepancy time.

Discrepancy time infinite

If you activate "Discrepancy time infinite", the time period for the discrepancy analysis never expires. As a result, a time-related discrepancy error will not be detected.

Nevertheless, the following switch-on condition applies: After a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again.

If this condition is not satisfied, especially in the event of a single-channel switch-off (i.e., signal OFF at only one of the two input channels of the relevant channel pair) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) even though the time for the discrepancy analysis has not expired. In data record 202, the bit 0.2 "= 1" is set in the status of the input monitoring of AS-i address n.

A discrepancy error is only detected if both input channels of the affected channel pair have not received the "0" signal simultaneously.

If "Discrepancy time infinite" is deactivated, the discrepancy analysis uses the value set for the "Discrepancy time" parameter.

Discrepancy time

You can specify the discrepancy time in the range of 0 to 60 000 ms for each channel pair.

The following settings are required:

- "Sensor evaluation": 1oo2 evaluation, equivalent
- "Discrepancy monitoring": Active
- "Discrepancy time infinite": Deactivated

In most cases, the discrepancy time is started but does not completely elapse, because the signal differences are evened out again after a short time.

Select a large enough discrepancy time so that in error-free cases, the difference between the two signals always disappears before the discrepancy time expires.

If the input signals do not match after expiration of the assigned discrepancy time, e.g., due to a mechanical defect of the sensor or sensor wire break, a discrepancy error is detected.

When discrepancy time is running, the switch-on condition also applies that after a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again. If this condition is not satisfied, especially in the event of brief switch-off of a channel (due to signal OFF at only one of the two input channels) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) if the time for the discrepancy analysis has not expired.

A detected discrepancy error indicates to the user that the switch-on condition is not satisfied.

Assign a discrepancy time that is greater than the input delay time.

Sequence monitoring

Overview

The sequence monitoring monitors the sequence of the signals of the channel pair when there is a signal change OFF >>> ON at the inputs of the safe AS-i slave.

The following settings are possible:

- Deactivated: The sequence is not a condition that has to be satisfied for switching on the function output.
- Ascending order: Input 1 before input 2 at "HIGH" state
- Descending order: Input 2 before input 1 at "HIGH" state

If the sequence is violated, the "Sequence condition violated" error is detected. The value transferred to the safety program is kept at "0" until the "OFF" signal is read in at both input channels. Switch-on condition is, for example, both switching contacts of the sensor open. The inputs must be switched on one after the other in the assigned sequence and must not switch on simultaneously.

You can activate the sequence monitoring if 1oo2 evaluation, equivalent, is set for the sensor evaluation. In this case, the discrepancy monitoring can be activated or deactivated.

Deactivated

The sequence of the inputs is not monitored.

Ascending order: Input 1 before input 2 at "HIGH" state

For switch-on of the channel, input channel 1 must first read in and hold an "ON" signal followed by input channel 2.

When the channel is switched off, the sequence of the input channels is not monitored.

Descending order: Input 2 before input 1 at "HIGH" state
For switch-on of the channel, input channel 2 must first read in and hold an "ON" signal followed by input channel 1.
When the channel is switched off, the sequence of the input channels is not monitored.

Reintegration after discrepancy error

This parameter is permanently set to: "Test 0-signal necessary on both channels".
A discrepancy error is not considered to be rectified until an "OFF" signal is present again at both input channels. Reintegration of the PROFIsafe channel is then possible.

6.2.5 Module parameters - Safe outputs

Configuration status

For operation of the switching group the AS-i master must activate communication with the associated AS-i address of the control unit in the F-CM. For this reason the configuration of the AS-i network must include a virtual AS-i slave with the profile IO.ID.ID2 = 6.B.D and ID1 = 0. If the slaves are not configured, the AS-i master must be set such that the AS-i address of the control unit in the F-CM is actively operating, for example, using the "SET" button of the master while the F-CM module is being configured and connected to the AS-i master.

Activate output control

With this parameter, you activate the corresponding switching group and the associated AS-i address of the control unit in the F-CM AS-i Safety ST module.
You will find additional information in Section Operating principle of the safe AS-i outputs (Page 26), "Operating principle of the safe AS-i outputs."
When output control is activated, the control unit in the F-CM AS-i Safety ST module is switched on so that the F-CM AS-i Safety ST module generates an additional AS-i address on the AS-i Bus. The associated value is output from the safe process image via this AS-i address.
When output control is deactivated, the corresponding control unit in the F-CM AS-i Safety ST module is switched off, and an AS-i slave is not emulated on the AS-i bus.

AS-i address

Here, you set the AS-i address within the range of 1 to 31 that the F-CM AS-i Safety ST module is to use for control of a safe AS-i output.

⚠ WARNING

Uniqueness of the AS-i address on the AS-i bus
Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

NOTE

Communication of the AS-i master with the AS-i address
The AS-i address of the control unit must be called by the AS-i master. Set up the communication of the AS-i master in such a way that communication with the AS-i address of the control unit functions properly.

NOTE

Slave profile of the control unit in the F-CM AS-i Safety ST module (control of a safe AS-i output)
The AS-i address of the control unit corresponds to a slave with slave profile (IO.ID.ID2) = 6.B.D and ID1 = 0.

Q address switching output

The output bit address is displayed here. It determines the switching state of the safe output (control signal F-OUT 1). Interconnect the "Q address switching output" in your safety program according to the required safety logic.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

Q address error acknowledgment

The output bit address that sends an acknowledgment signal to the safe output is displayed here.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

A positive edge (0 >>> 1) triggers the F-CM AS-i Safety ST module to first send the AUX1 auxiliary signal to the safe output followed by the AUX2 auxiliary signal. Another positive edge is necessary for sending another sequence of auxiliary signals.

The auxiliary signals are used, in general, for acknowledging an error state at the safe output. Refer to the AS-Interface (http://support.automation.siemens.com/WW/view/en/26250840/0/en) System Manual and the Operating Instructions of the safe output module

(http://support.automation.siemens.com/WW/view/en/43666143/0/en) used to find out which functions the auxiliary signals are used for.

NOTE

"Q address error acknowledgment"
The "Q address error acknowledgment" does not trigger an error acknowledgment in the F-CM AS-i Safety ST module. Rather, as described above, it sends an acknowledgement signal to the safe output module on the AS-i bus.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293/0/en)

6.3 Address space

6.3.1 Address assignment for user data and value status of the F-CM AS-i Safety ST module

Input and output address assignment

Of the assigned addresses of the F-CM AS-i Safety ST module, the user data occupy the following addresses in the F-CPU:

Table 1-561 Input address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 0	DI0.7 AS-i address 7	DI0.6 AS-i address 6	DI0.5 AS-i address 5	DI0.4 AS-i address 4	DI0.3 AS-i address 3	DI0.2 AS-i address 2	DI0.1 AS-i address 1	DI0.0 Reserved
x + 1	DI1.7 AS-i address 15	DI1.6 AS-i address 14	DI1.5 AS-i address 13	DI1.4 AS-i address 12	DI1.3 AS-i address 11	DI1.2 AS-i address 10	DI1.1 AS-i address 9	DI1.0 AS-i address 8
x + 2	DI2.7 AS-i address 23	DI2.6 AS-i address 22	DI2.5 AS-i address 21	DI2.4 AS-i address 20	DI2.3 AS-i address 19	DI2.2 AS-i address 18	DI2.1 AS-i address 17	DI2.0 AS-i address 16
x + 3	DI3.7 AS-i address 31	DI3.6 AS-i address 30	DI3.5 AS-i address 29	DI3.4 AS-i address 28	DI3.3 AS-i address 27	DI3.2 AS-i address 26	DI3.1 AS-i address 25	DI3.0 AS-i address 24
x + 4	Value status for DI0.7	Value status for DI0.6	Value status for DI0.5	Value status for DI0.4	Value status for DI0.3	Value status for DI0.2	Value status for DI0.1	Reserved
x + 5	Value status for DI1.7	Value status for DI1.6	Value status for DI1.5	Value status for DI1.4	Value status for DI1.3	Value status for DI1.2	Value status for DI1.1	Value status for DI1.0
x + 6	Value status for DI2.7	Value status for DI2.6	Value status for DI2.5	Value status for DI2.4	Value status for DI2.3	Value status for DI2.2	Value status for DI2.1	Value status for DI2.0
x + 7	Value status for DI3.7	Value status for DI3.6	Value status for DI3.5	Value status for DI3.4	Value status for DI3.3	Value status for DI3.2	Value status for DI3.1	Value status for DI3.0
x + 8	Value status for DQ0.7	Value status for DQ0.6	Value status for DQ0.5	Value status for DQ0.4	Value status for DQ0.3	Value status for DQ0.2	Value status for DQ0.1	Value status for DQ0.0

X = Module start address

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 9	Value status for DQ1.7	Value status for DQ1.6	Value status for DQ1.5	Value status for DQ1.4	Value status for DQ1.3	Value status for DQ1.2	Value status for DQ1.1	Value status for DQ1.0
x + 10	Reserved							
...								
x + 15	Reserved							

X = Module start address

NOTICE

Process value "0" is transmitted as a non-safety related value

Based on the transfer principle of the code sequences, the process value "1" is transferred via AS-Interface as a safe value, so that the enable for switching on a machine can be issued in a safety-related manner. If an error occurs during transfer of the value "1", this error is detected and substitute value "0" is used.

The process value "0" is transferred via AS-interface as an unsafe value. That is, a faulty transmission of the "0" value cannot be detected. The "0" value must therefore not be used as safety-related information that initiates a dangerous action (e.g. feedback "0" of a switch position).

Table 1-562 Output address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 0	DQ0.7 Switching group 7	DQ0.6 Switching group 6	DQ0.5 Switching group 5	DQ0.4 Switching group 4	DQ0.3 Switching group 3	DQ0.2 Switching group 2	DQ0.1 Switching group 1	DQ0.0 Switching group 0
x + 1	DQ1.7 Switching group 15	DQ1.6 Switching group 14	DQ1.5 Switching group 13	DQ1.4 Switching group 12	DQ1.3 Switching group 11	DQ1.2 Switching group 10	DQ1.1 Switching group 9	DQ1.0 Switching group 8
x + 2	Error acknowledg-ment for DQ0.7	Error acknowledg-ment for DQ0.6	Error acknowledg-ment for DQ0.5	Error acknowledg-ment for DQ0.4	Error acknowledg-ment for DQ0.3	Error acknowledg-ment for DQ0.2	Error acknowledg-ment for DQ0.1	Error acknowledg-ment for DQ0.0
x + 3	Error acknowledg-ment for DQ1.7	Error acknowledg-ment for DQ1.6	Error acknowledg-ment for D1.5	Error acknowledg-ment for DQ1.4	Error acknowledg-ment for DQ1.3	Error acknowledg-ment for DQ1.2	Error acknowledg-ment for DQ1.1	Error acknowledg-ment for DQ1.0
x + 4	Reserved							
...								
x + 7	Reserved							

X = Module start address

The error acknowledgment bit initiates the AUX1 and AUX2 signals one after the other.

NOTE

Use of the error acknowledgment bit of a safe AS-i output

The values in the PROFIsafe process output image have Safety Integrity Level SIL 3. In addition to the switching states, a control unit can send out two different auxiliary signals to a safe AS-i output: AUX1 and AUX2. These auxiliary signals are not safety-related signals. You can use the auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, these error acknowledgment bits are mapped in the safe process output image. If error acknowledgment bits are sent to a safe AS-i output, the *STEP 7* or SIMATIC Manager configuration tool is unable to detect that the error acknowledgment bits are not safe. This means: No warnings or faults will be output for it when the safety application is generated. The user is responsible for the correct processing of these signals in the safety application.

6.3.2 Value status

Properties

For each input signal and output signal, the F-CM AS-i Safety ST module provides information about the signal's validity, i.e., the "value status". Like the input signal, the value status is stored in the process image.

Value status for the digital input and output modules

The value status is binary supplementary information of a digital input or output signal. It is entered in the process input image simultaneously with the process signal. The value status provides information regarding the validity of the input or output signal.

The value status is influenced by the following:

- Code sequence errors, e.g, caused by a permanent fault on the AS-i bus, wiring error, etc.
- Missing safe AS-i input slaves
- Channel faults
- Replacement of a safe AS-i slave by a non-safe AS-i slave
- Discrepancy error
- Sequence error

Value status = 1: A valid process value is output for the channel.

Value status = 0: A substitute value is output for the channel or the channel is deactivated.

Assignment of the inputs and outputs to the value status in the process image

A value status is assigned to each channel of the F-CM AS-i Safety ST module in the process input image.

Additional information

A detailed description of the evaluation and processing of the value status can be found in the Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

See also

Address assignment for user data and value status of the F-CM AS-i Safety ST module (Page 42)

6.4 Data records for diagnostics

For diagnostic purposes, you can read out the following data records via your user program. In firmware V1.0.1 or higher the diagnostics data record 206 is available. This data record contains a summary of the information that is relevant for a comprehensive diagnosis via your user program.

NOTE

Use of the DS 206 for diagnostic purposes is recommended (firmware V1.0.1 or higher).

The data records 92, 202 and 204 are required for the diagnosis via the user program for a module with firmware V1.0.0. For reasons of compatibility, these data records also remain available in firmware V1.0.1 or higher.

See also

Firmware update (Page 18)

6.4.1 DS 92 Device-specific diagnostics

Meaning

NOTE
Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 92 contains device-specific messages and information on the device function states of the F-CM AS-i Safety ST module.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.0:

- The "Error code" column in the table below indicates which events are relevant here. If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- The text inside parentheses after the error code corresponds to the error text that is specified for the given error code according to the PROFIBUS Standard. Several error codes can be output. If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms in firmware V1.0.1 or higher are described in Section "DS 206 Diagnostic Data Record (Page 56)".

Table 1-563 DS 92 device-specific diagnostics

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
0.0 ... 0.7	Reserved	-	-
1.0 ... 1.7	Reserved	-	-
2.0 ... 2.7	Reserved	-	-
3.0 ... 3.7	Reserved	-	-
4.0 ... 4.7	Reserved	-	-
5.0 ... 5.7	Reserved	-	-
6.0 ... 6.7	Reserved	-	-
7.0 ... 7.7	Reserved	-	-
8.0 ... 8.7	Reserved	-	-
9.0 ... 9.7	Reserved	-	-
10.0 ... 10.7	Reserved	-	-
11.0 ... 11.7	Reserved	-	-
12.0	Serious device fault	9 ("Error")	See Section Error statuses (Page 14)
12.1	Group error	24 ("Switch-off")	At least one error is present.
12.2	AS-i communication error	19 ("Communication error")	Failure of an AS-i slave configured in the F-CM AS-i Safety ST module or code sequence error

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
12.3	Group_Message_Device	-	At least one message about the device state is present, e.g., configuration missing.
12.4	Group_Message_Application	-	At least one message about the application state is present, e.g., startup test necessary, safety sensor tripped (Emergency Stop, protective door, etc.).
12.5 ... 12.7	Reserved	-	-
13.0	Reserved	-	-
13.1	Device fault	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 14)
13.2	Parameter assignment error	24 ("Switch-off") 16 ("Parameter assignment error")	Parameter not permitted in configuration.
13.3	Process signal error	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 14)
13.4	Code sequence error	24 ("Switch-off") 26 ("External error")	A code sequence error can occur, for example, in case of: • Cross-circuit at the inputs • EMC problem Bit 18.0 is additionally set.
13.5	Logic error	24 ("Switch-off") 25 ("Safety-related switch-off")	A logic error can occur, for example, in case of: • Discrepancy error • Sequence error Bit 18.0 is additionally set.
13.6 ... 13.7	Reserved	-	-
14.0	Downloading of module parameters is not yet complete	-	-
14.1	Reserved	-	-
14.2	Cyclic data exchange is active	-	-
14.3 ... 14.7	Reserved	-	-
15 ... 17	Reserved	-	-
18.0	Group error code sequence_Logic	24 ("Switch-off")	A code sequence error or logic error is present for at least one safe input. Bytes 90 ... 91 contain the AS-i address of the first safe input for which the error is present.
18.1	Reserved	-	-
18.2	Group_Message_Input_Triggered	-	At least one monitored safe input has value status "0". Possible cause: • Startup test necessary • Safety sensor triggered Bytes 94 ... 95 contain the AS-i address of the first safe input for which the value status "0" is present.
18.3 ... 18.7	Reserved	-	-
19 ... 21	Reserved	-	-
22.0 ... 22.1	Reserved	-	-

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
22.2	Timeout	24 ("Switch-off") 8 ("Lower limit undershot")	An internal data processing error has occurred. The F-CM AS-i Safety ST module signals a device fault. Bit 13.2 is additionally set.
22.3 ... 22.6	Reserved	-	-
22.7	AS-i slave failure	26 ("External error")	No communication is detected in the case of at least one monitored safe input slave or control unit for a safe AS-i output.
23.0 ... 23.7	Reserved	-	-
24 ... 25	Reserved	-	-
26.0 ... 26.3	Reserved	-	-
26.4	Coding element error	24 ("Switch-off") 27 ("Unclear error")	A data error occurred or coding element is missing when a coding element is accessed. The F-CM AS-i Safety ST module signals a device fault.
26.5 ... 26.7	Reserved	-	-
27 ... 28	Reserved	-	-
29.0 ... 29.7	Reserved	-	-
30 ... 33	Reserved	-	-
34 ... 35	Parameter assignment error object	-	Object number for which a parameter assignment error was detected. 0 = No error 1 ... 31 = The number corresponds to the AS-i address of a safe input. 32 ... 47 = A number 32 ... 47 corresponds to the number of the switching group 0 ... 15
36 ... 37	Reserved	-	-
38.0	AS-i bus error	26 ("External error")	The AS-i data communication is interrupted, substitute values in the interconnection logic
38.1	AS-i parameter assignment error	26 ("External error")	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 55. If an AS-i address of an output switching group is not included by the AS-i master in the data communication, this bit is set. A substitute value will be used instead.
38.2	AS-i configuration error	-	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 39. This bit is set when SET ≠ ACTUAL on the AS-i bus, when, for example, an AS-i slave is missing. A substitute value will be used instead.

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
38.3	AS-i voltage too low	-	If the AS-i voltage is too low during operation, a serious device fault results.
38.4	Reserved	-	-
38.5	AS-i communication okay	-	-
38.6 ... 38.7	Reserved	-	-
39	Incorrect AS-i address	-	AS-i address of the AS-i slave that the device has identified as faulty: 0 = No error 1 ... 31 = AS-i slave address
40 ... 47	Reserved	-	-
48.0	ASIsafe safe input active	-	As soon as safe AS-i slaves become monitored, this bit is set.
48.1	ASIsafe safe output active	-	If safe AS-i outputs are controlled, this bit is set.
48.2 ... 48.7	Reserved	-	-
49.0	ASIsafe code sequences missing	26 ("External error")	Safe input In addition, the AS-i address is entered in byte 50.
49.1	ASIsafe code sequences duplicated	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.
49.2	ASIsafe code sequences new	-	New code sequences are available for transfer. In addition, the AS-i address is entered in byte 50.
49.3	ASIsafe code sequences known	-	The code sequences are taught and saved in the coding element.
49.4	ASIsafe code sequence error	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.
49.5	ASIsafe code sequence teaching active	-	The code sequences are being collected. When the code sequences for all safe AS-i input slaves detected on the bus are taught, this bit is reset.
49.6 ... 49.7	Reserved	-	-
50	Code sequence error object	-	This bit contains the lowest AS-i address for which a code sequence problem has occurred. Code sequence problems are: • 49.0 ASIsafe code sequences missing (Prio 3) • 49.1 ASIsafe code sequences duplicated (Prio 1) • 49.2 ASIsafe code sequences new (Prio 4) • 49.4 ASIsafe code sequence error (Prio 2)
51 ... 54	Reserved	-	-

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
55	Switching group error object	-	This byte contains the lowest AS-i address that is configured for an output switching group but is not addressed by the master. Correct the slave configuration of the master.
56 ... 61	Reserved	-	-
62.0	F_Dest_Adr does not match	24 ("Switch-off") 19 ("Communication error") 64 ("Different destination address")	-
62.1	F_Dest_Adr invalid	24 ("Switch-off") 19 ("Communication error") 65 ("Invalid destination address")	The coding element does not contain an F-address.
62.2	F_Source_Adr invalid	24 ("Switch-off") 19 ("Communication error") 66 ("Invalid source address")	-
62.3	F_WD-Time_0	24 ("Switch-off") 19 ("Communication error") 67 ("Watchdog time is 0 ms")	F_WD-Time value is 0 ms.
62.4	F_SIL value	24 ("Switch-off") 19 ("Communication error") 68 ("Parameter 'F_SIL' exceeds the appl. SIL")	F_SIL value exceeds SIL value of the specified device application
62.5	F_CRC_Length	24 ("Switch-off") 19 ("Communication error") 69 ("Parameter 'F_CRC_Length' does not match ...")	F_CRC_Length value does not match the actual CRC length.
62.6	F_Par_Version	24 ("Switch-off") 19 ("Communication error") 70 ("Incorrect F-parameter version or F_Block_ID")	F_Par_Version does not match the F-parameter set or F-Block_ID is invalid Block_ID
62.7	CRC1 error	24 ("Switch-off") 19 ("Communication error") 71 ("CRC1 error")	-
63.0 ... 63.2	Reserved	-	-
63.3	iPAR_CRC error	24 ("Switch-off") 19 ("Communication error") 75 ("Inconsistent I-parameters [iParCRC error]")	-
63.4	Operator acknowledge requested	-	Channel is ready for reintegration
63.5 ... 63.7	Reserved	-	-
64 ... 65	Reserved	-	-
70 ... 89	Reserved	-	-
90 ... 91	Object_Code_Sequence_Logic	-	AS-i address of the first safe AS-i slave for which a code sequence error or logic error is present. See also bit 18.0. 0 = No error 0 = No error 1 ... 31 = AS-i slave address ≥32 = Internal error numbers

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark		
92 ... 93	Reserved	-	-		
94 ... 95	Object_input_triggered	-	AS-i address of the first safe AS-i slave for which the input_triggered message is present. See also bit 18.2.		
			0	=	No error
			1 ... 31	=	AS-i slave address
			≥32	=	Internal error numbers
96 ... 199	Reserved	-	-		

6.4.2 DS 202 Status safe inputs/outputs

Description

NOTE
Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

DS 202 contains non-safety-related status information for the safe input slaves and for the control of the safe output slaves.

The status information for the control of the safe output slaves relates either to the control units activated in the F-CM AS-i Safety ST module or to data of external control units for safe output slaves that is also read on the AS-i bus.

Table 1-564 DS 202 Status safe inputs/safe outputs

Byte	Description
0 ... 1	Reserved
2 ... 5	Status input monitoring AS-i address 1
6 ... 9	Status input monitoring AS-i address 2
10 ... 13	Status input monitoring AS-i address 3
14 ... 17	Status input monitoring AS-i address 4
18 ... 21	Status input monitoring AS-i address 5
22 ... 25	Status input monitoring AS-i address 6
26 ... 29	Status input monitoring AS-i address 7
30 ... 33	Status input monitoring AS-i address 8
34 ... 37	Status input monitoring AS-i address 9
38 ... 41	Status input monitoring AS-i address 10
42 ... 45	Status input monitoring AS-i address 11
46 ... 49	Status input monitoring AS-i address 12
50 ... 53	Status input monitoring AS-i address 13
54 ... 57	Status input monitoring AS-i address 14
58 ... 61	Status input monitoring AS-i address 15
62 ... 65	Status input monitoring AS-i address 16
66 ... 69	Status input monitoring AS-i address 17

Byte	Description
70 ... 73	Status input monitoring AS-i address 18
74 ... 77	Status input monitoring AS-i address 19
78 ... 81	Status input monitoring AS-i address 20
82 ... 85	Status input monitoring AS-i address 21
86 ... 89	Status input monitoring AS-i address 22
90 ... 93	Status input monitoring AS-i address 23
94 ... 97	Status input monitoring AS-i address 24
98 ... 101	Status input monitoring AS-i address 25
102 ... 105	Status input monitoring AS-i address 26
106 ... 109	Status input monitoring AS-i address 27
110 ... 113	Status input monitoring AS-i address 28
114 ... 117	Status input monitoring AS-i address 29
118 ... 121	Status input monitoring AS-i address 30
122 ... 125	Status input monitoring AS-i address 31
126 ... 129	Status output control switching group 0
130 ... 133	Status output control switching group 1
134 ... 137	Status output control switching group 2
138 ... 141	Status output control switching group 3
142 ... 145	Status output control switching group 4
146 ... 149	Status output control switching group 5
150 ... 153	Status output control switching group 6
154 ... 157	Status output control switching group 7
158 ... 161	Status output control switching group 8
162 ... 165	Status output control switching group 9
166 ... 169	Status output control switching group 10
170 ... 173	Status output control switching group 11
174 ... 177	Status output control switching group 12
178 ... 181	Status output control switching group 13
182 ... 185	Status output control switching group 14
186 ... 189	Status output control switching group 15
190 ... 199	Reserved

Table 1-565 Input monitoring: Structure of the status information in DS 202

Byte.Bit	Message bit		Remark
0.0	Value = 1:	Startup test necessary	-
0.1	Value = 1:	Sequence condition violated	-
0.2	Value = 1:	Discrepancy condition violated	-
0.3	Value = 1:	Safety sensor triggered	-
0.4 ... 0.7	Reserved		-
1.0	Value = 1:	Code sequence error	Cross-circuit at input
1.1 ... 1.7	Reserved		-
2.0	Reserved		-
2.1	Value = 1:	Switch-on condition not met	-
2.2 ... 2.7	Reserved		-
3.0 ... 3.7	Reserved		

Table 1-566 Output control: Structure of the status information in DS 202

Byte.Bit	Message bit	Remark
0.0	Output active	The control unit of the switching group sends the "F-OUT 1" control signal.
0.1 ... 0.7	Reserved	-
1.0 ... 1.3	Reserved	-
1.4	Auxiliary signal AUX1 sent	Auxiliary control signal AUX1 was transferred with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.5	Auxiliary signal AUX2 sent	Auxiliary control signal AUX2 was transmitted with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.6 ... 1.7	Reserved	-
2.0 ... 2.7	Reserved	-
3.0 ... 3.7	Reserved	-

6.4.3 DS 204 Status code sequences

Description

NOTE
Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

The DS 204 contains the statuses of all AS-i slaves that are known to the F-CM AS-i Safety ST module.

Table 1-567 DS 204: Status code sequence for an AS-i address in DS 204

Byte	Description
0 ... 13	Reserved
14 ... 17	Status code sequence for AS-i address 1
18 ... 21	Status code sequence for AS-i address 2
22 ... 25	Status code sequence for AS-i address 3
26 ... 29	Status code sequence for AS-i address 4
30 ... 33	Status code sequence for AS-i address 5
34 ... 37	Status code sequence for AS-i address 6
38 ... 41	Status code sequence for AS-i address 7
42 ... 45	Status code sequence for AS-i address 8
46 ... 49	Status code sequence for AS-i address 9
50 ... 53	Status code sequence for AS-i address 10
54 ... 57	Status code sequence for AS-i address 11
58 ... 61	Status code sequence for AS-i address 12
62 ... 65	Status code sequence for AS-i address 13
66 ... 69	Status code sequence for AS-i address 14
70 ... 73	Status code sequence for AS-i address 15
74 ... 77	Status code sequence for AS-i address 16

Byte	Description
78 ... 81	Status code sequence for AS-i address 17
82 ... 85	Status code sequence for AS-i address 18
86 ... 90	Status code sequence for AS-i address 19
90 ... 91	Status code sequence for AS-i address 20
94 ... 97	Status code sequence for AS-i address 21
98 ... 101	Status code sequence for AS-i address 22
102 ... 105	Status code sequence for AS-i address 23
106 ... 109	Status code sequence for AS-i address 24
110 ... 113	Status code sequence for AS-i address 25
114 ... 117	Status code sequence for AS-i address 26
118 ... 121	Status code sequence for AS-i address 27
122 ... 125	Status code sequence for AS-i address 28
126 ... 129	Status code sequence for AS-i address 29
130 ... 133	Status code sequence for AS-i address 30
134 ... 137	Status code sequence for AS-i address 31
138 ... 199	Reserved

Table 1-568 Assignment of the bits of an AS-i address in the "Status code sequence" data structure

Byte	Bit	Description	Setting	Meaning of the setting
0	0 ... 2	Status of the slave	= 0	No slave present
			= 1	Standard slave (not safety-related)
			= 2	Safe slave, but the code sequence type safe input/safe output is not yet decoded.
			= 3	Code sequence type safe output
			= 4	Code sequence type safe input
			= 5 ... 7	Reserved
	3	-	Reserved	-
	4 ... 6	Status of parameter assignment	= 0	No safe AS-i output slave or AS-i input slave is configured.
			= 1	Reserved
			= 2	Safe AS-i slave is configured The detected slave corresponds to the activation.
			= 3	Safe AS-i slave is configured The detected slave does not correspond to the activation.
			= 4 ... 7	Reserved
	7	-	Reserved	-
1	0 ... 2	Status of the code sequence	= 0	Code sequence irrelevant: No activation or no slave is present.
			= 1	Code sequence missing: No code sequence is taught or transferred.
			= 2	Code sequence duplicated: At least one other slave has the same code sequence.
			= 3	Code sequence new: The taught code sequence does not correspond to the transferred code sequence.
			= 4	Code sequence known: The taught code sequence does not correspond to the transferred code sequence.
			= 5 ... 7	Reserved
	3	-	Reserved	-

Byte	Bit	Description	Setting	Meaning of the setting
1	4 ... 5	Status of the safe input 1	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.
	6 ... 7	Status of the safe input 2	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.
2	0 ... 1	Status of the "F-OUT 1" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	2 ... 3	Status of the "F-OUT 2" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	4 ... 5	Status of the "F-OUT 3" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	6 ... 7	Status of the "F-OUT 4" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
3	0 ... 1	Status of the auxiliary signal 1	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	2 ... 3	Status of the auxiliary signal 2	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	4 ... 7	-	Reserved = 0	-

6.4.4 DS 206 Diagnostic data record

Meaning

NOTE
Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 206 contains a summary of the information that is relevant for a comprehensive diagnosis of the F-CM AS-i Safety ST module via your user program.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.1 or higher:

- The "Error code" column in the table below indicates which events are relevant here.
- If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms for firmware V1.0.0 are described in Section "DS 92 Device-specific diagnosis (Page 46)".

Table 1-569 DS 206 Diagnosis

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0	Version High	-	-
1	Version Low	-	-
2.0	Overtemperature	1048	Maximum operating temperature exceeded
2.1	Undertemperature	786	Ambient temperature too low
2.2	Incorrect parameter value	16	Configuration data contains errors
2.3	Incorrect or inconsistent firmware	283	Firmware is faulty Firmware update necessary
2.4	Supply voltage too high	1038	AS-i voltage too high
2.5	Supply voltage too low	1039	AS-i voltage too low
2.6	Program cycle time exceeded	259	Internal cycle time exceeded
2.7	Device fault	1059	Self-test has determined a device fault. For details, see further error messages.
3.0	Serious device fault	9	Serious device fault. No communication possible
3.1	Teaching necessary	1055	New code tables are available for transfer.
3.2	Normal operation	-	Cyclic I/O data exchange active
3.3	Startup	-	Parameters are loaded No cyclic I/O data exchange
3.4	Serious device fault	-	Serious device fault. No communication possible
3.5	I/O device signal error	-	One or more channels are passivated
3.6	Code sequence cannot be read correctly	-	A code sequence is non-existent or incomplete

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
3.7	Reintegration necessary	-	Error is cleared, but at least one channel is still passivated
4.0	Access to device settings	-	Assignment of the F-address Acceptance of the code sequences Firmware update
4.1	ASIsafe code table teaching active	-	Teach LED flashes yellow; code sequences are collected. Is reset when the code tables for all safe AS-i input slaves detected on the bus have been taught.
4.2	Diagnostic memory overflow	33	Too many simultaneous error messages
4.3	Change of parameters not permissible	-	Modification of parameter data is rejected in normal mode
4.4 ... 4.7	Reserved	-	-
5.0	Status LED flashes green	-	-
5.1	Status LED lit green	-	-
5.2	Error LED flashes red	-	-
5.3	CFG LED flashes red	-	-
5.4	PSF LED flashes red	-	-
5.5	Teach LED flashes yellow	-	-
5.6	Teach LED lit yellow	-	-
5.7	ADDR LED flashes green	-	-
6.0	No access possible to the retentive storage of the F-address	781	The coding element (type H) in the BaseUnit is missing or there is an access error
6.1	Different destination address (F_Dest_Add)	64	The PROFIsafe driver has detected a different F-destination address.
6.2	Invalid target address (F_Dest_Add)	65	The PROFIsafe driver has detected an inadmissible F-destination address.
6.3	Invalid source address (F_Source_Add)	66	The PROFIsafe driver has detected an inadmissible F-source address.
6.4	Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67	The PROFIsafe driver has detected an inadmissible watchdog time.
6.5	Parameter "F_SIL" exceeds the application-specific SIL	68	The PROFIsafe driver has detected a discrepancy between the communication SIL setting and the application SIL setting.
6.6	Parameter "F_CRC_Length" does not match the generation	69	The PROFIsafe driver has detected a discrepancy in the CRC length.
6.7	Incorrect F-parameter version or F_Block_ID	70	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.
7.0	CRC1 error	71	The PROFIsafe driver has detected inconsistent F-parameters.
7.1	Inconsistent i-parameters (iParCRC error)	75	The PROFIsafe driver has detected inconsistent i-parameters.
7.2	PROFIsafe communication error (timeout)	92	
7.3	PROFIsafe communication error (CRC)	F93	

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
7.4	PROFIsafe address assignment error	F94	Coding element contains inadmissible data
7.5 ... 7.7	Reserved	-	-
8	Configured AS-i address for output switching group 0	-	-
9	Configured AS-i address for output switching group 1	-	-
10	Configured AS-i address for output switching group 2	-	-
11	Configured AS-i address for output switching group 3	-	-
12	Configured AS-i address for output switching group 4	-	-
13	Configured AS-i address for output switching group 5	-	-
14	Configured AS-i address for output switching group 6	-	-
15	Configured AS-i address for output switching group 7	-	-
16	Configured AS-i address for output switching group 8	-	-
17	Configured AS-i address for output switching group 9	-	-
18	Configured AS-i address for output switching group 10	-	-
19	Configured AS-i address for output switching group 11	-	-
20	Configured AS-i address for output switching group 12	-	-
21	Configured AS-i address for output switching group 13	-	-
22	Configured AS-i address for output switching group 14	-	-
23	Configured AS-i address for output switching group 15	-	-
24 ... 27	Status AS-i address 1	-	-
28 ... 31	Status AS-i address 2	-	-
32 ... 35	Status AS-i address 3	-	-
36 ... 39	Status AS-i address 4	-	-
40 ... 43	Status AS-i address 5	-	-
44 ... 47	Status AS-i address 6	-	-
48 ... 51	Status AS-i address 7	-	-
52 ... 55	Status AS-i address 8	-	-
56 ... 59	Status AS-i address 9	-	-
60 ... 63	Status AS-i address 10	-	-
64 ... 67	Status AS-i address 11	-	-

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
68 ... 71	Status AS-i address 12	-	-
72 ... 75	Status AS-i address 13	-	-
76 ... 79	Status AS-i address 14	-	-
80 ... 83	Status AS-i address 15	-	-
84 ... 87	Status AS-i address 16	-	-
88 ... 91	Status AS-i address 17	-	-
92 ... 95	Status AS-i address 18	-	-
96 ... 99	Status AS-i address 19	-	-
100 ... 103	Status AS-i address 20	-	-
104 ... 107	Status AS-i address 21	-	-
108 ... 111	Status AS-i address 22	-	-
112 ... 115	Status AS-i address 23	-	-
116 ... 119	Status AS-i address 24	-	-
120 ... 123	Status AS-i address 25	-	-
124 ... 127	Status AS-i address 26	-	-
128 ... 131	Status AS-i address 27	-	-
132 ... 135	Status AS-i address 28	-	-
136 ... 139	Status AS-i address 29	-	-
140 ... 143	Status AS-i address 30	-	-
144 ... 147	Status AS-i address 31	-	-

Table 1-570 Status AS-i addresses: Structure of the status information

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0.0	Reserved	-	-
0.1	Discrepancy error, channel status 0/1	1041	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".
0.2	Discrepancy error, channel status 1/0	1042	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.3 ... 0.4	Reserved	-	-
0.5	Sequence error, channel status 0/1	1045	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".
0.6	Sequence error, channel status 1/0	1046	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.7	Sequence error, channel status 1/1	1047	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "1".
1.0	Input slave missing or of the incorrect type	1050	-
1.1	Control unit of the output switching group not in cyclic data exchange	1051	The AS-i master does not address the configured AS-i address of the output switching group.

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
1.2	Code sequence error (systematic fault)	1054	Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the safe input module.
1.3	Code sequence missing in the memory of the F-CM	1056	-
1.4	ASIsafe code sequences duplicated	1057	Identical code sequence occurs several times
1.5	Sporadic code sequence error	1058	Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
1.6 ... 1.7	Reserved	-	-
2.0	Safety sensor triggered	-	-
2.1	Switch-on condition not met		The safe input value has been reset to the status "0"
2.2	Startup test necessary	-	Test of the input is necessary: Both inputs of the channel pair must assume the status "0".
2.3	Status of process image (user data)	-	-
2.4	Value status	-	Value status = 1: A valid process value is output for the channel. Value status = 0: A substitute value is output for the channel (error on channel or the channel is deactivated).
2.5... 2.7	Reserved	-	-
3.0	Safe AS-i input slave configured	-	-
3.1	Safe AS-i output slave configured	-	-
3.2	Unsafe slave detected	-	-
3.3	Safe slave detected, type unknown	-	-
3.4	Safe slave detected, type input slave	-	-
3.5	Safe slave detected, type output slave	-	-
3.6	Slave is located in cyclic data exchange	-	-
3.7	Reserved	-	-

Code sequences

7

The principle of the ASIsafe code sequences is briefly explained in Section Safety-related communication with AS-Interface (Page 26).

The F-CM AS-i Safety ST module manages the code sequences of the safe AS-i slaves in two steps. First, the F-CM AS-i Safety ST module reads all code sequences on the AS-i bus and checks whether the respective code sequence is plausible. This operation is referred to as "teaching the code sequences". The code sequences taught in this way are in volatile memory. The taught code sequences are transferred to the non-volatile memory after a request by the user.

Initial commissioning

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

Replacement of a safe AS-i input slave

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

For the transfer of the code sequences to the non-volatile memory, you can open the "Teach ASIsafe" dialog by pressing the "Teach ..." button.

Alternatively, the transfer is also possible by pressing the optional "TEACH" button (at least 3 s).

Replacement of the F-CM AS-i Safety ST module

The non-volatile memory is located in the BaseUnit. The transferred code sequences are retained in this memory after replacement of the F-CM AS-i Safety ST module.

Below is a description of the options offered by the F-CM AS-i Safety ST module for transferring code sequences.

See also

Connection (Page 20)

7.1 Transferring code sequences via STEP 7 online access

When code sequence are managed via *STEP 7* online access, you have the option of monitoring the status of the existing code sequences in a graphic overview. In particular, the graphic overview offers advantages for initial commissioning. In addition, you can use the graphic overview for transferring the code sequences of replaced slaves during operation. You can open the graphic overview for diagnostic purposes without changing the saved code sequences. The transfer of taught code sequences is possible but not mandatory.

In order to open this dialog, there must be an online connection to the controller or to the F-CM AS-i Safety ST module. Load the hardware configuration into the modules of the controller before teaching the code sequences so that the online configuration of the F-CM AS-i Safety ST module matches the offline configuration.

7.1.1 "Teach ASIsafe code sequences" dialog

The "Teach ASIsafe code sequences" dialog contains an overview of the code sequences of the existing safety-related AS-i slaves. In this dialog, you start the transfer of the code sequences read in on the AS-i bus into the memory of the F-CM AS-i Safety ST module.

The "Teach ASIsafe code sequences" dialog does not make any changes to the module configuration. You can open the dialog for information purposes during operation. The information displayed in the dialog are obtained online from the F-CM AS-i Safety ST module. There is no comparison with the offline configuration in this case.

Within the "AS-i addresses 0...15" and "AS-i adresses 16...31", you see the following information for each AS-i address:

- Slave status
- Code sequence
- F-IN 1 ... 2
- F-OUT 1 ... 4

For the AS-i address 0, only information about the slave status can be displayed because a slave with the address 0 does not exchange cyclic input/output data.

Below this information you see:

- The "Transfer taught code sequences" button
- The "Progress of teaching operation" display

By double-clicking the "Close" button, you can exit the dialog at any time. If the button is actuated, the data will not be changed. If the code sequences have not been transferred or have only been partially transferred, a corresponding notice appears.

"Slave Status" column

The "Slave status" column shows the following information about the AS-i address via a color code:

Gray	The address does not exist on the AS-i bus. It is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated)
Green (without check mark)	The address belongs to a slave that exists on the AS-i bus. However, the slave is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated). The slave on the AS-i bus is a safe slave or a standard slave. It is available for use by the AS-i master or another module.
Green (with check mark)	The address is present on the AS-i bus and corresponds to the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated).
Yellow	An error has been detected: The address is present on the AS-i bus but does not correspond to the configuration of the F-CM AS-i Safety ST module (input monitoring control or output monitoring control is activated). Check the slave. Replace the slave with the required slave or change the configuration.
Red	An error has been detected: The address is not present on the AS-i bus but is needed in the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated). • Check whether the slave exists on the AS-i bus and has been included in the communication by the AS-i master. • Check whether the slave is contained in the configuration of the AS-i master. Correct the configuration of the AS-i bus, if required.

"Code sequence" column

The "Code sequence" column shows the following information about the AS-i address via a color code:

Gray	No code sequence is needed for the address.
Green (without check mark)	A code sequence was taught but not transferred to the memory. Start the transfer of the code sequence by double-clicking the "Transfer taught code sequences" button.
Green (with check mark)	The code sequence was transferred to the non-volatile memory. Note: This status is also displayed when the output control is activated for this address. The code sequences for safe outputs are automatically predefined in the F-CM AS-i Safety ST module. They are not transferred to the non-volatile memory of the code sequences.

Yellow	An error has been detected: A code sequence was taught that is already being used by another slave. The code sequence cannot be used. Replace the slave with a different slave.
Red	Warning or error: The address is sending an incomplete or invalid code sequence. Check whether both inputs of the safe input slave are assigned with the "ON" signal. If required, actuate the associated safety contacts. The contacts must be closed. • Check whether a cross-circuit exists at the inputs. If necessary, correct the wiring of the inputs.

"F-IN 1 ... 2" column

The "F-IN 1 ... 2" column shows the following information about the AS-i address via a color code:

The numbers 1 to 2 designate the number of the input channel.

Gray	The input channel is not present. A safe input slave was not detected at the address.
Green	The input channel shows the value 1 ("ON" status).
White	The input channel shows the value 0 ("OFF" status).
Yellow	The input channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the input channel cannot be read in. Substitute value 0 is used.

"F-OUT 1 ... 4" column

The "F-OUT 1 ... 4" column shows the following information about the AS-i address via a color code:

The numbers 1 to 4 designate the number of the output channel.

Gray	The output channel is not present. A safe output channel was not detected at the address.
Green	The output channel shows the value 1 ("ON" status).

White	The output channel shows the value 0 ("OFF" status).
Yellow	The output channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the output channel cannot be read in.

If the output control is activated for the address, the F-CM AS-i Safety ST module can control the status for F-OUT 1. The F-CM AS-i Safety ST module cannot control F-OUT 2 ... 4. The value 0 is output here.

If an external control unit uses the output address, the dialog shows the statuses for F-OUT 1 ... 4 read in on the AS-i bus.

7.1.2 Transferring taught code sequences

In order for the input data of a safe AS-i input slave to be evaluated and made available to the safety program, the taught code sequences must be transferred to the non-volatile memory.

To do so, click the "Transfer taught code sequences..." button.

A dialog opens prompting you whether the code sequences are to be transferred. With "Yes" you confirm that you are addressing the correct module. For checking purposes, the "ADDR" LED flashes green on the front of the F-CM AS-i Safety ST module The code sequences are transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

With "No" you cancel the prompt without transferring the code sequence.

⚠ WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.
Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

The "Transfer taught code sequences" button is deactivated when all taught code sequences have already been transferred to the non-volatile memory.

7.1.3 "Progress of teaching operation" display

You can track the progress of the teaching operation.

Progress bar "Teaching in progress":
If at least one safe slave is detected on the AS-i bus whose code sequence has not yet been taught an active progress bar and the text "Teaching in progress" is displayed. Check the displays in the "Code sequences" column and ensure that the safe slaves send their code sequences.

For further information, refer to the "'Code sequence' column".

Taught slaves:
The "Taught slaves" output field shows the number of already transferred code sequences in relation to the number of code sequences that must still be transferred. You will additionally see the numerical ratio as a percentage. When 100% is indicated, all code sequences have been transferred to the non-volatile memory.

You will find additional information in the section "Accept taught code sequences".

7.2 Transferring code sequences with the "TEACH" button.

The use of the "TEACH" button provides an easy way of transferring taught code sequences.

The "TEACH" button can be used, for example, to transfer code sequences of replaced modules during operation. However, it is also suitable for initial commissioning.

To learn how to connect the button to the BaseUnit, refer to Section "Connecting". You can track the progress of the code sequence transfer via the LEDs.

Press the "TEACH" button for at least 3 s. This action causes all currently taught code sequences that are unique and consistent to be transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

⚠ WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.
Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

When the transfer of the code sequences has been ended successfully, the "TEACH" LED goes out and you can release the "TEACH" button.

If you press the "TEACH" button before all code sequences are taught, the code sequences received up to then will be transferred.

7.3 Final steps

7.3.1 Reintegrating passivated input channels

The input channels of the F-CM AS-i Safety ST module for which no valid code sequences are saved supply the substitute value "0" and are passivated.

After the transfer of the code sequences, the passivated channels must be reintegrated so that the application can work with the real process values.

The procedure for this can be found in the following Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

After transferring the code sequences, check the safety equipment for proper functioning.

Alarm, fault, and system events

8

8.1 Overview

Diagnostics options

The following diagnostics options are available for the F-CM AS-i Safety ST module:

- LEDs on the module
- Diagnostics in *STEP 7*:
  - Diagnostic buffer
- Alarm messages in user program

See also

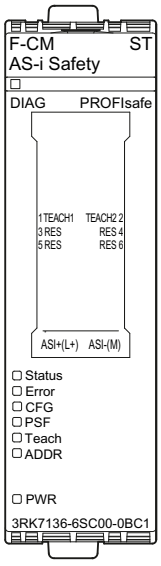
Meaning of the LEDs (Page 69)

8.2 LED statuses

8.2.1 Arrangement of the LEDs on the F-CM AS-i Safety ST

Introduction

LEDs on the front plate of the respective module display module-internal and module-external faults. The LEDs and their evaluation are described in the manuals for the relevant modules of the SIMATIC devices.



DIAG	Diagnosis
STATUS	Operating state of the module
Error	Operating state of the module
CFG	Fault on the AS-i bus
PSF	Process signal error, e.g.,channel fault on AS-i-F input slave
Teach	Teaching: Teaching of code sequences
ADDR	Addressing of the F-CM AS-i Safety ST module. F-addressing and teaching. The LED indicates whether the module is conducting safety-relevant communication with the software tool.
PWR	Supply voltage

Figure 1-274 LEDs of F-CM AS-i Safety ST

8.2.2 Meaning of the LEDs

The "F-CM AS-i Safety ST" module has 8 LEDs on the front:

LED "DIAG"

The "DIAG" LED displays the general status of the ET 200SP module

Table 1-571 Meaning of the "DIAG" LED

"DIAG"	Meaning
☐ Off	The voltage is not OK.
✳ Green flashes	The F-CM AS-i Safety ST module is not ready for operation. The module parameters are not assigned.
■ Green ON	The F-CM AS-i Safety ST module is parameterized and error-free. No diagnostic alarms of the F-CM AS-i Safety ST are active.
✳ Red flashes	The F-CM AS-i Safety ST module is parameterized and indicates a diagnostic fault, or a firmware update is in progress.
✳ ✳ The two-color LED alternately flashes red/green	The position (ping) is displayed for 3 seconds.

LED "Status"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 1-572 Meaning of the "Status" LED

"Status"	Meaning
■ Green ON	• The F-CM AS-i Safety ST module is OK. • Cyclic I/O data exchange active
✳ Green flashes	• The system is powering up. • No cyclic I/O data exchange

LED "Error"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 1-573 Meaning of the "Error" LED

"Error"	Meaning
■ Red ON	**Serious device fault, e.g.,** • Fault in the electronics • Overtemperature
✳ Red flashes	**Device fault, e.g.,** • Intermittent data processing error (EMC problem) • Contact problem with the backplane bus • Missing coding element in the BaseUnit • Missing firmware update
□ Off	No error

LED "CFG"

The "CFG" LED indicates errors on the AS-i bus.

Table 1-574 Meaning of the "CFG" LED

"CFG"	Meaning
■ Red ON	The AS-i bus is OK, but a code sequence error exists.
✳ Red flashes	Fault on the AS-i bus: • A code sequence does not exist or it is incomplete.
□ "Off"	All code sequences are completely transferred.

LED "PSF"

The "PSF" LED indicates process signal errors at one or more channels of the module.

Table 1-575 Meaning of the "PSF" LED

LED "PSF"	Meaning
■ Red ON	PROFIsafe channel fault for the complete F-CM AS-i Safety ST module, e.g. fault on F-CM AS-i input slave
✳ Red "flashes"	• Discrepancy error at the inputs of a safe AS-i input slave • Sequence error at the inputs of a safe AS-i input slave • Code sequence error at a safe AS-i input slave, e.g., due to cross-circuit at inputs or an EMC problem • Failure of a safe AS-i input slave The channel involved is passivated. The "PSF" LED goes out only after all channels have been reintegrated.
□ "Off"	No process signal error

LED "TEACH"

This LED indicates teaching of safe AS-i slaves. The "TEACH" LED indicates the progress of the teaching operation.

Table 1-576 Meaning of the "TEACH" LED

LED "TEACH"	Meaning
■ Yellow ON	The code sequences have been successfully taught, but have not yet been accepted. Transfer the code sequences either via the STEP 7 online dialog or by pressing the optional "TEACH" button (for at least 3 s). For more information, see the Section "Code sequences (Page 61)".
✳ Yellow flashes	Teaching of code sequences in progress.
□ "Off"	The code sequences are completely transferred.

LED "ADDR"

The "ADDR" LED indicates that the device is conducting safety-relevant communication with a software tool.

Table 1-577 Meaning of the "ADDR" LED

LED "ADDR"	Meaning
✳ Green flashes	Feedback that the module is addressed: • For assignment of the F-address • For transfer of the code sequences • Firmware update in progress
□ Off	Not relevant

LED "PWR"

The "PWR" LED indicates the status of the voltage supply.

Table 1-578 Meaning of the "PWR" LED

LED "PWR"	Meaning
■ Green ON	AS-i voltage is applied.
□ "Off"	Insufficient AS-i voltage is applied.

8.3 Diagnostic messages

The F-CM AS-i Safety ST module generates one or more alarms when various events occur.

NOTE

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the following must be observed:

With firmware V1.0.1 or higher, the F-CM AS-i Safety ST module generates a modified range of alarm messages compared with V1.0.0.

If the user program evaluates the error numbers of the generated alarms directly, the user program may have to be adapted if the firmware version is changed (e.g. when changing a device). If necessary, the firmware version of a replacement device can be modified to the previously used firmware version (see Section "Firmware update (Page 18)").

It is expected that the upgrading of the firmware version from V1.0.0 to V1.0.1 will not usually have any influence on the user program. The safety functionality of the F-CM AS-i Safety ST module does not change when the firmware is replaced.

If, after the replacement of a device, an alarm message of the F-CM AS-i Safety module appears in the message system (e.g. on an HMI panel), which contains an error code instead of a message text, then the assigned message texts are not known to the message system. In order to update the message texts, the project must be re-compiled with a current version of the TIA Portal / STEP 7 and loaded into the controller or into the message system. The function of the message system can be checked by generating an alarm (e.g. by removing an assigned AS-i safety slave).

Diagnostic messages for firmware V1.0.0

The following applies for firmware V1.0.0: Which events lead to which alarm messages is indicated in the description of data record DS 92 "Device-specific diagnostics" (Page 46).

The alarms use the diagnostic codes 0 to 31 according to the PROFIBUS Standard.

Diagnostic messages as from firmware V1.0.1

The following applies as from firmware V1.0.1: Which events lead to which alarm messages is indicated in the description of data record DS 206 "Data record diagnostics" (Page 56).

The alarms use diagnostic codes in the extended range of values according to the PROFINET Standard. The alarms allow a meaningful system diagnosis to be made, specifying the type of error and the AS-i address affected.

8.4 Replacement of defective devices

8.4.1 Replacing a safe AS-i input slave

Replace a failed safe AS-i input slave with a new device of the same type and assign the correct AS-i address to the slave. This address assignment can be performed automatically by the AS-i master (see manual of the AS-i master) or manually, e.g., with the AS-i addressing device (1904-2AB02).

Close the contacts on the inputs of the safe AS-i input slave so that the slave sends the code sequences.

The F-CM AS-i Safety ST module detects a new code sequence automatically and teaches it. For reintegration, the taught code sequence must be transferred.

The transfer can be started from the STEP 7 online dialog or by pressing the optional "TEACH" button (at least 3 s). For more information, see Section Code sequences (Page 61).

Observe the "CFG" and "TEACH" LEDs, see Section Meaning of the LEDs (Page 69).

To exclude impermissible duplicate code sequences for two safe input slaves, code sequences from all safe input slaves present on the AS-i bus must be transferred, regardless of whether the monitoring is activated or deactivated.

8.4.2 Replacing the safe AS-i output module (evaluation unit)

After replacement of a safe AS-i output module (evaluation unit), no setting is necessary on the F-CM AS-i Safety ST module.

Observe the operating instructions of the AS-i output module, and set the correct F-address for the AS-i output module and the AS-i address of any integrated standard slave.

An error acknowledgment for the affected output switching group must be performed, if necessary. See Section 6.3 Address space.

Non-safety related AS-i slaves (standard slaves) are not evaluated by the F-CM AS-i Safety ST module. Observe the replacement instructions in the operating instructions of the AS-i master or the slave.

8.4.3 Replacing the F-CM AS-i Safety ST module

When the F-CM AS-i Safety ST module is replaced, the new device automatically receives all necessary settings from the head module (IM) of the ET 200SP and the coding element in the BaseUnit.

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the instructions in Section "DS 206 Diagnostic data record (Page 56)" must be observed.

For more information, see Manual "ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293/0/en)

Technical specifications

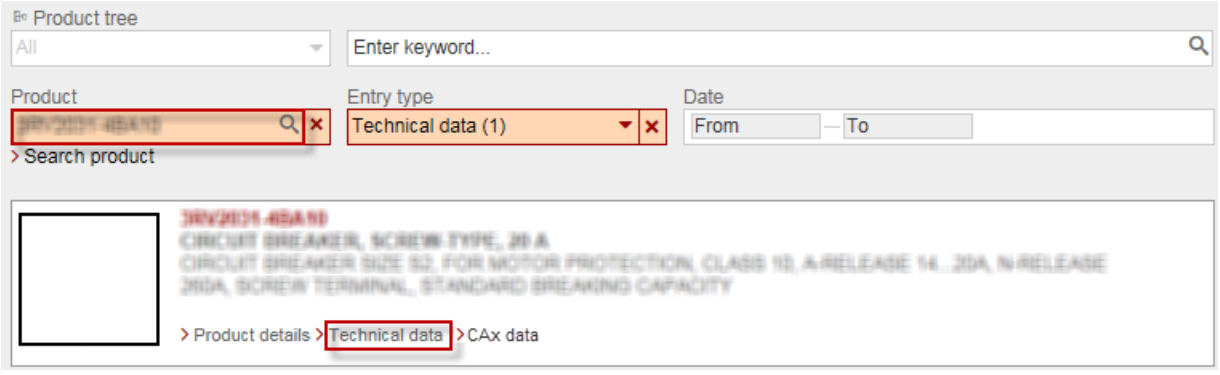
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9.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/15757/td).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data link.



9.2 Configuration software

Information on the configuration software that you can use can be found in the Table "Software for configuration of the F-CM AS-i Safety ST" in Section Configuring the F-CM AS-i Safety ST (Page 24).

9.3 Safe technical specifications

Safety characteristics

Table 1-579 Maximum achievable safety class in safety mode

Standard	Designation	Value
SIL according to IEC 61508	SIL	3
EN ISO 13849-1[1)]	PL	e
	Category	4

1) Performance Level

Table 1-580 **Safety characteristics**

Characteristic	Designation	Value
High Demand according to SIL 3[1)] Total value for AS-i system with the F-CM AS-i Safety ST module[2)]	PFH_D	1.00×10^{-9} x 1 / h 1.89×10^{-9} x 1 / h
Individual value for F-CM AS-i Safety ST	PFH_D	0.89×10^{-9} x 1 / h
Individual value for AS-Interface transfer procedure	PFH_D	1.00×10^{-9} x 1 / h
Individual value for AS-Interface slave[2)]	PFH_D	0
Proof test interval	T1	20 years
Low Demand according to SIL 3[3)] Total value for AS-i system with the F-CM AS-i Safety ST module[2)]	PFD	2.00×10^{-5} 1.55×10^{-5}
Individual value for F-CM AS-i Safety ST	PFD	0.55×10^{-5}
Individual value for AS-Interface transfer procedure	PFD	1.00×10^{-5}
Individual value for AS-Interface slave[2)]	PFD	0
Mean Time To dangerous Failure	$MTTF_d$	≥100 years (37 000 years) High (according to EN ISO 13849-1)
Diagnostic Coverage level	DC	>99 %
Common Cause Failure	CCF	75 points (requirements met according to EN ISO 13849-1)

1) Probability of a dangerous failure in the case of an operating mode with high or continuous demand rate

2) Value "0" as an approximation for the individual value for AS-Interface slave applies only under the assumption that the PFH

3) Probability of a dangerous failure in the case of an operating mode with lower demand rate

9.4 Response times

The response times specified below represent worst case specifications. The response times relate to the switch-off operation (status change "1" → "0").

The response times for the switch-on operation (status change "0" → "1") can be longer but are not relevant for the given safety-related examination.

Maximum response time in the input direction

The maximum response time in the input direction results from the calculation of the response time from the safe AS-i input slave up to the head module (IM) of the ET 200SP:

max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	20 ms	Module-internal processing
max.	2 ms	Transfer ET 200SP backplane bus
max.	32 ms	Total response time in input direction (with 0 ms input delay)

⚠ WARNING

Increased response time

If an input delay time > 0 is assigned for a safe input, this input delay time must be added to the total response time.

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the sensor
- Additional response time in the safe AS-i input slave (see operating instructions)
- Bus response time between the head module (IM) of the ET 200SP and the controller
- Response time of the controller
- Timeout time (F-monitoring time) of the controller in case of PROFIsafe failure

These influencing variables must be taken into consideration when calculating the system response time of the total system.

In the above-indicated total response time, it is taken into consideration that a maximum of 4 AS-i bus cycle times elapse between a safe input slave failure and detection of an error.

Maximum response time in the output direction

The maximum response time in the output direction results from the calculation of the response time from the head module (IM) of the ET 200SP to the safe AS-i input slave (evaluation unit).

max.	2 ms	Transfer ET 200SP backplane bus
max.	20 ms	Module-internal processing
max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	32 ms	Total response time in output direction (for disturbance-free PROFIsafe transmission)

⚠ WARNING

Increased response time

In case of PROFIsafe failure, the total response time in the output direction increases by the set timeout time of the F-CM AS-i Safety ST module (see F-parameters, F-monitoring time).

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the controller
- Bus response time between the controller and the head module (IM) of the ET 200SP
- Response time in the safe AS-i output module (evaluation unit), see operating instructions
- For response time of the safe AS-i output module (evaluation unit) in case of AS-i failure, see operating instructions
- Response time of the actuator (e.g., contactor)

These influencing variables must be taken into consideration when calculating the system response time of the total system.

Additional information

Further information is provided in

System Manual SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

For calculation of response times, the following aid is available on the Internet:

- For S7 Distributed Safety, the Excel file S7fcotia.xls (http://support.automation.siemens.com/WW/view/en/25412441)

9.5 Calculation of monitoring times and response times

The Excel file S7fcotia.xls for S7 Distributed Safety is available on the Internet to aid the approximate calculation of the runtime of the F-runtime group, the minimum F-monitoring time, and the maximum response time of the safety program:

S7fcotia (http://support.automation.siemens.com/WW/view/en/25412441)

Additional information is available in Manual "Safety Engineering in SIMATIC S7".

You can download this free of charge on the Internet at:

Safety Engineering in SIMATIC S7
(http://support.automation.siemens.com/WW/view/en/12490443/0/en)

Notes on completing the Excel file S7fcotia.xls (when used without IE/PB Link)

Tab "max. runtime F-run-time group"
Enter the number of modules (in the relevant F-runtime group) in the "F-CM AS-i Safety ST" row under "ET 200SP fail-safe modules".

Tab "min. F-Monitoring times"
In the "Configuring the PROFIsafe monitoring time" section, select one of the following variants depending on which head module (IM) of the ET 200SP is being used.

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 1-581 Values for calculating the minimum F-monitoring times

Description	Designation	Value
Max. acknowledgment time of the F-CM AS-i Safety ST	T_DAT	20 ms
F-I/O with inputs and outputs	-	Yes

Tab "max. response times"
In the "Input" section, select one of the following variants for the relevant signal flow of the safety function depending on which head module (IM) of the ET 200SP is being used:

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 1-582 Values for calculating the max. response times

Description	Designation	Value
Max. discrepancy time (Note: The safe value 0 is supplied while the discrepancy time is running)	T_DIS	0
Maximum response time in error-free operation	T_WCDT	20 ms
Maximum response time when an error is present	T_OFDT	20 ms

Description	Designation	Value
Max. acknowledgment time of the F-I/O	T_DAT	20 ms
Configured PROFIsafe monitoring time	T_PSTO, conf.	F_WD_TIME (see the setting on the PROFISAFE tab of the properties dialog)
Max. response time of sensor Note: For T_Sensor_DLY, the part of the system starting from the F-CM AS-i Safety ST module up to the sensor, including the AS-i bus, is considered.	T_Sensor_DLY	10 ms (signal flow of AS-i Bus) + Assigned input delay + Response time of the sensor + Additional response time in the safe AS-i input slave

List of abbreviations

A

A.1 List of abbreviations

Meaning of abbreviations

Abbreviation	Meaning
ADDR	Addressing
AS-i	AS-Interface
ATEX	Atmosphere Explosive
AUX	Auxiliary
BF	AS-i bus error
BU	BaseUnit
CFG	Configuration
CM	Communication Module
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DI	Digital Input
DIAG	Diagnosis
DP	Distributed peripherals
DS	Data record/data set
I/O	Input/Output
EMC	Electromagnetic compatibility
EN	Europäische Norm (European standard)
F-	Fail-safe
GSD	Generic Station Description
GSDML	Generic Station Description Markup Language
HF	High Feature
HSP	Hardware support package
HW	Hardware
HW ID	Hardware identifier
I&M	Identification and Maintenance
ID	Identifier
IEC	International Electrotechnical Commission
IM	Interface module
IO	Input Output
IP	Ingress Protection (enclosure class)
ISO	International Organization for Standardization
LED	Light Emitting Diode
LPS	List of configured AS-i slaves (list of "projected" slaves)
NEC	National Electrical Code

Abbreviation	Meaning
NFPA	National Fire Protection Association
PIQ	Process Image Output
PII	Process image input
PELV	Protective extra low voltage
PF	Peripheral fault
PFD	Probability of dangerous failure on demand (from IEC 61508)
PFH_D	Probability of dangerous failure per hour (from IEC 61508)
PL	Performance Level
PSF	Process signal error
PWR	Power
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
GF, CF	System fault
PLC	Programmable logic controller

References

B

B.1 References

Additional documentation

Further information is available in the following documents:

Document type	Internet link
System Manual	ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Manual	ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)
System Manual	ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Product Information	Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)
Programming and Operating Manual	SIMATIC Safety - Programming and configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
Programming and Operating Manual	S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)
Manual	CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)
System Manual	AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
FAQ	FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)
IEC 61508 standard	-
System Manual	SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

SIEMENS

SIMATIC

ET 200SP
ET 200SP F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

Equipment Manual

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Preface

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the *ET 200SP Distributed I/O System* system manual (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the *SIMATIC Safety – Configuring and Programming* programming and operating manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to the fail-safe CPUs of the S7-1200/1500 automation system, prior generation S7-300/S7-400 automation systems, and ET 200 CPUs.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software STEP 7 (TIA Portal).

Please observe notes marked as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product, or on the part of the documentation to which you ought to pay special attention.

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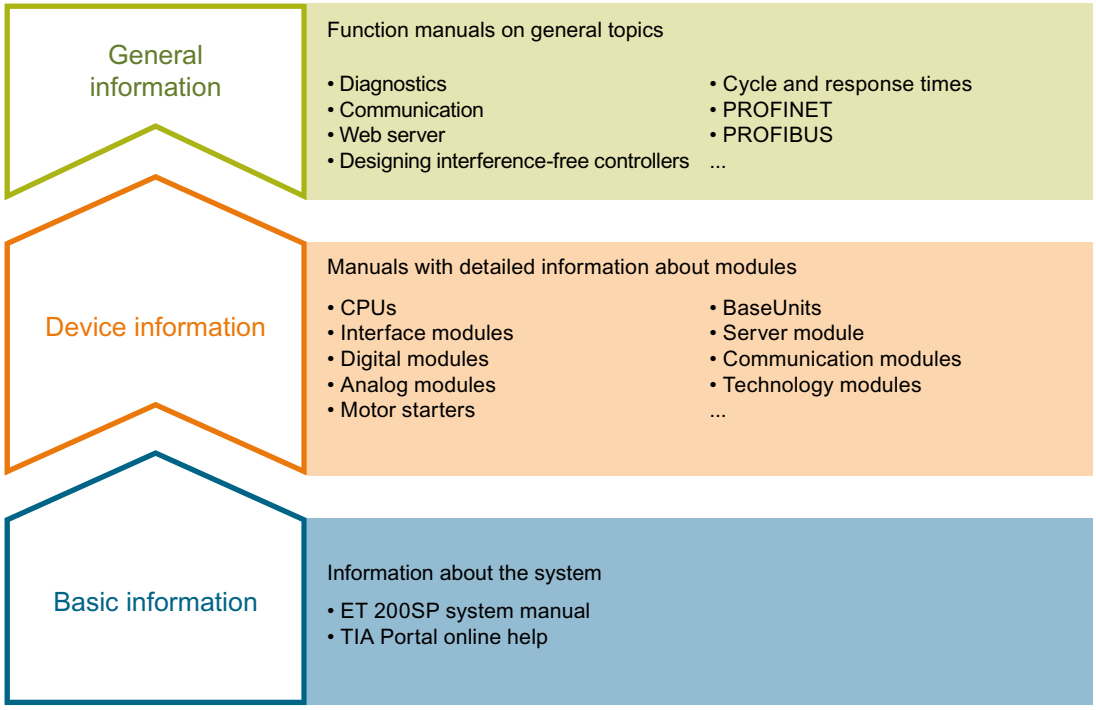
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Documentation guide

1

1.1 ET 200SP Documentation guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics, and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system (for example, diagnostics, communication, Web server, motion control, and OPC UA).

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/ww/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

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"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual. You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure, and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/us/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance include the following items:

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long-term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Safety technology support

Siemens provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, Functional Examples guide you in your safety applications, Siemens training (SITRAIN) classes offer training in safety standards and products, and you can calculate your maximum system response time using the SIMATIC STEP 7 Safety Advance F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT_calculator) Excel file.

You can find the Safety Evaluation Tool on the Internet (http://www.siemens.com/safety-evaluation-tool).

You can find Functional Examples on the Internet (http://www.siemens.com/safety-functional-examples).

You can find SITRAIN classes on the Internet (http://www.siemens.com/sitrain-safetyintegrated).

You can find the RT_calculator on the Internet (https://support.industry.siemens.com/cs/ww/en/view/58856512).

Product overview

2

2.1 Properties

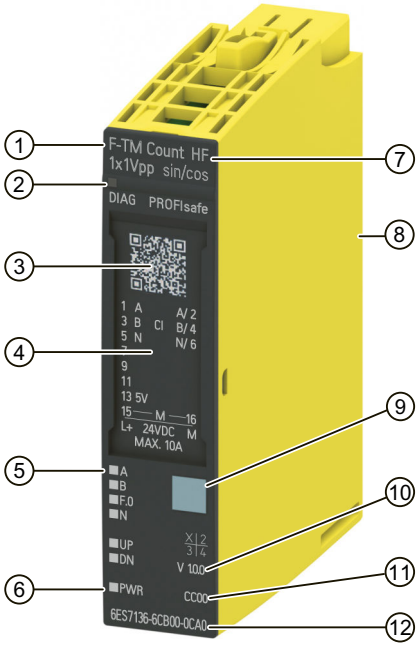
Article number

6ES7136-6CB00-0CA0

Firmware version

This manual describes the properties of the module with firmware version 1.00 or later.

View of the module



①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Electronic coding element connector (not shown)
③	2D matrix code	⑨	Color coding module type
④	Wiring diagram	⑩	Function and firmware version
⑤	LEDs for channel status	⑪	Color code for selecting the color identification labels
⑥	LED for supply voltage	⑫	Article number

Figure 1-275 View of the F-TM Count 1x1Vpp sin/cos HF module

Use of the module

The F-TM Count module reports events and statuses based on configured parameters and external movement operations in the SIMATIC ET 200SP distributed I/O system. It provides a SIN/COS encoder interface that can safely count up to a maximum speed of 200 kHz.

The F-TM Count module features a 15-mm wide, ET 200SP module housing. Refer to *Connecting* (Page 20) for a list of compatible BaseUnits (BUs).

The F-TM Count module supports safety-related applications up to SIL CL 3 according to EN 62061, or Cat. 4, PL e according to EN 13849-1. The input and output values of the safety-related F-TM Count module are addressed using the process image. You need an F-CPU for safety processing.

Properties

The F-TM Count module has the following technical properties:

- Failsafe module
- PROFIsafe (under supported system functions)
- 200 kHz counter input
- SIL 3, Cat. 4, PL e
  - Diagnostic display (DIAG red/green LED)
  - Status display for each input (green LED)
  - Error display for each input (red LED)
- Single configurable channel:
  - Interfaces:
    Sin/Cos differential encoder signals A, A/, B, B/, N and N/
    5 V DC encoder supply that is short-circuit proof
    Module supply voltage L+ (24V)
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break, short-circuit and signal quality
  - Monitoring of supply voltage
- Supported encoder/signal types:
  - Sin/Cos differential encoder with and without N signal
- Supported system functions:
  - Module and channel diagnostics
  - Firmware update
  - Identification and maintenance data (I&M 0-3)

Accessories

You can use the following accessories with the F-module; however, the accessories are not included in the product package:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector (article number 6ES7193-6SC00-1AM0)
- Cable (article number 6FX8008-1BD31-XXXX) sold by the meter or equivalent

Article numbers are provided for those items unique to the F-TM Count module. Additional information about accessories can be found in the *ET 200SP Distributed I/O System* system manual (http://support.automation.siemens.com/WW/view/en/58649293).

2.2 Functions

2.2.1 Safety

What are fail-safe automation systems?

Safety-related systems are primarily concerned with applications whose failure could have impact upon the safety of people and/or the environment. As a result, safety-related systems are used to mitigate hazards or failures that are likely to cause physical harm. Their intent is to achieve safety to an acceptable level of tolerable risk.

F-systems serve to control processes and ensure safe states upon detected failures. Failures are detected using very high levels of diagnostic coverage. Upon detection of failures, actions are taken to attempt to bring the respective application to a safe state.

F-systems provide improved fault detection and fault localization through detailed diagnostic identification and reporting. This is the primary difference between fail-safe systems and standard systems. Use of fail-safe systems should be considered for applications in which hazards are inherently present and may result in physical harm.

Supported safety monitoring functions

The F-TM Count module provides safety monitoring functions that may be used to monitor speed, position, and/or direction. These safety monitoring functions can be optionally enabled to report safety events if configured safety limits are exceeded. The safety monitoring functions include the following:

- Safe Direction (SDI) is used to monitor the direction of motion.
- Safety Limited Speed (SLS) is used to monitor that the motion does not exceed a preset speed limit.
- Safe Operating Stop (SOS) is used to monitor for unintentional movement.

⚠ WARNING

The F-TM Count module cannot take action that affects the safety functions.
The F-TM Count module reports when the parameter limits are exceeded to the F-CPU.
You must ensure code in your safety program does the following:

- Examines the safety-monitoring event data from the module
- Takes the necessary action to result in the appropriate outcome (for example, slowing down, or shutting down movement)

2.2.2 Detection of counting signals

The F-TM Count module monitors the encoder signals and evaluates them as quadrature encoded signals. The count direction is determined by the phase relationship of the encoder signals.

You can specify the counter characteristics using the functions described below.

Counting limits

You can configure the behavior of the counter at the counting limits. The counting limits define the counter value range used.

Start value

You can configure a start value within the counting limits.

2.2.3 Measured value determination

You can select one at a time from the following measured values reported:

- Frequency measurement with the unit of millihertz (-800000000 to +800000000 meaning -800000.000 to +800000.000 Hz)
- Period measurement with the unit of microseconds (-25000000 to +25000000 meaning -25.000000 to +25.000000 seconds)
- Velocity measurement is the calculated velocity * 1000 to include fractional portion of the calculation (-2147483648 to 2147483647 meaning -2147483.648 to +2147483.647 velocity unit)

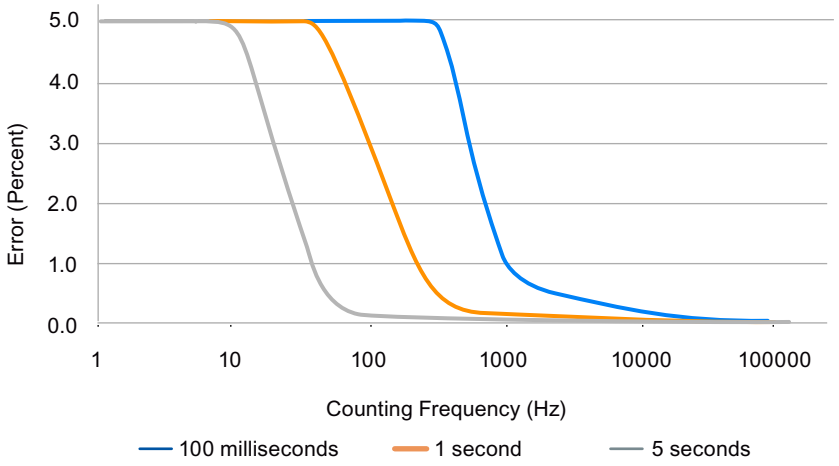
All measured values are returned as scaled integers with the units noted above.

Negative values are reported when counting down, positive values are reported when counting up.

Update time

Calculated measured value accuracy is influenced by the duration of selected update times. You can configure the interval at which the technology module updates the measured values cyclically to the F-CPU. Setting a longer update time interval allows the module to collect more data to calculate a more accurate measured value, but reaction time increases.

The following figure illustrates the effect of update time on the approximate accuracy of measured value calculations:



For example: the figure shows that at a frequency of 100 Hz, the percent error in the measured value is about 10 times greater at a 1 second update time as compared to a 5 second update time.

NOTE

The safety reaction time is influenced by the chosen update time when using measured values as part of your safety program (for example, at about 100 Hz, the relative error with a 1 second update time is approximately three times greater than a 5 second update time). For additional information, refer to Response times of the F-TM Count module (Page 75).

NOTE

The user should consider the measured value accuracy at the user's specified counting frequency range when determining the Safety Limited Speed "Speed limit" setting.

Gate control

Software (SW) gating is required to control when counting is permissible. When the SW gate is open, counting is enabled.

When the SW gate is closed the following occurs:

- Counting is disabled until the gate is opened again. Position is not maintained if movement occurs.
- Measured value calculations are still performed, but the last reported measured value is continually reported until the gate is opened again.
- Safety monitoring operations will still be performed. However, their progress is paused until the gate is again opened. Movement that violates specified limits will not be detected.

You can configure the reaction to the gate opening.

Examples of determining measured values

Use STEP 7 device configuration to set the values for the module in the following examples. For your velocity in meters per second, you set the "Time Base for Velocity Measurement" field to the value "1 second" and the "Counts per Unit for Velocity" to how many counts per meter the encoder will generate. The velocity value returned to your safety program will be the meters per second value * 1000. Multiplying the meters per second value by 1000 ensures the velocity value has sufficient resolution to show the fractional portion of the calculation.

Setting "Velocity" in meters per second
You set the parameter values as follows:

- "Measured value" to "Velocity"
- "Update Time" to 1000 milliseconds - Provides an updated velocity calculation to your safety program every second (1000 milliseconds)
- "Time Base for Velocity Measurement" value to "1 second"
- "Counts per Unit for Velocity" to 100 if your encoder generates 100 counts per meter

In this example, if you measured 452 counts during the one second update time and there are 100 counts per meter, the movement distance is 4.52 meters during the one second update time. Since the desired unit is meters per second, the velocity returns as a scaled value (velocity * 1000) and your safety program sees the velocity as 4520. You would then interpret the value as 4.520 meters per second.

Setting the "Update Time" to "100 milliseconds"
Use the same setup as the previous example, but set the "Update Time" to 100 milliseconds.

In this example, if you measure about 45 counts during the update time, convert this to meters per second. The result is a velocity measurement of 4500 which is 4.500 meters per second.

The module measured 4.5 meters per second, which is fewer than the previous measurement 4.52 meters per second. This results in you losing some resolution in the velocity measurement because of the shorter update time.

Setting the "Time Base for Velocity Measurement" to "100 milliseconds"
Use the same setup as the first example, but set the "Time Base for Velocity Measurement" to meters per 100 milliseconds.

In this example, if you measure 452 counts during the one second update time and there are 100 counts per meter, the movement distance is 4.52 meters during the one second update time. Since you want meters per 100 milliseconds, the velocity returns as a scaled value (velocity * 1000) and your safety program sees the velocity as 452. You would then interpret the value as 0.452 meters per 100 milliseconds.

2.2.4 Counter control and feedback

The safety-related counter input (feedback) and output (control) data are transferred to and from the F-CPU, via the PROFIsafe protocol to ensure the configured system operates safely.

Control

The following commands are set by your safety program and sent from the F-CPU to the F-TM Count module:

- Open SW Gate
- Reset Other Events
- Reset Safe Speed
- Reset Safe Stop
- Reset Safe Direction
- Set Start Value
- Enable Safe Speed
- Enable Safe Stop
- Enable Safe Direction
- Safe Direction

Feedback

The following feedback status and event data are sent from the F-TM Count module to the F-CPU:

- Direction Status
- Count Status
- Set Start Value Status
- Reset Other Events Status
- Reset Safe Speed Status
- SW Gate Status
- Reset Safe Stop Status
- Reset Safe Direction Status
- Value status (CQ HSC0)
- Zero Event
- Underflow Event
- Overflow Event
- Safe Speed Event
- Safe Stop Event

- Safe Direction Event
- HSC0 Current Value
- HSC0 Measured Value

See also

Refer to "Explanation of parameters (Page 32)" for additional information on the F-TM Count module control interface commands and feedback status and event data.

2.2.5 Counter input diagnostics

Counter discrepancy

The module uses multiple internal counters to monitor the single counter-module input. Discrepancy tests are performed to ensure respective internal counter values are compared for acceptable equivalency. If these evaluations do not provide expected results, a channel diagnostic event is generated.

After generating the diagnostic event, the module reinitializes its internal count to the last valid count before the discrepancy was detected. The module then continues monitoring the encoder and accumulating counts while the diagnostic is present.

A count value of zero and status values of zero (safe state values) are provided to your safety program while the diagnostic is present. When the error is resolved and the channel is reintegrated, the module will return the accumulated count and status values to your safety program.

⚠ WARNING

Discrepancy errors may result in a loss of counts due to the count being set back to the last known good values.
Your safety program must determine whether the reported count value remains representative of actual position.
If the position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

Maximum signal frequency

The F-TM Count module evaluates the input frequency. When encoder signal frequency reaches the maximum frequency rating (200 kHz), a reintegratable frequency error is generated.

⚠ WARNING

The count value can potentially be affected when exceeding the maximum supported signal frequency.
Your safety program must determine whether the reported count value remains representative of actual position. If position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

In situations where encoder signal frequency exceeds 250 kHz, the module generates a module is defective buffer diagnostic message. However, the module is not defective since the fatal error was caused by external events. The module must be power cycled to recover from the error.

N signal plausibility monitoring

This feature is only available when the encoder signal type is selected as an "A, B, N" signal and the "Pulses per revolution" is set to a non-zero value during module configuration in STEP 7. The test uses the "Pulses per revolution" parameter to determine the expected number of counts per revolution of the encoder. In situations where the N signal is not received at the configured "Pulses per revolution", a channel diagnostic event is generated.

The module continues monitoring the encoder and accumulating counts while the diagnostic is present. While the diagnostic is present, a count value of zero and status values of zero (safe state values) are provided to your safety program. When the error is resolved and the channel is reintegrated the module will return the accumulated count and status values to your safety program.

⚠ WARNING

It is possible for a channel fault to occur that is not readily detected by the module diagnostics if N signal plausibility monitoring is disabled.
Loss of the safety function can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.
If N signal plausibility monitoring is disabled, N signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

A and B signal monitoring

Signal monitoring evaluates the quality of the A and B signals. The following A and B signal quality faults can cause a channel diagnostic event to be generated.

- Phase angle of A and B signal has shifted from 90°
- Signal amplitude (voltage) is too great or too small
- Wire break, shorted signals, or encoder failure

NOTE

A wire break might not be detected if the encoder is stopped. However, movement of the encoder position will result in detection of the break.

The module continues monitoring the encoder and accumulating counts while the diagnostic is present. While the diagnostic is present, a count value of zero and status values of zero (safe state values) are provided to your safety program. When the error is resolved and the channel is reintegrated the module will return the accumulated count and status values to your safety program.

⚠ WARNING

The count value can potentially be affected when a signal quality fault occurs.
Your safety program must determine whether the reported count value remains representative of actual position. If position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

⚠ WARNING

Signal monitoring allows the module to meet SIL, Cat., PL rating. It is possible for a channel fault to occur that is not readily detected by the module diagnostics if signal monitoring is disabled.
Disabling this feature reduces the safety rating to SIL 1, Cat. 2, PL c, which causes a loss of the safety function. Disabling this feature can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.
If signal monitoring is disabled, A and B signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

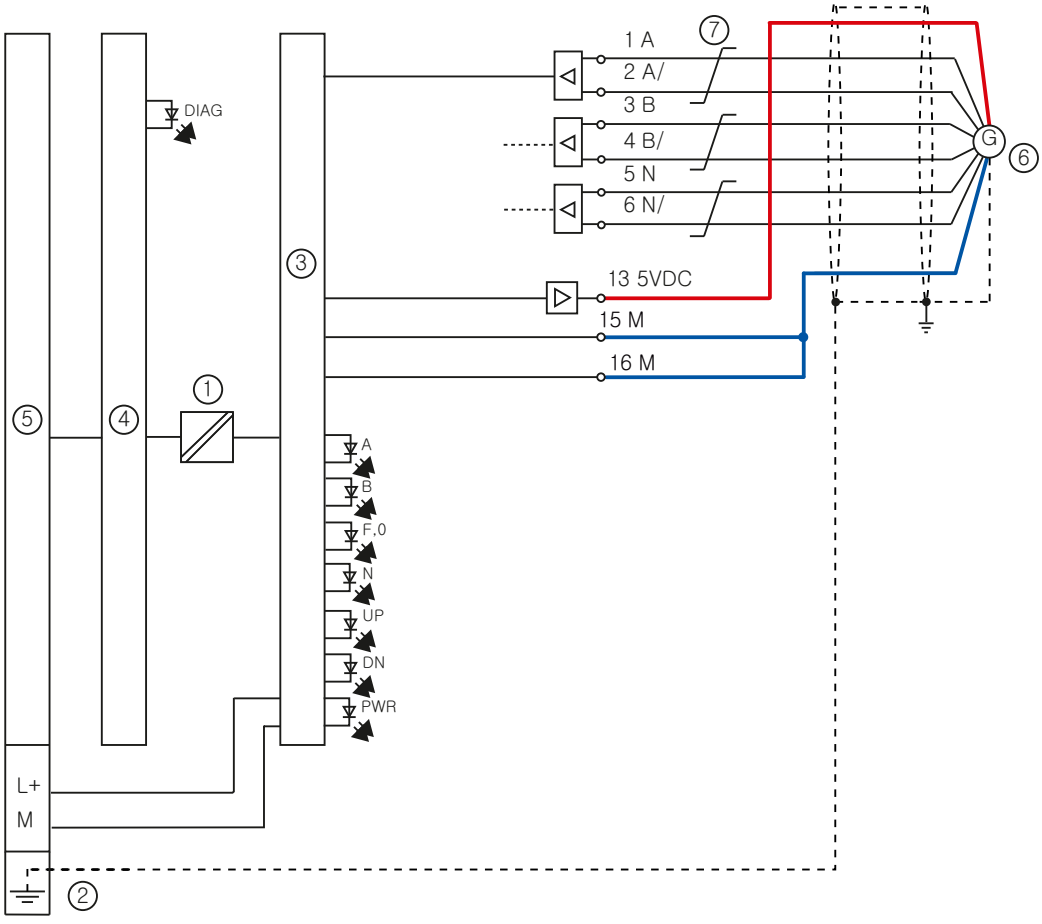
Connecting

3

3.1 Wiring and block diagram

This section provides the block diagram of the F-TM Count 1x1Vpp sin/cos HF module with the terminal assignment.

Block diagram



① Electrical isolation
② Shield connection on the BaseUnit
③ Technology
④ Backplane bus interface module of the F-TM Count module
⑤ Backplane bus
⑥ Sin/Cos encoder
⑦ Twisted in pairs

Figure 1-276 Block diagram with sin/cos encoder

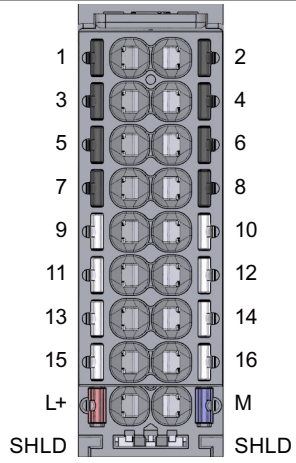
BaseUnit

The BaseUnit is not included with the delivery of the module.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the *ET 200SP Distributed I/O System*, system manual (https://support.industry.siemens.com/cs/pl/en/view/58649293).

Pin assignment of the BaseUnit

Table 1-583 Pin assignment of BaseUnit BU15-P16+A10+2B, BU type A0

Designation	Signal name		View	Signal name		Designation
SIN/COS differential encoder with or without signal N						
Encoder signal A	A	1		2	A/	Encoder signal A/
Encoder signal B	B	3		4	B/	Encoder signal B/
Encoder signal N	N	5		6	N/	Encoder signal N/
—	—	7		8	—	—
—	—	9		10	—	—
—	—	11		12	—	—
Encoder supply 5 V DC	5 VDC	13		14	—	—
Encoder supply ground	M	15		16	M	Encoder supply ground
Supply voltage 24 V DC	L+				M	Ground for supply voltage
Shield	—				—	Shield

Supply voltage L+/M

You connect the supply voltage to terminals L+ and M on a light BaseUnit. For a dark BaseUnit, the supply voltage of the module to the left is used. An internal protection circuit protects the F-TM Count module from reverse polarity of the supply voltage. The F-TM Count module monitors whether the supply voltage is connected.

⚠ CAUTION

Electrical noise risk
Electrical noise on the 24 V DC voltage supply lines can yield unexpected results. For example, inserting and removing modules into an I/O base that is powered on can generate electrical noise.
Avoid actions that have the possibility to generate electrical noise on the 24 V DC voltage supply lines. Electrical noise can occur when I/O connectors make and break contact between the base and module. This noise can become visible to all modules and sensors connected within the potential group. For F-TM Count applications, sensors include encoders, especially externally powered 24 V DC sensors. The electrical noise could result in unexpected influences, such as A and B signal failures. In this situation Siemens recommends a separate potential group for the F-TM Count module and encoder.

Encoder supply

The encoder supply from the F-TM Count module provides 5 V DC encoder sensor supply voltage. The encoder supply is only switched off during the following occurrences:

- There is a fatal error
- There is a firmware update in progress

NOTE

The F-TM Count module can only support 5 V DC encoders using the module's internal sensor supply. However, 10 to 30 V DC incremental encoders can be supported when externally powered.

3.2 Requirements for the Encoder

Encoder Characteristics

The selected incremental encoder must include the following capabilities:

- encoder generated signals at 1Vpp centered at 2.5V
- encoder generated A and B differential sinusoidal signals
- differential signals between A and A/, B and B/
- A and B signals are 90° phase-shifted
- N signal support is optional; the N terminals are unconnected when not used

Encoder signal names are defined by the encoder manufacturer and can differ from the signal names used in this manual. Signals herein are designated with the letters A, A/, B, B/, N and N/.

Due to anticipated safety application requirements when using the F-TM Count module, the connected encoder is evaluated in a safety-related manner. Encoder-generated faults, including correct A-to-B signal phase offsets, incorrect output signal voltages (1Vpp), wire breaks, parasitic oscillations, etc., are detected by the F-TM Count module. These faults are detected for any connected encoder, whether safety-rated or non-safety-rated.

To determine the achievable safety rating for the application, the encoder's functional safety failure characteristics must be determined--i.e., SIL, CAT, PL, $MTTF_d$, and $B10_d$. If such information cannot be found on the encoder manufacturer's data sheet, then the failure response data must be requested from the encoder manufacturer.

If encoders are used that specify no safety ratings, it is recommended that the failure response of the selected encoders causes the encoder signals to fall outside of the valid 1Vpp range. This allows the F-TM Count module to detect the encoder failure. Failure scenarios must be clarified with encoder manufacturers.

Siemens-specific encoder references may be found within the following SIOS entry:

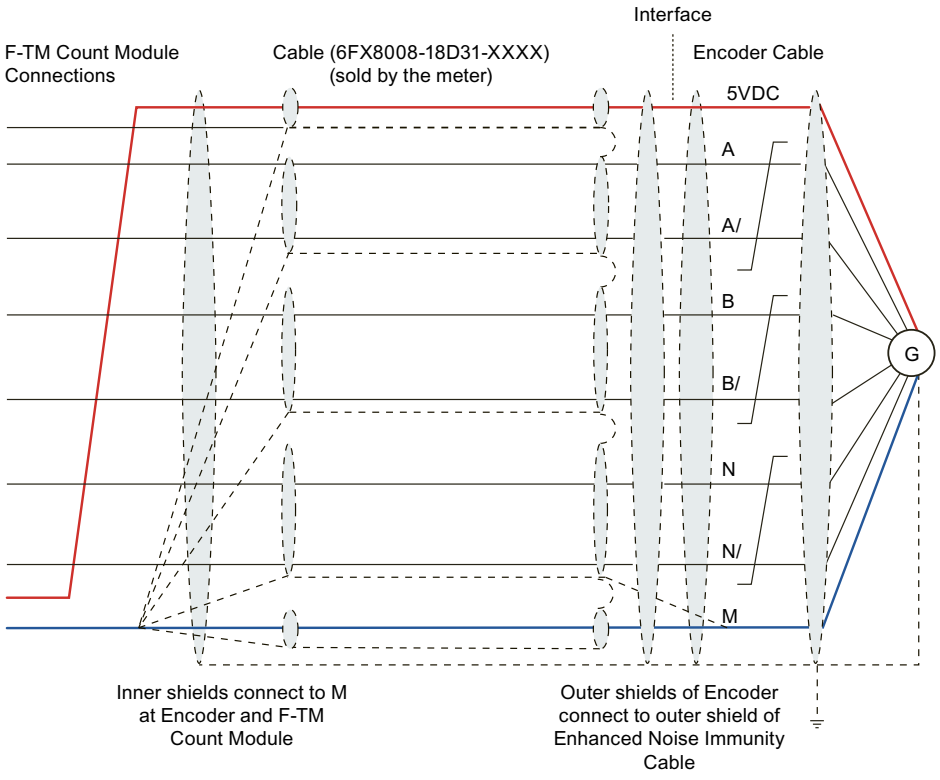
SINAMICS S120 drive system for SINUMERIK Safety Integrated
(https://support.industry.siemens.com/cs/de/en/view/33512621)

Immunity

⚠ WARNING

Failure to use properly shielded cable will result in degraded performance of the module because of lack of immunity.
To meet noise immunity standards, it is necessary to use cable (article number 6FX8008-1BD31-XXXX) sold by the meter for cable lengths greater than 1 meter or equivalent.

Wiring using the cable is shown in the following figure:



NOTICE
The right side of the F-TM Count module may exhibit some sensitivity to electrostatic discharge (ESD). Care should be taken to avoid exposure to ESD. If possible, it is recommended the F-TM Count module is not the last module on the right of the mounted configuration.

Radio frequency (RF) interference on encoder cables

Some encoders are sensitive to conducted RF on encoder cables. This can occur if the encoder cable is in a cable tray with other cables that can cause RF interference (for example, control cables).To prevent interference with the encoders, route control and encoder/sensor cables separately from each other. In the unlikely event that the encoder is still affected, you can place Type 28B ferrite clamp filters on the encoder cable at the encoder.

NOTE

For more information about the evaluation of differential signals, see "Quadrature evaluation of differential signal" (Page 43).

Parameters/address space

4

4.1 Configuring the F-TM Count module

All connected fail-safe I/O must have their operating properties configured by the STEP 7 Safety.

You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

Refer to the Configuring chapter of the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for step-by-step instructions.

Fail-Safe CPUs

You can use any of the following F-CPUs with the F-TM Count module:

- S7-1200/1500 F
- S7-300/400 F
- ET 200SP F
- ET 200S F
- ET 200pro F

Hardware components for PROFINET fail-safe system

You can use the following fail-safe PROFINET hardware components in a fail-safe system:

- F-CPUs with built-in PROFINET interface
- F-CPUs with optional PROFINET communication module (CM) interface modules
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - Fail-Safe GSDML-based, PROFIsafe-capable I/O devices (for example, a light curtain or laser scanner)

Hardware components for PROFIBUS DP fail-safe system

You can use the following fail-safe PROFIBUS DP components in a fail-safe system:

- F-CPUs with built-in PROFIBUS interface (PROFIBUS DP master)
- F-CPUs with optional PROFIBUS DP CM interface modules
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - Fail-Safe GSD-based, PROFIsafe-capable DP slaves (for example, a light curtain or laser scanner)

4.1.1 Using STEP 7 (TIA Portal V17 or greater)

Assigning a PROFIsafe address

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address and F-source address in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-TM Count modules to which you want to assign the configured F-destination and F-source addresses.
3. You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation as follows:
   - Right click on the F-TM Count module in the Device view in STEP 7.
   - Select "Assign PROFIsafe address" in the context menu.
   - Select the desired "Identification" method (LED flashing or serial number).
   - Select the check box on the left-hand side for the F-TM Count to assign an address to.
   - Click the "Identification" button.
   - Verify that the "Identification" method is correct (i.e. A and B channel LEDs flashing or serial number is correct).
   - Click the "Assign PROFIsafe addr..." button.
   - Click "Yes" in the prompt that follows.
   - If successful, the module is now operational.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Configuring F-TM Count module parameters

You specify the properties of the F-TM Count module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

1. Insert an ET 200SP CPU or an ET 200SP PROFINET or PROFIBUS interface module from the hardware catalog.
2. Insert the F-TM Count module from the hardware catalog under "Technology modules->Counting->F-TM Count".
3. Select the F-TM Count module (on the Device view or Device overview) and view the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select the drop-down arrows for "Module parameters" and "TM-C parameters" to and see a subset of the properties of the "F-parameters" and "TM-C parameters".
5. Select "F-parameters" property or one of the "TM-C parameters" properties in the left-side property tree and then set values in the right-side property fields.
6. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-TM Count module.

4.1.2 Using STEP 7 (TIA Portal) with GSDML (versions of TIA Portal prior to V17)

Configuring F-modules with a GSDML file

If you need to configure F-modules with a GSDML file, you need the *S7-FCT* in order to calculate the F_iPar_CRC and assign the PROFIsafe addresses. Operating instructions and additional information for the *S7-FCT V2.0 - Fail-safe Configuration Tool* can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833).

You can find *S7-FCT* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

Assigning a PROFIsafe address

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address and F-source address in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-TM Count modules to which you want to assign the configured F-destination and F-source addresses. F-destination addresses are generally assigned with lower numbers (for example, less than 100) for GSDML configured devices, and should be within the range of the F-CPU F-destination address range for PROFIsafe address type 1 devices.
3. Use "Assigning the F-source address and F-destination addresses to the F-I/Os" section in the instructions for the *S7-FCT V2.0 - Fail-safe Configuration Tool* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833) to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Configuring F-TM Count module parameters

You specify the properties of the F-TM Count module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

1. Insert the IM 155-6 PN interface module from the hardware catalog under "Other field devices->PROFINET I/O->I/O->SIEMENS AG->ET 200SP->Interface modules".
2. Insert the F-TM Count module from the hardware catalog under "Module->TM->Counting->F-TM Count". Select PROFIsafe V2.4 if you are using an S7-300 or S7-400 F-CPU. Select PROFIsafe V2.6 version if you are using an S7-1200 or S7-1500 F-CPU.
3. Select the F-TM Count module (on the Device view or Device overview) and view the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select the drop-down arrows for "Module parameters" and "TM-C parameters" to see a subset of the properties of the "F-parameters" and "TM-C parameters".

5. Select "F-parameters" property or one of the "TM-C parameters" properties in the left-side property tree and then set values in the right-side property fields.
6. Start the S7-FCT for the F-TM Count module and calculate the F_iParCRC.
7. Copy the F_iParCRC into the intended PROFIsafe parameter of the F-TM Count module.
8. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-TM Count module.

4.2 Reinitialize on parameterization download

Each time parameterization of the F-module occurs, reinitialization of internal module states is required. This means that internal module states are equivalent to power-up states. Reinitializing results in the following changes in the module:

- Process image status and event bits are reset
- Counter value is reinitialized to the start value
- Measured value calculations are reinitialized
- Process image command enables are reset
- Safety monitoring intermediate values are reset (for example, intermediate values associated with SOS, SDI, and SLS calculations)

In addition to a user commanded download of parameters from STEP 7 (TIA Portal), parameters will be downloaded, and the counter module will be reinitialized in the following circumstances:

- Power cycling of the F-CPU
- Pull/Plug of the module
- Power cycling the 24V user power to the module
- Power cycling of the IM on a remote rack
- Pull/Plug of the PROFInet cable to the IM remote rack

4.3 Reaction to CPU STOP

You set the response of the F-TM Count module to CPU STOP for the module in the device configuration.

Table 1-584 Response of technology module to CPU STOP

Option	Meaning
Continue counting	The F-TM Count channel continues to count pulses while the F-CPU is in STOP mode or while PROFIsafe communication is lost.
Stop counting	The F-TM Count channel does not continue to count. This is equivalent to closing the SW gate.

⚠ WARNING

In situations where the F-CPU is in STOP mode, the count value can potentially be affected.

The count value can be affected by the following behaviors:

- Your safety program states that may result during the commanded transition to STOP mode.
- External channel-related errors that could occur while the F-CPU is in STOP mode.
- Power cycling of the module while the F-CPU is in STOP mode.
- Your safety program control of the software gate signal when transitioning again to RUN mode. Closing of the software gate results in the loss of counts during external movement.

Your safety program must determine whether the reported count value remains representative of actual position when the behaviors above occur. If the position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

4.4 Reactions to counting limit violation

A counting limit can be violated when the counter value exceeds the high or low counting limit. Reactions to violating a counting limit are as follows:

Table 1-585 Response of technology module to counting limit violation

Option	Meaning
Continue counting	The F-TM Count channel continues to count pulses while the counting limit is violated after setting the count to either the opposite limit or to the start value.
Stop counting	The F-TM Count channel does not continue to count. This is equivalent to closing the SW gate.

4.5 Parameters of the F-TM Count

The following parameter settings are possible:

Table 1-586 Settable parameters and their default setting

Parameter	Value range	Default setting	Parameter reassignment in RUN	Scope STEP 7 (TIA Portal); STEP 7; GSD file
F-parameters				
Manual assignment of F-monitoring time	Check box: • Enable • Disable	Disable	No	Module
F-monitoring time [1]	14 to 65535 ms in 1 ms steps	150 ms	No	Module
F-destination address	1 to 65534	Address supplied by F-CPU (Always enabled)	No	Module
TM-C parameters				
Signal Monitoring	• Disable • Enable	Enable	No	Channel
Encoder related parameters				
Signal type [2]	• Sin/Cos encoder (A, B, N) • Sin/Cos encoder (A, B)	Sin/Cos encoder (A, B, N)	No	Channel
Invert direction	• Disable • Enable	Disable	No	Channel
Pulses per revolution	0 to 32767	1024	No	Channel
Reaction to signal N	• No reaction to signal N • Synchronization at signal N	No reaction to signal N	No	Channel
Counter parameters				
High counting limit	-2147483647 to 2147483647	2147483647	No	Channel
Start value	-2147483648 to 2147483647	0	No	Channel
Low counting limit	-2147483648 to 2147483646	-2147483648	No	Channel
Reaction to violation of a counting limit	• Continue counting • Stop counting	Continue counting	No	Channel
Reset when counting limit is violated	• Start value • Opposite counting limit	Start value	No	Channel
Reaction to gate start	• Set to start value • Continue with current value	Set to start value	No	Channel
Safety monitoring				
Measured value	• Frequency • Velocity • Period duration	Frequency	No	Channel
Update time	0 ms to 25000 ms	100 ms	No	Channel
Time base for velocity measurement [3]	• 1 millisecond • 10 milliseconds • 100 milliseconds • 1 second • 60 seconds	1 second	No	Channel

1 STEP 7 uses this number to set the F-monitoring time in each F-TM Count module unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

2 If (A, B) is selected, then "Pulses per revolution" and "Reaction to N signal" are disabled.

3 Velocity must be selected to configure this parameter.

Parameter	Value range	Default setting	Parameter reassignment in RUN	Scope
				STEP 7 (TIA Portal); STEP 7; GSD file
Counts per unit for velocity measurement [3]	1 to 65535	1	No	Channel
Safety Function - Safe Stop	• Enable • Disable	Disable	No	Channel
Standstill tolerance	0 to 65535 (counts)	0	No	Channel
Safety Function - Safe Direction	• Enable • Disable	Disable	No	Channel
Monitoring tolerance	0 to 65535 (counts)	0	No	Channel
Safety Function - Limited Speed [2]	• Enable • Disable	Disable	No	Channel
Speed limit [3]	0 - 2147483647 (Velocity * 1000)	0	No	Channel
Reaction to CPU STOP				
Reaction to CPU STOP	• Continue counting operation • Discontinue counting operation	Continue counting operation	No	Channel

1 STEP 7 uses this number to set the F-monitoring time in each F-TM Count module unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

2 If (A, B) is selected, then "Pulses per revolution" and "Reaction to N signal" are disabled.

3 Velocity must be selected to configure this parameter.

4.6 Explanation of parameters

4.6.1 F-parameters

Manual assignment of F-monitoring time

This is a selection to enable the "Manual assignment of F-monitoring time".

F-monitoring time

The monitoring time of safety-related PROFIsafe communication occurring between the F-CPU and the F-I/O module.

F-source address

A unique network-wide address for the fail-safe CPU assigned to the F-CPU with the "Central F-source address" parameter.

F-destination address

A unique F-destination address for each fail-safe module.

F-parameter signature (with addresses)

A signature for all F-parameters including F-addresses; used to easily determine whether parameterization changes have occurred.

F-parameter signature (without addresses)

Signature for all F-parameters without F-addresses; used to easily determine whether parameterization changes have occurred.

Behavior after channel fault

Specifies a passivation response by the F-TM Count module to channel faults. (Always set to "Passivate channel" for the F-TM Count module since there is a single channel.)

Reintegration after channel fault

Specifies a switchover from fail-safe values to process data (reintegration) after channel faults are eliminated. (Always set to "All channels manually" for the F-TM Count module since RIOforFA is not supported.)

RIOforFA safety

Specifies whether the module supports the "RIOforFA-Safety" profile. (Always set to "No" for the F-TM Count module since RIOforFA is not supported.)

PROFIsafe mode

Specifies the PROFIsafe mode being used by the F-module.

PROFIsafe protocol version

Specifies the PROFIsafe protocol version being used by the F-module.

F-I/O DB manual number assignment

You must select the check box to manually set the DB number of the F-I/O DB. An F-I/O DB is automatically created during compilation for each configured F-I/O module.

F-I/O DB number

The number of the F-I/O DB that is created during compilation.

F-I/O DB name

Specifies the symbolic name of the F-I/O DB that is created during compilation.

See also

S7-FCT V2.0 - Fail-safe Configuration Tool Operating Instructions
(https://support.industry.siemens.com/cs/ww/en/view/109763833)

SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/54110126)

4.6.2 TM-C parameters

Selection of channel activation

Enables channel activation. The counter channel is always activated since there is only a single channel.

Selection of operating type: Counting/Position input

Enables whether to provide integer counter value. This selection is always enabled for the counter module and a counter value is always returned.

Selection of operating type: Measuring

Enables whether to provide an additional counter measured value. This selection is always enabled for the counter module and a measured value is always returned.

Signal monitoring

Allows you to enable or disable signal monitoring. Signal monitoring evaluates the quality of A and B signals for phase, voltage, and wire break. If signal monitoring is disabled, you must evaluate and provide safety measures suitable for your application. See "A and B signal monitoring" in "Counter input diagnostics (Page 17)" for the effects on safety and the precautions you must make if you disable signal monitoring.

⚠ WARNING

It is possible for a channel fault to occur that is not readily detected by the module diagnostics if signal monitoring is disabled.
Disabling this feature reduces the safety rating to SIL 1, Cat. 2, PL c, which causes a loss of the safety function. Disabling this feature can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.
If signal monitoring is disabled, A and B signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

Signal Type

Specifies whether the encoder is providing A, B, or A, B, N signals. If (A, B) is selected, then Pulses per revolution and Reaction to N signal are disabled.

Invert direction

Specifies whether to reverse the counting direction.

Pulses per revolution

Specifies the total number of Sin/Cos pulses per revolution of the encoder. This is used for N signal plausibility monitoring. This field is only enabled when the "Signal type" selected is sin/cos encoder (A, B, N). Specifying a 0 value in this field disables N signal plausibility monitoring.

Signal evaluation

Specifies how many events per Sin/Cos pulse are counted. Only quadrature mode is supported. Quadrature mode evaluates all zero crossings of the sin/cos encoder signals, so that counts per revolution equal pulses per revolution times four.

Reaction to signal N

Specifies whether the reaction is to ignore the N signal or set the count to the start value. This field is only enabled when the "Signal type" selected is sin/cos encoder (A, B, N).

High counting limit

You limit the counting range by setting the high counting limit. An overflow event is triggered in the feedback interface when the current count exceeds the high counting limit. The current count will then be set to the start value or the low counting limit depending on parameterization. You can also select whether counting stops or continues after exceeding the high counting limit. The high counting limit must be greater than or equal to the start value and must be greater than the low counting limit. The allowed range is -2147483647 to 2147483647. The default setting is 2147483647.

Start value

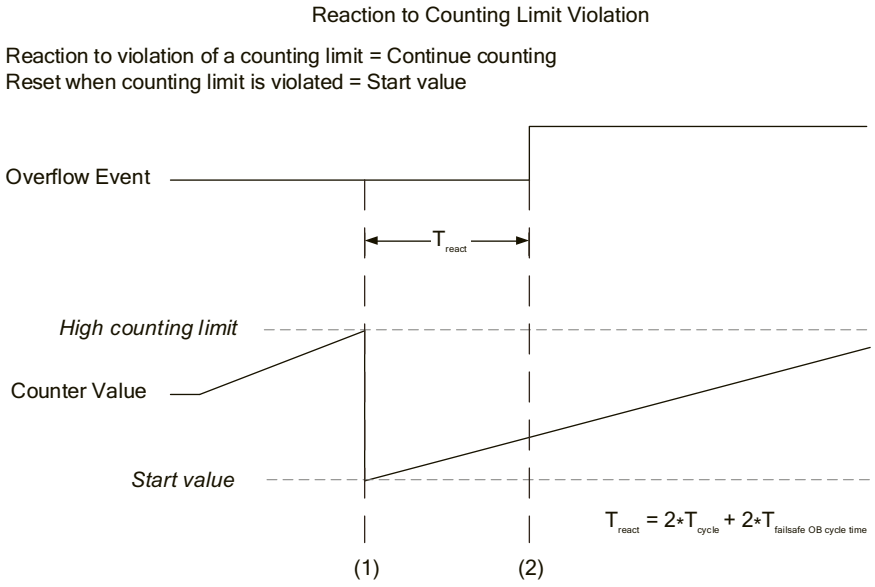
You specify the initial count value when counting starts by configuring the start value. The current count will be set to the start value after power up, after downloading parameters, when explicitly set, and other situations depending on configuration. The start value must be a value between or equal to the counting limits. The allowed range is -2147483648 to 2147483647. The default setting is 0.

Low counting limit

You limit the counting range by setting the low counting limit. An underflow event is triggered in the feedback interface when the current count exceeds the low counting limit while counting down. The current count will then be set to the start value or the high counting limit depending on parameterization. The allowed range is -2147483648 to 2147483646. The default setting is -2147483648.

Reaction to violation of a counting limit

Specifies the reaction when either the high or low counting limit is exceeded. You can choose to either continue counting or to stop counting. If you choose to stop counting, you must close and reopen the software gate to resume counting.



1 Counter value exceeds the configured high counting limit, is reset to the start value, and counting continues.

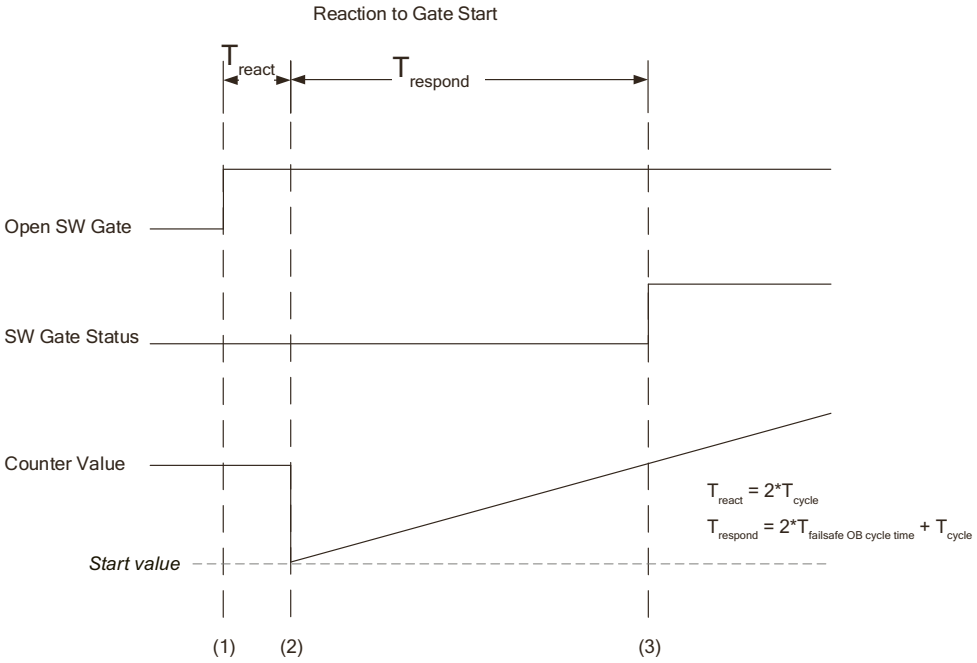
2 User program sees "Overflow Event" go high to indicate the high counting limit was exceeded and sees an updated counter value.

Reset when counting limit is violated

Specifies whether the count value is set to the start value or opposite counting limit when a counting limit is exceeded.

Reaction to gate start

Specifies whether the count value is set to the start value or continues with the current value when the SW gate is opened. This action occurs each time the SW gate changes from closed to open.



1 User program sets "Open SW Gate" high to open the software gate and enable counting.
2 Module sees the "Open SW Gate" command, opens the software gate, and sets the counter value to the start value.
3 User program sees "SW Gate Status" go high and an updated counter value.

Measured value

Specifies one of a possible three different engineering unit conversions as follows:

- **Frequency**: The average number of counts per second reported in millihertz (hertz * 1000)
- **Period duration**: The average period between two counts in microseconds (seconds * 1000000)
- **Velocity**: The speed of movement in a given direction. Velocity represents the units of measure per time base * 1000.

Negative values are reported when counting down, positive values are reported when counting up.

NOTE

Fields directly associated with velocity calculations are only enabled when velocity is selected.

Update time

Specifies the interval at which the F-TM Count module updates the measured values to the F-CPU. Setting a longer update time interval allows the module to collect more data to calculate a more accurate measured value, but increases the reaction time.

NOTE

The safety reaction time is influenced by the chosen update time when using measured values, and SLS as part of the safety application program.

Time base for velocity measurement

Specifies the time base unit for the velocity you want for the calculation output in increments of milliseconds or seconds.

Counts per unit of measure

Specifies the number of counts from the incremental encoder per relevant distance unit for the velocity measurement.

Safety Function - Safe Stop

Enables safe operating stop (SOS) monitoring.

Standstill tolerance

Specifies the acceptable standstill tolerance allowed for the SOS function measured in counts.

NOTE

The standstill tolerance selection is disabled if "Safety Function - Safe Stop" is disabled.

Safety Function - Safe Direction

Enables safe direction (SDI) monitoring.

Monitoring tolerance

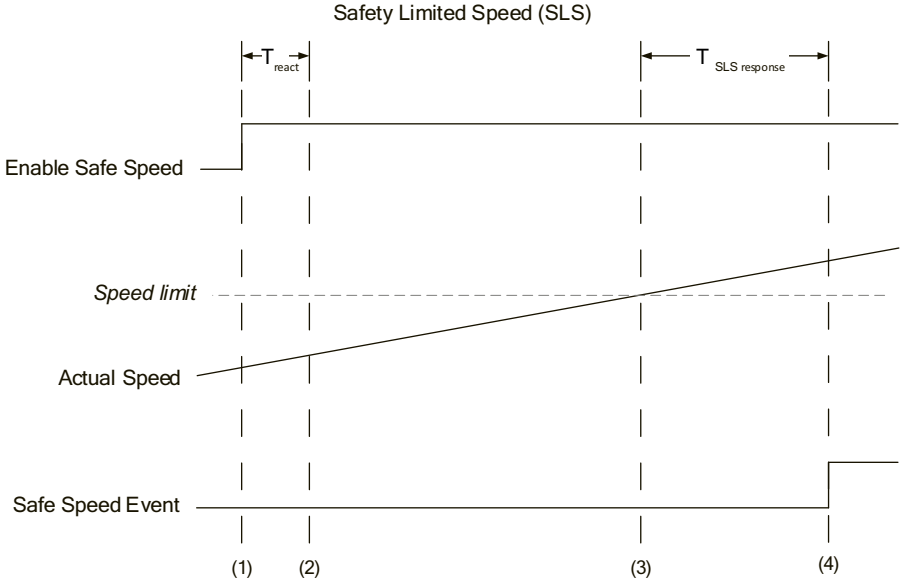
Specifies the acceptable tolerance in the unsafe direction for the SDI function measured in counts.

NOTE

The monitoring tolerance selection is disabled if "Safety Function - Safe Direction" is disabled.

Safety Function - Limited Speed

Enables safety limited speed (SLS) monitoring only when "Velocity" is selected as the measured value.

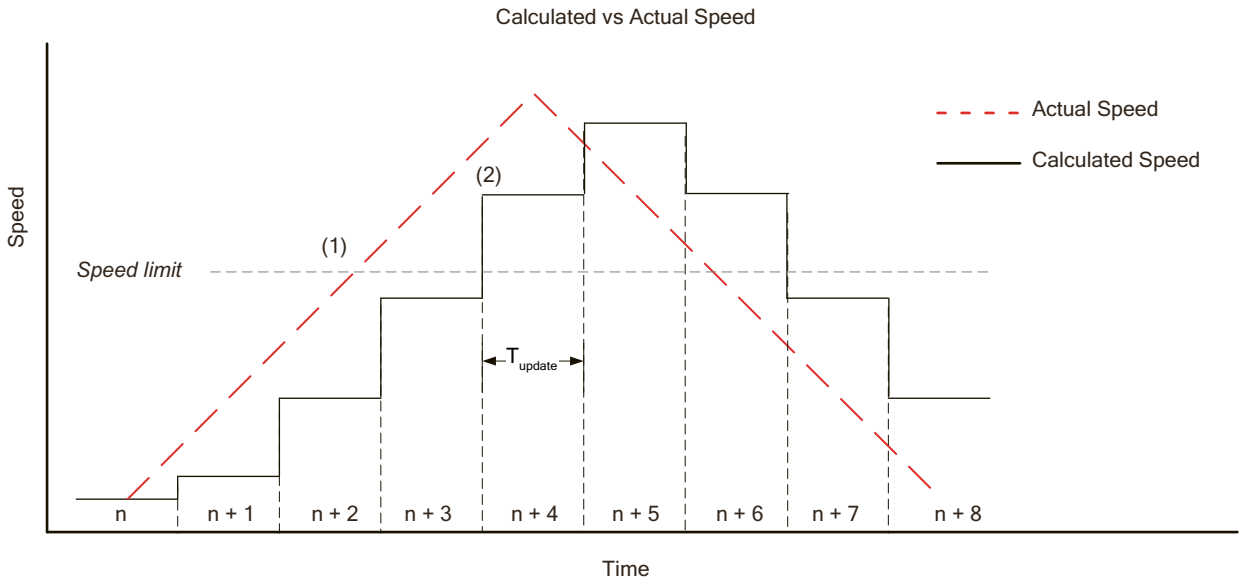


$T_{react} = 2*T_{cycle}$

$T_{SLS\ response} = 2*T_{failsafe\ OB\ cycle\ time} + T_{cycle} + T_{update}$

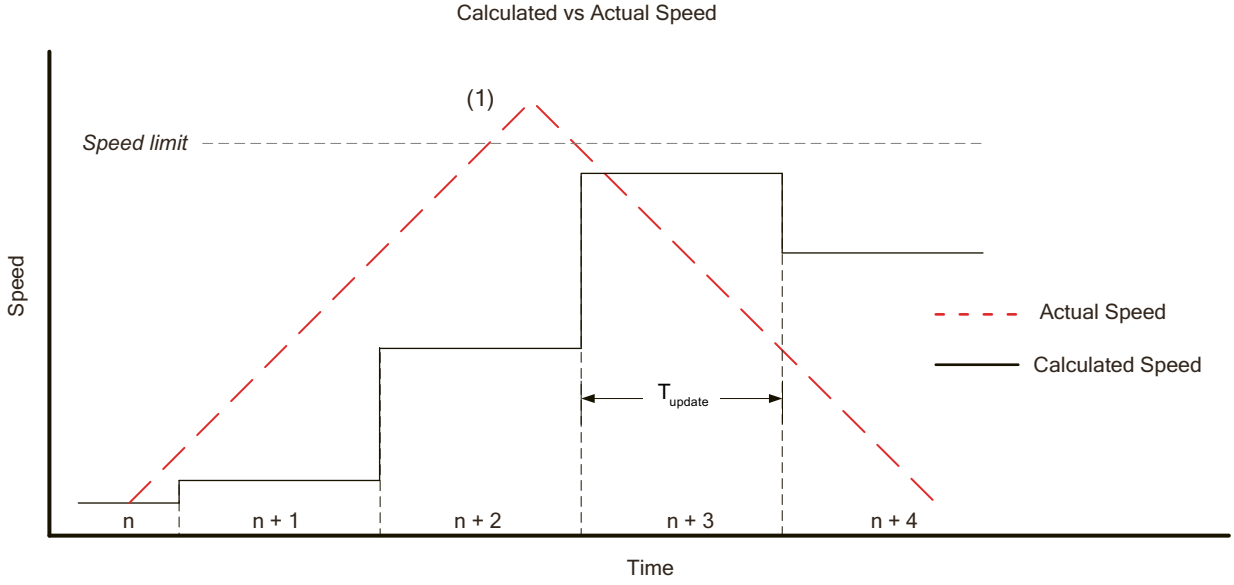
1 User program set "Enable Safe Speed" high to initiate SLS monitoring
2 Module process the "Enable Safe Speed" value and SLS monitoring is started.
3 Calculated speed exceeds the configured speed limit, "Safe Speed Event" set in the module.
4 User program sees "Safe Speed Event" go high to indicate an overflow occurred.

The calculated speed is updated once per configured update time and represents the average speed over the preceding interval. When determining what update time to use, it is important to consider the update time's effect on filtering of momentary speed limit violations and the overall response time of the SLS monitoring. Larger update time values result in more filtering of speed limit violations as well as an extended response time.



1 Actual speed exceeds the configured speed limit during the "n+2" update interval. Due to the averaging of the calculated speed, the measured value does not yet exceed the limit so no safe speed event is issued by the module now.

2 The calculated speed first exceeds the speed limit during the "n+4" update interval. A safe speed event will be issued by the module now.



1 The actual speed exceeds the configured speed limit during the "n+2" update interval. Due to the averaging of the measured value, the calculated speed never exceeds the speed limit so no safe speed event is issued by the module. Larger update times effectively filter out short speed limit violations. Therefore, if the application needs to detect momentary speed limit violations, a shorter update time should be configured.

Speed limit

Specifies the maximum acceptable speed in velocity units for the SLS function only when velocity is selected.

NOTE

The speed limit selection is disabled if "Safety Function - Limited Speed" is disabled.

Reaction to CPU STOP

Specifies whether the channel continues to count pulses while the F-CPU is in STOP mode.

4.7 Behavior at the counting limits

"Reaction to violation of a counting limit" selections are defined as follows:

- **"Continue counting"**: After a violation of a counting limit, counting surpasses the limit and goes to either the start value or the opposite counting limit (depending upon configuration), and then continues.
- **"Stop counting"**: After a violation of a counting limit, counting surpasses the limit and goes to either the start value or the opposite counting limit (depending upon configuration), and then stops. To restart counting, the SW gate must be closed and reopened.

⚠ WARNING

The "Stop counting" selection may not allow the module to react at counting limits.
Configuring the "Reaction to violation of a counting limit" selection to stop counting may have a direct and detrimental influence upon configured safety monitoring and measured value.
You must ensure your safety program has provisions for the immediate stopping of counting and any potential influence upon configured safety monitoring functions and measured value.

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another up-count is received. The low counting limit is violated when the current counter value is equal to the low counting limit and another down-count is received.

The appropriate status bit is set in the feedback interface in the event of limit violation:

Counting limit violated	Status bit
High counting limit	"Overflow Event" bit is set
Low counting limit	"Underflow Event" bit is set

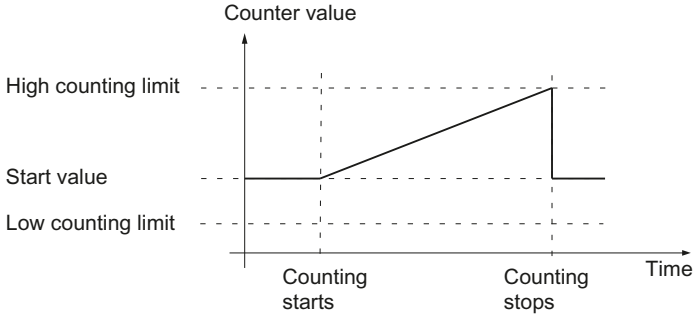
You can reset the status bits with "Reset Other Events" bit.

Following a counting limit violation, you can configure whether counting is to continue and whether counting is continued at the start value or at the opposite counting limit.

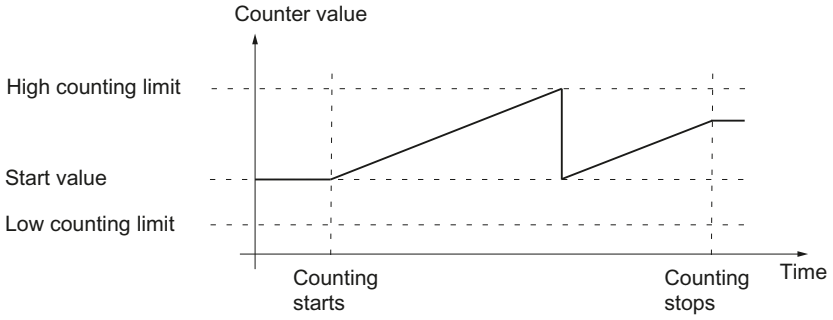
NOTE
The high and low counting limits define the value range of the counter.

Examples

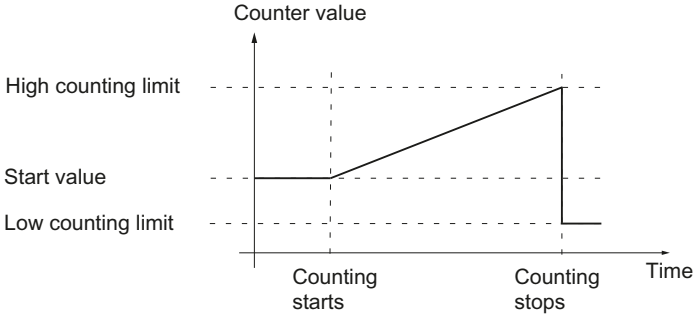
The figure below shows an example for terminating the counting process after an overflow and setting the counter to the start value:



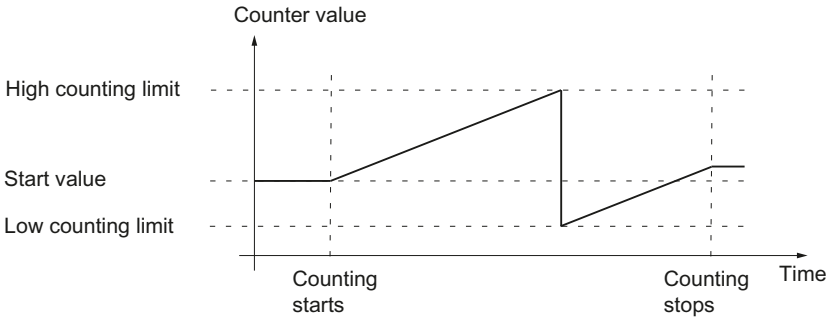
The figure below shows an example for continuing the counting process after an overflow and setting the counter to the start value:



The figure below shows an example for terminating counting after an overflow and setting the counter to the opposite counting limit:



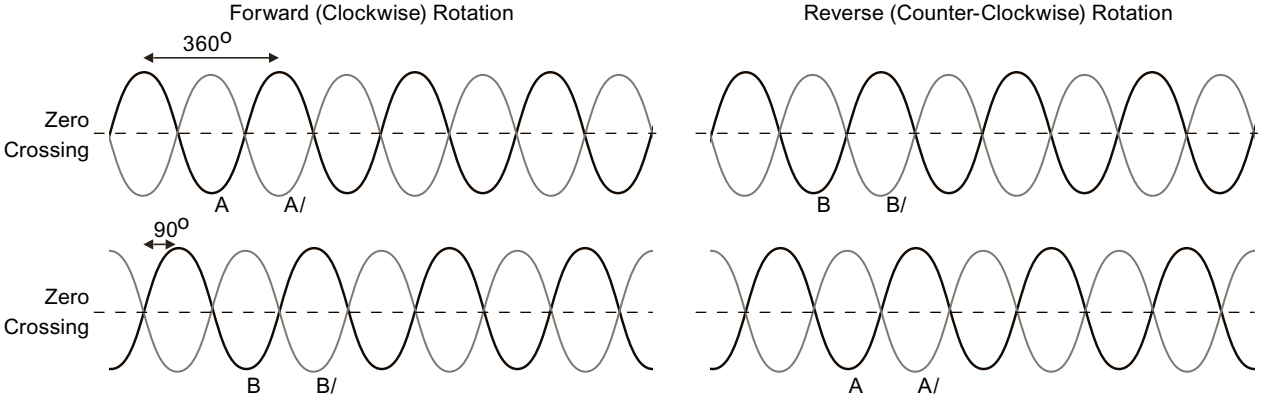
The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:



4.8 Quadrature evaluation of differential signals

With quadrature evaluation, the A and B signals are shifted by 90 degrees in relation to each other. When the A signal is leading, the movement is in the forward direction. When the B signal is leading, the movement is in the reverse direction.

Counting occurs at each "zero-crossing" of the A and B signals. As a result, each complete waveform has a total effect of 4 counts. For example, given a 200 kHz frequency, 800K counts per second can be achieved. These relationships are illustrated in the figure below:



4.9 Safety functions

This provides a quick overview of the principle mode of operation of the F-TM Count module safety functions.

The description of the safety functions is based on the definition according to standard EN 61800-5-2 and some simple examples for using the function.

The description of the functions is simplified, as far as possible, to clearly show essential properties and configuration options.

4.9.1 Safe Operating Stop (SOS)

SOS monitoring

SOS monitoring is initiated whenever the "Enable Safe Stop" bit is set in the control interface and subsequently processed by the F-TM Count module. SOS monitoring terminates whenever the "Enable Safe Stop" bit is reset in the process output image and subsequently processed by the module.

Each time SOS monitoring is initiated, the current position is stored. A "Safe Stop Event" is set whenever any movement is detected in either direction that exceeds the configured "Standstill tolerance" as measured from the stored position.

Standstill tolerance is configured in counts.

Once set, the "Safe Stop Event" bit remains set and counting continues after the event is triggered. The "Safe Stop Event" remains set until the "Reset Safe Stop" bit is set to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a value of 0 for the standstill tolerance results in the "Safe Stop Event" being set immediately after the first pulse in either direction.

⚠ WARNING

Safe stop monitoring continues when counting is suspended and SOS monitoring is enabled.
Since there is no active counting operation, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.
You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SOS monitoring

The safe stop position is stored when SOS monitoring is initiated by turning on the "Enable Safe Stop" bit and is used for the entire SOS monitoring session.

Your safety program examines the "Safe Stop Event" bit in the feedback interface and takes appropriate action during the SOS monitoring session.

Set the "Reset Safe Stop" bit to 1 to clear the "Safe Stop Event" bit in the feedback interface.

If you want to start a new SOS monitoring session, the "Enable Safe Stop" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

The "Safe Stop Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded.
If you reset the "Safe Stop Event" and the safe stop is still in violation, the "Safe Stop Event" bit will immediately set back to 1.

SOS suspension by external events

Suspension of counting operations can result from the following external events:

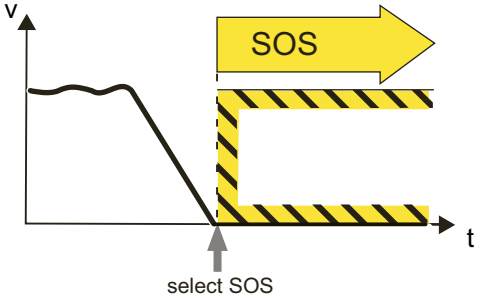
- SW gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation (Page 30)" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits shall have no effect in determining whether a safe stop violation has occurred.
This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Stop Event" is only initiated upon violation of the specified "Standstill tolerance".

4.9.1.1 Function of SOS

The SOS function monitors the count value and notifies the user if the encoder/count deviates more than a defined amount from the stopped position.



SOS Selection

Example of how the function can be used

Example	Possible solution
A protective door can only be opened if a machine is in the safe standstill state.	• Stop the movement of the hazard from your safety program. • Ensure no further movement as follows: – Engage/energize (brake/motor) – Engage the safety related actuator • Enable SOS monitoring in the counter module via the safety program in the F-CPU • Disable the door lock to permit access to the machine • Perform an appropriate safety reaction if the "Safe Stop Event" ever occurs

4.9.1.2 Example using SOS monitoring

The protected machine areas can be entered without having to shut down the machine as long as SOS is active.

Machine stopping is monitored using an SOS tolerance window. At the instant this function becomes enabled, the current position is stored as the comparison position until SOS is disabled again.

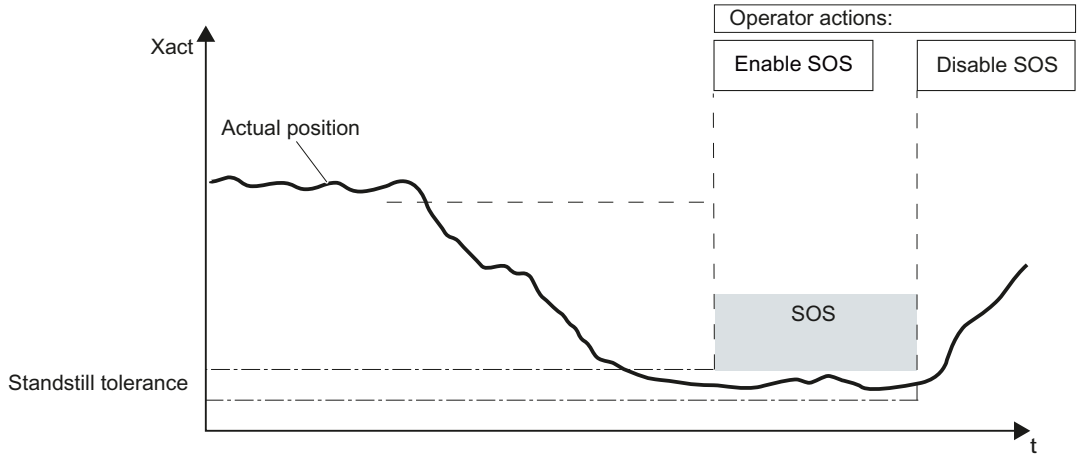


Figure 1-277 Standstill tolerance

4.9.1.3 Configuring SOS

In STEP 7 do the following to configure SOS monitoring:

- Configure "Safety Function - Safe Stop"
- Configure the "Standstill tolerance" in counts
- Download this project to the F-CPU

4.9.1.4 Enabling SOS

In your safety program, set the "Enable Safe Stop" bit to 1 to begin SOS monitoring.

From that point, if the module ever detects a movement in either direction that exceeds the configured "Standstill tolerance", the "Safe Speed Event" bit is set to 1.

4.9.1.5 Responding to SOS

Your safety program examines the "Safe Stop Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Stop Event" bit remains set to 1 until either of the following actions occur:

- Your safety program sets the "Reset Safe Stop" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.9.2 Safety Limited Speed (SLS)

Safe speed monitoring

SLS monitoring is initiated whenever the "Enable Safe Speed" bit is set in the control interface and subsequently processed by the F-TM Count module. SLS monitoring terminates whenever the "Enable Safe Speed" bit is reset in the process output image and subsequently processed by the module.

A "Safe Speed Event" is set whenever the calculated speed in either direction is greater than the configured "Speed limit". Once set, the "Safe Speed Event" bit remains set and counting continues after the event is triggered. The "Safe Speed Event" remains set until the "Reset Safe Speed" control bit to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a "Speed limit" value of 0 results in the "Safe Speed Event" being set immediately after the first pulse in either direction.

NOTE

Triggering a "Safe Speed Event" is also dependent on the measured value, configured as "Velocity", that updates your safety program once every update time.

⚠ WARNING

Safe speed monitoring continues when counting is suspended and SLS monitoring is enabled.

Since there is no active counting operation when counting is suspended, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SLS monitoring

SLS monitoring is initiated by turning on the "Enable Safe Speed" bit.

Your safety program examines the "Safe Speed Event" bit in the feedback interface and takes appropriate action during the SLS monitoring session.

Set the "Reset Safe Speed" bit to 1 to clear the "Safe Speed Event" bit in the feedback interface.

If you want to start a new SLS monitoring session, clear and enable the "Enable Safe Speed" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

Once set, the "Safe Speed Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded. If you reset the "Safe Speed Event" and the safe speed is still in violation, the "Safe Speed Event" bit will immediately set back to 1.

SLS suspension by external events

SLS monitoring suspension can result from the following external events:

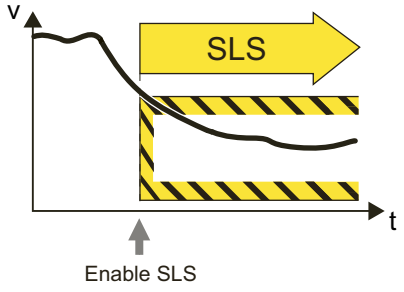
- SW gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits have no effect in determining whether a safe speed violation has occurred.
This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Speed Event" is only initiated upon actual violation of the specified "Speed limit".

4.9.2.1 Function of Safety Limited Speed (SLS)

The SLS function monitors the encoder and notifies the user if the calculated speed exceeds the specified speed limit in either direction.



Examples of how the function can be used

Example	Possible solution
The machine operator must be able to enter the machine after the protective door has been opened and slowly move a horizontal conveyor with an acknowledgment button in the danger zone.	• Enable SLS in the counter via your safety program in the F-CPU. • The counter monitors the velocity of the horizontal conveyor.
A spindle drive, depending on the selection of the cutting tool, must not exceed a specific maximum speed.	• Enable SLS in the counter via your safety program in the F-CPU.

4.9.2.2 Configuring SLS

In STEP 7 do the following to configure SLS:

- Configure the "Measured Value" to be "Velocity" and specify the desired values for the following:
  - "Update time"
  - "Time base for velocity measurement"
  - "Counts per unit for velocity measurement"
- Configure "Safety Function - Limited Speed"
- Configure the "Speed limit"
- Download this project to the F-CPU

NOTE

SLS speed can only be configured if the measured value is set to velocity.

4.9.2.3 Enabling SLS

In your safety program, set the "Enable Safe Speed" bit to 1 to begin SLS monitoring.

From that point, if the module ever detects a speed in either direction that exceeds the configured "Speed limit", the "Safe Speed Event" bit is set to 1.

4.9.2.4 Responding to SLS

Your safety program examines the "Safe Speed Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Speed Event" bit remains set until either of the following actions occur:

- Your safety program sets the "Reset Safe Speed" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.9.3 Safe Direction (SDI)

Safe direction (SDI) monitoring

SDI monitoring is initiated whenever the "Enable Safe Direction" bit is set in the control interface and subsequently processed by the F-TM Count module. SDI monitoring terminates whenever the "Enable Safe Direction" bit is reset in the process output image and subsequently processed by the module.

Each time safe direction monitoring is initiated, the current position and the specified safe direction are stored. The "Safe Direction Event" bit is set whenever a movement is detected in the unsafe direction and exceeds the configured "Monitoring tolerance". The "Monitoring tolerance" is measured from the farthest position achieved in the safe direction. As movement progresses in the safe direction, the tolerance of movement in the unsafe direction shall be measured from this farthest position.

Monitoring tolerance is configured in counts. The safe direction is specified in the process output image.

Once set, the "Safe Direction Event" bit remains set and counting continues after the event is triggered. The "Safe Direction Event" remains set until the "Reset Safe Direction" bit is set to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a value of 0 for the monitoring tolerance results in the "Safe Direction Event" being set immediately after the first pulse in the unsafe direction.

⚠ WARNING

Safe direction monitoring continues when counting is suspended and SDI monitoring is enabled.

Since there is no active counting operation when counting is suspended, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SDI monitoring

The safe direction is stored when SDI monitoring is initiated by enabling the "Enable Safe Direction" bit and is used for the entire SDI monitoring session. While the SDI monitoring session is in progress, subsequent changes to the "Safe Direction" bit are ignored.

Your safety program examines the "Safe Direction Event" bit in the feedback interface and takes appropriate action during the SDI monitoring session.

Set the "Reset Safe Direction" bit to 1 to clear the "Safe Direction Event" bit in the feedback interface.

If you want to start a new SDI monitoring session, clear and enable the "Enable Safe Direction" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

Once set, the "Safe Direction Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded. If you reset the "Safe Direction Event" and the safe direction is still in violation, the "Safe Direction Event" bit will immediately set back to 1.

SDI suspension by external events

SDI monitoring suspension can result from the following external events:

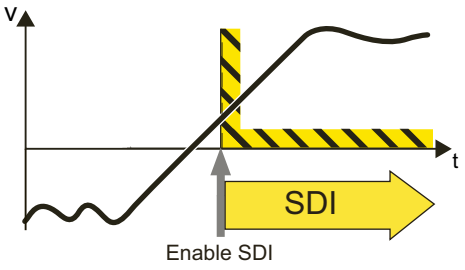
- Software gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits have no effect in determining whether a safe direction violation has occurred.
This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Direction Event" is only initiated upon actual violation of the specified "Monitoring tolerance".

4.9.3.1 Function of Safe Direction (SDI)

The SDI function monitors the encoder and notifies the user if the encoder/count moves more than a defined amount in the unintended direction.



Examples of how the function can be used

Example	Possible solution
A protective door can only be opened if a conveyor belt moves in the safe direction (away from the operator).	• Specify the safe direction using the "Safe Direction" control bit in your safety program in the F-CPU. • Enable SDI in the counter via your safety program in the F-CPU. • Enable the locking mechanism of the protective doors via the PROFIsafe status bit of the counter.
When replacing the pressure cylinders of the plates, the conveyor can only move in the safe direction.	• Specify the safe direction using the "Safe Direction" control bit in your safety program in the F-CPU. • Enable SDI in the counter via your safety program in the F-CPU. • Inhibit the direction of motion that is not permitted in the counter.
Once the protection against jamming has been triggered, a roller shutter gate can only start moving in one direction.	
At an operational limit switch, the trolley of a crane can only start moving in the opposite direction.	

4.9.3.2 Configuring SDI

In STEP 7 do the following to configure SDI:

- Configure "Safety Function - Safe Direction"
- Configure the "Monitoring tolerance"
- Download this project to the F-CPU

4.9.3.3 Responding to SDI

Your safety program examines the "Safe Direction Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Direction Event" bit remains set until either of the following actions occur:

- Your safety program sets the "Reset Safe Direction" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.10 Address space

Address space of the technology module

Table 1-587 Size of input and output addresses of the F-TM Count for PROFIsafe version 2.4 (with S7-300/S7-400)

	Control (Outputs)	Feedback (Inputs)
Range for control and feedback interface	6 bytes	14 bytes

Table 1-588 Size of input and output addresses of the F-TM Count for PROFIsafe version 2.6.1 (with S7-1200/S7-1500)

	Control (Outputs)	Feedback (Inputs)
Range for control and feedback interface	7 bytes	15 bytes

4.11 Control and feedback interface

4.11.1 Assignment of the control interface

Your safety program uses the control interface to influence the behavior of the F-TM Count module.

Control interface

The following table shows the assignment of the control interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reset Safe Direction	Reset Safe Stop	Reserved	Reset Safe Speed	Reserved	Reserved	Reset Other Events	Open SW Gate
1	Safe Direc-tion	Enable Safe Direction	Enable Safe Stop	Enable Safe Speed	Reserved	Set Start Value	Reserved	Reserved

Explanations

Byte	Bit	Control bit/value	Explanations
0	0	Open SW Gate	The "Open SW Gate" bit controls when the software gate is open and counting is enabled. • 0: SW gate is closed and counting is stopped • 1: SW gate is open and counting is allowed
0	1	Reset Other Events	The "Reset Other Events" bit is used to reset the following event bits in the feedback interface: • Zero Event • Underflow Event • Overflow Event As long as the "Reset Other Events" bit is set to 1, the "Zero Event", "Underflow Event", and "Overflow Event" bits are continually cleared.
0	4	Reset Safe Speed	The "Reset Safe Speed" bit is used to reset the "Safe Speed Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Speed Event" bit As long as the "Reset Safe Speed" bit is set to 1, the "Safe Speed Event" bit is continually cleared.
0	6	Reset Safe Stop	The "Reset Safe Stop" bit is used to reset the "Safe Stop Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Stop Event" bit As long as the "Reset Safe Stop" bit is set to 1, the "Safe Stop Event" bit is continually cleared.
0	7	Reset Safe Direction	The "Reset Safe Direction" bit is used to reset the "Safe Direction Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Direction Event" bit As long as the "Reset Safe Direction" bit is set to 1, the "Safe Direction Event" bit is continually cleared.

Byte	Bit	Control bit/value	Explanations
1	2	Set Start Value	The "Set Start Value" bit sets the current count to the configured start value. • 0: No action • 1: Set the count to the start value The "Set Start Value" action is initiated whenever this bit is set. The current count value is continually set to the "Start Value" while the "Set Start Value" bit is set to 1.
1	4	Enable Safe Speed	The "Enable Safe Speed" bit enables the SLS monitoring function. The "Enable Safe Speed" is set in the control interface. • 0: Disabled • 1: Enabled SLS monitoring is initiated in the module whenever the "Enable Safe Speed" bit is set. SLS monitoring is active until the "Enable Safe Speed" bit is reset or a power cycle occurs. SLS monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.
1	5	Enable Safe Stop	The "Enable Safe Stop" bit enables the SOS monitoring function. The "Enable Safe Stop" is set in the control interface. • 0: Disabled • 1: Enabled SOS monitoring is initiated in the module whenever the "Enable Safe Stop" bit is set. SOS monitoring is active until the "Enable Safe Stop" bit is reset or a power cycle occurs. SOS monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.
1	6	Enable Safe Direction	The "Enable Safe Direction" bit enables the SDI monitoring function. The "Enable Safe Direction " is set in the control interface. • 0: Disabled • 1: Enabled SDI monitoring is initiated in the module whenever the "Enable Safe Direction" bit is set. SDI monitoring is active until the "Enable Safe Direction" bit is reset or a power cycle occurs. SDI monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.
1	7	Safe Direction	The "Safe Direction" bit in the control interface specifies the safe direction of movement for the safe direction monitoring function. • 0: Counting down is the safe direction • 1: Counting up is the safe direction Changing the safe direction requires you to reset the "Safe Direction Enable" bit. The safe direction must be set prior to setting the "Enable Safe Direction" bit.

4.11.2 Assignment of the feedback interface

Your safety program receives current values and status information from the F-TM Count module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reset Safe Direction Status	Reset Safe Stop Status	SW Gate Status	Reset Safe Speed Status	Reset Other Events Status	Set Start Value Status	Count Status	Direction Status
1	Reserved	Safe Direction Event	Safe Stop Event	Safe Speed Event	Overflow Event	Underflow Event	Zero Event	Value status (CQ HSC0)
2...5	High Speed Counter 0 - Current Value DINT: Current counter value Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
6...9	High Speed Counter 0 - Measured Value Measured Value as a scaled DINT							

Explanations

Byte	Bit	Feedback bit/value	Explanations
0	0	Direction Status	The "Direction Status" bit reflects the direction of the last movement. • 0: Last count was down • 1: Last count was up After power-up, the "Direction Status" bit resets to 0 and reinitializes to the actual state upon the next movement.
0	1	Count Status	The "Count Status" bit reflects the current counting status. • 0: No counts in the previous 500 ms • 1: At least one count received in the previous 500 ms
0	2	Set Start Value Status	The "Set Start Value Status" bit is used to acknowledge that the module has received and reacted to the "Set Start Value" bit from the control interface as follows: • When the "Set Start Value" bit is set to 1, the module sets the count value to the start value, then sets the "Set Start Value Status" bit to 1 • When the "Set Start Value" bit is set to 0, the "Set Start Value Status" bit is also set to 0
0	3	Reset Other Events Status	The "Reset Other Events Status" bit is used to acknowledge that the module has received and reacted to the "Reset Other Events" bit from the control interface as follows: • When the "Reset Other Events" bit is set to 1, the module resets the "Overflow Event", "Underflow Event", and "Zero Event" bits, then the "Reset Other Events Status" bit is set to 1 • When the "Reset Other Events" bit is set to 0, the "Reset Other Events Status" bit is set to 0

Byte	Bit	Feedback bit/value	Explanations
0	4	Reset Safe Speed Status	The "Reset Safe Speed Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Speed" bit in the control interface as follows: • When the "Reset Safe Speed" bit is set to 1, the module resets the "Safe Speed Event" bit, then the "Reset Safe Speed Status" bit is set to 1 • When the "Reset Safe Speed" bit is set to 0, the "Reset Safe Speed Status" bit is set to 0
0	5	SW Gate Status	The "SW Gate Status" bit is used to acknowledge that the module has received and reacted to the "Open SW Gate" bit from the control interface as follows: • When the "Open SW Gate" bit is set to 1, the module performs the configured gate action, then the "SW Gate Status" bit is set to 1 • When the "Open SW Gate" bit is set to 0, the "SW Gate Status" bit is also set to 0
0	6	Reset Safe Stop Status	The "Reset Safe Stop Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Stop" bit from the control interface as follows: • When the "Reset Safe Stop" bit is set to 1, the module resets the "Safe Stop Event" bit, then the "Reset Safe Stop Status" bit is set to 1 • When the "Reset Safe Stop" bit is set to 0, the "Reset Safe Stop Status" bit is set to 0
0	7	Reset Safe Direction Status	The "Reset Safe Direction Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Direction" bit from the control interface as follows: • When the "Reset Safe Direction" bit is set to 1, the module resets the "Safe Direction Event" bit, then the "Reset Safe Direction Status" bit is set to 1 • When the "Reset Safe Direction" bit is set to 0, the "Reset Safe Direction Status" bit is set to 0
1	0	Value status (CQ HSC0)	The value status bit provides information on the validity operational quality of the corresponding channel. • 0: Fail-safe values (0 values) are provided for the channel • 1: Valid process values are provided for the channel
1	1	Zero Event	The "Zero Event" bit is set whenever the current count value transitions to 0. • 0: No event • 1: Count transitioned to 0 The "Zero Event" occurs when the count transitions to 0 from either direction. The "Zero Event" bit remains set until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.
1	2	Underflow Event	The "Underflow Event" bit is set whenever the current count value exceeds the configured "Low Counting Limit". • 0: No violation of limit • 1: Low counting limit was exceeded The "Underflow Event" bit remains set until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.
1	3	Overflow Event	The "Overflow Event" bit is set whenever the current count value exceeds the configured "High Counting Limit". • 0: No violation of the limit • 1: High counting limit was exceeded The "Overflow Event" bit remains set to 1 until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.

Byte	Bit	Feedback bit/value	Explanations
1	4	Safe Speed Event	The "Safe Speed Event" bit informs the safety program that a safe speed violation has occurred. • 0: No violation • 1: The calculated speed, in either direction, was detected to be greater than the configured "Speed limit" The "Safe Speed Event" bit is cleared following an event when the "Reset Safe Speed" bit is set to 1 in the control interface.
1	5	Safe Stop Event	The "Safe Stop Event" bit informs the safety program that a safe stop violation has occurred. • 0: No violation • 1: A movement was detected in either direction that exceeded the configured "Standstill tolerance" as measured from the stored position The "Safe Stop Event" bit is cleared following an event when the "Reset Safe Stop" bit is set to 1 in the control interface.
1	6	Safe Direction Event	The "Safe Direction Event" bit informs the safety program that a safe direction violation has occurred. • 0: No violation • 1: A movement was detected in the unsafe direction that exceeded the configured "Monitoring tolerance" The "Safe Direction Event" bit is cleared following an event when the "Reset Safe Direction" bit is set to 1 in the control interface.
2...5	31...0	High Speed Counter 0 - Current Value	This signed double integer (DINT) value shows the current count. The position corresponds to the sign and the count value (process value). The count value assumes values between -2147483648 and 2147483647 unless restricted by the high and low counting limits.
6...9	31...0	High Speed Counter 0 - Measured Value	The measured value is returned as a scaled integer (DINT) value shown as one of the following, depending upon configuration: • Frequency is in millihertz (hertz * 1000) • Period is in microseconds (seconds * 1000000) • Velocity is units of measure per time base you select (velocity * 1000) Note that negative values are reported when counting down, positive values are reported when counting up.

Applications of the F-I/O module

5

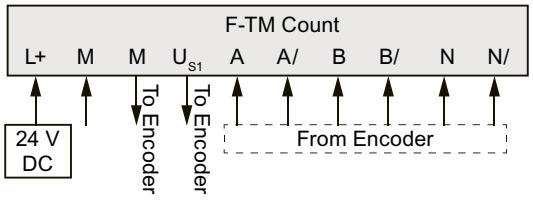
5.1 Application mode 1: A/B with N

Application mode 1: A/B with N

The F-TM Count module supports the following application mode:

- A, B differential encoder signals
- N pulse per revolution differential encoder signal

The figure below is an example of the A/B with N application mode:



NOTE

The encoder may also be powered from an external source. If an external source is used, only the M supply voltage "To Encoder" must be connected to the encoder's ground/external power source ground.

WARNING

An external source of power for the encoder must be at the same ground potential as the power source for the F-TM Count module.

Ensure that ground potential for the external power source for the encoder and the F-TM Count module power source are the same. Any potential differences in the two power sources will cause current to flow through the modules that can cause damage to F-TM Count module, power supplies and the encoder.

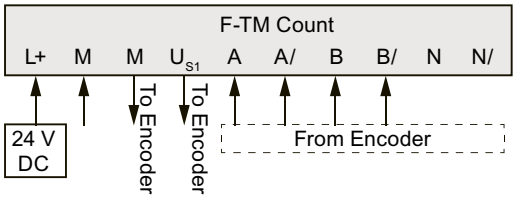
5.2 Application mode 2: A/B without N

Application mode 2: A/B without N

The F-TM Count module supports the following application mode:

- A, B differential encoder signals

The figure below is an example of the A/B without N application mode:



NOTE

The encoder may also be powered from an external source. If an external source is used, only the M supply voltage "To Encoder" must be connected to the encoder's ground/external power source ground.

WARNING

An external source of power for the encoder must be at the same ground potential as the power source for the F-TM Count module.
Ensure that ground potential for the external power source for the encoder and the F-TM Count module power source are the same. Any potential differences in the two power sources will cause current to flow through the modules that can cause damage to F-TM Count module, power supplies and the encoder.

Interrupts/diagnostic messages 6

6.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables.

The safety function requires that safe state values be applied to the fail-safe channel instead of process values (passivation of the fail-safe module or channel) in the following situations:

- When the fail-safe system is started up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, N signal plausibility monitoring or discrepancy errors)

The fail-safe CPU enters detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, the modules detect any faults that still exist.

Fail-Safe value for fail-safe modules

If the F-TM Count module input channel is passivated, the fail-safe system always provides "0" values for the count value, measured value, and event and status bits.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates the module.

Response to faults in the fail-safe system

You should prepare maintenance procedures for your system to assure that returning to operation after a detected fault is controlled and documented.

The following steps must be performed:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe module

A channel or module can be reintegrated after successful diagnostics determine that a fault has cleared. The F-TM Count module requires that counting faults such as N-signal, discrepancy, frequency, and A and B signal monitoring must be cleared for at least 10 seconds before allowing reintegration. High and low voltage diagnostics require that the input voltage returns to the allowed range for 60 seconds before reintegration is possible.

The channel to be manually reintegrated must also be acknowledged in your safety program after the fault has cleared. The bits you use for this acknowledgement are referenced in the F-I/O data blocks (under the system blocks).

The "ACK_REQ" bit for that module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Fatal diagnostic errors require a power cycle with successful diagnostics.

Reintegration after high stress events

High temperature, high voltage, and excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future failure may be increased.

⚠ WARNING

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.
Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the module, refer to the Diagnostic messages (Page 66) section.

At reintegration, the following occurs:

- Updated count value, measured value, and the event and status bits are provided to your safety program.
- Control outputs from your safety program are again transferred to the counter module.

Safety repair time

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours.
If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic messages (Page 66).

The repair time used for probability of dangerous failure per hour (PFH) and probability of dangerous failure on demand (PFD) calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

If module or channel passivation persists for 100 hours, the module is taken to a fatal error state and the module's defective buffer diagnostic message is issued. The module is recovered through a power cycle.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating F-CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

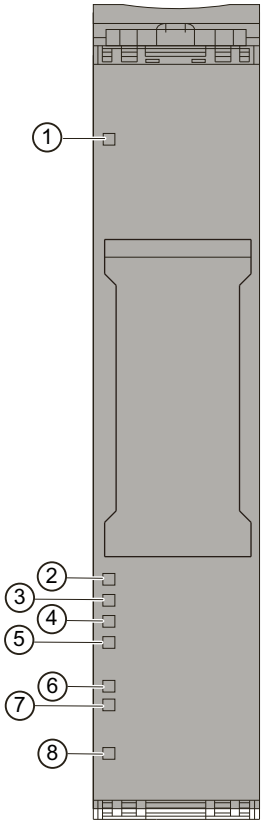
Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

6.2 Status and error display

LEDs

The following figure shows you the LED displays (status and error displays) of F-TM Count module:



①	DIAG (green/red)	⑤	N (green)
②	A (green)	⑥	UP (green)
③	B (green)	⑦	DN (green)
④	F.0 (red)	⑧	PWR (green)

Figure 1-278 LED displays of the F-TM Count

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic messages (Page 66).

DIAG LED

The DIAG LED indicates system and module faults.

Table 1-589 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP is not OK
Flashes	Module reintegratable diagnostic event has been resolved and the module or channel is awaiting reintegration. This can include the following events: • Reintegratable over-voltage error • Reintegratable under-voltage error • Module detected PROFIsafe CRC error • Module detected PROFIsafe timeout error • Reintegratable channel errors
Flashes	Module parameters are set, and module has active diagnostics (at least one error is present)
Flashes	Module parameters are not configured
On	Module parameters are configured, and module has no active diagnostics

Channel status/channel fault LEDs

The A and B LEDs indicate the current level of the associated input signals. At low counting speeds the A and B LEDs show the actual state of the signals. At higher counting speeds, the A and B LEDs will change at a limited rate to show activity. A and B LEDs flash when setting the profisafe address.

Table 1-590 Meaning of the channel status/channel fault LEDs

A/B Channel	F.0	Meaning
Off	Off	Counter input signal is at 0 level and no active channel diagnostics
On	Off	Counter input signal is at 1 level and no active channel diagnostics
Off	On	Active channel diagnostics
Flashes		Prior diagnostic event has been resolved and the channel is awaiting reintegration

N LED

The N LED indicates the current level of the counter N pulse signal from the encoder. The N LED will show the state of the N signal only when the encoder is configured as A/B with N. The N LED will be in the ON state if the N signal is disconnected (but configured).

Table 1-591 Meaning of the N LED

N	Meaning
Off	Counter N signal is at 0 level
On	Counter N signal is at 1 level

UP/DN LEDs

The UP and DN LEDs indicate the logical counting direction.

Table 1-592 Meaning of the UP and DN LEDs

UP	DN	Meaning
□ Off	□ Off	No count has been detected within the last 0.5 s.
■ On	□ Off	The last count has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count has decremented the counter and took place no more than 0.5 s ago.

PWR LED

Table 1-593 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage missing
■ On	Supply voltage is present and OK

6.3 Interrupts

Diagnostic interrupts

The F-module generates a diagnostic interrupt for each diagnostics alarm described in *Diagnostic messages* (Page 66).

The table below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module:

Table 1-594 Diagnostic interrupts of the F-TM Count module

Diagnostic interrupt	Fault code	Scope of diagnostics interrupt	Configurable
Overtemperature	16#0005	F-module	No
Parameter failure (invalid parameters)	16#0010		
Supply voltage missing	16#0011		
Mismatch of safety destination address (F_Dest_Add)	16#0040		
Safety destination address not valid (F_Dest_Add)	16#0041		
Safety source address not valid (F_Source_Add)	16#0042		
CRC1 fault	16#0047		
Inconsistent iParameters (iParCRC error)	16#004B		
Transmission error: data inconsistent (CRC error)	16#004D		
Transmission error: timeout (watchdog time 1 or 2 elapsed)	16#004E		
Module is defective	16#0100		
Watchdog tripped	16#0103		
Invalid/inconsistent firmware present	16#011B		
Diagnostic queue overflow	16#013E		

Diagnostic interrupt	Fault code	Scope of diagnostics interrupt	Configurable
F-address memory not accessible	16#030D	F-module	No
No valid F-address available	16#030E		
Undertemperature	16#0312		
Supply voltage too high	16#0321		
Supply voltage too low	16#0322		
Load voltage too low	16#0324		
No pulses detected	16#030A	Channel	Yes
Sensor signal flutters	16#0310		No
Failure in the input circuit	16#0313		
Internal discrepancy failure	16#0315		
Illegal A/B signal ratio	16#0500		Yes
Frequency outside specification	16#0501		No

6.4 Diagnostic messages

Diagnostic alarms

The display of diagnostics is in plain text in STEP 7 in the online and diagnostics view. You can evaluate the error codes with your safety program.

NOTE

If you use a GSDML file for configuration, the diagnostic alarm text is only available in the project that installed the GSDML. The fault codes may be different, but the CPU diagnostic buffer will match the diagnostic alarm text in the table below.

NOTE

Some solutions below suggest pulling (removing) and plugging (reinserting) the module. For technology modules such as this one, L+ power must be switched off prior to pulling and plugging the module.

The following diagnostics can be signaled:

Table 1-595 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Fault code	Meaning	Solution
Overtemperature	16#0005	An excessively high temperature was measured in the F-module.	• Operate the F-module within the specified temperature range (see Technical specifications). • Once the temperature has been reduced and returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Parameter failure (invalid parameters)	16#0010	On detection of invalid parameters, the module remains present in the system but goes to an unparameterized state and the	Check the i-Parameter CRC, i-parameter, and PROFIsafe parameter assigned to

Diagnostics alarm	Fault code	Meaning	Solution
		module LEDs give an immediate indication of the fault. The module is included in STEP 7 (TIA Portal V17 or later), which includes detailed dependency checks. However, configuration may also be accomplished using the GSDML, which contains limited dependency checking. This error is seen when using the GSDML to configure the module since there is limited dependency checking performed by the GSDML. Possible causes: • i-Parameter CRC error • Invalid i-parameters (for example, invalid selection, parameter out-of-range, unsupported feature selected, and wrong value of reserved field) • Any PROFIsafe parameterization problem detected by the PROFIsafe driver	the F-module in the GSDML configuration.
Supply voltage missing	16#0011	Missing or insufficient supply voltage L+ Possible causes: • Operating the F-module outside the specified supply voltage range • Critical overvoltage range exceeded	• Operate the F-module within the specified supply voltage range. • After a critical over-voltage event, once the voltage returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Mismatch of safety destination address (F_Dest_Add)	16#0040	The PROFIsafe driver has detected a different F-destination address. Checked after new parameters received.	• Check the parameter assignment of the PROFIsafe address assigned to the F-module. • Reassign or reinitialize the PROFIsafe F-addresses using STEP 7.
Safety destination address not valid (F_Dest_Add)	16#0041	The PROFIsafe driver has detected an invalid destination address. Checked after new parameters received.	
Safety source address not valid (F_Source_Add)	16#0042	The PROFIsafe driver has detected a source address mismatch or an invalid source address. Checked after new parameters received.	
CRC1 fault	16#0047	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present.	• Check PROFINET or PROFIBUS communications between the F-module and F-CPU. • Eliminate the electromagnetic interference. • Power switched OFF and ON for station. • Reassign or reinitialize the PROFIsafe F-addresses using STEP 7.
Inconsistent iParameters (iParCRC error)	16#004B		
Transmission error: data inconsistent (CRC error)	16#004D		
Transmission error: timeout (watchdog time 1 or 2 elapsed)	16#004E	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Adjust F-monitoring time. • Adjust the F-runtime group cycle time. • Ensure that communication is functioning correctly.

Diagnostics alarm	Fault code	Meaning	Solution
Invalid/inconsistent firmware present	16#011B	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module. • Power cycle to restore the module to the firmware versions prior to getting the error.
Diagnostic queue overflow	16#013E	Overflow of the diagnostics memory. It was not possible to send all pending diagnostics. This error can lead to deactivation of the F-module.	Remedy the cause of the diagnostics surge.
No pulses detected	16#030A	The expected number of pulses was not received within a given revolution, where the revolution is determined by the module receiving an active N signal event. Possible causes: • There is a faulty N signal. • The "Pulses per revolution" configuration does not match the encoder's pulses per revolution. • The module is configured to use the N signal, but the encoder does not use an N signal or there is a wire break. • There is noise on the N signal line.	• Check the N signal process wiring. • Check the parameter is set to match the sinusoidal cycles per revolution.
F-address memory not accessible	16#030D	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
No valid F-address available	16#030E	The electronic coding element contains an invalid F-address.	Assign a PROFIsafe address to the F-module.
Module is defective	16#0100	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner. • Encoder frequencies received above 250kHz. In this situation, the module is not defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • Ensure encoder frequencies below 200kHz and reapply power to the module. • Replace defective F-module.
Watchdog tripped	16#0103	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	
Sensor signal flutters	16#0310	An internal diagnostic has been triggered due to instability of the encoder signals. Possible causes: • Consistent presence of external electrical noise • Placing encoder signal wires in the same tray with AC power wiring or high-energy, rapidly-switching DC wiring • Using unshielded encoder cables or improper shielded encoder cables	• Ensure that you are using proper shielded cables between the encoder and the module to meet noise immunity standards. • Reduce or eliminate the electrical noise influencing the encoder. • Avoid placing encoder signal wires in the same tray with AC power wiring and high-energy, rapidly-switched DC wiring.

Diagnostics alarm	Fault code	Meaning	Solution
Undertemperature	16#0312	The minimum permissible temperature limit has been violated.	• Operate the F-module within the specified temperature range (see Technical Specifications). • Once the temperature has increased and returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Failure in the input circuit	16#0313	The F-module has detected an internal error in the input circuits. Possible cause: • F-module is defective	• Replace defective F-module.
Internal discrepancy failure	16#0315	The internal counters of the F-module have resulted in divergent count values. Possible causes: • Impermissibly high electromagnetic interference is present • Encoder failure • Excessive frequency • F-module is defective	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • Replace encoder. • Operate within specified frequency range. • Replace defective F-module.
Supply voltage too high	16#0321	The supply voltage is too high.	• Operate the F-module within the specified voltage range (see Technical Specifications). • After a critical over-voltage event, once the voltage returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Supply voltage too low	16#0322	The supply voltage is too low.	
Load voltage too low	16#0324	The encoder supply voltage is out of the allowed range. This could be because of an internal module problem or a problem external to the module.	Disconnect the encoder and power cycle the module. • If the error goes away, there could be a problem with the encoder that causes the encoder supply to be out of range. • If the error is still present after a power cycle with no encoder attached, replace defective F-module.
Illegal A/B signal ratio	16#0500	The encoder's A and B signals are outside the allowed phase shift tolerance, or the amplitude (voltage) tolerance. Possible causes: • Encoder faulty • Process wiring faulty • Wire break • F-module is defective	• Check process wiring. • Check encoder. • Replace defective F-module.
Frequency outside specification	16#0501	The maximum frequency for the F-module has been exceeded.	Reduce the frequency of the application (see Technical Specifications).

6.5 Value status (CQ HSC0)

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of the count and status values in the feedback interface. The value status is available in the process image along with the count and status values for the channel.

Value status for the F-TM Count module

The value status is additional binary information provided in the feedback interface. It is provided in the process image of the inputs (PII) at the same time as the process values. It provides information about the validity of the process inputs.

The value status is influenced by channel and module wide diagnostic results.

- 1_B: Valid process values are provided for the channel.
- 0_B: Fail-safe process values are provided for the channel.

If the F-TM Count module input channel is passivated, the fail-safe system always provides ("0") for the count value, measured value, and event and status bits.

Assignment of inputs for the value status in the PII

The input channel of the F-module is assigned a value status (CQ HSC0) in the process image of the inputs. You can find the assignment in section Address space (Page 52).

Reference

A detailed description of the evaluation and processing of the value status can be found in the *SIMATIC Safety – Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Technical specifications

7

7.1 Specifications

	6ES7136-6CB00-0CA0
General information	
Product type designation	F-TM Count, 1x1Vpp sin/cos HF
Firmware version	V1.0
FW update possible	Yes
Product version	V1.0
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	Step 7 V17 or higher: use GSDML for prior versions
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
permissible range, lower limit (DC)	20,4 V
permissible range, upper limit (DC)	28,8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	50 mA; Without load, 150 mA with 300 mA Encoder load
Encoder supply	
5 V	Yes; 5.1 V ±3.5 %
Short-circuit protection	Yes; Electronic overload protection; no protection on applying a normal or counter voltage.
Output current, max.	300 mA
Power loss	
Power loss, typ.	1,25 W
Address area	
Address space per module	
Inputs	14 byte; S7-300/400F CPU, 13 byte
Outputs	5 byte; S7-300/400F CPU, 4 byte
Digital inputs	
Number of digital inputs	1; (Counter Input)
Digital inputs, parameterizable	Yes
Digital input functions, parameterizable	
Gate start/stop	Yes

	6ES7136-6CB00-0CA0
Counter for incremental encoder	Yes
Number, max.	1
Input voltage	
Type of input voltage	sin/cos 1 Vpp; monitored to +/- 20% resolution
Input delay (for rated value of input voltage)	
Minimum pulse width for program reactions	2.5 µs for parameterization "none"
for technological functions	
parameterizable	Yes
Cable length	
shielded, max.	150 m
Encoder	
Connectable encoders	
Incremental encoder (symmetrical)	Yes; up to 200 kHz depending on cable type and length
Encoder signals, incremental encoder (symmetrical)	
Input voltage	1 Vpp, centered at 2.5 V offset
Input frequency, max.	200 kHz
Counting frequency, max.	800 kHz; with quadruple evaluation
Cable length, shielded, max.	150 m
Incremental encoder with A/B tracks, 90° phase offset	Yes; sin/cos
Incremental encoder with A/B tracks, 90° phase offset and zero track	Yes; sin/cos/zero
Interrupts/diagnostics/status information	
Diagnostics function	Yes; see chapter "Diagnostic Messages" in the manual
Alarms	
Diagnostic alarm	Yes
Hardware interrupt	No
Diagnoses	
Monitoring the supply voltage	Yes
Wire-break	Yes
Short-circuit	Yes
A/B transition error at incremental encoder	Yes
Diagnostics indication LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of the supply voltage (PWR-LED)	Yes; green LED
Channel status display	Yes; green LED
for channel diagnostics	Yes; red LED
for module diagnostics	Yes; green/red DIAG LED
Integrated Functions	
Number of counters	1
Counting frequency (counter) max.	800 kHz; with quadruple evaluation
Safety monitoring functions	
Safe Operating Stop (SOS)	Yes

	6ES7136-6CB00-0CA0
Safely-Limited Speed (SLS)	Yes
Safe Direction (SDI)	Yes
Safe Speed Monitor (SSM)	Yes
Counting functions	
Continuous counting	Yes
Counter response parameterizable	Yes
Software gate	Yes
Counting range, parameterizable	Yes
Measuring functions	
Measuring range	
Frequency measurement, min.	Hz
Frequency measurement, max.	800 kHz
Cycle duration measurement, min.	1 µs
Cycle duration measurement, max.	25 s
Velocity measurement, min.	0; (user defined units)
Velocity measurement, max.	2147483; +/- (user defined units)
Accuracy	
Frequency measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Cycle duration measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Velocity measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Potential separation	
Potential separation channels	
between the channels	No; Only one channel is available
between the channels and backplane bus	Yes
Between the channels and load voltage L+	No
between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
Performance level according to ISO 13849-1	Cat. 4, PL e
SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
Low demand mode: PFDavg in accordance with SIL 1	2.00E-03 signal monitoring disabled

	6ES7136-6CB00-0CA0
Low demand mode: PFDavg in accordance with SIL 3	< 3.00E-05
High demand/continuous mode: PFH in accordance with SIL 1	< 3.00E-08 1/h signal monitoring disabled
High demand/continuous mode: PFH in accordance with SIL 3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
horizontal installation, min.	0 °C
horizontal installation, max.	60 °C
vertical installation, min.	0 °C
vertical installation, max.	50 °C
Altitude during operation relating to sea level	
Ambient air temperature-barometric pressure-altitude	On request: Ambient temperatures lower than 0 °C (without condensation) and/or installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	42 g

Response times

A

A.1 Maximum response time of the system

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (https://support.industry.siemens.com/cs/ww/en/view/58856512)" Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{cycle} parameter value in the following paragraph includes an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

A.2 Response times of the F-TM Count module

Maximum response time of the F-module input values

$T_{WCDT_i} = T_{cycle} * 2$

Where:

T_{cycle} 6 ms	Internal cycle time of the fail-safe module
T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the fail-safe module's counter input to the reliable availability of the safety message frame available for the fail-safe CPU request

Count, status, and event values are reported during each T_{cycle}. In situations where an individual count of a movement is slower than T_{cycle}, the same value can be reported across one or more T_{cycles}.

The response time for counts, status, and event values is essentially a single T_{cycle}. For output image register commands, the response time behavior $T_{cycle} * 2$ applies. The maximum response time is defined as twice the cycle time for simplicity.

Maximum fault response time of the F-module input

$T_{WCDT_i} = (T_{cycle} * 2) + T_{signal}$ (when moving)

$T_{OFDT_i} = (T_{cycle} * 2) + T_{diagrep}$ (when not moving or moving slower than a single count per second)

Where:

T_{cycle} 6 ms	Internal cycle time of the fail-safe module
$T_{diagrep}$ 250 ms	Internal diagnostic repetition rate
T_{OFDT_i}	One Fault Delay Time: Maximum response time for the fail-safe module to report a channel as passivated
T_{signal} 20 ms	Maximum transition time of the signal monitoring error output
T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the fail-safe module's counter input to the reliable availability of the safety message frame available for the fail-safe CPU request

Response times that use measured value

Measured values are calculated and updated by the module to the F-CPU at the rate specified by the configured "Update time". Safety reaction times that use measured values in your safety program (for example, SLS) are therefore dependent on the configured update time. Refer to Measured value determination (Page 13) to calculate measure values.

Parameter data record

B

B.1 Parameter defaults and dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the setting of some parameters are dependent on each other.

F-TM Count module and encoder

The following are F-TM Count module default parameters:

Channel activation	Count/Pos input	Measuring	Signal monitoring
Enabled	Enabled	Enabled	Enabled

The following are encoder default parameters:

Signal type	Invert direction	Pulses per revolution	Signal evaluation	Reaction to N signal
Sin/Cos	Disabled	1024	Quadruple	No reaction

The following are F-TM Count default parameters using STEP 7 or GSD:

	High limit	Start value	Low limit	Counting violation	Reset upon violation	Reaction to Gate start
STEP 7	2147483647	0	-2147483648	Continue	Start value	Set to start
GSD	2147483647 [1]	0 [1]	0 [1],[2]	Continue	Start value	Set to start

[1] Parameter errors result whenever "Low Limit" >= "High Limit", "High Limit" < "Start Value", or "Start Value" < "Low Limit".

[2] Signed values are not supported using FCT V2.0. Negative values must be entered as their equivalent two's compliment values (for example, 2147483648 = - 2147483648 and 4294967295 = -1).

Measured value

The following are measured value default parameters:

Measured value	Update time	Time base (velocity)	Counts/Unit (velocity)
Frequency	100	0	1
Period	100	0	1
Velocity	100	0	1

Safety monitoring

The following are safety monitoring default parameters:

SOS enable	SDI enable	SLS enable
Disabled	Disabled	Disabled [1]

SOS tolerance	SDI tolerance	SLS speed
0	0	0

[1] When SLS is enabled, a measured value other than velocity will result in a parameter error.

PLC data types

C

C.1 PLC data types for F-TM Count

PLC data types for F-TM Count

Fail-Safe compliant PLC user-defined data types (UDTs) for the F-TM-C module are available from SIOS. These PLC data types define and represent the F-TM-C input image register and the F-TM-C output image register. You can import these PLC data types into your TIA Portal project using "External source files" in the project tree.

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/view/109792746)

SIEMENS

SIMATIC

ET 200SP
F-TM ServoDrive ST 1x24V..48V

Equipment Manual

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Introduction

1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Purpose of the documentation

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE
The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109781459).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE
A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE
Recommendation relating to third-party products
This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.
You can use equivalent products from other manufacturers.
Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.4 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.5 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Figure 1-279 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:



Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:



Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)



YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet. (https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 FAQ

You will find FAQs on TM Drive on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.4.2 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.



Figure 1-280 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals
- Downloads
- Compatibility tool
- Newsletter with product selection

- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.3 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Intended use of hardware products
This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.
Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.
EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions 2

2.1 General safety instructions

⚠ WARNING

Electric shock and danger to life due to other energy sources
Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance
Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance
Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

⚠ WARNING

Electric shock if there is no ground connection
For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

⚠ WARNING

Electric shock due to connection to an unsuitable power supply
When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

⚠ WARNING

Electric shock due to equipment damage
Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

⚠ WARNING

Electric shock due to unconnected cable shield
Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

⚠ WARNING

Arcing when a plug connection is opened during operation
Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection
An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

⚠ WARNING

Electromagnetic interference due to inadequate shield support
A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

⚠ WARNING

Active implant malfunctions due to electromagnetic fields
Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

⚠ CAUTION

Symptomatic respiratory and skin reaction to chemicals
A newly purchased product might contain traces of substances that are identified as sensitizers.
Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.
Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

⚠ WARNING

Unexpected machine movement caused by radio devices or cellphones
Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

⚠ CAUTION

Radio frequency interference in residential areas
When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.
When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances
Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position
The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests
High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests
High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

⚠ WARNING

Unexpected movement of machines caused by inactive safety functions
Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings
As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge
Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

⚠ WARNING

Unsafe operating states resulting from software manipulation
Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation
2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter

3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system offers the necessary flexibility and performance for a wide range of control applications.

The F-TM ServoDrive ST is a product from the TM Drive range of modules in the ET 200SP network. The term TM Drive is synonymous with the F-TM ServoDrive ST in this manual.

The F-TM ServoDrive ST technology module offers you the following application possibilities:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

The F-TM ServoDrive has proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

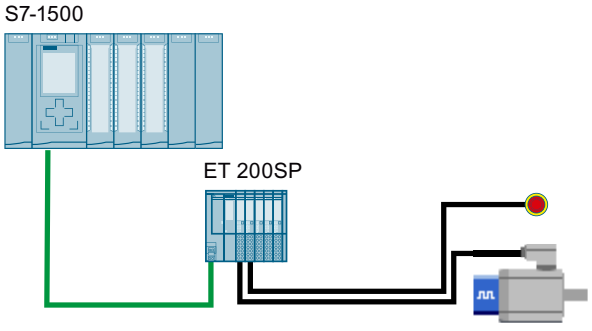


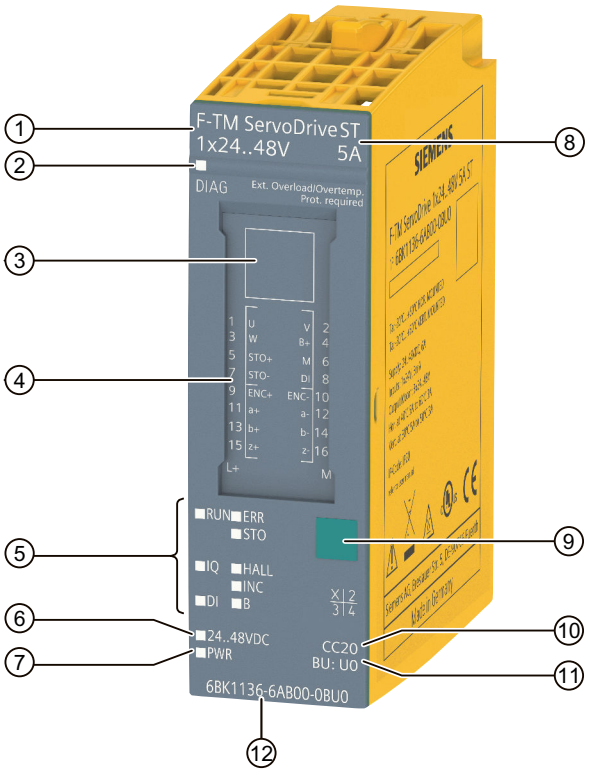
Figure 1-281 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6AB00-0BU0

View of the module



①	Module type and designation	⑧	Function class
②	LED for diagnostics	⑨	Color coding of module type
③	2D matrix code	⑩	Color code for selection of the color-coded labels
④	Wiring diagram	⑪	BU type
⑤	LEDs for motor control	⑫	Article number
⑥	LED for supply voltage		
⑦	LED for power		

Figure 1-282 View of the F-TM ServoDrive module

Properties

The F-TM ServoDrive has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of IQ encoder technology
- Support of incremental encoders with (A, B, Z track)
- 24 V digital input
- Support of individually configurable motors (permanent-magnet synchronous motors (PMSM))
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Braking chopper, external braking resistor
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 as of V16

Accessories

The following accessories that are not included in the module's scope of delivery can be used with the module:

Designation	Article number
Feed BaseUnit (light)*	6ES7193-6BP00-0DU0
Expansion BaseUnit (dark)*	6ES7193-6BP00-0BU0
MCB, B, 6 A	5SY6106-6
MCB, B, 10 A	5SY6110-6
MCB, B, 6 A for UL markets	5SJ4106-6HG40
MCB, B, 10 A for UL markets	5SJ4110-6HG40
Shield connection	6ES7193-6SC00-1AM0

* A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For additional information on accessories such as:

- Labeling strips
- Color-coded labels
- Reference identification labels

refer to the System Manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

Unsuitable electronic fuses

Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

F-TM ServoDrive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

F-TM ServoDrive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

The TM Drive supports the following communication types:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.
- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.
- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 43).

Potential group

Up to a continuous input current of max. 10 A for each potential group, up to 3 TM Drives can be connected together to form a drive line-up.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (e.g. TDK Electronics 2-wire filter B84113C series) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group. For a potential group with only one TM Drive, we recommend using an appropriate miniature circuit breaker with 6 A nominal current and characteristic B.
- You must not use voltage sources with low impedance such as supercaps without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short-circuit, it is still imperative to rectify the fault before switching it on again. Otherwise, the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers
(https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

SCCR (short circuit current rating)

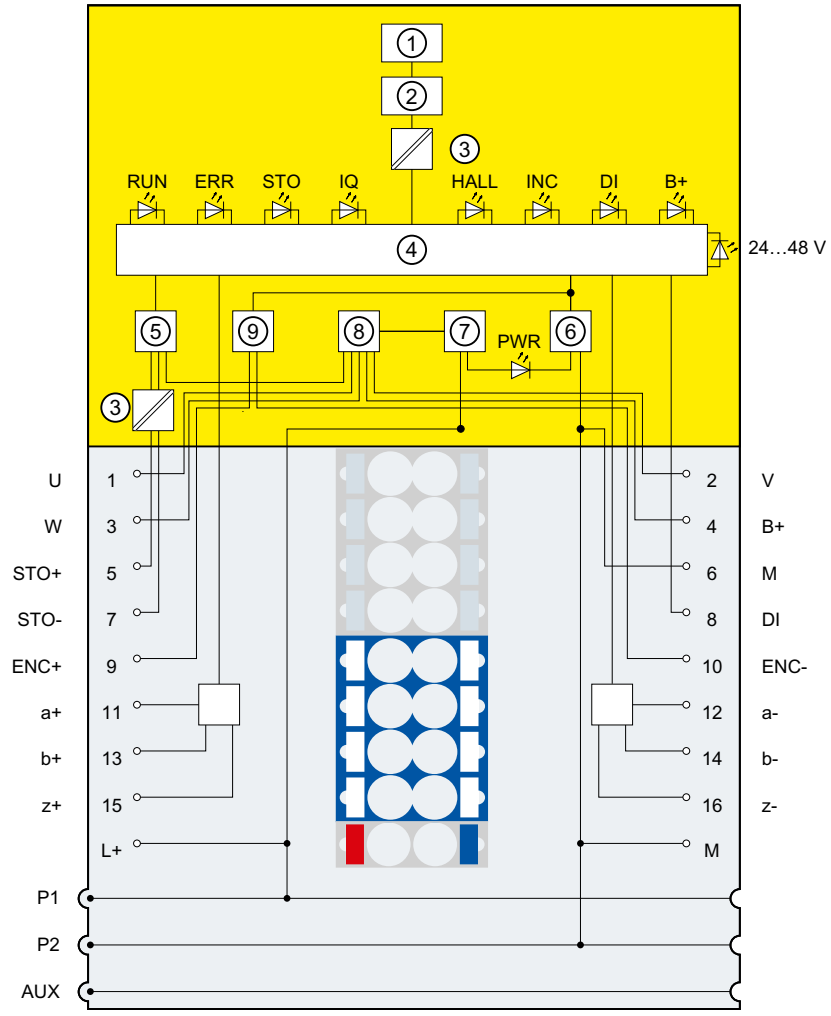
Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

⚠ WARNING

Fuse for the load circuit
In general, use a suitable overcurrent protection device to protect the F-TM ServoDrive.

Schematic circuit diagram



①	Backplane bus	**PMSM**	
②	Backplane bus interface module of the technology controller	U	Phase U
③	Electrical isolation	V	Phase V
④	Technology controller	W	Phase W
⑤	Safe Torque Off circuitry	B+	Connection of braking resistor
		Encoder supply	
⑥	Digital input circuit	ENC+	Power supply encoder 5 V

⑦	Power supply/Preparation
⑧	Reverse polarity protection
⑨	Power electronics
⑩	Encoder power supply
Power supply	
L+	Power supply 24 - 48 V
M	Power supply GND
Inputs	
STO+	STO+ input (24 V)
M	Negative connection, e.g. for braking resistor
STO-	Negative STO input
DI	Digital input
ENC-	Power supply encoder, negative connection
Incremental / IQ encoder	
a+	Differential encoder signal a+
a-	Differential encoder signal a-
b+	Differential encoder signal b+
b-	Differential encoder signal b-
z+	Differential encoder signal z+
z-	Differential encoder signal z-

Figure 1-283 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 1-596 Wiring rules for the interfaces

Connector	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
U/V/W	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
B+	Connection of external braking resistor	2 m	≥ 0.5 m shielded
a, b, z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair
STO	Safe Torque Off	10 m	-

* American Wire Gauge

CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.

NOTE

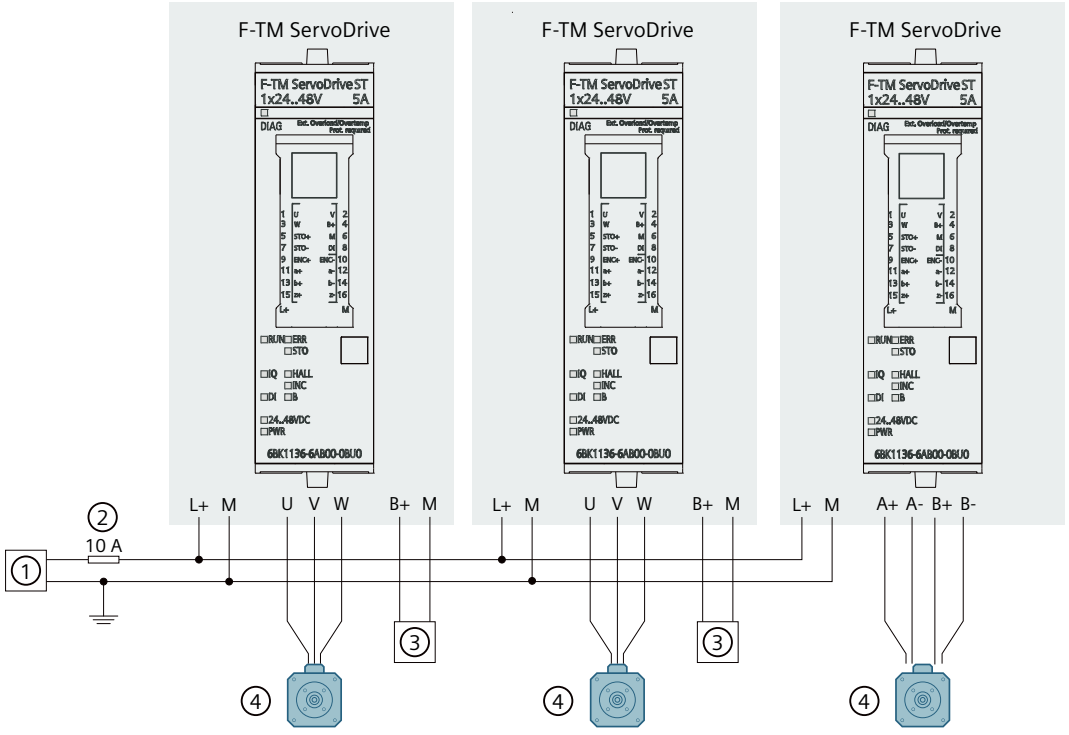
In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple F-TM ServoDrive

In a potential group

You can connect multiple TM Drives to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drives to form a drive line-up



① Power supply unit
② Protective device
③ Braking resistor
④ Motor

Figure 1-284 Wiring of multiple TM Drives to form a drive line-up

See also

Pin assignment (Page 28)

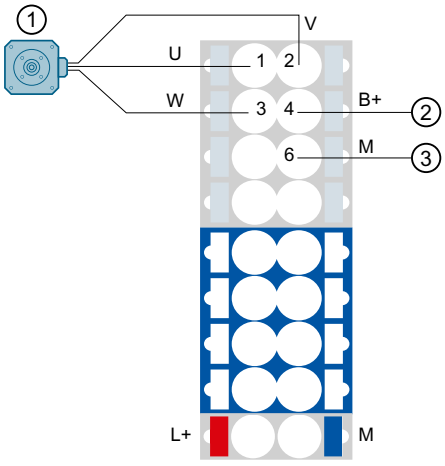
4.4 Connecting the motor

Overview

The F-TM ServoDrive supports permanent-magnet synchronous motors (PMSM).

Connecting the motor phases (PMSM)

The following figure shows the connection of the motor phases to the BaseUnit:



①	PMSM	②	Braking resistor
U, V, W	Motor phases	③	Negative connection for braking resistor

Figure 1-285 Connecting the motor

NOTE
In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	B+	Braking resistor
6	M	Negative connection, e.g. for braking resistor

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

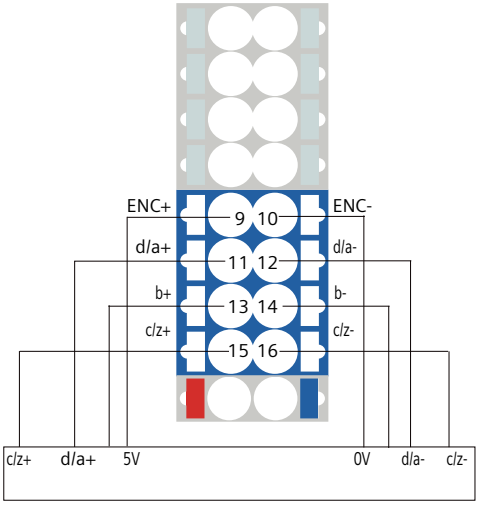


Figure 1-286 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 1-597 Power supply and signal processing conditions of the incremental encoder

Encoder property	Range/Value
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V
	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V

*The quadrature interface results in a maximum step resolution of 2000 kHz.

Encoder property	Range/Value
Maximum current consumption of the encoder	150 mA
Encoder output	Push Pull
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz.

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting IQ-Encoders

Motors from the SIMATIC MICRO-DRIVE Product Partner Program have an IQ encoder.
The following figure shows the connection of IQ encoders to the BaseUnit.

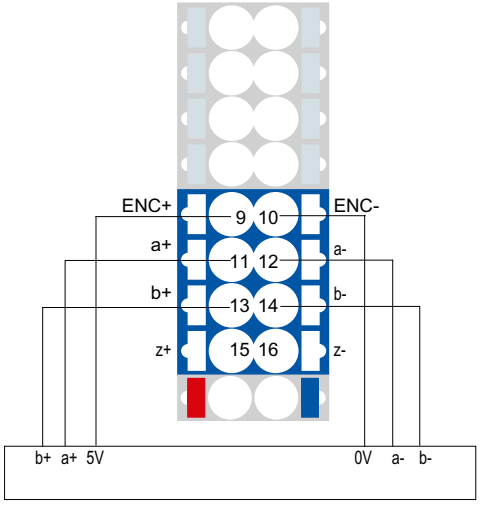


Figure 1-287 IQ encoder connection with differential signals

Pin assignment of IQ encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	-
16	z-	-

Specifying the encoder interface

You connect the IQ encoder to the incremental encoder inputs like a two-channel standard incremental encoder. The polar wheel angle information is also transmitted via the interface (see Technical specifications (Page 133)).

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.3 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

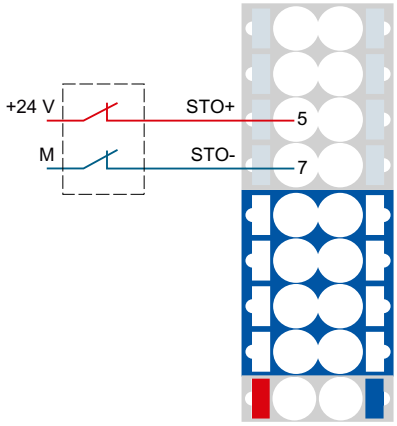
⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO



STO+ STO input 24 V
STO- STO input, negative connection

Figure 1-288 Connection of Hardware STO

NOTE
Use different voltage supplies for the STO inputs and for the power supply.

Table 1-598 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

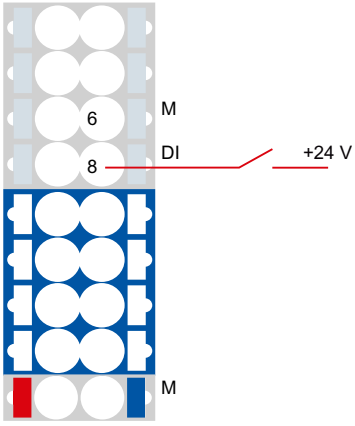
Route the hardware STO (STO+/STO-) cables separately from other cables, especially power cables.

Minimize the risk of crushing and short-circuits in ground connections by using appropriate routing.

Exclude premature aging of the cables due to continuous UV radiation.

4.5.4 Connecting the 24 V digital input

Connecting a 24 V digital input



DI 24 V digital input
M Ground

Figure 1-289 24 V digital input connection

Table 1-599 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

4.6 Connecting an external braking resistor

External braking resistor

To ensure high dynamics of the drive due to fast acceleration and braking ramps, you need to connect a braking resistor to the TM Drive.

Recommendation: Use a braking resistor for power supplies with low intrinsic capacitance or an unregulated six-pulse bridge circuit (B6U).

A connected external braking resistor must be activated in the configuration software.

⚠ CAUTION

Risk of burns due to high surface temperature of the braking resistor

The braking resistor can become very hot. Touching the surface can cause severe burns.

- Mount the braking resistor so that it cannot be touched. In situations in which this is not possible, attach a clearly visible and understandable warning notice in areas at risk.

Wiring a non-Siemens external braking resistor

WARNING

Damage to braking resistor – Risk of fire!
If you use a non-Siemens external braking resistor, connect an overtemperature detection device to a digital input (e.g. a bimetallic switch that opens when the temperature is too high).
Implement fire prevention measures for the external braking resistor (e.g. fire protection housing, temperature fuse). The resistance of the externally connectable braking resistor must be ≥ 5 ohms.
Design the required power as a function of the braking energy to be converted.

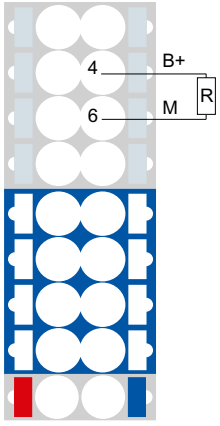
Connection for external braking resistor

Table 1-600 Connection of external braking resistor

Function	Maximum cable length	Cable type	Cable cross-section
Connection of external braking resistor	2 m	≥ 0.5 m shielded	Solid and stranded supply cable: AWG: 18 to 14 or 1.0 mm^2 to 2.5 mm^2

Wiring an external braking resistor

The figure below shows the connection of an external braking resistor as an example:



B+ Positive terminal of braking resistor
M Negative terminal of braking resistor

Figure 1-290 Connection of external braking resistor

Pin assignment

Table 1-601 Pin assignment: Wiring an external braking resistor

Pin	Designation	Function
4	B+	Connection of external braking resistor
6	M	

External braking resistor for potential group with multiple TM Drives

If you have connected multiple TM Drives to form a potential group, it may be sufficient to equip only one module with an external braking resistor.

Safety functions integrated in the drive

5

5.1 Basic safety information

5.1.1 General safety information

⚠ WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM ServoDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM ServoDrive documentation.
- Consider the residual risks for the risk evaluation.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

⚠ WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 133)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

⚠ WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 139).

Examples of safety devices and 3 F-TM ServoDrive

NOTE
The supply voltage for the STO inputs must be different from that of the power supply.

The following figure shows various safety devices that are connected to 3 F-TM ServoDrive.

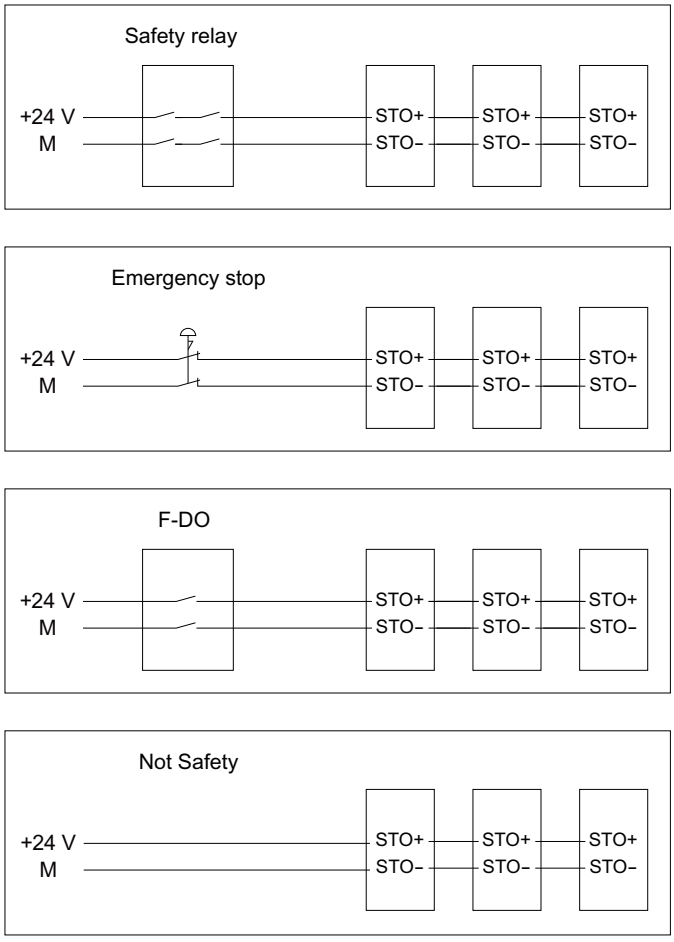


Figure 1-291 Safety devices and 3 F-TM ServoDrive

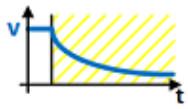
NOTE
The F-TM ServoDrive does not support startup protection.
Measure:
Startup protection via additional safety relay or in higher-level controller, depending on the safety requirements.

Operating voltage range

Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

5.1.4.1 Safe Torque Off (STO)



Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM ServoDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

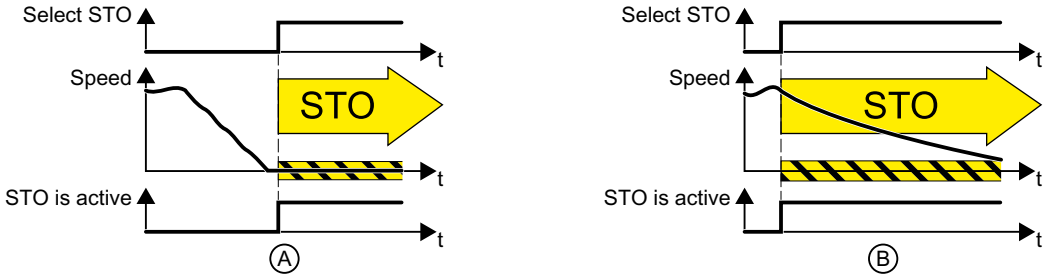


Figure 1-292 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a PMSM. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

The STO function can be used when the motor is already at a standstill. If the motor is in operation, the STO function causes the drive to coast down.

The STO function enables safe working when the protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM ServoDrive internally monitors the fail-safe digital input at the STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM ServoDrive is therefore not needed.

⚠ WARNING

Forced checking procedure

You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) of the corresponding standards are a measure of the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 2 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

The standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies for the functional safety of variable-speed drives.

Function groups

The safety functions are divided into the following function groups for the F-TM ServoDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM ServoDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 1-602 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM ServoDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM ServoDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal HW fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EC Machinery Directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.
  See "Acceptance test" below in this section.
  For the F-TM ServoDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.
  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring
Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

⚠ WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test
Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 1-603 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 1-604 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 1-605 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 1-606 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	
2.	**Switch on motor**	

No.	Description		Status
2.	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer
Professional execution of the above-stated tests and checks is confirmed.

Table 1-607 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer
The correctness of the parameter assignment documented above is confirmed.

Table 1-608 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM ServoDrive drive system meet the following requirements:

- Safety Integrity Level SIL 2 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM ServoDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM ServoDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system
  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM ServoDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM ServoDrive

For information on how to perform the electrical wiring for the F-TM ServoDrive, refer to section Wiring (Page 28)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 36).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

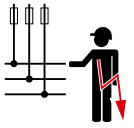
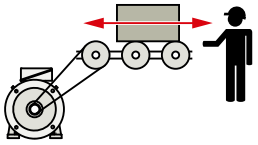
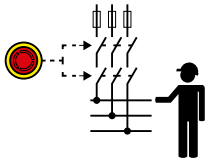
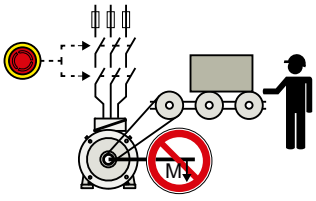
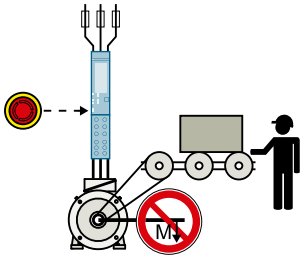
EMERGENCY OFF Risk of electric shock	**EMERGENCY STOP** Risk of unexpected movement
	

Table 1-609 Measures and solutions

Command	**EMERGENCY OFF**	**EMERGENCY STOP**
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 	Switch off the drive power supply. 
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO.  You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring

6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring an ET 200SP TM Drive.

You can perform the following tasks, for example, with STEP 7 (TIA Portal):

- You configure the TM Drive (insert into the project and configure input addresses)
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 24)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 28).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).
- You have installed the HSP0311.

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

For acceptance of the system, you must use the safety summary created according to the above manual.

Configuring a TM Drive (minimum configuration)

To configure a TM Drive, follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.
4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.

6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 1-610 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Siemens telegram 102 PZD-10/6	Speed setpoint 32 bits with one position encoder and torque reduction	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Dynamic torque reduction (MOMRED) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These values provide the current **incremental and, for absolute encoders, also the absolute actual position** of the measuring system and are read cyclically by the "Positioning axis" technology object, for example, and processed accordingly (see also section 8.3 (Page 122)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the position actual value is structured as follows:

- G1_XIST1 is aligned right
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.
- Shift factor for G1_XIST1 and G1_XIST2 is 2

NOTE

Dependence on the configured encoder resolution
The single-turn value ("increments / revolution") in Gx_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 1-611 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 130).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "increments per revolution" with a fine resolution of 2:

Table 1-612 Structure G1_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 1-613 Structure G1_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 IQ encoder

If you are using a motor from the Siemens Product Partner Program with IQ encoder (incremental encoder) and have configured this accordingly for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 1-614 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Default: 100 Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 130).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Table 1-615 Structure G1_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 1-616 Structure G1_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

Parameter assignment is also possible via data sets (see appendix Data sets (Page 142)).

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning a TM Drive

⚠ CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury
Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 41) before commissioning and before operation.

⚠ WARNING

Personal injury and property damage from the collapse of a suspended axis
If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected collapse of a suspended axis can result in personal injury and property damage.
Before commissioning, you need to ensure that a cross brace is fitted to hold the suspended axis in place and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Personal injury and property damage from the collapse of a suspended axis
An unexpected collapse of a suspended axis can result in personal injury and property damage.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE

Performing tests
You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.
Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform parameter assignment as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Online & diagnostics
- Parameters
- Device configuration

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Define telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):
  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:
  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM Engineering.

- Drive:
  Drive data set, General settings, Motor, Motor gear, Thermal model, DC link voltage, Brake module
- Setpoint channel:
  Reference values, application limits, ramp-function generator
- Open-loop/closed-loop control:
  Control type, controller settings, speed controller, current controller
- Messages/monitoring
  Motor (thermal motor type), power output stage (utilization)

NOTE
The F-TM ServoDrive is not able to provide a holding torque for locking the drive.
In the application, especially note that abrupt movement of the axis can occur when lifting and lowering loads.

"Commissioning" area

Contents in the "Commissioning" area of the TM Drive TM Engineering.

- Configuration:
  Link to the parameter dialog
- Identification:
  Identification mode
  Encoder and pole position identification
  Encoder values
- Tuning:
  Calculate speed/current controller values
  Tuning the speed controller
  Transfer controller values to drive parameters

See also

PMSM drive parameters (Page 75)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

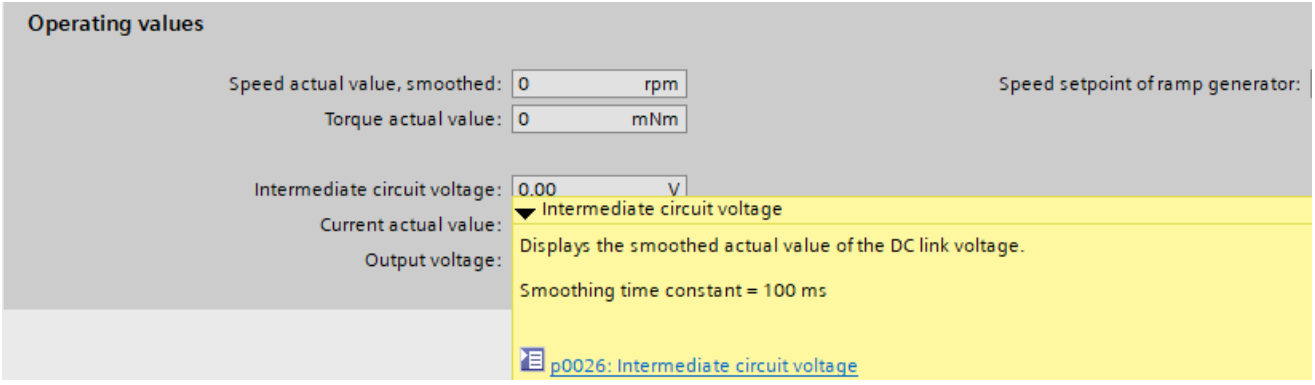


Figure 1-293 DC link voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.
  Or
- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

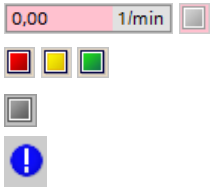
P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

1,0000 Nm	Project (offline)	Parameter value can be changed and stored in the project.
48,0 V	Project (offline)	The parameter value is write-protected.
24,0 V	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the engineering of the TM Drive:



Drive value (online) could not be determined

Bit parameter active (1-signal)

Bit parameter inactive (0-signal)

Binding values to be set by the commissioning engineer

Automatic check of the configured drive parameters

The configured parameters are checked both in STEP 7 and in the drive in order to detect incorrect parameter assignments and possible functional restrictions even before commissioning.

Both warning and error messages are output. In STEP 7, you obtain additional information and corrective measures about the respective message.

The causes of errors in the drive parameterization that prevent the drive from operating are listed below.

Parameter group	Possible causes of error
Motor	Electrical time constants of the connected motor are too low
	Torque constant is not consistent with other motor parameters
Encoders	Motor/encoder combination is not permitted
Speed/current controller	Controller parameters have not yet been set or are not permissible
DC link voltage	DC link volage limits are prohibited
Brake module	Brake chopper settings are not permitted

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Constraints

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Conditions

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You need to activate the drive via a new drive command.
- If you send an invalid parameter to the F-TM ServoDrive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 28)
  - Configuring (Page 58)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?

Module installation and wiring

- Is the TM Drive plugged in / installed and firmly connected or screwed in according to the assembly plan and the configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the F-TM ServoDrive and the motor?

- Is the digital input connected?
- Was an external braking resistor optionally connected to the F-TM ServoDrive?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive.

Table 1-617 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data set	Use one of the following options in the "Import drive data set" dialog under "Parameters > Drive": • Select pre-configured drive data set from list • Import drive data from file system	Drive data sets (Page 71)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp-function generator	Setpoint channel (Page 85)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Speed control (cascade) (Page 90)
4	Configure DC link voltage monitoring and optionally the brake module	• Define limits for the DC link voltage • Brake chopper settings • Motor holding brake settings	DC link voltage monitoring (Page 101)
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 107)

Step	Procedure	Comments	See section ...
6	Optional: Depending on motor type and encoder, determine commutation angle offset and encoder values	• Perform automatic encoder identification in commissioning under "Encoder identification".	Setting the commutation angle offset and pole position identification (Page 79)
7	Optional: Perform automatic controlled system detection	• Automatic controlled system detection can be performed for setting the current and speed controller in the commissioning under "Controlled system detection".	Automatic controlled system detection
8	Optional: Perform online optimization	• Tuning the speed controller	Section Manual controller tuning Speed controller (cascade)

7.4 Drive data sets

Introduction

So that you can optimally handle the requirements of drive technology, the TM Drive drive system is compatible with motors (Dunkermotoren, ebm-papst) and connecting cables (Harting, KnorrTec) of proven product partners of Siemens. This allows you to optimally combine suitable products from proven product partners for your individual application.

You can find more information about the Siemens Product Partner Program in the Internet (https://new.siemens.com/global/en/products/drives/sinamics/servo-drive-system-simatic-micro-drive.html).

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection system, electrical safety, EMC, etc., as described in this manual.

Drive data record

The motor or drive configuration of the TM Drive drive system is configured using a drive data set (DDS). A drive data record contains the settings and information for the following drive components:

- Motor
- Motor gear
- Thermal motor model

NOTE

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive system supports PMSM. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the product information Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The motor encoder (p0404) can be selected based on the motor type (p0300). The following combinations are available:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)

(1) Incremental encoder (A, B, Z track)
When selecting encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also called I-track) can be connected as an index track to identify the pole position.

(5) IQ encoder
If you are using a motor with IQ encoder, you must select the encoder type IQ encoder.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 107) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Download preconfigured drive data sets as a file for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460).
- Create a user-defined drive data record and configure your motor manually.

NOTE
In TM Drive engineering, the drive parameters can only be edited in the "Parameters" > "Drive" area if you are using a user-defined drive data record.

NOTICE

After a change of the drive data record, you must adapt or optimize the parameters for the current and speed controllers, if necessary.
See section Speed control (cascade) (Page 90).

7.4.2 Using preconfigured drive data sets

You have the option of using preconfigured drive data sets for configuring your motor. You can obtain preconfigured drive data sets for selected motors from Siemens Industry Online Support or product partners.

Installing the drive data record

Pre-configured drive data sets are provided as a file (tms *.mpk) and must be installed in STEP 7 engineering. A drive data record file can contain the configuration of one or more motors.

Expand the list of drives by installing new drive data sets from the file system:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Click "Install the drive data record"  and select one or more drive data record files that you want to install.
5. Confirm the disclaimer by clicking on "I agree".
   If you do not agree to the disclaimer, close the dialog with "Cancel". In this case, no drive data record file will be installed.

You have installed a drive data record and can now use it.

NOTE

An installed drive data record is installed locally on the PG/PC only for the current STEP 7 version. To open the local installation folder, click the "Locally installed drives" link in the "Configure drive data record" wizard.

Using a preconfigured drive data record

You can search for the desired drive in the list of all locally installed drives.

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Select the desired drive from the list under "Search here for drive or enter filter".
5. The selected drive data record is displayed in the report area and you can check the data.
6. Accept the configuration with "Yes".

You have selected and set up a preconfigured drive data record.

NOTE
You can pass on a saved engineering project with preconfigured drive data record or use it on a different PG/PC on which the utilized drive is not installed. In this case, no optional additional information on the drive is displayed, e.g. manufacturer or order number. This is displayed as soon as you have installed the utilized drive.

7.4.3 Drive data export / import

In addition to the pre-defined drive data sets, custom drive data sets can also be exported and imported.

The standard CSV format with ',' (comma) as column separator including a line header is used.

The data is stored according to the file header and also read in again on the basis of this line.

The formatting of decimal numbers is region-independent using a '.' (dot) as the decimal separator.

For negative values, the value must be preceded by a '-' (minus).

UTF-8 is defined as the character coding.

The header line is defined as follows:

##PNU(mandatory)##,##name##,##value(mandatory)##,##unit##,##dataType##, ##group##,##ECLASS number##

- Motor
- Motor gear
- Encoders
- Thermal model
- Motor holding brake

All parameters contained in the CSV file are included in an import. The CSV file can be customized and, for example, unused parameters can be removed. For example, only one parameter can be imported.

The parameters are assigned via the PNU, where the value must be present. Name, unit, data type and ECLASS number are used for better readability and are ignored during import.

Quotation marks and spaces are hidden during import, which is why no further commas are supported except for column separation.

Export drive data

The existing drive parameter assignments can be exported and saved as a file (*.csv) from STEP 7 Engineering.

1. Open "Parameters" > "Drive".
2. Start the export via the "Export drive data set..." button in the "Drive data set" area.
3. In the "Save" dialog, select a folder and the file name and confirm with "Save".

Import drive data

The drive parameter assignment can be imported as a file (*.csv) in STEP 7 Engineering. A drive data set may contain all or part of the parameters supported by the TM Drive used.

NOTE
Importing the drive parameter assignments overwrites all parameters with the values contained in the csv file.
Parameters not contained in the drive data set are not changed and retain their value.
The "Undo" function is not possible for the "Import drive data set" function.
Save your parameter assignments before importing a drive data set.

1. Open "Parameters" > "Drive".
2. Start the configuration wizard via the "Import drive data set..." button in the "Drive data set" area.
3. Select the "Import drive data set from file system" option.
4. Select the drive data set (*.csv) via the file folder button.
5. The drive data set is displayed in the log area and you can check the data.
6. Apply the configuration with "Yes".

Status messages about the import are displayed in the Inspector window in the General tab.

7.4.4 Using a user-defined drive data set

Create a user-defined drive data set and configure your motor manually.

You can freely configure the current drive data at any time, even if it was imported via a pre-defined drive data set or a parameter table.

⚠ WARNING
Avoiding incorrect parameter assignments
Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

See also

Motor (Page 108)
PI DS ServoDrive (https://support.industry.siemens.com/cs/ww/en/view/109773204)

7.4.5 PMSM drive parameters

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0304	Nominal voltage	Refer to the motor data sheet for the nominal voltage of the motor. The nominal data of the motor are based on this voltage.	V

p0305	Nominal current	The nominal motor current is the current value at which the motor delivers its nominal power and nominal torque under nominal conditions. The nominal current value refers to the ambient conditions specified by the motor manufacturer. If, for example, the motor ambient temperature differs from that of the motor manufacturer, the nominal current must be adjusted according to the manufacturer's specifications.	A
p0311	Nominal speed	Nominal motor speed is the speed at which the nominal values of the motor are valid.	rpm
p0312	Nominal torque	Nominal torque is the torque at the nominal operating point of the machine.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0323	Maximum current	The maximum current is the maximum motor current permitted for a short time. The motor can be operated briefly up to this current without resulting in damage, but continuous operation is only permissible up to the maximum nominal current. The maximum current can flow until the limitation of the thermal model intervenes. Specifications such as permissible motor peak currents, e.g: for the duration of 1 s, are not to be entered here.	A
p0316	Torque constant	The torque constant of the motor is the proportionality factor between the RMS current of the q current and the internal torque of the motor. The motor torque is calculated from this constant.	mNm/A
p0314	Number of pole pairs	Number of pole pairs of the motor. For example, an 8-pole motor has 4 pole pairs	-
p0372	Connection resistance (= internal resistance)	Connection resistance of the motor between two motor phases.	Ohm
p0376	Connection inductance q component (=winding inductance q)	Connection inductance between two motor phases in the q axis. When only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0377	Motor connection inductance d component (=winding inductance d)	Connection inductance between two motor phases in the d axis. If only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH

p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p0318	Standstill current (= holding current)	The standstill current of the motor corresponds to the current value with which the motor can be permanently loaded at standstill under the ambient conditions specified by the motor manufacturer.	A
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.6 Motor encoder

7.4.6.1 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Parameter number	Name	Description	Unit
Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

Depending on the motor type, you can select the following encoders:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)

7.4.6.2 Encoder parameters incremental encoder and IQ encoder

The encoder types incremental encoder and IQ encoder use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder, IQ encoder

The increments per revolution must be set for the incremental encoder and the IQ encoder. The increments can be independently detected at the incremental encoder by the automatic encoder detection of the TM Drive.

7.4.6.3 Assign encoder counting direction parameters

For encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting parameter p0410, Invert encoder counting direction. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows.

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

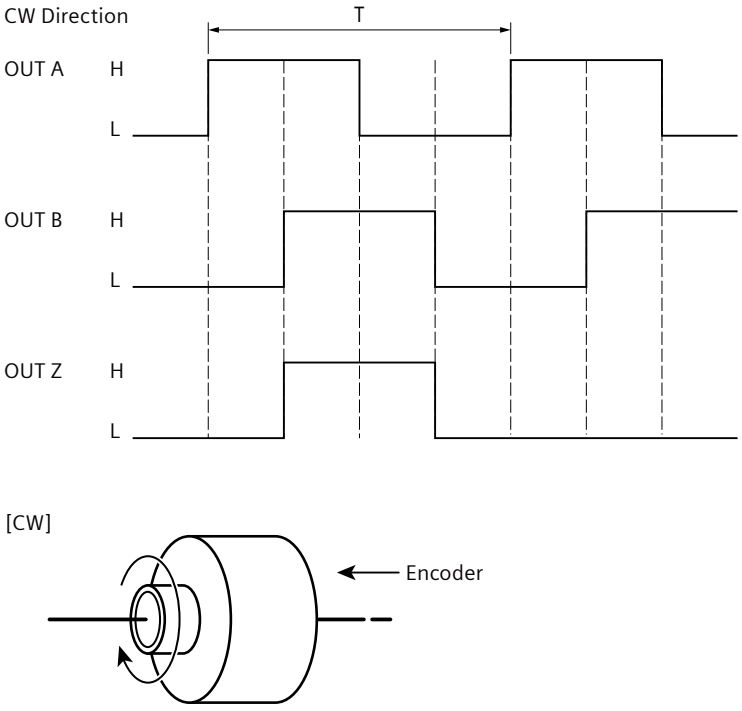


Figure 1-294 Direction of rotation for the incremental encoder

Definition:
A positive speed in TM Drive is defined as follows:
The motor rotates clockwise looking down on the motor shaft. The encoder value increments during this process.

Table 1-618 **Additional encoder values**

Parameter number	Name	Description	Unit
p0410	Reverse encoder counting direction	This setting negates the counting direction of the encoder.	-

7.4.6.4 Setting the commutation angle offset and pole position identification

For the commutation of a PMSM with the encoder type

- [1] Incremental encoder (A, B, Z track)

it is necessary to know the commutation angle offset or to determine it.
The commutation angle offset is the angle offset between a reference (Z-track for incremental encoders and the rotor / pole position).

Encoder calibration at each start (p1990)
If the parameter (p1990) "Encoder calibration at each start" is set, the determination of the commutation offset angle is repeated, for example, by voltage interruption at each restart or after each configuration of the drive.
If the parameter (p1990) is not selected, the value entered in the commutation angle offset (p0431) is used for commutation. If the offset angle is known, this can either be entered or

automatically determined by TM Drive (see section Automatic encoder / pole position identification (Page 83)).

NOTE

Incremental encoder

After a new configuration or after switching off the power supply, the pole position is unknown when using an incremental encoder. If the parameter (p1990) "Encoder calibration at each start" is not set, the motor control is speed controlled with a fixed motor (running) current depending on the motor current parameters until there is synchronization of the pole position.

If synchronization with the Z-track is not possible, the control is aborted.

If the rotor position has not yet been synchronized, the drive may be twisted by an external load. If you want to prevent the drive from rotating directly after drive activation, you can use the Additional torque parameter (p1511) to ensure that a corresponding hold torque is applied to the motor (see section Speed control (cascade) (Page 90)).

NOTE

Motor replacement

When replacing the motor, remember that the motor encoder in a motor series is not always calibrated in the same way.

If the encoder calibration is selected at every start, no further action is required.

If this is not the case, the commutation angle offset must be determined again in the encoder / pole position identification (see section Automatic encoder / pole position identification (Page 83)).

⚠ WARNING

Incorrectly set commutation offset angle

It must always be ensured that the commutation offset angle is set correctly.

Otherwise, there will be insufficient control of the drive and it will not achieve its full performance or it will proceed in an uncontrolled manner.

Table 1-619 Additional encoder values

Parameter number	Name	Description	Unit
p1990	Encoder calibration at each start	If this option is selected, the commutation angle offset is determined again at every restart (new configuration or switching off the supply voltage). It is recommended to determine the commutation angle offset once during commissioning. Calibration is then no longer necessary, except when replacing the motor.	-
p0431	Commutation angle offset	Setting of the commutation angle offset. The commutation angle offset is the angle between the rotor pole position and the 0° degree pulse of the encoder. If the angle offset is not known, it can be determined by the module during commissioning. The offset angle is defined as follows. Incremental encoder:	-

Parameter number	Name	Description	Unit
		0° offset is present if the Z pulse is applied at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. Absolute encoder: 0° offset is present if the angle value is 0 at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. **Warning:** **An incorrectly set commutation angle offset can lead to uncontrolled behavior of the drive!**	

7.4.6.5 Calibration process of the commutation angle offset

When selecting parameter p1990 "Encoder calibration at each start", the TM Drive restarts the calibration process of the motor pole angle after:

- Every initial enable of the drive
- Every time the power supply is switched on again
- After re-configuration
- If certain malfunctions of the module occur

After that, the TM Drive references with the determined offset angle over the Z-track.

The motor is energized for the calibration process and thereby generates torque.

The motor current is limited by:

- Prospective locked rotor current (p0318)
- Equivalent current from the nominal torque of the motor (p0312)
- The equivalent current from the torque limitation (p1520)
- The maximum converter current

The smaller limitation in each case takes effect.

A possibly existing motor holding brake must be opened, so that a rotation of the motor is possible. If the motor holding brake is configured via the TM Drive and connected accordingly, the task of opening the holding brake is assumed by the TM Drive.

NOTE

If you have selected (p1990) "Encoder calibration at each start", the drive must retrain itself at initial commissioning and each time the power supply is switched back on or a new project download is performed. This process can take between 1 - 4 seconds. The motor can move by a maximum of 180° / number of pole pairs. Such movement must be possible in the application.

The following constraints must be observed:

- The motor must be able to rotate freely in both directions of rotation and the axis must not be loaded with a static load.
- With suspended loads, the option (p1900) "Encoder calibration at every start" must not be used.
- It is recommended to use a TM Drive with absolute encoder function and corresponding motor especially for suspended loads.
- The calibration process cannot be performed when the axis is rotating, or the speed must be below the standstill detection p1226.

NOTICE

Open motor holding brake

The motor holding brake is opened during calibration of the commutation angle offset. Especially with suspended axes, it is therefore important to ensure that it is possible to open the motor holding brake.

An unexpected collapse of a suspended axis can result in personal injury and property damage.

Before commissioning, you must ensure that a cross brace is fitted to hold the suspended axis in position and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Motor movement by measurement on unbraked motors

The measurement can be used to trigger a rotation or movement of the motor via the specified current on unbraked motors. The magnitude of the movement depends on the specified current as well as on the moment of inertia of motor and load.

7.4.6.6 Automatic encoder / pole position identification

Automatic encoder pole position identification is found in the Commissioning submenu of the configured TM Drive. This function is only possible with the PMSM motor type. Incremental encoders can be detected. Depending on the encoder type, the following encoder / motor parameters are automatically detected:

Incremental encoder (1)

- Commutation angle offset (p0431)
- Number of pole pairs (p0314)
- Increments per revolution (p0408)
- Invert encoder counting direction (p0410)

For automatic encoder / pole position identification please proceed as follows:

Preconditions

- Motor type PMSM
- The motor parameters are known and the calculation of the controller parameters under open-loop/closed-loop control has been performed and transferred to the drive.
- The device is in RUN state and the drive is at standstill.
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during encoder detection, the commutation offset angle may not be correctly detected. The motor can then only deliver a reduced torque.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the encoder / pole position identifier.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:
The configured motor type and motor encoder is displayed under Commissioning encoder / Pole position identification. Insert the identification current allowed for the test. This is always automatically set to the rated motor current. However, it can be adjusted if required.

NOTE
If the motor is already installed in an application, you may need to increase the identification current in steps. The motor maximum current p0323 must not be exceeded. If necessary, observe idle times between the identification cycles to avoid overheating the motor. Especially for motors with an increased cogging torque, it may be necessary to increase the identification current so that the encoder and pole position information can be accurately detected.

Step 3:
Start the encoder / pole position identification with the selection button "Start encoder detection".

A configured motor holding brake is opened during encoder / pole position identification. This is signaled via ZSW1 bit 12 both in the process image and in data set 209.

NOTICE

Open motor holding brake
The motor holding brake is opened during encoder / pole position identification. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a suspended axis can result in personal injury and property damage.

Step 4:
If the drive is still in operation, execution of the identification commands is rejected. Stop the operation of the drive before the encoder / pole position identification. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the identification after the confirmation of the safety prompt. It is necessary that the drive can be turned safely in both directions.

Step 5:
If the encoder / pole position identification is successfully executed, the determined values are displayed.

NOTE
Before you apply the determined values, you need to check them for plausibility.

Step 6:
You can now select which of the determined values you want to transfer to the offline project. By clicking the "Transfer determined values to offline project" button, the selected values are transferred to the offline project.

NOTE
The determined settings are stored only temporarily on the module. They are replaced by the permanently stored parameters on the next restart.
If you want to store the settings permanently on the module, change the drive parameters offline and download them again with "Download to device".

Step 7:
When you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device".

Encoder / pole position identification is completed. The option "Encoder calibration at each start" (p1990) is no longer required and should be deselected.

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 86)
- Application limits (Page 86)
- Ramp-function generator and speed setpoint filter (Page 88)

The figure below shows the processing of the speed setpoint in the drive controller.

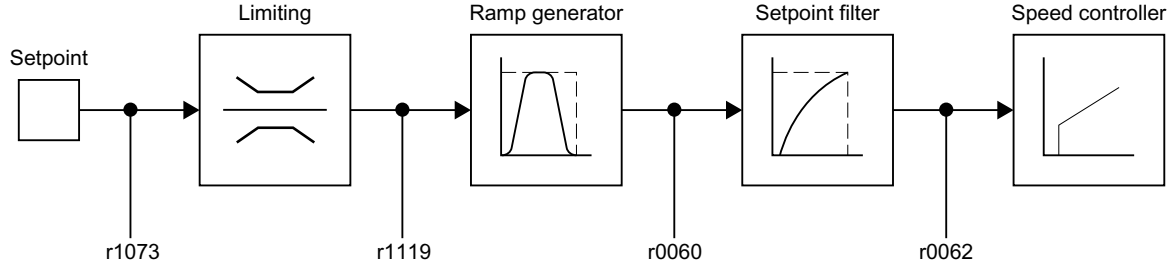


Figure 1-295 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 86).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 86).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp-function generator and speed setpoint filter (Page 88).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.
- Torques are normalized to the reference torque (p2003) in the drive telegram.

Parameters p2000 and p2003 are definitive as reference values (telegram content = 4000 hex or 4000 0000 hex for double words, if the input value has the value p2000 or p2003).

Example of the normalization of the speed:

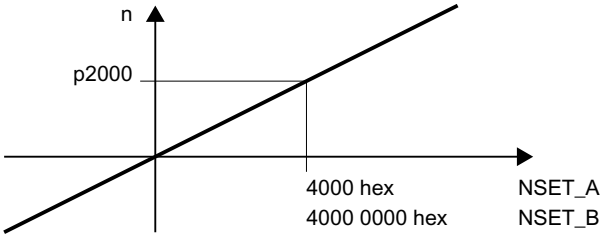


Figure 1-296 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.
Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:
   "Parameters" > "Setpoint channel" > "Reference values".

⚠ WARNING

Uncontrolled drive behavior
Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur. We therefore recommend that commissioning of the drive and thus specification of the references values be completed first before you commission the CPU and, for example, a technology object.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent limiting of the speed p1083 and p1086, you can define speed limits for each direction.

Torque limiting

You can specify the torque limitation p1520 as an absolute value. The limiting acts both when motoring as well as generating.

⚠ WARNING

Accuracy of torque limitation
The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.
The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.
Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Internal motor constant p0316
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses

⚠ WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment
Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.
Ensure the correct parameterization.

Zero speed detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).
As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.
If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted
as soon as the it falls below the speed threshold for the standstill detection.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)
  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)
  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback
- "On delay time" (p2167)
  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

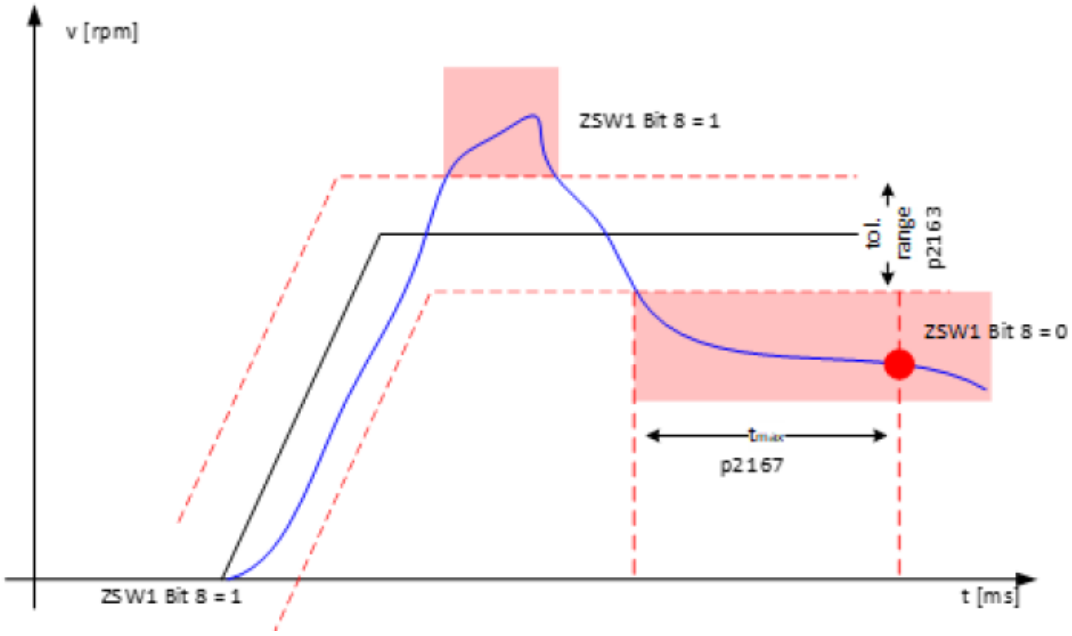


Figure 1-297 Speed setpoint - actual value deviation within tolerance

7.5.3 Ramp-function generator and speed setpoint filter

Speed ramp-function generator

The TM Drive uses the speed ramp-function generator type "Basic ramp-function generator" p1115[0].

The ramp-function generator can be switched off with the setting "No ramp-function generator".

The speed ramp-function generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

NOTE
On principle, the ramp-up and ramp-down times of the ramp-function generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.

Procedure

You enter the settings for the speed ramp-function generator under "Parameters" > "Parameters" > "Ramp-function generator":

- Rampup time
- Ramp-down time
- Speed

NOTE
The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp-function generator ramp-up time" (p1120) and "Speed ramp-function generator ramp-down time" (p1121).
When using the GSD file, directly enter the values relative to 10,000 rpm.

Speed setpoint filter

The drive has a first-order time-delay element (low pass PT1) as a speed setpoint filter. The filter time constant can be set with p1416.

The speed setpoint filter is able to attenuate harmonic components of the setpoint and thus to prevent any overshooting of the higher-level controller.

The speed setpoint filter has no effect on the stability of the speed controller because it is in the setpoint channel before the control loop. The dynamics of the response to setpoint changes is reduced by smoothing.

As a rule, set the speed setpoint filter to a low value, since the upstream ramp-function generator ensures sufficient limitation of the setpoint signal.

7.6 Controller settings

7.6.1 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type. The following combinations are available:

Motor type: PMSM motor

- [100] Closed-loop speed control (cascade)

7.6.2 Speed control (cascade)

In Speed controller (cascade) mode, the speed difference between the actual and the nominal speed is detected using an encoder and the speed deviation is controlled accordingly. Since the speed controller is followed by a current controller, this speed control method is referred to as cascade control.

General controller settings

Speed and current controllers can be optimally tuned if the properties of the load mechanics of your machine and the electrical properties of the drive are specified as correctly as possible.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399
- Additional torque p1511
- Speed actual value filter p1441

Speed stability can be improved using the actual speed filter, depending on the encoder resolution.

Constant loads can be compensated using additional torque p1511. This reduces compensation processes when the drive is switched on using motor holding brakes.

Additional important settings

The values for speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Precontrol p1496

Using the precontrol (p1496), the precontrol of the moments of inertia, consisting of Motor (p0341), Motor gear (p2725) and Moment of inertia load (p1496), can be specified as a percentage value. The precontrol allows the drive to be moved more dynamically. The precontrol is switched off with a preset of 0%. The precontrol is preset by the automatic controlled system detection (see section Automatic controlled system detection (Page 93)) depending on the controller dynamics.

To use this function, the setpoint speed must be preset by a ramp. For this, you can either use the internal ramp-function generator (see section Ramp-function generator and speed setpoint filter) or corresponding acceleration/deceleration functions in technology objects.

Viscous friction p1399

The friction of the system is precontrolled using Viscous friction (p1399). This is specified as a linear friction torque as a function of the speed and is detected during automatic controlled system detection.

Additional torque p1511

Constant loads can be compensated using additional torque (p1511). This reduces compensation processes when the drive is switched on using motor holding brakes.

Speed actual value filter p1441

The drive has a first-order time-delay element (low pass PT1) as a speed actual value filter. The filter time constant can be set via (p1441).

The parameter is preset depending on the parameter "Increments per revolution" p0408 in the HSP. If you configure the device using a GSDML, you can use the following table as a guide.

Table 1-620 Actual speed filter times as a function of the encoder resolution

Encoder resolution (Steps per revolution p0409 or [2]Single-turn resolution p0423)	**Speed actual value filter p1441 in ms**
400	11
512	10
1024	8
2048	6
4096	4
6000	2
10000	1
16000	0

Speed controller and current controller

You can either have the speed and current controller parameters calculated via the controller settings of STEP 7 or you can perform the automatic controlled system detection (7.6.2). It is also possible to set the controller settings manually.

Having controller settings calculated
To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click the "Calculate speed number/current controller settings" button in the area for the controller settings.
   The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. If needed, you can re-adjust the controller settings via the "Controller behavior" and "Load fluctuation" sliders.
   – "Controller behavior": If the value is increased, the controllers react more strongly to controller differences. At the same time, the controller tends to overshoot.
   The default setting here is 70%.
   – "Load fluctuation": A larger value allows more oscillation in the stable state. The speed deviations are greater during a load step.
   The default setting here is 30%.

NOTE
There is no guarantee that readjustment of the controller calculation will always result in a stable system.
Change the settings for "Controller behavior" and "Load fluctuation" incrementally. Always check the settings with low speed and load profiles.

3. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually
Enter the settings for the speed controller under "Parameters" > "Control/closed-loop control" > "Speed controller".

- Prop. gain
- Integral action time
- Speed setpoint filter
- Speed actual value filter

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Iq proportional gain
- Iq integral action time
- Id proportional gain
- Id integral action time

NOTE

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.
Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.3 Automatic controlled system detection

You can find the automatic controlled system detection in the Commissioning submenu of the configured TM Drive. This function is only possible with the cascade control mode (p1300).

During the measurement run, the system is measured using test signals. The drive is moved in the process. Configured torque (p1520) and speed limits (p1083 and p1086) are taken into account and can also be used to protect the drive or the application.

The drive accelerates to the test setpoint speed, stops and executes the same travel profile in the reverse direction of rotation. The motor is thereby approximately at the starting position again after the measurement run.

The "Reversal of direction of rotation" checkbox can be used to specify the direction of rotation for the measurement run. If the check box is selected, the motor rotates counterclockwise when viewing the motor shaft, otherwise the motor shaft rotates clockwise. By specifying the number of motor revolutions, it is possible to limit the maximum rotation of the drive. The input of the number of revolutions limits the test setpoint speed if necessary.

The following parameters are automatically determined during controlled system detection:

- Motor connection resistance including motor cable line resistance
- Current control parameters
  - Iq proportional gain p1715
  - Iq integral action time p1717
  - Id proportional gain p1735
  - Id integral action time p1736
- Speed controller parameters
  - Prop.gain p1460
  - Integral action time p1462
- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399

The controlled system detection function automatically provides you with the controller parameters specific to your application and motor.

The controlled system detection function can be adapted to different system requirements.

The connection resistance of the system is detected during the controlled system detection. The determined resistance is divided between the connection resistance (p0372) and the resistance of the motor supply line (p0352).

- If the measured resistance is greater than the connection resistance (p0372), the additional portion is allocated to the motor cable line resistance (p0352).
- If the measured resistance is less than the connection resistance (p0372), this is adjusted and the portion of the motor cable line resistance (p0352) is set to 0.

⚠ WARNING

Unplanned movement of the motor during speed controller tuning
Speed controller tuning causes movement of the drive which can result in death, serious injury or material damage.

- Ensure that nobody is present in the hazardous zone and that the mechanical system can move freely.

NOTE

Directions of rotation and permissible motor rotation range
In the application, the motor must be able to move at least in the specified motor rotation range (p8991). The machine may be damaged if the traversing range is not accordingly limited.
If this is not permissible due to your plant conditions, it is prohibited to perform controlled system detection.
Before commissioning, ensure that the motor and application parameters are correct.

Procedure

Preconditions

- Cascade control mode
- The motor and application parameters are known and transferred to the drive.
- Speed and torque limitation are configured and transferred to the drive.
- The device is in RUN mode and the drive is at standstill
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during the controlled system detection, this may result in the speed and current controller parameters not being detected correctly.

Step 1:
Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the controlled system detection.

You can abort controlled system detection at any time by pressing the "Exit" button. The drive coasts to a stop and the motor holding brake closes. The drive may have to be returned to its start position before a new measurement run.

NOTE
In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:
Make the settings for controlled system detection.

- Measurement run dynamics p8990

  The acceleration gradient of the rotating measurement run can be influenced using the measurement run dynamics factor.

  A high value is suitable for torsionally stiff systems and low mass inertias and a low value for elastic systems or systems with high mass moment of inertia.

  Generally, a high measurement run dynamic factor provides better results for the rotating controlled system detection. However, too high a measurement run dynamics factor can possibly lead to twisting, bending or other damage to the machine.

  Recommendation: Start with a low measurement run dynamics factor and, if necessary, repeat the controlled system detection with an increased measurement run dynamics factor.

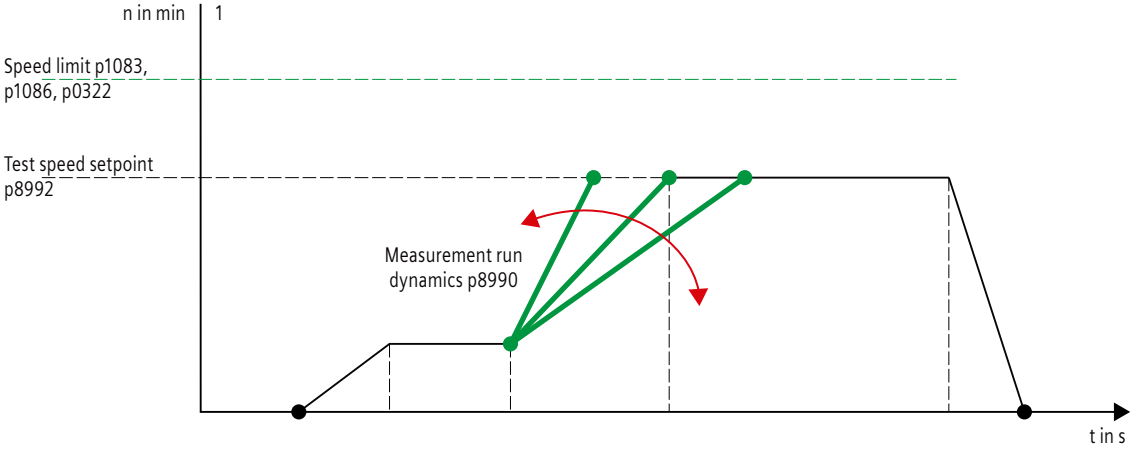


Figure 1-298 Measurement run dynamics

- Max. number of motor revolutions p8991

  Specifies how many revolutions the motor may cover during the measurement. Ensure that a rotation with the configured number of motor revolutions is possible in the direction in which the motor is moved (specified via the "Reversal of direction of rotation" check box).

- Test speed setpoint p8992

  If possible, enter a typical speed value for the test speed setpoint at which the drive is to be operated later.

  If the measurement run is not possible due to the entry from max. number of motor revolutions (p8991) in combination with the test speed setpoint (p8992), this is displayed and a maximum possible test speed setpoint (p8992) is suggested in the text box.

- Torque limitation p1520
  The torque limitation is displayed as a parameter (read only). The setting must be made in the "Application limits" mask and the parameter must be loaded into the module.
- Controller dynamic factor
  Using the controller dynamic factor, you can set how the speed controller should be set up.
  – Conservative: Slow control – low mechanical load. (60% precontrol)
  – Default: Optimum between fast speed control and load of the mechanics. (80% precontrol)
  – Dynamic: Fast speed control – high mechanical load. (100% precontrol)

  A parameter check is performed automatically. This ensures that the drive can perform the measurement run with the configured dynamics within the configured max. number of revolutions. If the measurement run with the configured values is not possible, a warning is displayed and a reduced value for the test speed setpoint is entered.

Step 3:
Start the controlled system detection with the "Start controlled system detection" selection button.

A configured motor holding brake is opened during controlled system detection. This is signaled via ZSW1 bit 12.

NOTICE
Open motor holding brake The motor holding brake is opened during controlled system detection. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a hanging axis can result in personal injury and property damage.

Step 4:
If the drive is still in operation, execution of the controlled system detection is rejected. Stop the operation of the drive before the controlled system detection. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the controlled system detection after the confirmation of the safety prompt. The drive is moved several revolutions for this.

Step 5:
After successful controlled system detection, the system variables and suitable controller values determined are displayed.

Depending on the application, it may be advantageous to perform the controlled system detection several times in succession and, if needed, to adjust the measurement run dynamics p8900.

NOTE
Before you apply the determined values, you need to check them for plausibility. If necessary, the control can be tested for stable behavior by traveling briefly in both directions (+/-).

Step 6:
You can now select which of the determined values you want to transfer to the offline project. The selected values are transferred to the offline project using the "Transfer determined values to offline project" button.

Step 7:
Once you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device". Otherwise, the parameters will be lost after switching the module off and on.

Automatic controller tuning is now complete.

Check the settings automatically found using a measurement run with your application. For additional optimization of the controller settings, you can use manual controller tuning from the section Manual controller tuning Speed controller (cascade).

NOTE
If the automatic controlled system detection could not determine any controller parameters, a new measurement run can be initiated by entering a higher moment of inertia of the load under control/closed-loop control parameters and repeating the controlled system detection. The controller parameters can thus be adapted for the machine. The measurement run is thus set to the increased inertia of the load.
You can save the measurement run to a csv file using the "Export measurement data" button.

Faults during controlled system detection

Faults during controlled system detection are displayed directly in the commissioning screen and can be acknowledged.

Table 1-621 Causes of faults and errors

Fault number	Description	Cause / Solution
1055	Motor resistance detection could not be performed	If the motor phases are not connected correctly or insufficiently contacted, or if there is an asymmetry between the individual winding resistors, the error "Unable to successfully perform motor resistance detection" is set. Check the motor connections or the motor for defects and breaks.
1056	Following error during controlled system detection	If the drive is not able to follow the setpoint travel curve, this error is displayed. In this case, it is likely that the Measurement run dynamics p8990 was selected too large. Reduce the Measurement run dynamics p8990 and repeat the controlled system detection. It is also possible that the drive is blocked or the motor holding brake has not been configured or connected correctly.
1057	Position error during controlled system detection	If the maximum number of revolutions is exceeded, e.g. by an external load acting on the drive, this error is set and the drive is switched off. Either the controlled system detection is not possible in the application or reduce the external force on the drive train.

7.6.4 Manual controller tuning Speed controller (cascade)

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure
For manual controller tuning, proceed as follows:

Step 1:
Go online to the module with TIA Portal by clicking on the "Connect online" selection button.

Step 2:
If you have not already calculated the controller parameters under Control/closed-loop control, you can do this again here. First, enter the mass moment of inertia of the load.
Use the "Calculate" selection button to calculate the controller parameters.

Step 3:
The calculated controller values are displayed. The online values, i.e. the currently active values, are also displayed on the module.

Step 4:
With the selection "Apply online" button, the new controller values are directly transferred and take effective.

NOTE
When the axis is in operation, the enable is automatically canceled and the new parameters are applied.

Step 5:
You can now put the drive into operation with a speed or positioning TO, for example, and evaluate the control behavior using a trace recording.
If the control behavior is satisfactory, continue with step 7.

Step 6:
If additional optimization is required, there are 2 options to better adjust the control parameters.

1. You can calculate the controller parameters again as described in step 2 and readjust the parameters accordingly using the sliders. (See section Control/closed-loop control under Speed controller and current controller)
2. You set the controller parameters manually. You can orientate yourself on the old values and change the proportional gain and/or the integral action time as well as the precontrol step-by-step.

Perform the steps starting with step 4 again.

Step 7:
After you have performed the optimization, you still need to transfer the detected controller parameters to the drive parameters using the selection button "Apply controller values".

Now you must disconnect the online connection ("Go offline" selection button) and then reload the project onto the module using "Download to device". This ensures that the parameters are still active in the project and on the module after a restart.

Controller tuning is now completed.

7.7 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp-function generator ramp-down (p1120, p1121).

If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or a timeout is detected, the pulses are inhibited after the motor brake closing time p1217 has elapsed. "Switching on inhibited" is activated.

Timeout
With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within 2 times of this time, the drive is de-energized and it coasts down.

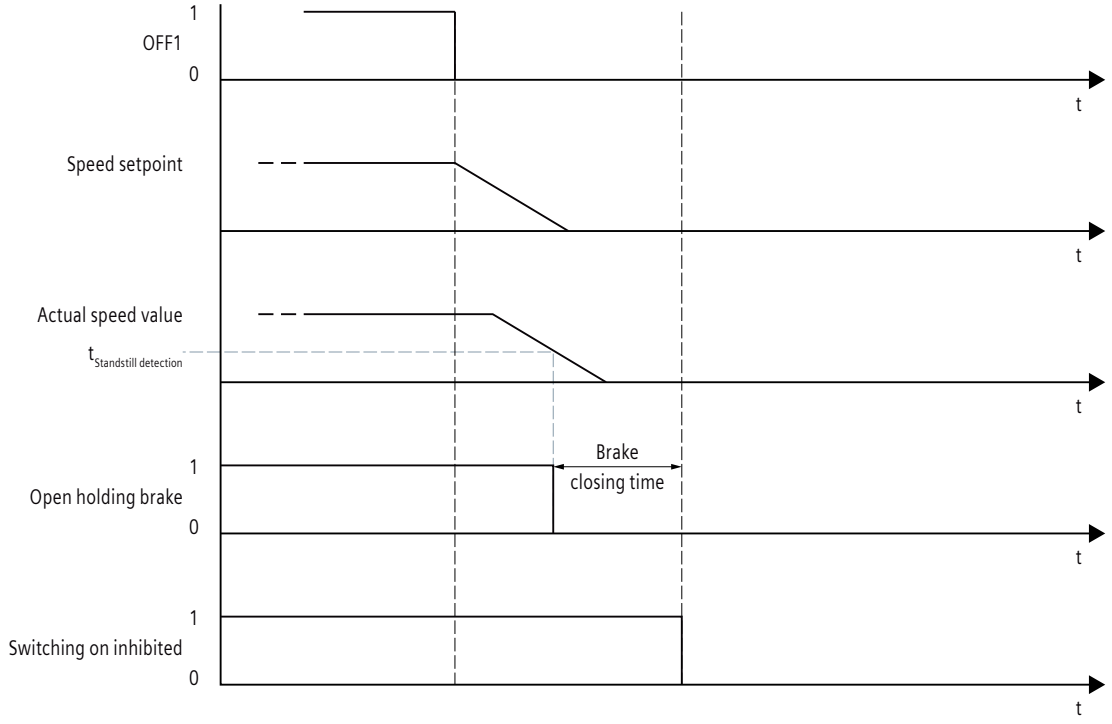


Figure 1-299 OFF1 sequence diagram when standstill detection is reached p1226

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). Immediate pulse cancellation occurs, any configured motor holding brake is closed. The drive coasts to a stop without a motor holding brake. "Switching on inhibited" is activated.

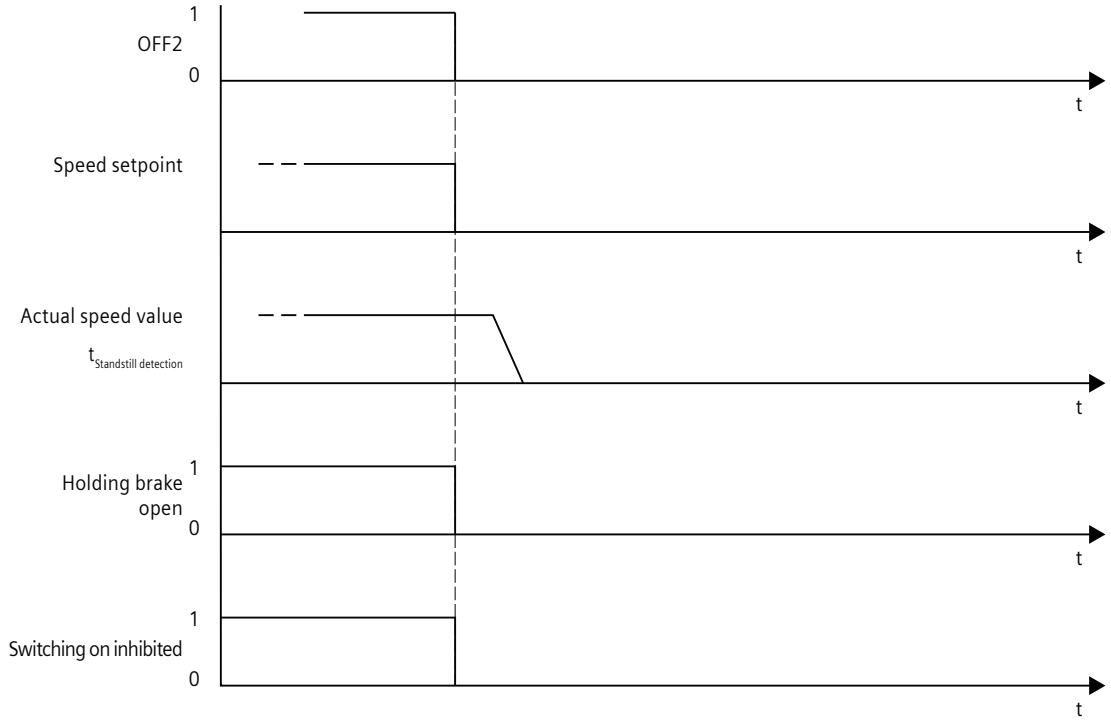


Figure 1-300 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp-function generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)
You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp-function generator").

Timeout
The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

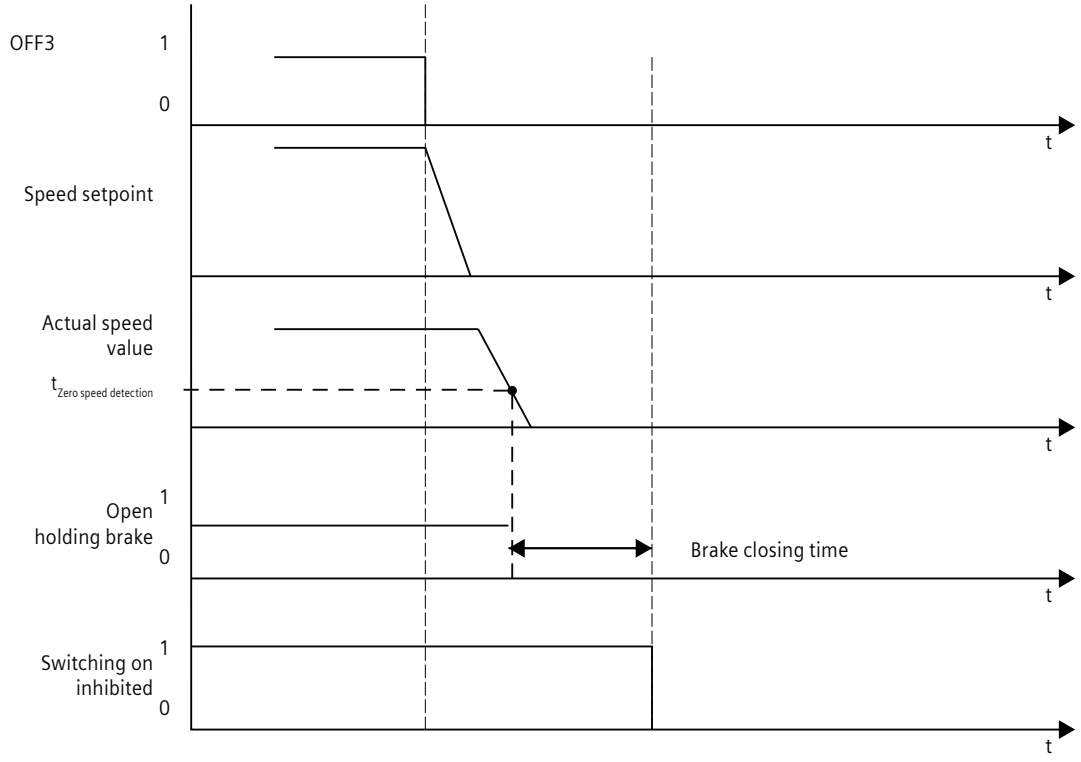


Figure 1-301 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)
- OFF2 (coast down) > OFF3 (quick stop)

7.8 DC-link voltage

The TM Drive system cyclically monitors the DC link voltage. The limits can be set under "Drive/Monitoring".

The regenerative feedback into the DC power supply cannot be suppressed. This has several advantages.

When the drive is braked and the brake chopper is not connected and configured, energy is fed back, which results in an increase in the DC link voltage. For this reason, the DC link voltage is monitored by the module.

You can freely set the DC link voltage monitoring limits within the permissible range.

If the limits are exceeded, the module switches off. Before the module switches off, it issues a warning (limit ∓ 5%) stating that the limit is almost exceeded.

Procedure

1. Open the "DC link voltage" area in the context of the drive under "Parameters" > "Drive/monitoring".
2. Configure:
   – Minimum value of the DC link voltage p0390
   – Maximum value of the DC link voltage p0391

⚠ WARNING

Operation above the voltage setting range
Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and motor gear. Otherwise, the DC link voltage may increase when the control is inactive via 60 V DC.

7.9 Brake module

7.9.1 Brake module

The TM Drive system has a brake chopper for connection of an external brake resistor and can control a motor holding brake externally via the process image using a DQ or relay module. These functions can be activated individually or in parallel.

You can select the following options for the PMSM motor type under "Brake module":

- [0] No function
- [2] Brake chopper
- [3] Brake chopper and motor holding brake external via the process image
- [4] Motor holding brake externally via the process image

7.9.2 Brake chopper

If the brake chopper function is enabled, you need to configure the following parameters in the "Parameters" > "Drive" > "Brake module" area.

Set the following values for the brake chopper:

- Chopper switch-on voltage
- Chopper switch-off voltage
- Thermal resistance of the braking resistor
- Time constant of the brake resistor
- Maximum temperature
- Ambient temperature
- Response to max. temperature

The switch-on and switch-off voltage of the brake chopper must be set correctly according to the DC voltage supply. The chopper switch-off voltage p6011 must be higher than the supply voltage (example UDC = 48 V à p6011 = 50 V; chopper switch-on voltage p6010 = 52 V).

The voltage thresholds of the brake chopper should be adjusted accordingly with the parameters of the DC link voltage monitoring (7.7).

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

NOTICE
Risk of fire The switch-off voltage must not be lower than the DC supply voltage, otherwise the brake chopper will not switch off after activation and it may lead to an overload of the brake resistor and/or the module.

Capacity of the braking chopper output
The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

You can find information about power calculation and resistor design in the appendix Braking resistor and brake chopper power (Page 140).

Monitoring of the braking resistor
The specific values of the braking resistor, such as heat resistance and time constant, can be obtained from the manufacturer of the braking resistor (data sheet). Typical values are stored as default values in the TIA Portal. The default values must be checked and adjusted if necessary.

- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

You use the maximum temperature to define the switch-off temperature for the resistor. The switch-off temperature is calculated in a thermal model based on the ambient temperature.

You use "Response to max. temperature" to define the behavior that is triggered when the maximum temperature is reached.

- Shutdown when temperature is exceeded Brake chopper operation is stopped and a warning is generated.
- No shutdown when temperature is exceeded Brake chopper operation is still possible.
- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

NOTICE
Risk of fire If braking chopper operation continues despite reaching the maximum operating temperature, this can result in a sharp increase in the temperature at the braking resistor. This can damage surrounding components or even result in fires in the worst case. In addition, always ensure that the minimum distances between the braking resistor and other modules are maintained.

⚠ CAUTION

Risk of burns due to hot surfaces
The braking resistor heats up during operation. Touching the hot braking resistor can result in personal injury and burns.
Avoid contact with the hot braking resistor.

7.9.3 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the motor shaft (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the "Parameters" > "Drive" > "Brake module" area.

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is configured, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example, with a DQ module or relay module.

NOTE

When selecting the additional module, make sure that the current carrying capacity is suitable. This must be dimensionless depending on the current consumption of the motor holding brake.

RC circuit of a TM Drive with DQ module and motor holding brake

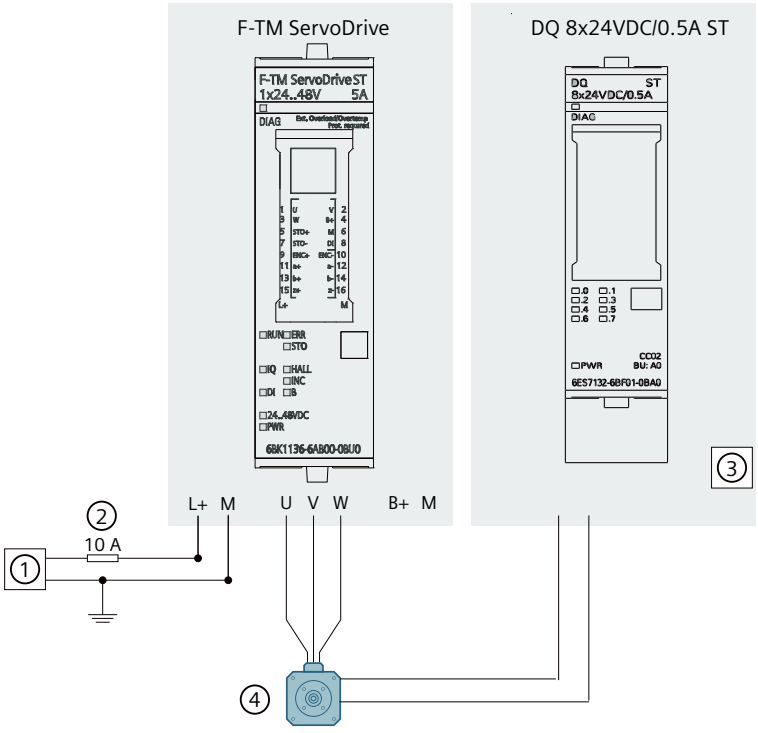


Figure 1-302 RC circuit of a TM Drive with DQ module and motor holding brake

Suspended axes

The additional torque p1511 is used to set an additional load torque.

To prevent a suspended axis without mechanical weight compensation from sagging after the holding brake is released, you can set up an electronic weight compensation via a supplementary torque p1511, section 7.8.1.

This reduces the compensation action after the release of a holding brake and specifies the holding torque directly after switch-on of the motor.

The option (p1900) "Encoder calibration at every start" must not be used with suspended loads.

NOTE

Suspended load with incremental encoder

For motors with incremental encoders where the commutation offset angle has not yet been synchronized, the axis may drop. This can be counteracted using the additional torque p1511, although a slight movement of the axis cannot be ruled out even then.

- It is recommended to use an absolute encoder especially for suspended loads.

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

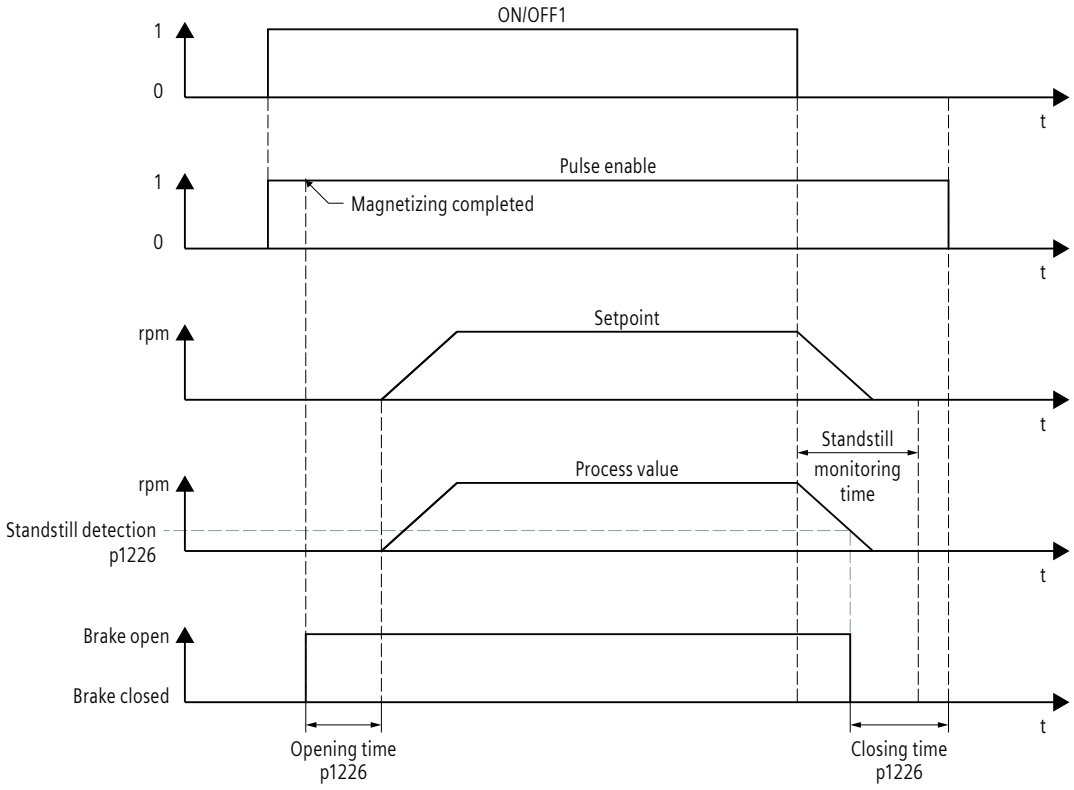


Figure 1-303 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.10 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Braking resistor
  - Temperature model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor and brake resistance values

The thermal motor and braking resistor utilization are calculated quantities. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 133).

7.10.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

⚠ WARNING

Thermal motor utilization cannot be immediately determined after initialization
The thermal model is reinitialized after changing the drive data set and when switching on the device.
After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.
During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model
The I2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

Motor type PMSM
If the PMSM reaches the 100% threshold, the motor current is limited to the rated motor current to prevent overheating.

⚠ WARNING

Compliance with the ambient conditions specified by the motor manufacturer
The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.
If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.
If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.10.2 Braking resistor

Thermal monitoring of braking resistor

The braking resistor is monitored by a temperature model. You can specify the warning threshold (p0291[2]) relative to the shutdown threshold "Braking resistance maximum temperature" (p6023).

Procedure

1. Open the "Braking resistor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[2].

⚠ WARNING

Thermal braking resistance load cannot be determined immediately after initialization
The thermal model is reinitialized after changing the drive data record and when switching on the device.
The thermal braking resistance load cannot be determined immediately after initialization because the model must settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal parameters; the accuracy depends on to what extent the specific installation situation deviates from the model. During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay.
The installation situation should be taken into account for the thermal parameters of the braking resistor and, if necessary, less favorable parameters should be selected, for example, for the heat transfer resistance, so that deviations will generally occur towards the safe side.

7.10.3 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage TPU. When operating with cyclic overload, the rated power is not exceeded by the time-averaged power (rms).

PMSM

With a PMSM, a double overload of the rated current In cyclic for a duration of $t_{overload}$ = 3 s and a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload} \approx 0.75$ s.

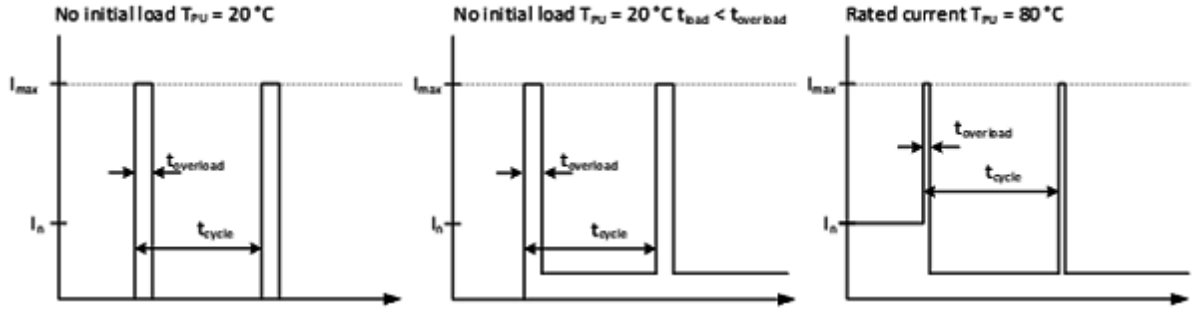


Figure 1-304 Overload behavior of TM Drive

Observe the information on derating depending on the ambient conditions (e.g. temperature, mounting position) in the section Derating of the F-TM ServoDrive ST (Page 137)

NOTE

Overload capability of the power unit

Operation with a peak current of 10 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.11 Dynamic torque reduction

If dynamic torque reduction is required, this can be realized using the MOMRED signal via drive telegram 102. The torque limit currently in effect in the drive is reduced via this setpoint. MOMRED is used to specify the percentage by which the torque limit is to be reduced.

$$M_{limit.actual} = M_{reference} \bullet \left(1 - \frac{MOMRED}{16384}\right)$$

NOTE

The MOMRED signal is normalized to 4000 hex (16384 dec). The value 4000 hex (16384 dec) in the MOMRED control word corresponds to a 100% reduction of the configured reference torque p2003.

The dynamic torque limit is set to the respective minimum of the configured torque limitation (p1520), the limitation via MOMRED or the limitation by the max. permissible torque-forming current value.

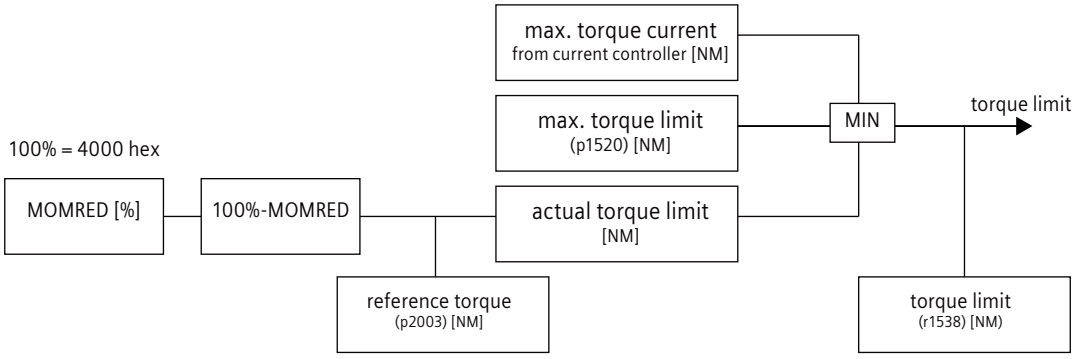


Figure 1-305 Dynamic torque limitation (MOMRED)

The torque values that are output by the drive and the torque limitation currently in effect can be viewed under "Online & Diagnostics" > "Diagnostics" > "Drive Diagnostics" > "Operating Values" if an online connection to the drive is established.

The following actual values are available:

- Torque setpoint (at the output of the speed controller) (r0079)
- Torque actual value (r0080)
- Torque limit (r1538)

Programming

8

The TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 112)
- Control via the SINA_SPEED (Page 121) instruction
- Control with a technology object (Page 122)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The telegrams can be set in the "Properties" area under "General" and further via "Basic parameters". Set the Telegram extension active option to make the status available via the digital input and the status of the STO input via the process image.

NOTE

The telegram extension option is not available for telegram 102.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Frame	1		2		3		102	
PZD1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1
PZD2	NSET_A	NACT_A	NSET_B	NACT_B	NSET_B	NACT_B	NSET_B	NACT_B
PZD3								
PZD4			STW2	ZSW2	STW2	ZSW2	STW2	ZSW2
PZD5					G1_STW	G1_ZSW	MOMRED	MELDW
PZD6						G1_XIST1	G1_STW	G1_ZSW
PZD7								G1_XIST1
PZD8						G1_XIST2		
PZD9								G1_XIST2
PZD10								

Standard telegram 1 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word STW1	**Structure**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5

Element	Data type	Offset
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Element	Data type	Offset
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4

Element	Data type	Offset
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Encoder position actual value 1 G1_XIST1	**DWord**	**10.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3

Element	Data type	Offset
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Siemens telegram 102: Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7

Element	Data type	Offset
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Message word MELDW	**Word**	**8.0**
Encoder status word G1_ZSW	**Struct**	**10.0**
Bit08_Probe1Deflected	Bool	10.0
Bit09_Probe2Deflected	Bool	10.1
Bit10_Reserved	Bool	10.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	10.3
Bit12_HomePositionExecuted	Bool	10.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	10.5
Bit14_ReservedParkingSensorExecuted	Bool	10.6
Bit15_ParkingSensorExecuted	Bool	10.7
Bit00_Function1Active	Bool	10.0
Bit01_Function2Active	Bool	11.1
Bit02_Function3Active	Bool	11.2
Bit03_Function4Active	Bool	11.3
Bit04_Value1Available	Bool	11.4
Bit05_Value2Available	Bool	11.5
Bit06_Value3Available	Bool	11.6

Element	Data type	Offset
Bit07_Value4Available	Bool	11.7
Encoder position actual value 1 G1_XIST1	**DWord**	**12.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**16.0**

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**4.0**
Bit08_Reserved	Bool	4.0
Bit09_Reserved	Bool	4.1
Bit10_Reserved	Bool	4.2
Bit11_Reserved	Bool	4.3
Bit12_Reserved	Bool	4.4
Bit13_Reserved	Bool	4.5
Bit14_Reserved	Bool	4.6
Bit15_Reserved	Bool	4.7
Bit00_Reserved	Bool	5.0
Bit01_Reserved	Bool	5.1
Bit02_Reserved	Bool	5.2
Bit03_Reserved	Bool	5.3
Bit04_Reserved	Bool	5.4
Bit05_Reserved	Bool	5.5
Bit06_Reserved	Bool	5.6
Bit07_Reserved	Bool	5.7
Torque reduction MOMRED	**Word**	**6.0**
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0

Element	Data type	Offset
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the F-TM ServoDrive.
4. Control the F-TM ServoDrive by setting outputs bit-by-bit. You can find a description on how to set the outputs to control the F-TM ServoDrive in the PROFIdrive standard. You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the F-TM ServoDrive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams (Page 59).

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive itself does not have integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select the "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance

9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 1-622 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 128).

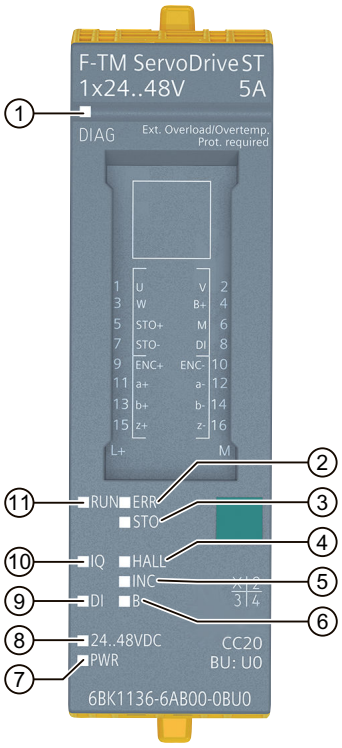
Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the F-TM ServoDrive.



①	DIAG (red/green)	⑦	PWR (green)
②	ERR (red)	⑧	24..48V (green)
③	STO (yellow) Display not safety-related	⑨	DI (green)
④	HALL (green)	⑩	IQ (green)
⑤	INC (green)	⑪	RUN (green)
⑥	B (green)		

Figure 1-306 LED display on F-TM ServoDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 1-623 DIAG status and error display

DIAG LED	Meaning	
Off	Backplane bus supply of the ET 200SP not OK	
Flashing	Module parameters not assigned	
On	Module parameters assigned and no module diagnostics	
Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 128).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 1-624 RUN status and error display

RUN LED	Meaning	
Off	Device is not yet ready for operation	
On	Device is ready for operation and error-free	
Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 1-625 ERR status and error display

ERR LED	Meaning
Off	No fault
On	Device has a fault and needs to be restarted. This corresponds to a critical device fault.

DI LED

Table 1-626 DI status and error display

DI LED	Meaning
Off	Input is faulty/inactive
On	Input is error-free/active

B LED

Table 1-627 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 1-628 STO status and error display

STO LED	Meaning
■ On	Safety sensor is connected and has not tripped
☼ flashes (0.5 Hz)	Safety sensor has tripped (motor is disconnected from power)

IQ LED

Table 1-629 Status and error display IQ (encoder)

IQ LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated
Flashes (2 Hz)	IQ speed encoder could not be initialized IQ speed encoder has a connection problem (A/B track not connected)

Hall LED

Table 1-630 Status and error display Hall (encoder)

Hall LED	Meaning
■ On	Hall speed encoder was assigned parameters/activated

INC LED

Table 1-631 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

24..48V LED

Table 1-632 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LED

Table 1-633 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the F-TM ServoDrive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**
  The general diagnostic information is displayed for:
  - Module
  - Module information
  - Manufacturer information
- **Diagnostics status**
  "Diagnostics status" shows the current diagnostics status of the TM Drive.

- **Active messages**
  "Active messages" displays the currently pending alarms and faults in the TM Drive module.
- **Drive diagnostics**
  The current diagnostic information of the drive is displayed for:
  - Status bits
  - Operating values
  - Encoders
  - Temperatures
  - Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE
In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1006	Braking resistor short-circuit	Overload
1019	External braking resistor/motor holding brake of the 4th phase interrupted	Wire break
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature

Fault number	Description	S7 diagnostics alarm
1037	Permissible temperature of the braking resistor exceeded	Overtemperature
1039	Connection to IQ encoder interrupted	Wire break
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the control electronics exceeded	Overtemperature
1044	Permissible temperature of the braking resistor exceeded The drive is switched off.	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1049	Zero point calibration could not be performed. The rotor may be blocked. The motor holding brake may not be open.	External error
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1051	Zero point calibration could not be performed due to a timeout. The system may be oscillating too much.	External error
1053	Overload of the brake chopper control	Overload
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1055	Motor resistance detection could not be performed	Wire break
1056	Following error during controlled system detection	Overload
1057	Position error during controlled system detection	Overload
1200	CRC checksum error in absolute encoder	Error in actuator/sensor
1201	Internal encoder error in the absolute encoder	Error in actuator/sensor
1202	No communication with absolute encoder possible or communication establishment failed.	Wire break
1203	Internal error in encoder interface	Error
1300	There is an error in the parameter assignment of the motor type.	Parameterization error
1301	Electrical time constant of the q axis is too low.	Parameterization error
1302	Electrical time constant of the d axis is too low.	Parameterization error
1303	Torque constant inconsistent	Parameterization error
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error
1999	General error	Error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The F-TM ServoDrive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2005	Thermal overload of the braking resistor
2007	Switch-on delay because axis is still rotating.

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE
All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 1-634 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 1-635 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r1045	Speed setpoint in front of the ramp-function generator	rpm
r0080	Torque actual value	Nm
r0079	Torque setpoint	Nm
r1538	Torque limit	Nm
r0026	DC link voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 1-636 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Steps	-
p979[2]	Increments per revolution	-

Number	Parameter	Display/unit
P979[5]	Number of revolutions	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits
P979[4]	Fine resolution bits in actual value Gx_XIST2	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 1-637 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 1-638 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Technical specifications

11

11.1 Technical specifications

Technical specifications of the TM Drive

Article number	6BK1136-6AB00-0BU0
General information	
Product type designation	F-TM ServoDrive ST
HW functional status	V1.0
Firmware version	V1.3
• FW update possible	Yes
Product description	Control of EC motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	Yes
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V

Article number	**6BK1136-6AB00-0BU0**
Output current	
Current output (rated value)	5 A
Output current, max.	10 A
Output frequency	599 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	No
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1

Article number	6BK1136-6AB00-0BU0
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	2
• SIL according to DIN EN 61800-5-2	2
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	Yes

Technical specifications of the IQ encoder

Type	IQ encoder
Output signals	2 square wave signals (A, B), 2 square wave signals inverse (nA, nB) Output differential or single ended TTL compatible, phase shifted
Number of pulses per revolution	100 (default)
Limit frequency	5 kHz
Supply voltage	+ 5 V (+/- 10 %)
Current consumption	Typ. 40 mA max. 100 mA
Permissible output current	Max. 20 mA
Permissible deviation of the pulse width from electrical 180°	+/- 90 °
Phase shift of channel A and B	Typ. 90 ° (+/- 30 °)
Output voltage (low level)	Typ. 0.25 V, max. 0.8 V (I = 20 mA at 5 V)
Output voltage (high level)	Typ. 4.25 V, max. 3.8 V (I = 20 mA at 5 V)
Permissible ambient temperature range (TU)	-25 °C ... +105 °C
Reverse polarity protection	Occurs due to a short-circuit of the supply voltage via a protective diode, max. 200 mA continuous current permissible

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation
For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. The motor current and the output current of the outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)
When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

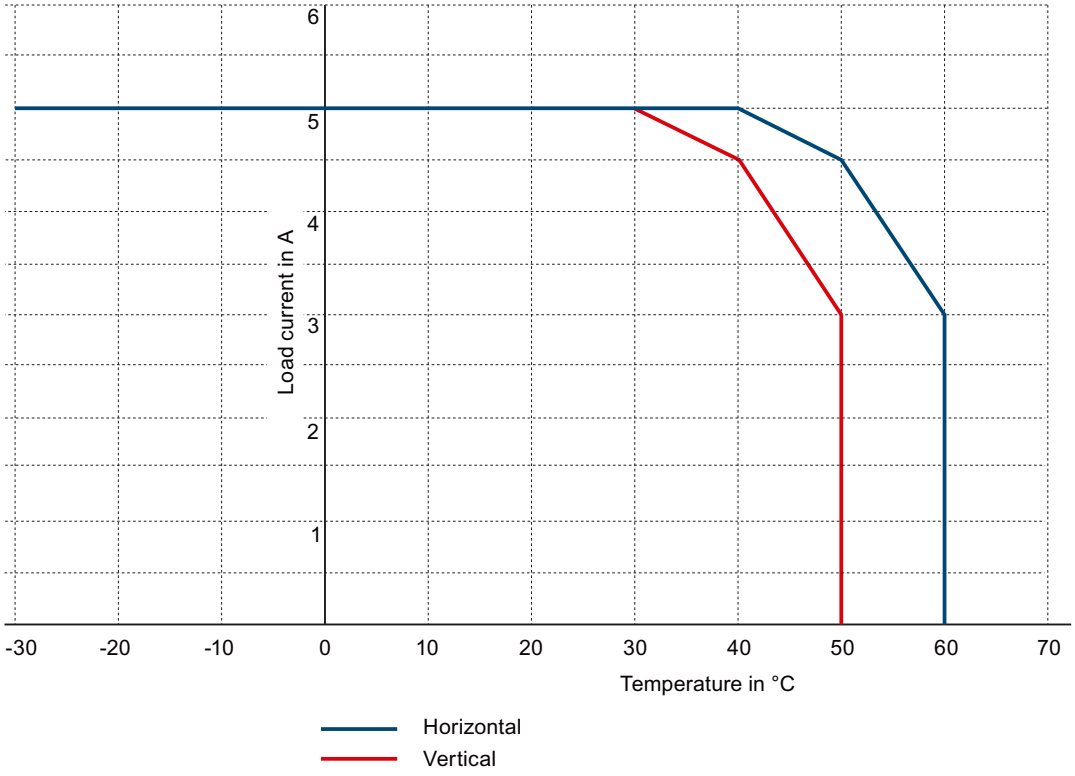


Figure 1-307 Derating of the TM Drive

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix

A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP 7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

A.2 Braking resistor and brake chopper power

The maximum continuous current of the brake chopper end stage is 5 A. The end stage can be overloaded, so that higher currents / powers are possible for a short time.

The average braking current of 5 A is monitored using an I2t model. Once the end stage has fully cooled down, a braking current of 10 A is possible for approx. 15 s, for example.

Related to 60 s, this results in a load cycle of 25%. For other current values, the load cycle can be estimated using the following figure.

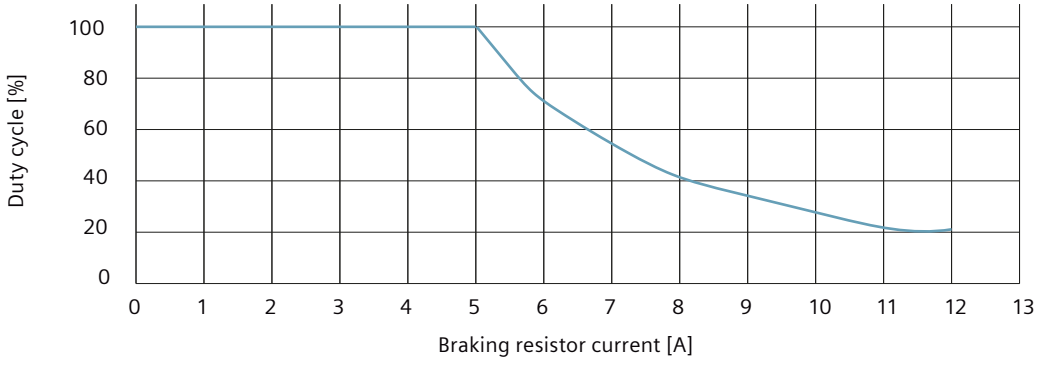


Figure 1-308 Load cycle as a function of the braking resistor current

NOTE
The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Calculation of the continuous braking power of the end stage

The continuous power of the end stage can be estimated using the following formula.

$$P_{chopper_{rated}} = 0.5 \bullet (U_{on} + U_{off}) \bullet 5A$$

Table 1-639 Examples of continuous power of the end stage

Average DC link voltage	Continuous power
26 V	130 W
50 V	250 W

Calculation of the continuous braking power as a function of the braking resistor
The average braking power of the braking resistor depends on the braking resistance value and the DC link voltage or the switch-on and switch-off values of the brake chopper (U_{on} p6010 and U_{off} p6011). It can be estimated with the following formula.

$$P_{brake\ resistor} = \frac{(0.5 \bullet (U_{on} + U_{off}))^2}{R_{brake\ resistor}}$$

Table 1-640 Examples for braking resistor line

Average DC link voltage	Braking resistor value	Braking resistor power
26 V	5 Ω	135.2 W
	10 Ω	67.6 W
50 V	5 Ω	500 W
	10 Ω	250 W

Determination of the braking resistor peak power
In order to calculate the short-time peak power of the resistor, the configured switch-on voltage U_{on} p6010 of the brake chopper must be used.

$$P_{brake\ resistor\ max\ peak} = \frac{U_{on}^{\ 2}}{R_{brake\ resistor}}$$

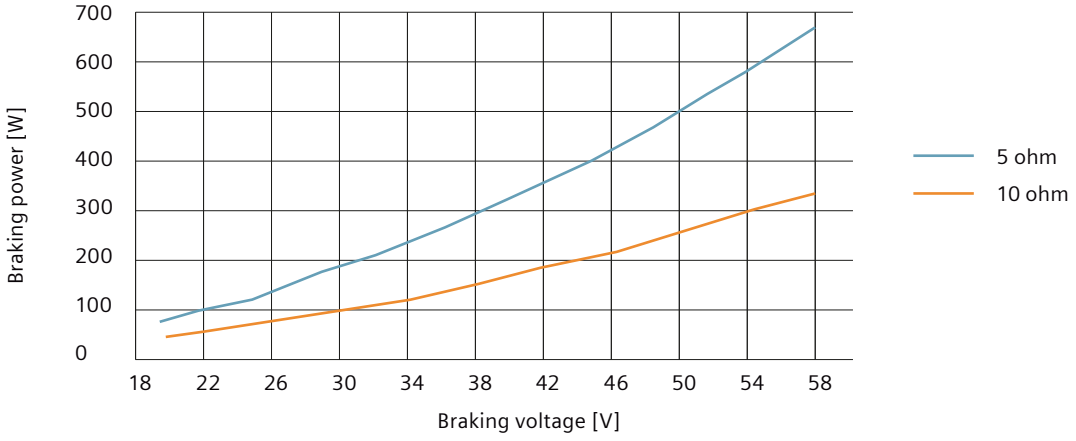


Figure 1-309 Maximum peak power of the braking resistor

It must be checked whether the braking resistor can absorb the peak power and, if needed, the continuous power expected.

A.3 Data sets

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.4 Device disposal

Recycling and disposal



For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE
The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.5 Directives and standards

Directives and standards that are complied with

TM Drive complies with the requirements of the following directives and standards:

CE

European Machinery Directive
TM Drive meets the requirements of the Machinery Directive, 2006/42/EU through compliance with EN 61800-5-2, insofar as the equipment is used within the area of application of this directive.

TM Drive has been fully evaluated for compliance with the material provisions relating to health and safety in the directive when used in a typical machine application.

European EMC Directive
The compliance of TM Drive with the regulations of Directive 2014/30/EU has been verified through full compliance with EN 61800-3.

Safety Integrated
TM Drive complies with the requirements for functional safety/machine safety.

RoHS
TM Drive complies with Directive 2011/65/EU on the restriction of the use of certain hazardous substances.



Underwriters Laboratories (North American market)
TM Drive equipment bearing any of the test symbols shown to the left complies with the requirements for the North American market as a component of drive applications and is listed accordingly.

- UL file number for DC mains connection: E229808



Eurasian conformity
TM Drive complies with the requirements of the Eurasian Customs Union (EAC).



Australia and New Zealand (RCM formerly C-Tick)
TM Drive equipment bearing the symbol shown complies with the EMC requirements for Australia and New Zealand.



EMC requirements for South Korea
TM Drive equipment bearing the KC symbol on the rating plate complies with the EMC requirements for South Korea.

Certificates for download

- EC declaration of conformity:
- Certificates for the relevant directives, prototype test certificates, manufacturers declarations and test certificates for functions relating to functional safety ("Safety Integrated"): (https://support.industry.siemens.com/cs/ww/en/ps/26085/cert)
- Certificates of products that were certified by UL: (https://iq.ulprospector.com)

Standards that are not relevant



China Compulsory Certification
TM Drive does not fall within the scope of China Compulsory Certification (CCC).

UKCA - United Kingdom Conformity Assessed



The TM Drive series complies with the conformity requirements for England, Scotland and Wales.

China RoHS

The TM Drive drive series complies with the China RoHS.
You will find more information at:
China RoHS (https://support.industry.siemens.com/cs/ww/en/ps/26085/cert)

SIEMENS

SIMATIC

ET 200SP
F-TM ServoDrive HF 1x24..48V 5A

Equipment Manual

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Introduction

1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Content of the Equipment Manual

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE
The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109801314).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE
A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE
Recommendation relating to third-party products
This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.
You can use equivalent products from other manufacturers.
Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.4 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.5 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Figure 1-310 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:



Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:



Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)



YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet. (https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.



Figure 1-311 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals
- Downloads
- Compatibility tool
- Newsletter with product selection
- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.2 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.4.3 FAQ

You will find FAQs on TM Drive on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC and stepper motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Intended use of hardware products
This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.
Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.
EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions 2

2.1 General safety instructions

⚠ WARNING

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance

Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance
Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

⚠ WARNING

Electric shock if there is no ground connection
For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

⚠ WARNING

Electric shock due to connection to an unsuitable power supply
When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

⚠ WARNING

Electric shock due to equipment damage
Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

⚠ WARNING

Electric shock due to unconnected cable shield
Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

⚠ WARNING

Arcing when a plug connection is opened during operation
Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection
An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

⚠ WARNING

Electromagnetic interference due to inadequate shield support
A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

⚠ WARNING

Active implant malfunctions due to electromagnetic fields
Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

⚠ CAUTION

Symptomatic respiratory and skin reaction to chemicals
A newly purchased product might contain traces of substances that are identified as sensitizers.
Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.
Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

⚠ WARNING

Unexpected machine movement caused by radio devices or cellphones
Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

⚠ CAUTION

Radio frequency interference in residential areas
When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.
When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances
Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position
The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests
High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests
High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

⚠ WARNING

Unexpected movement of machines caused by inactive safety functions
Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings
As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge
Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

⚠ WARNING

Unsafe operating states resulting from software manipulation
Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation
2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter

3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system offers the necessary flexibility and performance for a wide range of control applications.

The F-TM ServoDrive HF is a product from the TM Drive range of modules in the ET 200SP network. The term TM Drive is synonymous with the F-TM ServoDrive HF in this manual.

The F-TM ServoDrive HF technology module offers you the following application possibilities:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

TM Drives have proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

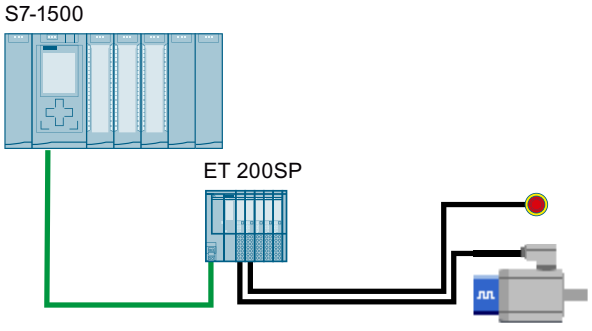


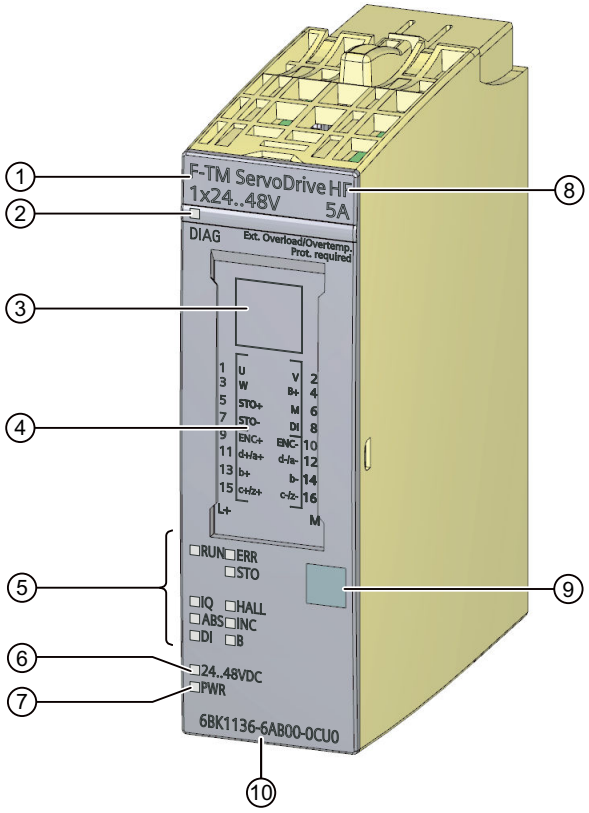
Figure 1-312 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6AB00-0CU0

View of the module



① Module type and designation
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for motor control
⑥ LED for supply voltage
⑦ LED for power
⑧ Function class
⑨ Color coding of module type
⑩ Article number

Figure 1-313 View of the F-TM ServoDrive HF module

Properties

The F-TM ServoDrive HF has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of IQ encoder technology
- Support of incremental encoders with (A, B, Z track)
- Support of BiSS-C absolute encoders
- 24 V digital input
- Support of individually configurable motors (permanent-magnet synchronous motor (PMSM) and bipolar stepper motors)
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Braking chopper, external braking resistor
- Thermal monitoring of the braking resistor
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 as of V16

Accessories

The following accessories that are not included in the module's scope of delivery can be used with the module:

Designation	Article number
Feed BaseUnit (light)*	6ES7193-6BP00-0DU0
Expansion BaseUnit (dark)*	6ES7193-6BP00-0BU0
MCB, B, 6 A	5SY6106-6
MCB, B, 10 A	5SY6110-6
MCB, B, 6 A for UL markets	5SJ4106-6HG40
MCB, B, 10 A for UL markets	5SJ4110-6HG40
Shield connection	6ES7193-6SC00-1AM0

* A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For additional information on accessories such as:

- Labeling strips
- Color-coded labels
- Reference identification labels

refer to the System Manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

Unsuitable electronic fuses

Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

The TM Drive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

The TM Drive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

TheTM Drive supports the following types of communication:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.
- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.
- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 45).

Potential group

Up to a continuous input current of max. 10 A for each potential group, up to 3 TM Drives can be connected together to form a drive line-up.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (e.g. TDK Electronics 2-wire filter B84113C series) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group. For a potential group with only one TM Drive, we recommend using an appropriate miniature circuit breaker with 6 A nominal current and characteristic B.
- You must not use voltage sources with low impedance such as supercaps without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short-circuit, it is still imperative to rectify the fault before switching it on again. Otherwise the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers
(https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

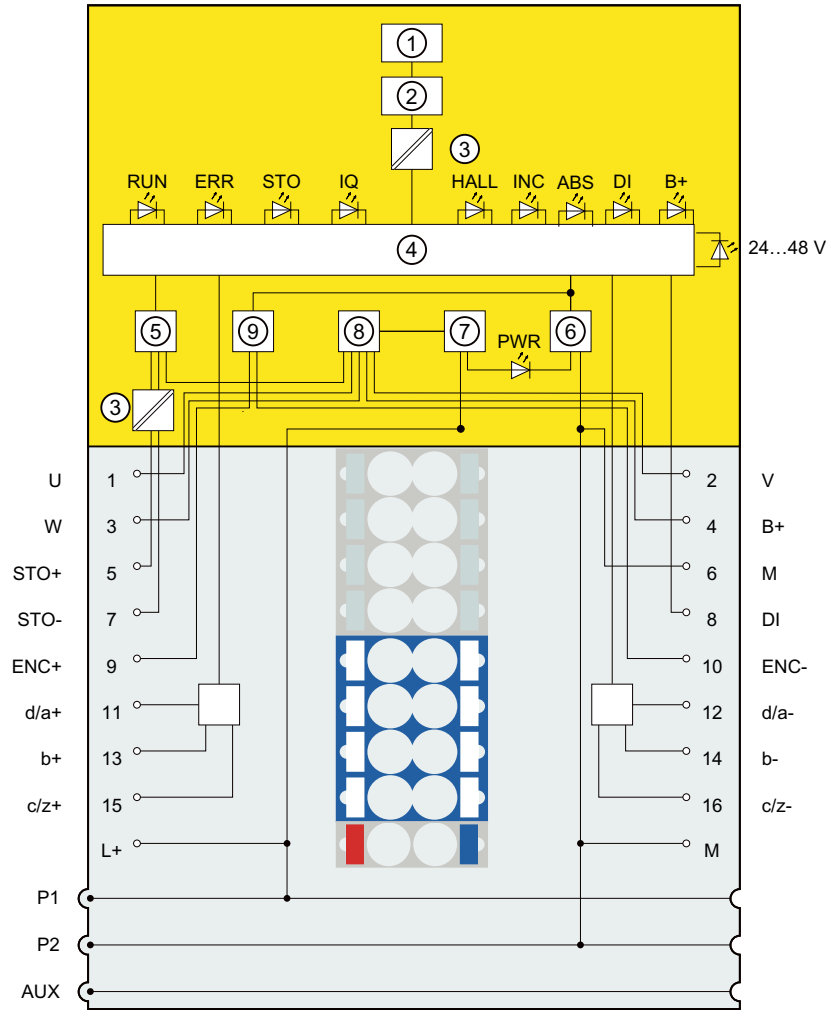
SCCR (short circuit current rating)

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

> **WARNING**
>
> **Fuse for the load circuit**
> In general, use a suitable overcurrent protection device to protect the TM Drive.

Schematic circuit diagram



①	Backplane bus	**PMSM**	
②	Backplane bus interface module of the technology controller	U	Phase U
③	Electrical isolation	V	Phase V
④	Technology controller	W	Phase W
⑤	Safe Torque Off circuitry	B+	Connection of braking resistor
		Stepper motor	
⑥	Digital input circuit	U	Phase A-

⑦	Power supply/Preparation	V	Phase A+
⑧	Reverse polarity protection	W	Phase B-
⑨	Power electronics	B+	Phase B+
		Encoder supply	
⑩	Encoder power supply	ENC+	Power supply encoder 5 V
Power supply		ENC-	Power supply encoder, negative connection
L+	Power supply 24 - 48 V	**Incremental / IQ encoder**	
M	Power supply GND	d/a+	Differential encoder signal a+
Inputs		d/a-	Differential encoder signal a-
STO+	STO+ input (24 V)	b+	Differential encoder signal b+
M	Negative connection, e.g. for braking resistor	b-	Differential encoder signal b-
STO-	Negative STO input	c/z+	Differential encoder signal z+
DI	Digital input	c/z-	Differential encoder signal z-
		BiSS-C	
		d/a+	Dat+
		d/a-	Dat-
		c/z+	Clk+
		c/z-	Clk-

Figure 1-314 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 1-641 Wiring rules for the interfaces

Pins	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
U/V/W or A+/A-/B+/B-	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
B+	Connection of external braking resistor	2 m	≥ 0.5 m shielded
d/a, b, c/z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair In order to achieve higher transmission frequencies, it is recommended to shield the clock and data signal lines separately for a BiSS-C encoder.
STO	Safe Torque Off	10 m	-

Permissible cable cross-sections depend on the BaseUnit used. See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) equipment manual.

 CABLE SPEC.	Note that the electrical connections must be designed according to the expected current value at maximum ambient temperature and installation type in accordance with applicable standards.

NOTE

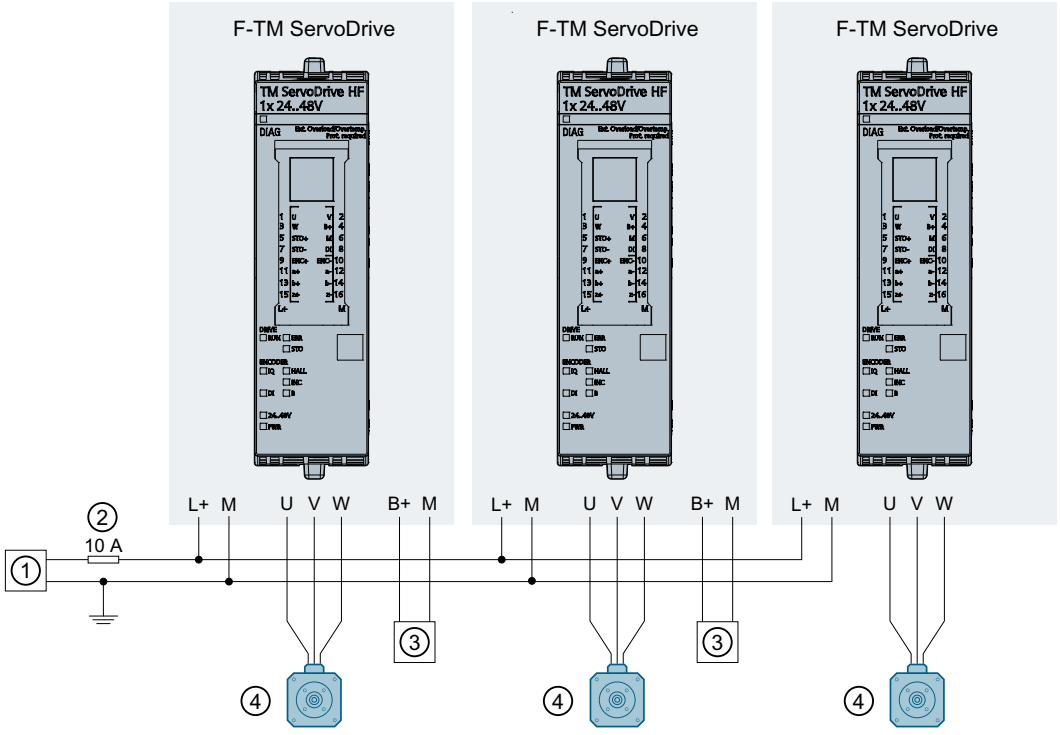
In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple TM Drive

In a potential group

You can connect multiple TM Drives to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drive to form a drive line-up



① Power supply unit
② Protective device
③ Braking resistor
④ Motor

Figure 1-315 Wiring of multiple TM Drive to form a drive line-up

See also

Pin assignment (Page 28)

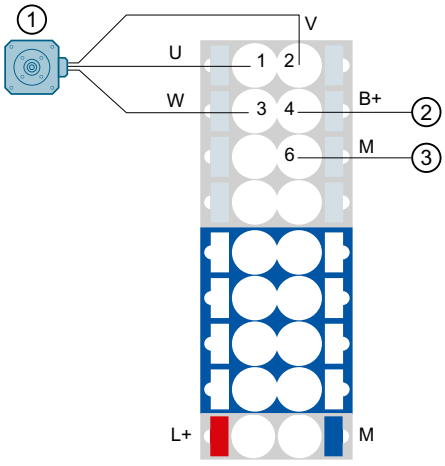
4.4 Connecting the motor

Overview

F-TM ServoDrive supports permanent magnet synchronous motors (PMSM) with suitable encoders and bipolar interconnected stepper motors.

4.4.1 Connecting the motor phases (PMSM)

The following figure shows the connection of the motor phases to the BaseUnit:



①	PMSM	②	Braking resistor
U, V, W	Motor phases	③	Negative connection for braking resistor

Figure 1-316 Connecting the motor

NOTE

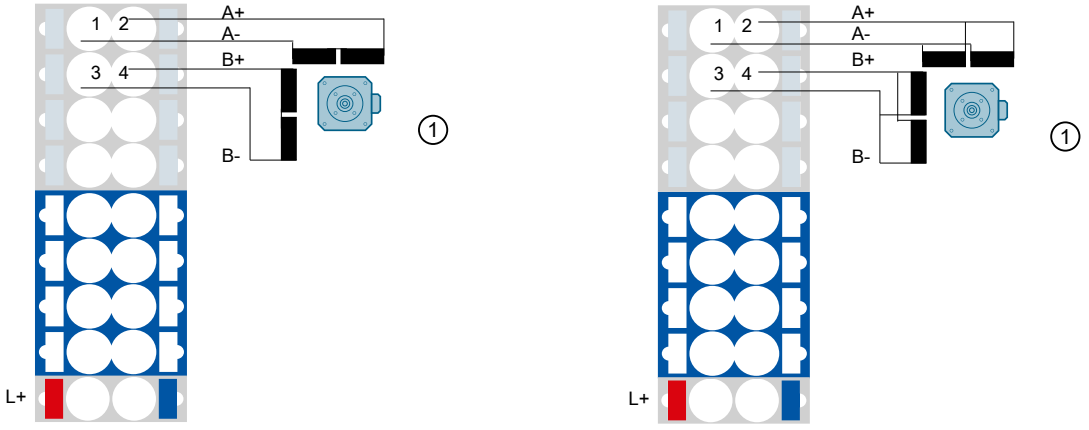
In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	B+	Braking resistor
6	M	Negative connection, e.g. for braking resistor

4.4.2 Wiring the motor phases (stepper motor)

The following figure shows the connection of the motor phases to the BaseUnit:



①	Stepper motor
A+, A-, B+, B-	Motor phases

Figure 1-317 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	A-	Motor phase A-
2	A+	Motor phase A+
3	B-	Motor phase B-
4	B+	Motor phase B+

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

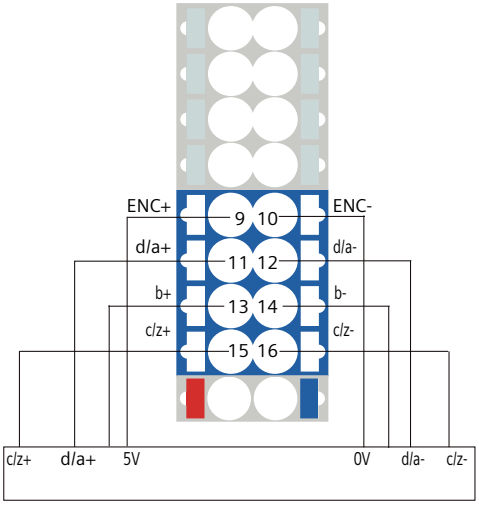


Figure 1-318 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 1-642 Power supply and signal processing conditions of the incremental encoder

Encoder property	Range/Value
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V
	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V

*The quadrature interface results in a maximum step resolution of 2000 kHz.

Encoder property	Range/Value
Maximum current consumption of the encoder	150 mA
Encoder output	Push Pull
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz.

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting IQ-Encoders

Motors from the SIMATIC MICRO-DRIVE Product Partner Program have an IQ encoder.
The following figure shows the connection of IQ encoders to the BaseUnit.

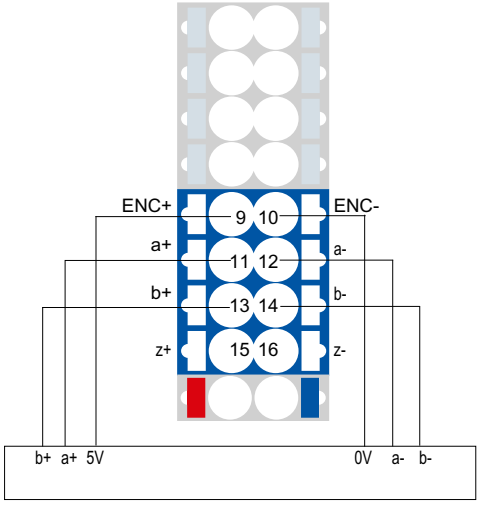


Figure 1-319 IQ encoder connection with differential signals

Pin assignment of IQ encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	-
16	z-	-

Specifying the encoder interface

You connect the IQ encoder to the incremental encoder inputs like a two-channel standard incremental encoder. The polar wheel angle information is also transmitted via the interface (see Technical specifications (Page 143)).

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.3 Connecting a BiSS-C encoder

You can connect motors with a BiSS-C interface to the TM Drive .

The following figure shows the connection of a BiSS encoder to the BaseUnit.

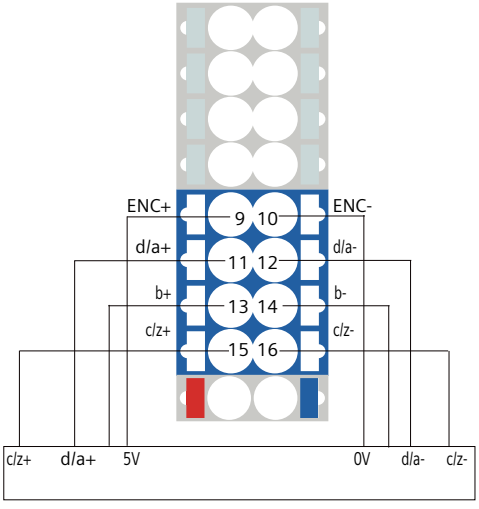


Figure 1-320 Absolute encoder connection

Pin assignment of BiSS encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	d/a+	Dat+
12	d/a-	Dat-
15	c/z+	Clk+
16	c/z-	Clk-

Table 1-643 Power supply and signal processing conditions of the absolute encoder

Encoder property	Range/Value
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Maximum transmission frequency	2.8 MHz
CRC (Cyclic Redundancy Check)	43 hex

NOTE
In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

Requirement of the BiSS-C interface

In addition to the electrical specification from Table 4-3, the BiSS-C interface must meet the following requirements:

- Unidirectional communication according to BiSS-C standard
- Transfer code: Dual
- CRC (Cyclic Redundancy Check) polynomial 43 hex
- Evaluation of the warning / alarm bits
- Sum of single-turn, multiturn and number of bits before position value <= 56
- See Table 4-1 for the cable and shielding requirements.

4.5.4 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

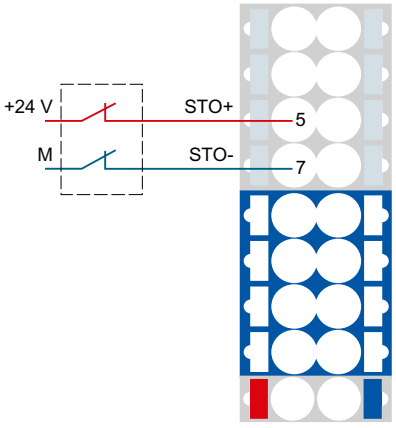
The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

⚠ WARNING

Danger to life due to coasting down of the drive with STO
The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO



STO+ STO input 24 V
STO- STO input, negative connection

Figure 1-321 Connection of Hardware STO

NOTE
Use different voltage supplies for the STO inputs and for the power supply.

Table 1-644 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

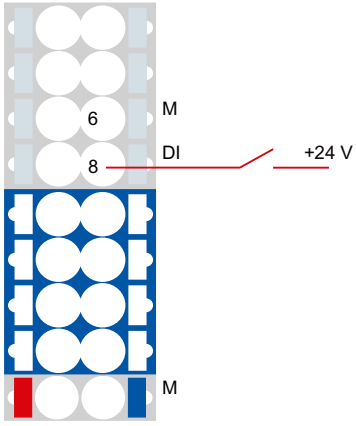
Route the hardware STO (STO+/STO-) cables separately from other cables, especially power cables.

Minimize the risk of crushing and short-circuits in ground connections by using appropriate routing.

Exclude premature aging of the cables due to continuous UV radiation.

4.5.5 Connecting the 24 V digital input

Connecting a 24 V digital input



DI 24 V digital input
M Ground

Figure 1-322 24 V digital input connection

Table 1-645 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

4.6 Connecting an external braking resistor

External braking resistor

To ensure high dynamics of the drive due to fast acceleration and braking ramps, you need to connect a braking resistor to the TM Drive.

Recommendation: Use a braking resistor for power supplies with low intrinsic capacitance or an unregulated six-pulse bridge circuit (B6U).

A connected external braking resistor must be activated in the configuration software.

⚠ CAUTION

Risk of burns due to high surface temperature of the braking resistor

The braking resistor can become very hot. Touching the surface can cause severe burns.

- Mount the braking resistor so that it cannot be touched. In situations in which this is not possible, attach a clearly visible and understandable warning notice in areas at risk.

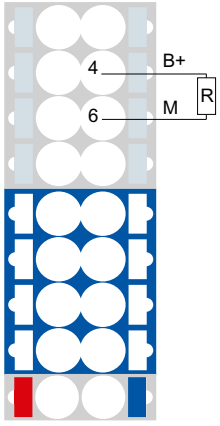
Wiring a non-Siemens external braking resistor

⚠ WARNING

Damage to braking resistor – Risk of fire!
If you use a non-Siemens external braking resistor, connect an overtemperature detection device to a digital input (e.g. a bimetallic switch that opens when the temperature is too high).
Implement fire prevention measures for the external braking resistor (e.g. fire protection housing, temperature fuse). The resistance of the externally connectable braking resistor must be ≥ 5 ohms.
Design the required power as a function of the braking energy to be converted.

Wiring an external braking resistor

The figure below shows the connection of an external braking resistor as an example:



B+ Positive terminal of braking resistor
M Negative terminal of braking resistor

Figure 1-323 Connection of external braking resistor

Pin assignment

Table 1-646 Pin assignment: Wiring an external braking resistor

Pin	Designation	Function
4	B+	Connection of external braking resistor
6	M	

External braking resistor for potential group with several TM Drive

If you have connected multiple TM Drive to form a potential group, it may be sufficient to equip only one module with an external braking resistor.

Safety functions integrated in the drive

5

5.1 Basic safety information

5.1.1 General safety information

⚠ WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM ServoDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM ServoDrive documentation.
- Consider the residual risks for the risk evaluation.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

⚠ WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 143)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

⚠ WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 149).

Examples of safety devices and 3 F-TM ServoDrive

NOTE
Use different voltage supplies for the STO inputs and for the power supply.

The following figure shows various safety devices that are connected to 3 F-TM ServoDrive.

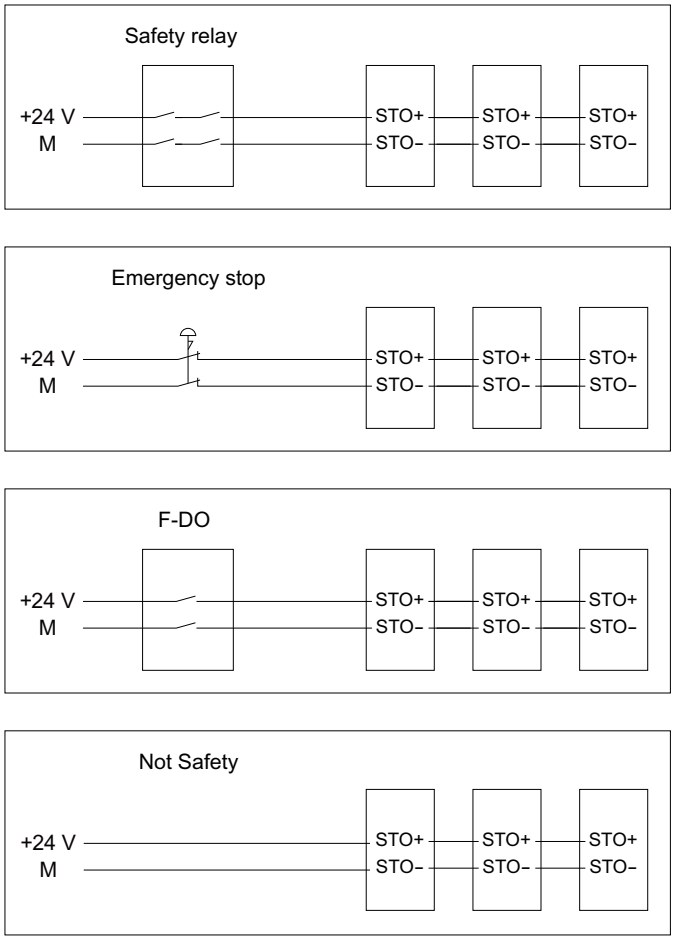


Figure 1-324 Safety devices and 3 F-TM ServoDrive

NOTE
The F-TM ServoDrive does not support startup protection.
Measure:
Configure startup protection with an additional safety relay or in the higher-level controller, depending on the safety requirements.

Operating voltage range

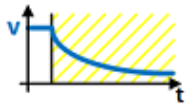
Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

Switching on again after power off

An On delay of more than 2 s must be observed between tripping and restarting the module, for example switching the power supply off and on. Otherwise the module can register an internal STO error and the module switches off in a safety-oriented manner.

5.1.4.1 Safe Torque Off (STO)



Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM ServoDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

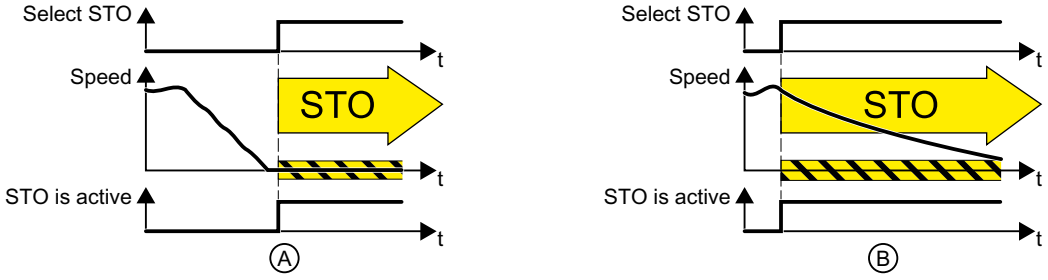


Figure 1-325 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a PMSM or bipolar connected two-phase stepper motor. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

The STO function can be used when the motor is already at a standstill. If the motor is in operation, the STO function causes the drive to coast down.

The STO function enables safe working when the protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM ServoDrive internally monitors the fail-safe digital input at STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM ServoDrive is therefore not needed.

⚠ WARNING

Forced checking procedure

You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) as defined in the corresponding standards are a measure for the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

For functional safety of variable-speed drives, the standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies.

Function groups

The safety functions are divided into the following function groups for the F-TM ServoDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM ServoDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 1-647 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM ServoDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM ServoDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal hardware fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EU machinery directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.
  See "Acceptance test" below in this section.
  For the F-TM ServoDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.
  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring
Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

⚠ WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test
Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 1-648 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 1-649 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 1-650 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 1-651 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	
2.	**Switch on motor**	

No.	Description		Status
2.	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer
Professional execution of the above-stated tests and checks is confirmed.

Table 1-652 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer
The correctness of the parameter assignment documented above is confirmed.

Table 1-653 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM ServoDrive drive system meet the following requirements:

- Safety integrity level SIL3 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM ServoDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM ServoDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system
  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM ServoDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM ServoDrive

For information on how to perform the electrical wiring for the F-TM ServoDrive, refer to section Wiring (Page 28)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 39).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

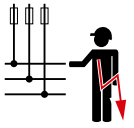
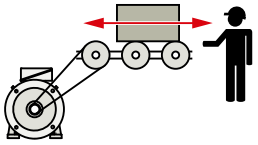
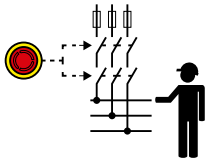
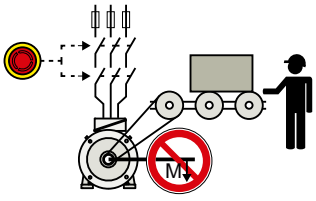
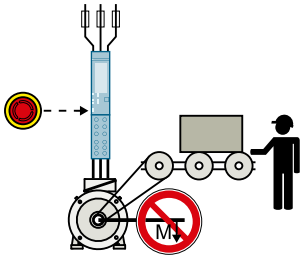
EMERGENCY OFF Risk of electric shock	**EMERGENCY STOP** Risk of unexpected movement
	

Table 1-654 Measures and solutions

Command	**EMERGENCY OFF**	**EMERGENCY STOP**
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 	Switch off the drive power supply. 
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO.  You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring

6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring a ET 200SP TM Drive.

You perform the following tasks with STEP 7 (TIA Portal), for example:

- You configure the TM Drive (insertion into the project and setting the input addresses).
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 24)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 28).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).
- You have installed the HSP0311.

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

To accept the plant, you must use the safety summary created in accordance with this manual.

Configuring a TM Drive (minimal configuration)

To configure a TM Drive , follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.
4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.

6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 1-655 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Siemens telegram 102 PZD-10/6	Speed setpoint 32 bits with one position encoder and torque reduction	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Dynamic torque reduction (MOMRED) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive module in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These values provide the current **incremental and, for absolute encoders, also the absolute actual position** of the measuring system and are read cyclically by the "Positioning axis" technology object, for example, and processed accordingly (see also section 8.3 (Page 131)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the position actual value is structured as follows:

- Gx_XIST1 and Gx_XIST2 are right-aligned
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.

NOTE

Dependence on the configured encoder resolution
The single-turn value ("increments / revolution") in Gx_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 1-656 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 140).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a fine resolution of 2:

Table 1-657 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 1-658 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 IQ encoder

If you are using a motor from the Siemens Product Partner Program with IQ encoder (incremental encoder) and have configured this accordingly for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 1-659 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Default: 100 Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 140).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Table 1-660 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 1-661 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.3 Encoderless / calculated

If you have set encoder (0) encoderless / calculated as encoder type, the encoder position actual value is calculated. Actual encoder position value is structured as follows.

Table 1-662 Structure of the encoder position actual value

User data	**Contents**	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 140).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of a "simulated encoder" with 4096 "steps per revolution", this corresponds to 1024 "increments per revolution" with a offset factor of 2:

Table 1-663 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 1-664 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.4 Absolute encoder BiSS

If you are using a motor with an BiSS encoder and you have configured this for the type of motor encoder (p404), the structure of the encoder position actual value is as follows:

Table 1-665 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 140).
	Number of revolutions	
	Bits in Gx_XIST1 "Offset factor"	S* <= 16: Gx_XIST1 = 0 S* > 16: Bits in Gx_XIST1 = S - 16
Encoder position actual value 2 (Gx_XIST2)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 140).
	Number of revolutions	
	Bits in Gx_XIST2 "Offset factor"	S* <= 16: Bit in Gx_XIST2 = 0 S* + M* <= 32 and S > 16: Bit in Gx_XIST2 = S - 16 S* + M* > 32 and S > 16: Bits in Gx_XIST2 = 16 - M; Minimum 0.
	Encoder type	Absolute

*S = Bits_Singleturn_resolution, M = Bits_Multiturn_resolution

For some absolute encoders, the total length of single-turn and multiturn bits can be greater than 32 bits (e.g. encoders with 17-bit single-turn resolution and 16-bit multiturn resolution). However, since only 32 bits are available in the actual position value Gx_XISTx, the following strategy is then used:

- For the actual position value in G1_XIST1, all single-turn bits are included if possible and higher-order bits of the multiturn value are truncated.
- For the actual position value in G1_XIST2, all multiturn bits are included if possible and lower-order bits of the single-turn value are truncated.

The values calculated automatically by the device are displayed in the Drive Diagnostics 10.2.3 in online mode and can be transferred directly from there to the configuration of the technology object or you can also take the offset factors from the following tables.

	Bits_Singleturn																		
Offset factor Gx_XIST1	1	...	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Offset factor Gx_XIST2		**Bits_Singleturn**																	
		1	**...**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Bits_Multi-	**0**	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

turn	**1**	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15
	2	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14	14
	3	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	13	13	13
	4	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	12	12	12	12
	5	0	...	0	1	2	3	4	5	6	7	8	9	10	11	11	11	11	11	11
	6	0	...	0	1	2	3	4	5	6	7	8	9	10	10	10	10	10	10	10
	7	0	...	0	1	2	3	4	5	6	7	8	9	9	9	9	9	9	9	9
	8	0	...	0	1	2	3	4	5	6	7	8	8	8	8	8	8	8	8	8
	9	0	...	0	1	2	3	4	5	6	7	7	7	7	7	7	7	7	7	7
	10	0	...	0	1	2	3	4	5	6	6	6	6	6	6	6	6	6	6	6
	11	0	...	0	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	5
	12	0	...	0	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4
	13	0	...	0	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	14	0	...	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	15	0	...	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	16	0	...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	32	0	...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Example of an absolute encoder with a resolution of 13 bits (8192 "increments per revolution") single-turn S and 12 bits (4096 "distinguishable revolutions") multiturn M.

Table 1-666 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")

Table 1-667 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

Parameter assignment is also possible via data sets (see appendix Data sets).

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning an TM Drive drive

⚠ CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury
Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 43) before commissioning and before operation.

⚠ WARNING

Personal injury and property damage from the falling down of a suspended axis
If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected falling down of a hanging axis can result in personal injury and property damage.
Before commissioning, you need to ensure that a cross brace is fitted to hold the suspended axis in place and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Personal injury and property damage from the collapse of a suspended axis
An unexpected collapse of a suspended axis can result in personal injury and property damage

.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE

Performing tests
You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.
Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform configuration as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Online & diagnostics
- Parameters
- Device configuration

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Set telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):
  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:
  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM engineering.

- Drive:
  Drive data set, General settings, Motor, Motor gear, Thermal model, Intermediate circuit voltage, Brake module
- Setpoint channel:
  Reference values, application limits, speed-ramp sensor
- Open-loop/closed-loop control:
  Control type, controller settings, speed controller, current controller
- Messages/monitoring:
  Motor (thermal motor type), power output stage (utilization)

"Commissioning" area

Contents in the "Commissioning" area of the TM Drive TM Engineering.

- Configuration:
  Link to the parameter dialog
- Identification:
  Identification mode
  Encoder and pole position identification
  Encoder values
- Tuning:
  Calculate speed/current controller values
  Tuning the speed controller
  Transfer controller values to drive parameters

See also

PMSM drive parameters (Page 79)
Drive parameters stepper motor (Page 81)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

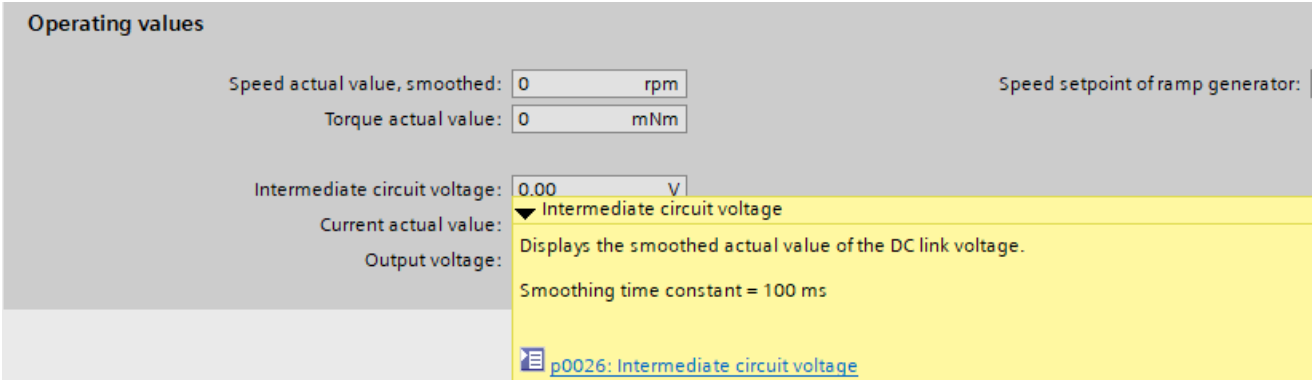


Figure 1-326 Intermediate circuit voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.
  Or
- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

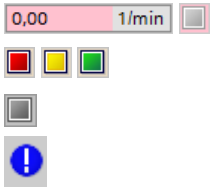
P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

1,0000 Nm	Project (offline)	Parameter value can be changed and stored in the project.
48,0 V	Project (offline)	The parameter value is write-protected.
24,0 V	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the TM Drive engineering:



Drive value (online) could not be determined

Bit parameter active (1-signal)

Bit parameter inactive (0-signal)

Binding values to be set by the commissioning engineer

Automatic check of the configured drive parameters

The configured parameters are checked both in STEP 7 and in the drive in order to detect incorrect parameter assignments and possible functional restrictions even before commissioning.

Both warning and error messages are output. In STEP 7, you obtain additional information and corrective measures about the respective message.

The causes of errors in the drive parameter assignments that prevent the drive from operating are listed below.

Parameter group	Possible causes of error
Motor	Electrical time constants of the connected motor are too low
	Torque constant is not consistent with other motor parameters
Encoders	Motor/encoder combination is not permitted
Speed/current controller	Controller parameters have not yet been set or are not permissible
Intermediate circuit voltage	Intermediate circuit limits are prohibited
Brake module	Brake chopper settings are not permitted

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Constraints

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 28)
  - Configuring (Page 60)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Has the shielding of the motor/encoder cable been applied over a large area on the device and on the motor/encoder?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?
- Are the grounding terminals correctly attached and is the motor/encoder cable correctly connected?

Module installation and wiring

- Is the TM ServDrive plugged in / installed and firmly connected or screwed according to the assembly plan and configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the TM Drive and the motor and installed according to the guidelines?
- Is the digital input connected?
- Was an external braking resistor optionally connected to the TM Drive?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive .

Table 1-668 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data set	Use one of the following options in the "Import drive data set" dialog under "Parameters > Drive": • Select pre-configured drive data set from list • Import drive data from file system	Drive data sets (Page 75)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp generator	Setpoint channel (Page 91)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Speed control (cascade) (Page 96)
4	Configure intermediate circuit voltage monitoring and optionally the brake control module	• Define limits for intermediate circuit voltage • Brake chopper settings • Motor holding brake settings	Intermediate circuit voltage
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 116)
6	Optional: Depending on motor type and encoder, determine commutation angle offset and encoder values	• Perform automatic encoder identification in commissioning under "Encoder identification".	Setting the commutation angle offset and pole position identification (Page 86)
7	Optional: Perform automatic controlled system detection	• Automatic controlled system detection can be performed for setting the current and speed controller in the commissioning under "Controlled system detection".	Automatic controlled system detection (Page 99)
8	Optional: Perform online optimization	• Tuning the speed controller	Section Manual controller tuning Speed controller (cascade) (Page 104)

7.4 Drive data sets

Introduction

So that you can optimally handle the requirements of drive technology, the TM Drive drive system is compatible with motors (Dunkermotoren, ebm-papst) and connecting cables (Harting, KnorrTec) of proven product partners of Siemens. This allows you to optimally combine suitable products from proven product partners for your individual application.

You can find more information about the Siemens Product Partner Program in theInternet (https://new.siemens.com/global/en/products/drives/sinamics/servo-drive-system-simatic-micro-drive.html).

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection system, electrical safety, EMC, etc., as described in this manual.

For the F-TM ServoDrive HF this also includes stepper motors which can be connected bipolar, and which meet the constraints explained in this manual.

Drive data set

The motor or drive of the TM Drive drive system is configured using a drive data set (DDS). A drive data set contains the settings and information for the following drive components:

- Motor
- Gearbox
- Thermal motor model

NOTE

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive drive system supports PMSM and stepper motors. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The motor encoder (p0404) can be selected based on the motor type (p0300). The following combinations are available:

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)
- (6) Absolute encoder BiSS-C

(0) No encoder / calculated
The setting (0) encoderless / calculated is only supported in connection with a stepper motor. In this case, the rotor position is calculated and transferred to the control depending on the increments per revolution (p0408) or the steps per revolution (p0409).

(1) Incremental encoder (A, B, Z track)
When selecting encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also called I-track) can be connected as an index track to identify the pole position.

(5) IQ encoder
If you are using a motor with IQ encoder, you must select the encoder type IQ encoder.

(6) Absolute encoder BiSS-C
A BiSS-C encoder transmits encoder value digitally and checks the data for transmission errors. Absolute encoders with multiturn and single-turn values as well as pure single-turn encoders with dual coding can be used.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 116) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Download preconfigured drive data sets as a file for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460).
- Create a user-defined drive data set and configure your motor manually.

NOTICE
After a change of the drive data set, you must adapt or optimize the parameters for the current and speed controllers, if necessary. See section Speed control (cascade) (Page 96).

7.4.2 Drive data export / import

In addition to the pre-defined drive data sets, custom drive data sets can also be exported and imported.

The standard CSV format with ',' (comma) as column separator including a line header is used.

The data is stored according to the file header and also read in again on the basis of this line.

The formatting of decimal numbers is region-independent using a '.' (dot) as the decimal separator.

For negative values, the value must be preceded by a '-' (minus).

UTF-8 is defined as the character coding.

The header line is defined as follows:

##PNU(mandatory)##,##name##,##value(mandatory)##,##unit##,##dataType##, ##group##,##ECLASS number##

- Motor
- Motor gear
- Encoders
- Thermal model
- Motor holding brake

All parameters contained in the CSV file are included in an import. The CSV file can be customized and, for example, unused parameters can be removed. For example, only one parameter can be imported.

The parameters are assigned via the PNU, where the value must be present. Name, unit, data type and ECLASS number are used for better readability and are ignored during import.

Quotation marks and spaces are hidden during import, which is why no further commas are supported except for column separation.

Export drive data

The existing drive parameter assignments can be exported and saved as a file (*.csv) from STEP 7 Engineering.

1. Open "Parameters" > "Drive".
2. Start the export via the "Export drive data set..." button in the "Drive data set" area.
3. In the "Save" dialog, select a folder and the file name and confirm with "Save".

Import drive data

The drive parameter assignment can be imported as a file (*.csv) in STEP 7 Engineering. A drive data set may contain all or part of the parameters supported by the TM Drive used.

NOTE

Importing the drive parameter assignments overwrites all parameters with the values contained in the csv file.
Parameters not contained in the drive data set are not changed and retain their value.
The "Undo" function is not possible for the "Import drive data set" function.
Save your parameter assignments before importing a drive data set.

1. Open "Parameters" > "Drive".
2. Start the configuration wizard via the "Import drive data set..." button in the "Drive data set" area.
3. Select the "Import drive data set from file system" option.
4. Select the drive data set (*.csv) via the file folder button.
5. The drive data set is displayed in the log area and you can check the data.
6. Apply the configuration with "Yes".

Status messages about the import are displayed in the Inspector window in the General tab.

7.4.3 Using preconfigured drive data sets

You have the option of using preconfigured drive data sets for configuring your motor. You can obtain preconfigured drive data sets for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460) or product partners.

Installing the drive data record

Pre-configured drive data sets are provided as a file (tms *.mpk) and must be installed in STEP 7 engineering. A drive data record file can contain the configuration of one or more motors.

Expand the list of drives by installing new drive data sets from the file system:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Click "Install the drive data record" and select one or more drive data record files that you want to install.
5. Confirm the disclaimer by clicking on "I agree".
   If you do not agree to the disclaimer, close the dialog with "Cancel". In this case, no drive data record file will be installed.

You have installed a drive data record and can now use it.

NOTE

An installed drive data record is installed locally on the PG/PC only for the current STEP 7 version. To open the local installation folder, click the "Locally installed drives" link in the "Configure drive data record" wizard.

Using a preconfigured drive data record

You can search for the desired drive in the list of all locally installed drives.

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Select the desired drive from the list under "Search here for drive or enter filter".

5. The selected drive data record is displayed in the report area and you can check the data.
6. Accept the configuration with "Yes".

You have selected and set up a preconfigured drive data record.

NOTE

You can pass on a saved engineering project with preconfigured drive data record or use it on a different PG/PC on which the utilized drive is not installed. In this case, no optional additional information on the drive is displayed, e.g. manufacturer or order number. This is displayed as soon as you have installed the utilized drive.

7.4.4 Using a user-defined drive data set

Create a user-defined drive data set and configure your motor manually.

You can freely configure the current drive data at any time, even if it was imported via a predefined drive data set or a parameter table.

⚠ WARNING

Avoiding incorrect parameter assignments

Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

7.4.5 PMSM drive parameters

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0304	Nominal voltage	Refer to the motor data sheet for the nominal voltage of the motor. The nominal data of the motor are based on this voltage.	V
p0305	Nominal current	The nominal motor current is the current value at which the motor delivers its nominal power and nominal torque under nominal conditions. The nominal current value refers to the ambient conditions specified by the motor manufacturer. If, for example, the motor ambient temperature differs from that of the motor manufacturer, the nominal current must be adjusted according to the manufacturer's specifications.	A
p0311	Nominal speed	Nominal motor speed is the speed at which the nominal values of the motor are valid.	rpm
p0312	Nominal torque	Nominal torque is the torque at the nominal operating point of the machine.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm

Parameter number	Name	Description	Unit
p0323	Maximum current	The maximum current is the maximum motor current permitted for a short time. The motor can be operated briefly up to this current without resulting in damage, but continuous operation is only permissible up to the maximum nominal current. The maximum current can flow until the limitation of the thermal model intervenes. Specifications such as permissible motor peak currents, e.g: for the duration of 1 s, are not to be entered here.	A
p0316	Torque constant	The torque constant of the motor is the proportionality factor between the RMS current of the q current and the internal torque of the motor. The motor torque is calculated from this constant.	mNm/A
p0314	Number of pole pairs	Number of pole pairs of the motor. For example, an 8-pole motor has 4 pole pairs	-
p0372	Connection resistance (= internal resistance)	Connection resistance of the motor between two motor phases.	Ohm
p0376	Connection inductance q component (=winding inductance q)	Connection inductance between two motor phases in the q axis. When only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0377	Motor connection inductance d component (=winding inductance d)	Connection inductance between two motor phases in the d axis. If only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p0318	Standstill current (= holding current)	The standstill current of the motor corresponds to the current value with which the motor can be permanently loaded at standstill under the ambient conditions specified by the motor manufacturer.	A
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s

Parameter number	Name	Description	Unit
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.6 Drive parameters stepper motor

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0305	Nominal current	Nominal current per coil in full step mode.	A
p0312	Hold torque	Hold torque of the stepper motor in full step mode and nominal current.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0372	Connection resistance	Connection resistance of a phase	Ohm
p0376	Connection inductance	Connection inductance one phase	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p30000	Step angle	Step angle of the stepper motor in full step mode.	°
p30001	Number of steps	The number of steps indicates the number of steps per mechanical revolution in full step mode. The value cannot be edited and is calculated from the step angle. Number of steps = 360° / step angle	-
p0014	Number of pole pairs	The number of pole pairs indicates the number of pole pairs in the motor. The value cannot be edited and is calculated from the step angle. Number of pole pairs = step angle / 4.	-
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the	s

Parameter number	Name	Description	Unit
		motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.7 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Parameter number	Name	Description	Unit
Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

Depending on the motor type, you can select the following encoders:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)
- (6) Absolute encoder BiSS-C

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

7.4.7.1 Encoder parameters, incremental encoder, IQ encoder and encoderless/calculated

The encoder types incremental encoder, IQ encoder and encoderless/calculated use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder, IQ encoder

The increments per revolution must be set for the incremental encoder and the IQ encoder. The increments can be independently detected at the incremental encoder by the automatic encoder detection of the TM Drive.

Encoderless / calculated with stepper motor

With the setting encoderless / calculated, the motor moves at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution (increments per revolution (p0408)) must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

It is recommended to set every integer multiple of the motor full step angle (p30001); a step division into partial steps (1/2, 1/4, 1/8, etc.) is not necessary but can improve the positioning accuracy, especially with multi-pole stepper motors. The following table shows how the corresponding step subdivisions are determined for this.

Step resolution	**Steps per revolution (p0409)**	**Increments per revolution (p0408)**	**Example: Step angle = 1.8°; Number of steps = 200; Number of pole pairs = 50**	
			Steps per revolution (p0409)	**Increments per revolution (p0408)**
Full step	1 x number of steps (p30001)	1/4 x number of steps (p30001)	200	50
1/2 half step	2 x number of steps (p30001)	2/4 x number of steps (p30001)	400	100
1/4 fourth step	4 x number of steps (p30001)	4/4 x number of steps (p30001)	800	200
1/8 eighth step	8 x number of steps (p30001)	8/4 x number of steps (p30001)	1600	400
.	.	.	.	.
1/64 sixty-fourth of a step	64 x number of steps (p30001)	64/4 x number of steps (p30001)	12800	3200

7.4.7.2 Encoder parameters for absolute encoder BiSS-C

A BiSS-C encoder transmits absolute encoder position as single-turn and optionally as multiturn values. The transmission occurs according to the specified BiSS-C protocol. The following figure shows the structure of the protocol. Using the BiSS-C protocol, in addition to the encoder position values single-turn (ST) and multiturn values (MT), an encoder-side alarm bit and a warning bit can also be transmitted. Transmission errors are detected using a CRC (Cyclic Redundancy Check).

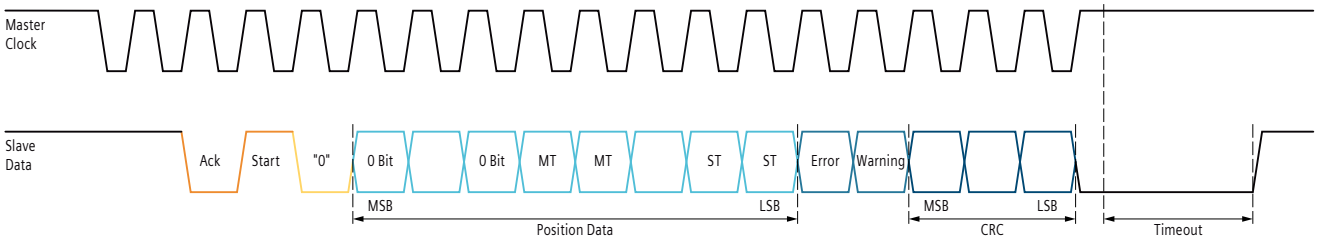


Figure 1-327 BiSS-C protocol

Table 1-669 **Encoder values**

Additional absolute encoder BiSS-C			
Parameter number	**Name**	**Description**	**Unit**
p0423	Single-turn resolution	Number of bits of the single-turn resolution The resolution of the single-turn value (ST) is calculated as follows 2^(p0423[0]). The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits
p0421	Multiturn resolution	Number of bits of the multiturn resolution The resolution of the multiturn value (MT) is calculated as follows 2^(p0421[1]). The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits
p0449	Number of bits before position value	Number of bits before the position value In some telegrams, so-called empty bits (0-bit) are inserted before the position bits. The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits
p0429:0..1	Transfer code	Selection of the transmission code Valid values: [1] Dual	-
p0427	Transmission frequency	Selection of the transmission frequency between the module and the encoder. The following values can be set: [0] 350 kHz [1] 700 kHz [2] 1.4 MHz [3] 2.8 MHz The maximum transmission speed depends on the cable length and its shielding as well as the technical specifications of the absolute encoder.	kHz

Additional absolute encoder BiSS-C			
p0429:2	Encoder diagnostics	Selection whether the encoder diagnostic bits are to be evaluated or ignored. If diagnostics are not selected, warnings and errors of the encoder are ignored.	-
p0450	CRC polynomial	Input of the polynomial length of the cyclic redundancy check (CRC). Note: Only the recommended CRC value for BiSS-C encoders with 43 hex is supported.	-

7.4.7.3 Assign encoder counting direction parameters

For encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting parameter p0410, Invert encoder counting direction. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows.

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

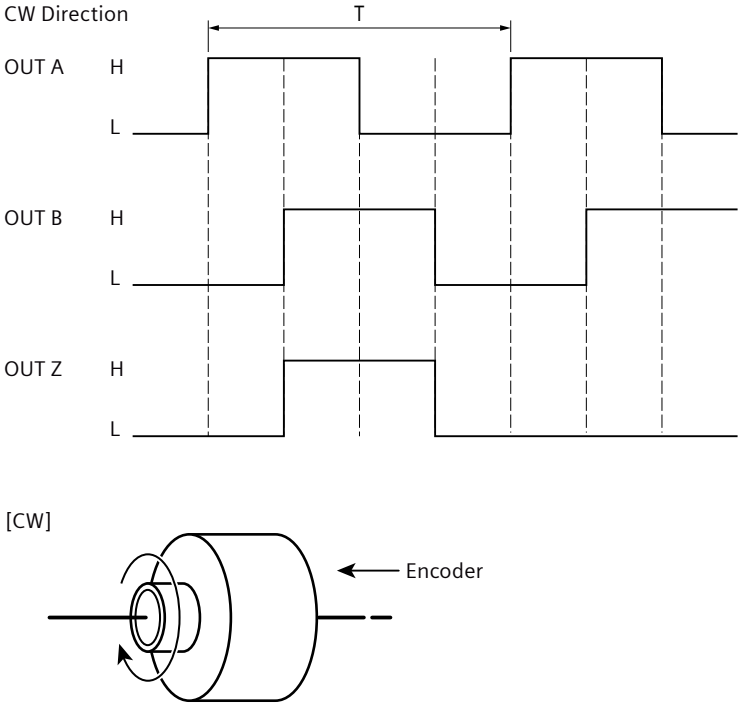


Figure 1-328 Direction of rotation for the incremental encoder

Definition:
A positive speed in TM Drive is defined as follows:

The motor rotates clockwise looking down on the motor shaft. The encoder value increments during this process.

Table 1-670 **Encoder values**

Parameter number	Name	Description	Unit
p0410	Reverse encoder counting direction	This setting negates the counting direction of the encoder.	-

7.4.7.4 Setting the commutation angle offset and pole position identification

For the commutation of a PMSM with the encoder type

- [1] Incremental encoder (A, B, Z track)
- [6] Absolute encoder BiSS-C

it is necessary to know the commutation angle offset or to determine it.

The commutation angle offset is the angle offset between a reference (Z-track for incremental encoders or the (single-turn) value "0" for absolute encoders) and the rotor / pole position.

Encoder calibration at each start (p1990)

If the parameter (p1990) "Encoder calibration at each start" is set, the determination of the commutation offset angle is repeated, for example, by voltage interruption at each restart or after each configuration of the drive.

If the parameter (p1990) is not selected, the value entered in the commutation angle offset (p0431) is used for commutation. If the offset angle is known, this can either be entered or automatically determined by TM Drive (see section Automatic encoder / pole position identification (Page 89)).

NOTE

Incremental encoder

After a new configuration or after switching off the power supply, the pole position is unknown when using an incremental encoder. If the parameter (p1990) "Encoder calibration at each start" is not set, the motor control is speed controlled with a fixed motor (running) current depending on the motor current parameters until there is synchronization of the pole position.

If synchronization with the Z-track is not possible, the control is aborted.

If the rotor position has not yet been synchronized, the drive may be twisted by an external load. If you want to prevent the drive from rotating directly after drive activation, you can use the Additional torque parameter (p1511) to ensure that a corresponding hold torque is applied to the motor (see section Speed control (cascade) (Page 96)).

NOTE

Motor replacement

When replacing the motor, remember that the motor encoder in a motor series is not always calibrated in the same way.

If the encoder calibration is selected at every start, no further action is required.

If this is not the case, the commutation angle offset must be determined again in the encoder / pole position identification (see section Automatic encoder / pole position identification (Page 89)).

⚠ WARNING

Incorrectly set commutation offset angle
It must always be ensured that the commutation offset angle is set correctly.
Otherwise, there will be insufficient control of the drive and it will not achieve its full performance or it will proceed in an uncontrolled manner.

Table 1-671 Encoder values

Parameter number	Name	Description	Unit
p1990	Encoder calibration at each start	If this option is selected, the commutation angle offset is determined again at every restart (new configuration or switching off the supply voltage). It is recommended to determine the commutation angle offset once during commissioning. Calibration is then no longer necessary, except when replacing the motor.	-
p0431	Commutation angle offset	Setting the commutation angle offset The commutation angle offset is the angle between the rotor pole position and the 0° degree pulse of the encoder. If the angle offset is not known, it can be determined by the module during commissioning. The offset angle is defined as follows. Incremental encoder: 0° offset is present if the Z pulse is applied at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. Absolute encoder: 0° offset is present if the angle value is 0 at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. **Warning:** **An incorrectly set commutation angle offset can lead to uncontrolled behavior of the drive!**	-

7.4.7.5 Calibration process of the commutation angle offset

When selecting parameter p1990 "Encoder calibration at each start", the TM Drive restarts the calibration process of the motor pole angle after:

- Every initial enable of the drive
- Every time the power supply is switched on again
- After re-configuration
- If certain malfunctions of the module occur

After that, the TM Drive references with the determined offset angle over the Z-track or the encoder steps of the absolute encoder.

The motor is energized for the calibration process and thereby generates torque.

The motor current is limited by the:

- Prospective locked rotor current (p0318)
- Equivalent current from the nominal torque of the motor (p0312)
- The equivalent current from the torque limitation (p1520)
- The maximum converter current

The smaller limitation in each case takes effect.

A possibly existing motor holding brake must be opened, so that a rotation of the motor is possible. If the motor holding brake is configured via the TM Drive and connected accordingly, the task of opening the holding brake is assumed by the TM Drive.

NOTE

If you have selected (p1990) "Encoder calibration at each start", the drive must retrain itself at initial commissioning and each time the power supply is switched back on or a new project download is performed. This process can take between 1 - 4 seconds. The motor can move by a maximum of 180° / number of pole pairs. Such movement must be possible in the application.

The following constraints must be observed:

- The motor must be able to rotate freely in both directions of rotation and the axis must not be loaded with a static load.
- With suspended loads, the option (p1900) "Encoder calibration at every start" must not be used.
- It is recommended to use an absolute encoder especially for suspended loads.
- The calibration process cannot be performed when the axis is rotating, or the speed must be below the standstill detection p1226.

NOTICE

Open motor holding brake

The motor holding brake is opened during calibration of the commutation angle offset. Especially with suspended axes, it is therefore important to ensure that it is possible to open the motor holding brake.

An unexpected collapse of a hanging axis can result in personal injury and property damage.

Before commissioning, you must ensure that a cross brace is fitted to hold the suspended axis in position and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Motor movement by measurement on unbraked motors

The measurement can be used to trigger a rotation or movement of the motor via the specified current on unbraked motors. The magnitude of the movement depends on the specified current as well as on the moment of inertia of motor and load.

7.4.7.6 Automatic encoder / pole position identification

Automatic encoder pole position identification is found in the Commissioning submenu of the configured TM Drive. This function is only possible with the PMSM motor type. Incremental encoders and absolute encoders can be detected. Depending on the encoder type, the following encoder / motor parameters are automatically detected:

Incremental encoder (1) and absolute encoder (6)

- Commutation angle offset (p0431)
- Number of pole pairs (p0314)

Incremental encoder only (1)

- Increments per revolution (p0408)
- Invert encoder counting direction (p0410)

For automatic encoder / pole position identification please proceed as follows:

Preconditions

- Motor type PMSM
- The motor parameters are known and the calculation of the controller parameters under open-loop/closed-loop control has been performed and transferred to the drive.
- The device is in RUN state and the drive is at standstill.
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during encoder detection, the commutation offset angle may not be correctly detected. The motor can then only deliver a reduced torque.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the encoder / pole position identifier.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:
The configured motor type and motor encoder is displayed under Commissioning encoder / Pole position identification. Insert the identification current allowed for the test. This is always automatically set to the rated motor current. However, it can be adjusted if required.

NOTE
If the motor is already installed in an application, you may need to increase the identification current in steps. The motor maximum current p0323 must not be exceeded. If necessary, observe idle times between the identification cycles to avoid overheating the motor. Especially for motors with an increased cogging torque, it may be necessary to increase the identification current so that the encoder and pole position information can be accurately detected.

Step 3:
Start the encoder / pole position identification with the selection button "Start encoder detection".

A configured motor holding brake is opened during encoder / pole position identification. This is signaled via ZSW1 bit 12.

NOTICE

Open motor holding brake
The motor holding brake is opened during encoder / pole position identification. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a suspended axis can result in personal injury and property damage.

Step 4:
If the drive is still in operation, execution of the identification commands is rejected. Stop the operation of the drive before the encoder / pole position identification. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the identification after the confirmation of the safety prompt. It is necessary that the drive can be turned safely in both directions.

Step 5:
If the encoder / pole position identification is successfully executed, the determined values are displayed.

NOTE
Before you apply the determined values, you need to check them for plausibility.

Step 6:
You can now select which of the determined values you want to transfer to the offline project. By clicking the "Transfer determined values to offline project" button, the selected values are transferred to the offline project.

NOTE
The determined settings are stored only temporarily on the module. They are replaced by the permanently stored parameters on the next restart.
If you want to store the settings permanently on the module, change the drive parameters offline and download them again with "Download to device".

Step 7:
When you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device".

Encoder / pole position identification is completed. The option "Encoder calibration at each start" (p1990) is no longer required and should be deselected.

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 92)
- Application limits (Page 92)
- Ramp generator and speed setpoint filter (Page 95)

The figure below shows the processing of the speed setpoint in the drive controller.

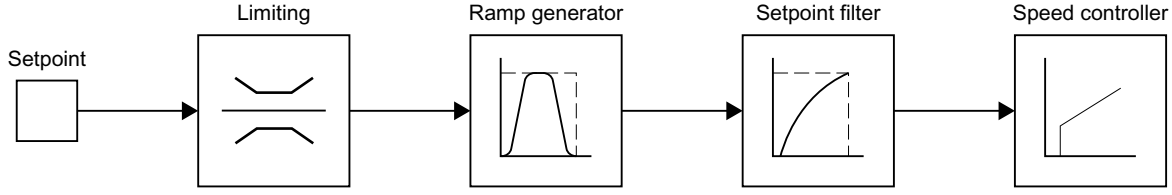


Figure 1-329 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 92).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 92).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp generator and speed setpoint filter (Page 95).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.
- Torques are normalized to the reference torque (p2003) in the drive telegram.

Parameters p2000 and p2003 are definitive as reference values (telegram content = 4000 hex or 4000 0000 hex for double words, if the input value has the value p2000 or p2003).

Example of the normalization of the speed:

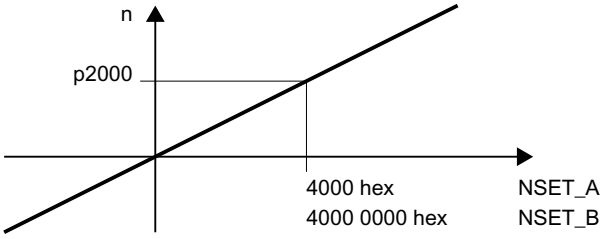


Figure 1-330 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.
Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:
   "Parameters" > "Setpoint channel" > "Reference values".

⚠ WARNING

Uncontrolled drive behavior
Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur.
Recommendation: First, complete the commissioning of the drive and thereby the definition of the reference values before you start up the CPU and a technology object, for example.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent limiting of the speed p1083 and p1086, you can define speed limits for each direction.

Torque limiting

You can specify the torque limitation p1520 as an absolute value. The limiting acts both when motoring as well as generating.

⚠ WARNING

Accuracy of torque limitation
The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.
The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.
Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Internal motor constant p0316
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses of the motor

⚠ WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment
Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.
Ensure the correct parameterization.

Zero speed detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).
As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.
If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted as soon as the speed threshold for standstill detection has been undershot.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)
  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)
  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback
- "On delay time" (p2167)
  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

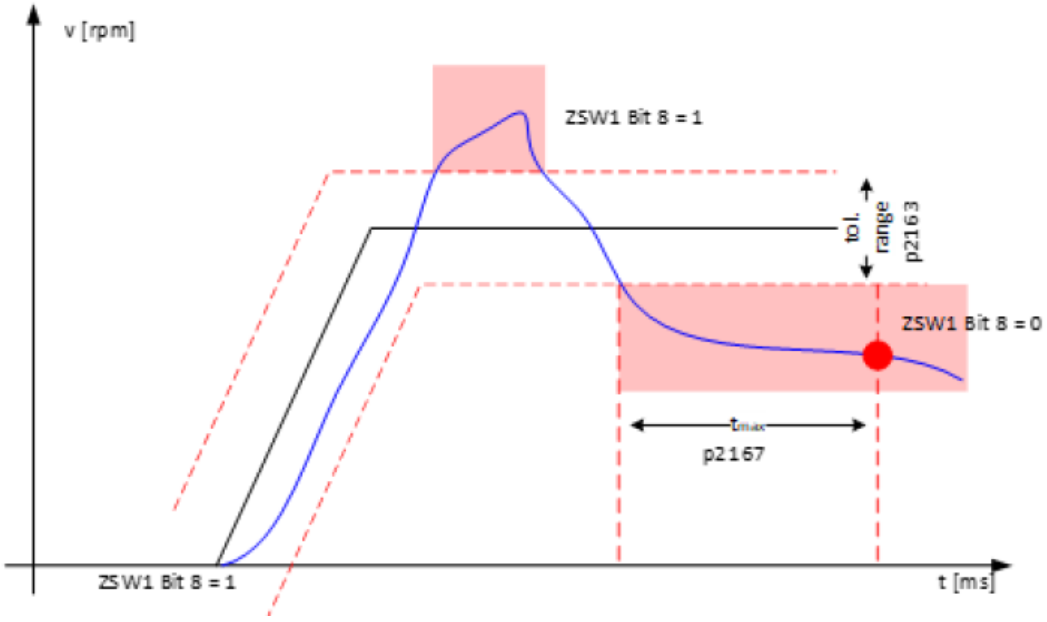


Figure 1-331 Sets the ON-delay time (p2167) and the speed threshold value 4 (p2163)

End stop detection and step loss detection with the stepper motor

When an incremental encoder and the control type [103] controlled (I = const.) are used with a stepper motor, end stop detection or step loss detection can be implemented using bit 8 in the ZSW1. The parameters "speed threshold value 4" (p2163) and "On delay" (p2167) can be used to set the detection tolerance range.

7.5.3 Ramp generator and speed setpoint filter

Speed ramp generator

The TM Drive uses the speed ramp generator type "Basic ramp-function generator" p1115[0].

The ramp generator can be switched off with the setting "No ramp generator".

The speed ramp generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

NOTE

On principle, the ramp-up and ramp-down times of the ramp generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.
Especially with the control type [103] controlled (I = const.), the ramp-up and ramp-down times must not be set too steep, as otherwise the rotor cannot follow the controlled rotating field.

Procedure

You enter the settings for the speed ramp generator under "Parameters" > "Parameters" > "Ramp generator":

- Rampup time
- Ramp-down time
- Speed

NOTE

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp generator ramp-up time" (p1120) and "Speed ramp generator ramp-down time" (p1121).
When using the GSD file, directly enter the values relative to 10,000 rpm.

Speed setpoint filter

The drive has a first-order time-delay element (low pass PT1) as a speed setpoint filter. The filter time constant can be set with p1416.

The speed setpoint filter is able to attenuate harmonic components of the setpoint and thus to prevent any overshooting of the higher-level controller.

The speed setpoint filter has no effect on the stability of the speed controller because it is in the setpoint channel before the control loop. The dynamics of the response to setpoint changes is reduced by smoothing.

As a rule, set the speed setpoint filter to a low value, since the upstream ramp generator ensures sufficient limitation of the setpoint signal.

7.6 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type. The following combinations are available:

Motor type: PMSM motor

- [100] Closed-loop speed control (cascade)

Motor type: Stepper motor

- [103] Controlled (I = constant)

7.6.1 Speed control (cascade)

In Speed controller (cascade) mode, the speed difference between the actual and the nominal speed is detected using an encoder and the speed deviation is controlled accordingly. Since the speed controller is followed by a current controller, this speed control method is referred to as cascade control.

General controller settings

Speed and current controllers can be optimally tuned if the properties of the load mechanics of your machine and the electrical properties of the drive are specified as correctly as possible.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399
- Additional torque p1511
- Speed actual value filter p1441

Speed stability can be improved using the actual speed filter, depending on the encoder resolution.

Constant loads can be compensated using additional torque p1511. This reduces compensation processes when the drive is switched on using motor holding brakes.

Additional important settings

The values for speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Precontrol p1496

Using the precontrol (p1496), the precontrol of the moments of inertia, consisting of Motor (p0341), Motor gear (p2725) and Moment of inertia load (p1496), can be specified as a percentage value. The precontrol allows the drive to be moved more dynamically. The precontrol is switched off with a preset of 0%. The precontrol is preset by the automatic controlled system detection (see section Automatic controlled system detection (Page 99)) depending on the controller dynamics.

To use this function, the setpoint speed must be preset by a ramp. For this, you can either use the internal ramp generator (see section Ramp generator and speed setpoint filter (Page 95)) or corresponding acceleration/deceleration functions in technology objects.

Viscous friction p1399

The friction of the system is precontrolled using Viscous friction (p1399). This is specified as a linear friction torque as a function of the speed and is detected during automatic controlled system detection.

Additional torque p1511

Constant loads can be compensated using additional torque (p1511). This reduces compensation processes when the drive is switched on using motor holding brakes.

Speed actual value filter p1441

The drive has a first-order time-delay element (low pass PT1) as a speed actual value filter. The filter time constant can be set via (p1441).

The parameter is preset depending on the parameter "Increments per revolution" p0408 in the HSP. If you configure the device using a GSDML, you can use the following table as a guide.

Table 1-672 Actual speed filter times as a function of the encoder resolution

Encoder resolution (Steps per revolution p0409 or [2]Single-turn resolution p0423)	**Speed actual value filter p1441 in ms**
400	11
512	10
1024	8
2048	6
4096	4
6000	2
10000	1
16000	0

Speed controller and current controller

You can either have the speed and current controller parameters calculated via the controller settings of STEP 7 or you can perform the automatic controlled system detection (7.6.2). It is also possible to set the controller settings manually.

Having controller settings calculated
To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click the "Calculate speed number/current controller settings" button in the area for the controller settings.
   The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. If needed, you can re-adjust the controller settings via the "Controller behavior" and "Load fluctuation" sliders.
   – "Controller behavior": If the value is increased, the controllers react more strongly to controller differences. At the same time, the controller tends to overshoot.
   The default setting here is 70%.
   – "Load fluctuation": A larger value allows more oscillation in the stable state. The speed deviations are greater during a load step.
   The default setting here is 30%.

NOTE
There is no guarantee that readjustment of the controller calculation will always result in a stable system.
Change the settings for "Controller behavior" and "Load fluctuation" incrementally. Always check the settings with low speed and load profiles.

3. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually
Enter the settings for the speed controller under "Parameters" > "Control/closed-loop control" > "Speed controller".

- Prop. gain
- Integral action time
- Speed actual value filter

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Iq proportional gain
- Iq integral action time
- Id proportional gain
- Id integral action time

NOTE
If you manually set the controller parameters to inappropriate values, the drive system can be damaged.
Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.2 Automatic controlled system detection

You can find the automatic controlled system detection in the Commissioning submenu of the configured TM Drive. This function is only possible with the cascade control mode (p1300).

During the measurement run, the system is measured using test signals. The drive is moved in the process. Configured torque (p1520) and speed limits (p1083 and p1086) are taken into account and can also be used to protect the drive or the application.

The drive accelerates to the test setpoint speed, stops and executes the same travel profile in the reverse direction of rotation. The motor is thereby approximately at the starting position again after the measurement run.

The "Reversal of direction of rotation" checkbox can be used to specify the direction of rotation for the measurement run. If the check box is selected, the motor rotates counterclockwise when viewing the motor shaft, otherwise the motor shaft rotates clockwise. By specifying the number of motor revolutions, it is possible to limit the maximum rotation of the drive. The input of the number of revolutions limits the test setpoint speed if necessary.

The following parameters are automatically determined during controlled system detection:

- Motor connection resistance including motor cable line resistance
- Current control parameters
  - Iq proportional gain p1715
  - Iq integral action time p1717
  - Id proportional gain p1735
  - Id integral action time p1736
- Speed controller parameters
  - Prop.gain p1460
  - Integral action time p1462
- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399

The controlled system detection function automatically provides you with the controller parameters specific to your application and motor.

The controlled system detection function can be adapted to different system requirements.

The connection resistance of the system is detected during the controlled system detection. The determined resistance is divided between the connection resistance (p0372) and the resistance of the motor supply line (p0352).

- If the measured resistance is greater than the connection resistance (p0372), the additional portion is allocated to the motor cable line resistance (p0352).
- If the measured resistance is less than the connection resistance (p0372), this is adjusted and the portion of the motor cable line resistance (p0352) is set to 0.

⚠ WARNING

Unplanned movement of the motor during speed controller tuning
Speed controller tuning causes movement of the drive which can result in death, serious injury or material damage.

- Ensure that nobody is present in the hazardous zone and that the mechanical system can move freely.

NOTE

Directions of rotation and permissible motor rotation range
In the application, the motor must be able to move at least in the specified motor rotation range (p8991). The machine may be damaged if the traversing range is not accordingly limited.
If this is not permissible due to your plant conditions, it is prohibited to perform controlled system detection.
Before commissioning, ensure that the motor and application parameters are correct.

Procedure

Preconditions

- Cascade control mode
- The motor and application parameters are known and transferred to the drive.
- Speed and torque limitation are configured and transferred to the drive.
- The device is in RUN mode and the drive is at standstill
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during the controlled system detection, this may result in the speed and current controller parameters not being detected correctly.

Step 1:
Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the controlled system detection.

You can abort controlled system detection at any time by pressing the "Exit" button. The drive coasts to a stop and the motor holding brake closes. The drive may have to be returned to its start position before a new measurement run.

NOTE
In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:
Make the settings for controlled system detection.

- Measurement run dynamics p8990

  The acceleration gradient of the rotating measurement run can be influenced using the measurement run dynamics factor.

  A high value is suitable for torsionally stiff systems and low mass inertias and a low value for elastic systems or systems with high mass moment of inertia.

  Generally, a high measurement run dynamic factor provides better results for the rotating controlled system detection. However, too high a measurement run dynamics factor can possibly lead to twisting, bending or other damage to the machine.

  Recommendation: Start with a low measurement run dynamics factor and, if necessary, repeat the controlled system detection with an increased measurement run dynamics factor.

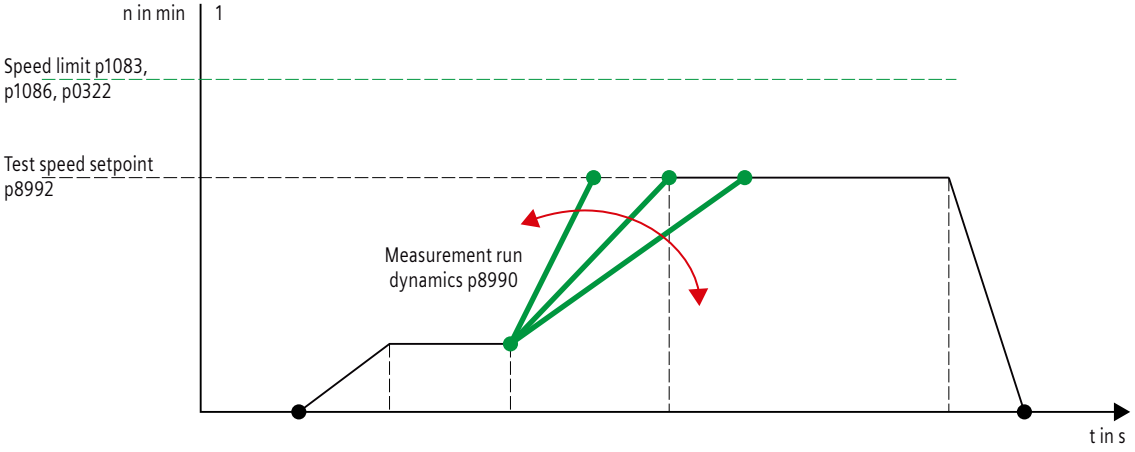


Figure 1-332 Measurement run dynamics

- Max. number of motor revolutions p8991

  Specifies how many revolutions the motor may cover during the measurement. Ensure that a rotation with the configured number of motor revolutions is possible in the direction in which the motor is moved (specified via the "Reversal of direction of rotation" check box).

- Test speed setpoint p8992

  If possible, enter a typical speed value for the test speed setpoint at which the drive is to be operated later.

  If the measurement run is not possible due to the entry from max. number of motor revolutions (p8991) in combination with the test speed setpoint (p8992), this is displayed and a maximum possible test speed setpoint (p8992) is suggested in the text box.

- Torque limitation p1520
  The torque limitation is displayed as a parameter (read only). The setting must be made in the "Application limits" mask and the parameter must be loaded into the module.
- Controller dynamic factor
  Using the controller dynamic factor, you can set how the speed controller should be set up.
  – Conservative: Slow control – low mechanical load. (60% precontrol)
  – Default: Optimum between fast speed control and load of the mechanics. (80% precontrol)
  – Dynamic: Fast speed control – high mechanical load. (100% precontrol)

  A parameter check is performed automatically. This ensures that the drive can perform the measurement run with the configured dynamics within the configured max. number of revolutions. If the measurement run with the configured values is not possible, a warning is displayed and a reduced value for the test speed setpoint is entered.

Step 3:
Start the controlled system detection with the "Start controlled system detection" selection button.

A configured motor holding brake is opened during controlled system detection. This is signaled via ZSW1 bit 12.

NOTICE
Open motor holding brake The motor holding brake is opened during controlled system detection. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a hanging axis can result in personal injury and property damage.

Step 4:
If the drive is still in operation, execution of the controlled system detection is rejected. Stop the operation of the drive before the controlled system detection. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the controlled system detection after the confirmation of the safety prompt. The drive is moved several revolutions for this.

Step 5:
After successful controlled system detection, the system variables and suitable controller values determined are displayed.

Depending on the application, it may be advantageous to perform the controlled system detection several times in succession and, if needed, to adjust the measurement run dynamics p8900.

NOTE
Before you apply the determined values, you need to check them for plausibility. If necessary, the control can be tested for stable behavior by traveling briefly in both directions (+/-).

Step 6:
You can now select which of the determined values you want to transfer to the offline project. The selected values are transferred to the offline project using the "Transfer determined values to offline project" button.

Step 7:
Once you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device". Otherwise, the parameters will be lost after switching the module off and on.

Automatic controller tuning is now complete.

Check the settings automatically found using a measurement run with your application. For additional optimization of the controller settings, you can use manual controller tuning from the section Manual controller tuning Speed controller (cascade) (Page 104).

NOTE
If the automatic controlled system detection could not determine any controller parameters, a new measurement run can be initiated by entering a higher moment of inertia of the load under control/closed-loop control parameters and repeating the controlled system detection. The controller parameters can thus be adapted for the machine. The measurement run is thus set to the increased inertia of the load.
You can save the measurement run to a csv file using the "Export measurement data" button.

Faults during controlled system detection

Faults during controlled system detection are displayed directly in the commissioning screen and can be acknowledged.

Table 1-673 Causes of faults and errors

Fault number	Description	Cause / Solution
1055	Motor resistance detection could not be performed	If the motor phases are not connected correctly or insufficiently contacted, or if there is an asymmetry between the individual winding resistors, the error "Unable to successfully perform motor resistance detection" is set. Check the motor connections or the motor for defects and breaks.
1056	Following error during controlled system detection	If the drive is not able to follow the setpoint travel curve, this error is displayed. In this case, it is likely that the Measurement run dynamics p8990 was selected too large. Reduce the Measurement run dynamics p8990 and repeat the controlled system detection. It is also possible that the drive is blocked or the motor holding brake has not been configured or connected correctly.
1057	Position error during controlled system detection	If the maximum number of revolutions is exceeded, e.g. by an external load acting on the drive, this error is set and the drive is switched off. Either the controlled system detection is not possible in the application or reduce the external force on the drive train.

7.6.3 Manual controller tuning Speed controller (cascade)

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure

For manual controller tuning, proceed as follows:

Step 1:
Go online to the module with TIA Portal by clicking on the "Connect online" selection button.

Step 2:
If you have not already calculated the controller parameters under Control/closed-loop control, you can do this again here. First, enter the mass moment of inertia of the load.
Use the "Calculate" selection button to calculate the controller parameters.

Step 3:
The calculated controller values are displayed. The online values, i.e. the currently active values, are also displayed on the module.

Step 4:
With the selection "Apply online" button, the new controller values are directly transferred and take effect.

NOTE
When the axis is in operation, the enable is automatically canceled and the new parameters are applied.

Step 5:
You can now put the drive into operation with a speed or positioning TO, for example, and evaluate the control behavior using a trace recording.
If the control behavior is satisfactory, continue with step 7.

Step 6:
If additional tuning is required, there are 2 options to better adjust the control parameters.

1. You can calculate the controller parameters again as described in step 2 and readjust the parameters accordingly using the sliders. (See section Control/closed-loop control (Page 96) under Speed controller and current controller)
2. You set the controller parameters manually. You can orientate yourself on the old values and change the proportional gain and/or the integral action time as well as the precontrol step-by-step.

Perform the steps starting with step 4 again.

Step 7:
Once you have performed the tuning, you need to transfer the detected controller parameters to the drive parameters using the selection button "Apply controller values".
Terminate the online connection ("Go offline" selection button) and then reload the project onto the module using "Download to device". This ensures that the parameters are still active in the project and on the module after a restart.
Controller tuning is now completed.

7.6.4 Controlled (I = const.)

General controller settings

In the controlled control mode (I = const.), the speed is controlled by an angle adjuster. Depending on the respective speed, the control angle of the motor is switched faster or slower in quantified steps in the desired direction of rotation.

Speed controller
Recommendation: Specify speed changes along an acceleration and deceleration ramp, otherwise it is not possible for the drive to follow the speed specification.

The internal ramp-function generator (section 7.5.3) can be used as speed ramp.

Current controller
With the control mode controlled (I = const.), the current controller applies a constant current value to the motor. The motor current is specified using two current values for travel mode (p1738 run current) and standstill mode (p1739 stop current). The current values are effective values.

- Run current p1738
- Stop current p1739

The stop current is impressed on the motor while it is at a standstill and ensures a corresponding holding torque. If a speed not equal to 0 1/min is specified, the current setpoint is switched from stop current to run current. If the motor comes to a standstill from a movement, the setpoint current is switched from run current to stop current after 1 s.

In many applications, the stop current can be reduced during standstill. As a result, energy can be saved during the stop phases and the motor is subjected to less thermal stress.

For reasons of protection, the run and stop current may not be greater than 1.5 times the rated motor current (p0305).

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398

Additional important settings
The speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Current controller

You can either set the current controller manually or have the controller settings calculated by STEP 7.

Having controller settings calculated
To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click on the "Calculate current controller settings" button in the Controller settings area. The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- I proportional gain
- I integral action time

NOTE
If you manually set the controller parameters to inappropriate values, the drive system can be damaged.
Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.7 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp generator ramp-down (p1120, p1121).

If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or a timeout is detected, the pulses are inhibited after the motor brake closing time p1217 has elapsed. "Switching on inhibited" is activated.

Timeout
With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within twice this time, the drive is deenergized and coasts to a stop.

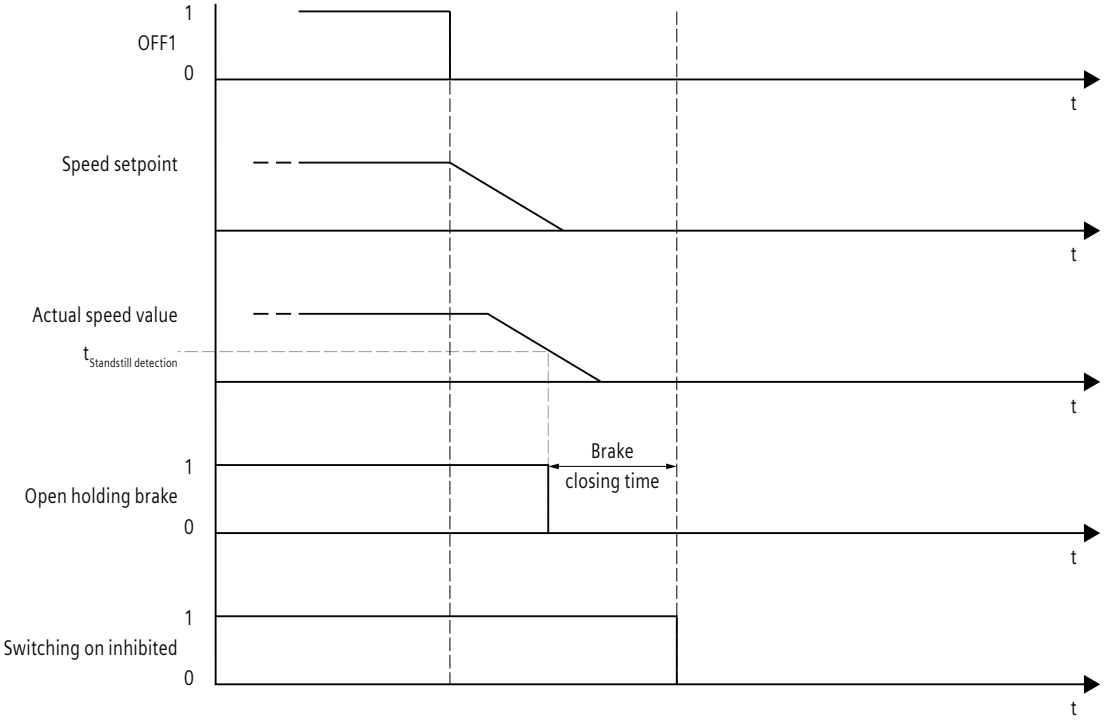


Figure 1-333 OFF1 sequence diagram when standstill detection is reached p1226

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). Immediate pulse cancellation occurs, any configured motor holding brake is closed. The drive coasts to a stop without a motor holding brake. "Switching on inhibited" is activated.

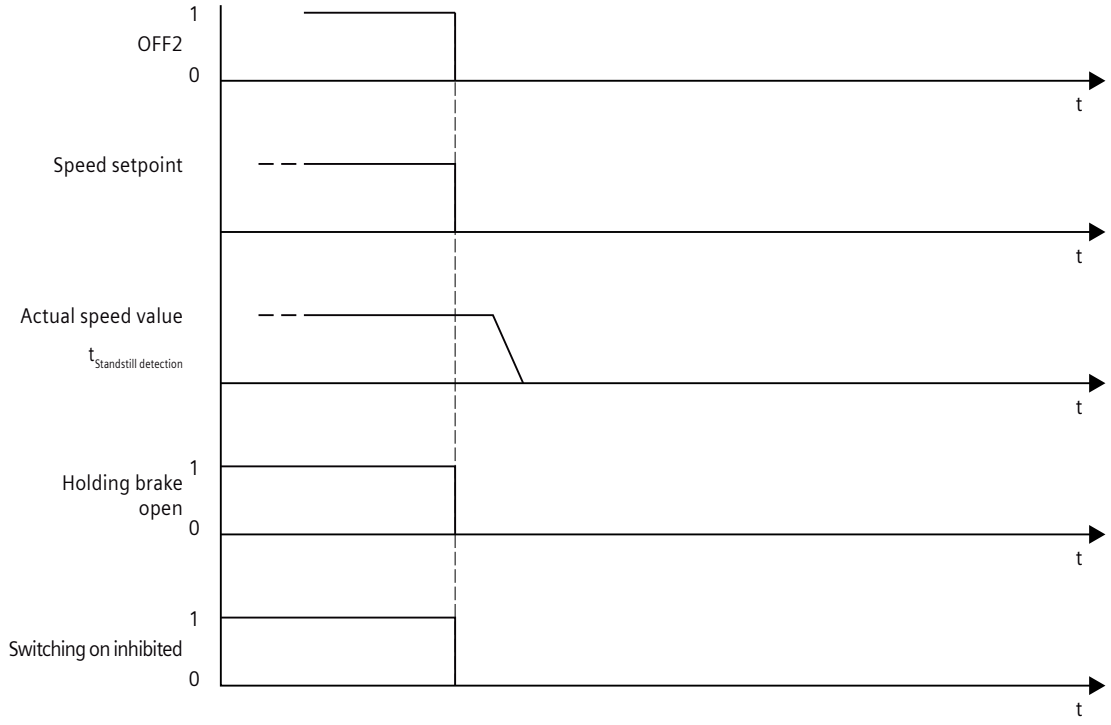


Figure 1-334 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator").

Timeout
The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

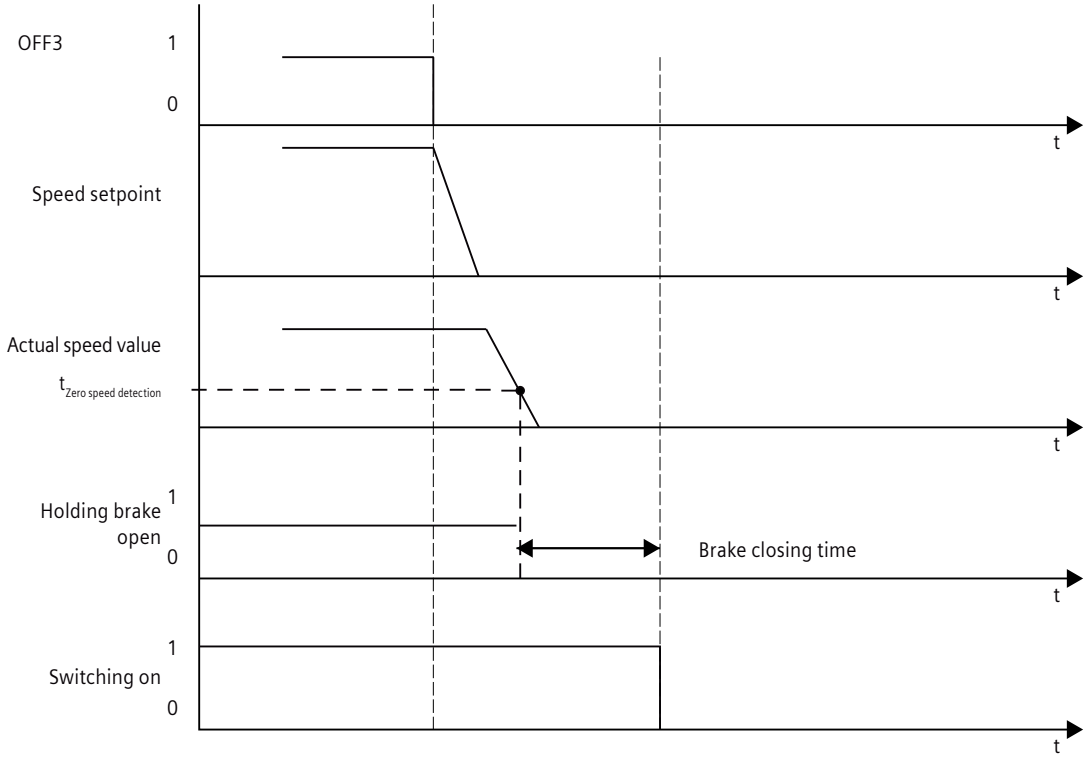


Figure 1-335 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)
- OFF2 (coast down) > OFF3 (quick stop)

7.8 DC-link voltage

The TM Drive system cyclically monitors the intermediate circuit voltage. The limits can be set under "Drive/Monitoring".

The regenerative feedback into the DC power supply cannot be suppressed. This has several advantages.

When the drive is braked and the brake chopper is not connected and configured, energy is fed back, which results in an increase in the interemeidate circuit voltage. For this reason the intermediate circuit voltage is monitored by the module.

You can freely set the intermediate circuit voltage monitoring limits within the permissible range.

If the limits are exceeded, the module switches off. Before the module switches off, it issues a warning (limit ∓ 5%) stating that the limit is almost exceeded.

Procedure

1. Open the "Intermediate circuit voltage" area in the context of the drive under "Parameters" > "Drive/monitoring".
2. Configure:
   – Minimum value of the intermediate circuit voltage p0390
   – Maximum value of the intermediate circuit voltage p0391

⚠ WARNING

Operation above the voltage setting range
Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and motor gear. Otherwise, the intermediate circuit voltage may increase when the control is inactive via 60 V DC.

7.9 Brake module

The TM Drive system has a brake chopper for connection of an external brake resistor and can control a motor holding brake externally via the process image using a DQ or relay module. These functions can be activated individually or in parallel.

You can select the following options for the PMSM motor type under "Brake module":

- [0] No function
- [2] Brake chopper
- [3] Brake chopper and motor holding brake external via the process image
- [4] Motor holding brake externally via the process image

You can select the following options for the stepper motor type under "Brake module":

- [0] No function
- [4] Motor holding brake externally via the process image

If stepper motors are selected, the brake chopper function cannot be used. If a brake chopper is required nevertheless, you can install another TM Drive module (except StepDrive) in the same potential group, connect the brake resistor there and configure the brake chopper as well. If no motor is connected to this module select a motor type (p0300) "[0] no motor".

7.9.1 Brake chopper

If the brake chopper function is enabled, you need to configure the following parameters in the "Parameters" > "Drive" > "Brake module" area.

Set the following values for the brake chopper:

- Chopper switch-on voltage
- Chopper switch-off voltage
- Thermal resistance of the braking resistor
- Time constant of the brake resistor
- Maximum temperature
- Ambient temperature
- Response to max. temperature

The switch-on and switch-off voltage of the brake chopper must be set correctly according to the DC voltage supply. The chopper switch-off voltage p6011 must be higher than the supply voltage (example U_{DC} = 48 V à p6011 = 50 V; chopper switch-on voltage p6010 = 52 V).

The voltage thresholds of the brake chopper should be adjusted accordingly with the parameters of the intermediate circuit voltage monitoring (7.7).

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

NOTICE
Risk of fire The switch-off voltage must not be lower than the DC supply voltage, otherwise the brake chopper will not switch off after activation and it may lead to an overload of the brake resistor and/or the module.

Capacity of the braking chopper output

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

You can find information about power calculation and resistor design in the appendix Braking resistor and brake chopper power (Page 150).

Monitoring of the braking resistor

The specific values of the braking resistor, such as heat resistance and time constant, can be obtained from the manufacturer of the braking resistor (data sheet). Typical values are stored as default values in the TIA Portal. The default values must be checked and adjusted if necessary.

- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

You use the maximum temperature to define the switch-off temperature for the resistor. The switch-off temperature is calculated in a thermal model based on the ambient temperature.

You use "Response to max. temperature" to define the behavior that is triggered when the maximum temperature is reached.

- Shutdown when temperature is exceeded Brake chopper operation is stopped and a warning is generated.
- No shutdown when temperature is exceeded Brake chopper operation is still possible.
- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

NOTICE

Risk of fire
If braking chopper operation continues despite reaching the maximum operating temperature, this can result in a sharp increase in the temperature at the braking resistor. This can damage surrounding components or even result in fires in the worst case.
In addition, always ensure that the minimum distances between the braking resistor and other modules are maintained.

⚠ CAUTION

Risk of burns due to hot surfaces
The braking resistor heats up during operation. Touching the hot braking resistor can result in personal injury and burns.
Avoid contact with the hot braking resistor.

NOTE

Brake chopper operation with STO selected
When STO is selected, the brake chopper of the respective module is inactive. This means that when STO is active, no braking energy of either the own or other axes can be dissipated by the braking resistor.
If the brake chopper function is mandatory despite STO release, you can install another TM Drive module (except F-TM StepDrive) into the same potential group, connect the brake resistor there and configure the brake chopper as well. If no motor is connected to this module, select the "[0] no motor" for motor type (p0300).

7.9.2 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the motor shaft (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the "Parameters" > "Drive" > "Brake module" area.

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

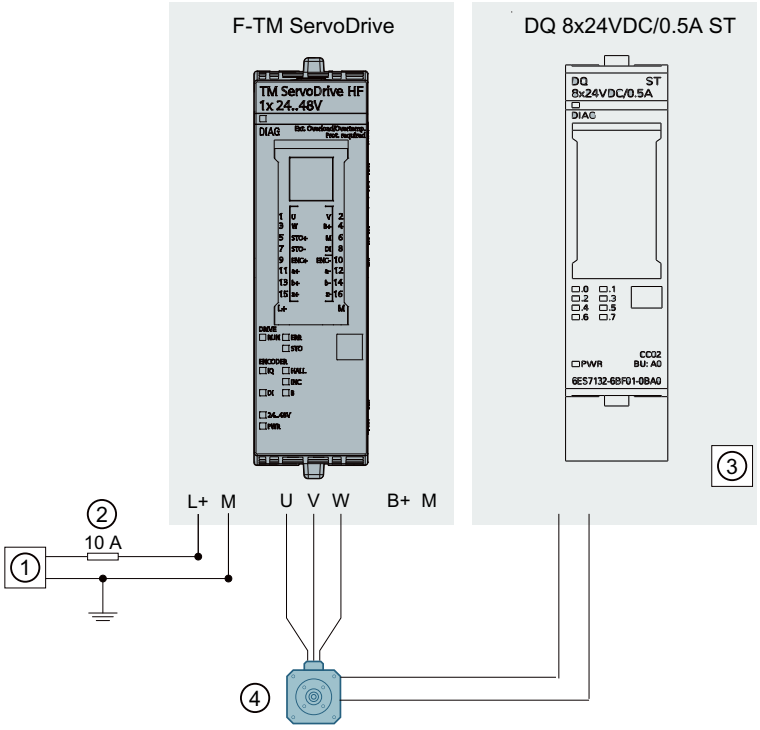
p1217 = motor brake closing time + relay closing time

If the motor holding brake is configured, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example, with a DQ module or relay module.

NOTE

When selecting the additional module, make sure that the current carrying capacity is suitable. This must be dimensionless depending on the current consumption of the motor holding brake.

RC circuit of a TM Drive with DQ module and motor holding brake



① Power supply unit
② Protective device
③ DQ module
④ Motor with holding brake

Figure 1-336 RC circuit of a TM Drive with DQ module and motor holding brake

Suspended axes

The additional torque p1511 is used to set an additional load torque.

To prevent the axis from sagging after the holding brake has been released, you can set an electronic counterweight via an additional torque p1511, section 7.8.1, for a suspended axis without mechanical weight compensation.

This reduces the compensation action after the release of a holding brake and specifies the holding torque directly after switch-on of the motor.

The option (p1900) "Encoder calibration at every start" must not be used with suspended loads.

NOTE

Suspended load with incremental encoder

For motors with incremental encoders where the commutation offset angle has not yet been synchronized, the axis may drop. This can be counteracted using the additional torque p1511, although a slight movement of the axis cannot be ruled out even then.

- It is recommended to use an absolute encoder especially for suspended loads.

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

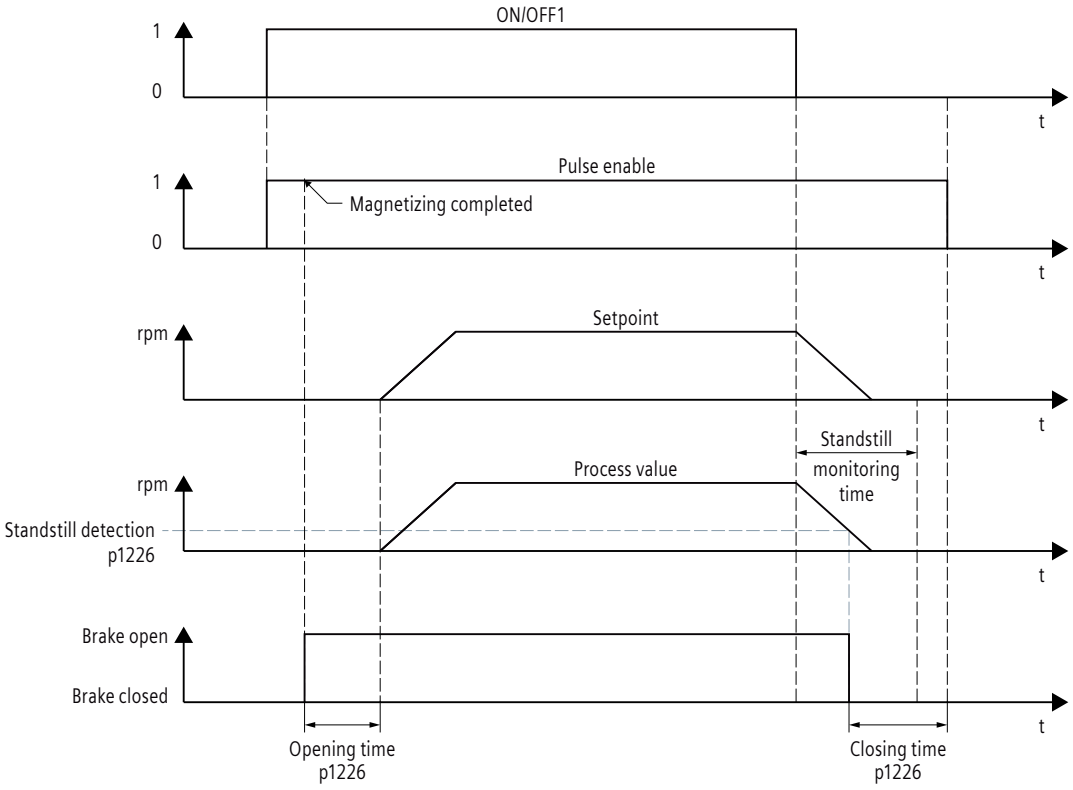


Figure 1-337 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 (Page 106) OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.10 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Braking resistor
  - Temperature model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor and brake resistance values

The thermal motor and braking resistor utilization are calculated quantities. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 143).

7.10.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

⚠ WARNING

Thermal motor utilization cannot be immediately determined after initialization
The thermal model is reinitialized after changing the drive data set and when switching on the device.
After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.
During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model
The I^2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

Motor type PMSM
If the PMSM reaches the 100% threshold, the motor current is limited to the rated motor current to prevent overheating.

Motor type stepper motor
When the stepper motor reaches the 100% utilization threshold, the drive is switched off and an error is set.

⚠ WARNING

Compliance with the ambient conditions specified by the motor manufacturer
The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.
If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.
If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.10.2 Braking resistor

Thermal monitoring of braking resistor

The braking resistor is monitored by a temperature model. You can specify the warning threshold (p0291[2]) relative to the shutdown threshold "Braking resistance maximum temperature" (p6023).

Procedure

1. Open the "Braking resistor" area in the context of the drive under "Parameters"" > "Messages/monitoring".
2. Configure the warning threshold p0291[2].

⚠ WARNING

Thermal braking resistance load cannot be determined immediately after initialization
The thermal model is reinitialized after changing the drive data record and when switching on the device.
The thermal braking resistance load cannot be determined immediately after initialization because the model must settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal parameters; the accuracy depends on to what extent the specific installation situation deviates from the model. During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay.
The installation situation should be taken into account for the thermal parameters of the braking resistor and, if necessary, less favorable parameters should be selected, for example, for the heat transfer resistance, so that deviations will generally occur towards the safe side.

7.10.3 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage T_{PU}. When operating with cyclic overload, the rated power is not exceeded the by the time-averaged power (rms).

PMSM

With a PMSM, a 3-fold overload of the rated current I_n is possible cyclically for a duration of $t_{overload}$ = 1.5 s and a subsequent recovery time of 12.5 s at T_{PU} = 20 °C. At T_{PU} = 80 °C, the overload time $t_{overload} \approx 0.35$ s.

Stepper motor

With a stepper motor, a double overload of the rated current I_n cyclic for a duration of $t_{overload}$ = 3 s with a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload} \approx 0.75$ s.

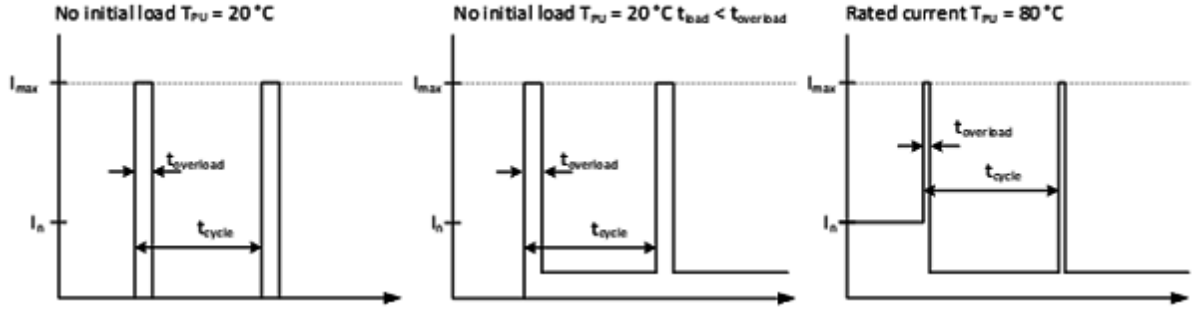


Figure 1-338 Overload behavior of TM Drive

Observe the information on derating depending on the ambient conditions (e.g. temperature, mounting position) in the section Derating of the F-TM ServoDrive HF (Page 147).

NOTE

Overload capability of the power unit
Operation with a peak current of 15 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.11 Dynamic torque reduction

If dynamic torque reduction is required, this can be realized using the MOMRED signal via drive telegram 102. The torque limit currently in effect in the drive is reduced via this setpoint. MOMRED is used to specify the percentage by which the torque limit is to be reduced.

$$M_{limit.actual} = M_{reference} \bullet (1 - \frac{MOMRED}{16384})$$

NOTE

The MOMRED signal is normalized to 4000 hex (16384 dec). The value 4000 hex (16384 dec) in the MOMRED control word corresponds to a 100% reduction of the configured reference torque p2003.

The dynamic torque limit is set to the respective minimum of the configured torque limitation (p1520), the limitation via MOMRED or the limitation by the max. permissible torque-forming current value.

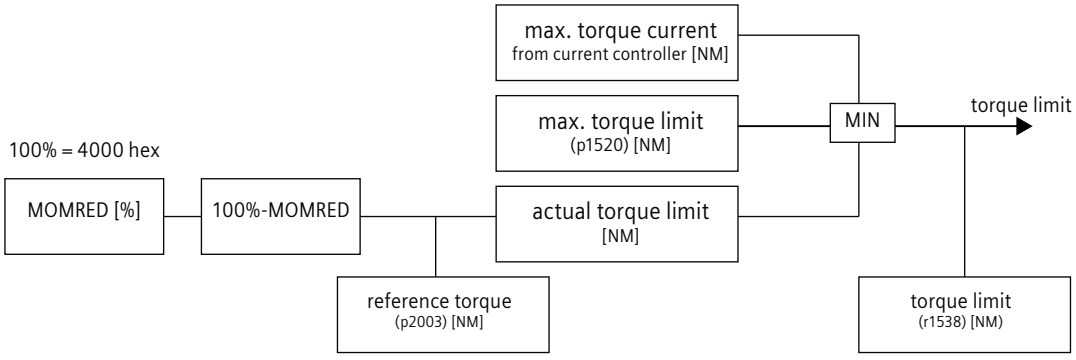


Figure 1-339 Dynamic torque limitation (MOMRED)

The torque values that are output by the drive and the torque limitation currently in effect can be viewed under "Online & Diagnostics" > "Diagnostics" > "Drive Diagnostics" > "Operating Values" if an online connection to the drive is established.

The following actual values are available:

- Torque setpoint (at the output of the speed controller) (r0079)
- Torque actual value (r0080)
- Torque limit (r1538)

Programming

8

TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 121)
- Control via the SINA_SPEED (Page 130) instruction
- Control with a technology object (Page 131)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The telegrams can be set in the "Properties" area under "General" and further via "Basic parameters". Set the Telegram extension active option to make the status available via the digital input and the status of the STO input via the process image.

NOTE

The telegram extension option is not available for telegram 102.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Frame	1		2		3		102	
PZD1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1
PZD2	NSET_A	NACT_A	NSET_B	NACT_B	NSET_B	NACT_B	NSET_B	NACT_B
PZD3								
PZD4			STW2	ZSW2	STW2	ZSW2	STW2	ZSW2
PZD5					G1_STW	G1_ZSW	MOMRED	MELDW
PZD6						G1_XIST1	G1_STW	G1_ZSW
PZD7								G1_XIST1
PZD8						G1_XIST2		
PZD9								G1_XIST2
PZD10								

Standard telegram 1 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word STW1	**Structure**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5

Element	Data type	Offset
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Element	Data type	Offset
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4

Element	Data type	Offset
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Encoder position actual value 1 G1_XIST1	**DWord**	**10.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3

Element	Data type	Offset
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Siemens telegram 102: Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7

Element	Data type	Offset
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Message word MELDW	**Word**	**8.0**
Encoder status word G1_ZSW	**Struct**	**10.0**
Bit08_Probe1Deflected	Bool	10.0
Bit09_Probe2Deflected	Bool	10.1
Bit10_Reserved	Bool	10.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	10.3
Bit12_HomePositionExecuted	Bool	10.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	10.5
Bit14_ReservedParkingSensorExecuted	Bool	10.6
Bit15_ParkingSensorExecuted	Bool	10.7
Bit00_Function1Active	Bool	10.0
Bit01_Function2Active	Bool	11.1
Bit02_Function3Active	Bool	11.2
Bit03_Function4Active	Bool	11.3
Bit04_Value1Available	Bool	11.4
Bit05_Value2Available	Bool	11.5
Bit06_Value3Available	Bool	11.6

Element	Data type	Offset
Bit07_Value4Available	Bool	11.7
Encoder position actual value 1 G1_XIST1	**DWord**	**12.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**16.0**

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**4.0**
Bit08_Reserved	Bool	4.0
Bit09_Reserved	Bool	4.1
Bit10_Reserved	Bool	4.2
Bit11_Reserved	Bool	4.3
Bit12_Reserved	Bool	4.4
Bit13_Reserved	Bool	4.5
Bit14_Reserved	Bool	4.6
Bit15_Reserved	Bool	4.7
Bit00_Reserved	Bool	5.0
Bit01_Reserved	Bool	5.1
Bit02_Reserved	Bool	5.2
Bit03_Reserved	Bool	5.3
Bit04_Reserved	Bool	5.4
Bit05_Reserved	Bool	5.5
Bit06_Reserved	Bool	5.6
Bit07_Reserved	Bool	5.7
Torque reduction MOMRED	**Word**	**6.0**
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0

Element	Data type	Offset
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the TM Drive.
4. Control the TM Drive by setting outputs bit-by-bit. A description of how to set the outputs to control the TM Drive can be found in the PROFIdrive standard.
   You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the TM Drive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams (Page 61).

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive does not have an integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance

9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 1-674 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 138).

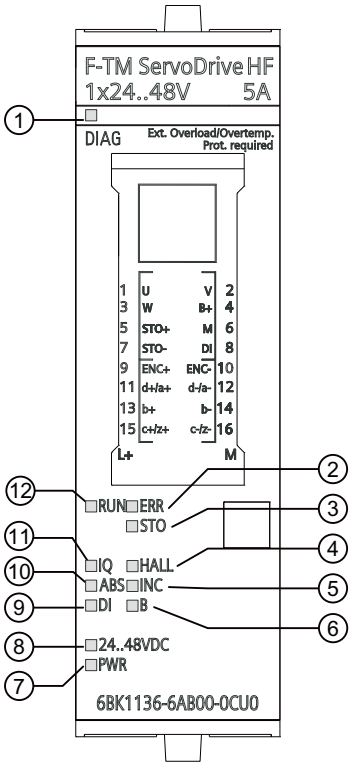
Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the TM Drive.



①	DIAG (red/green)	⑦	PWR (green)
②	ERR (red)	⑧	24..48V (green)
③	STO (yellow) Display not safety-related	⑨	DI (green)
④	HALL (green)	⑩	ABS (green)
⑤	INC (green)	⑪	IQ (green)
⑥	B (green)	⑫	RUN (green)

Figure 1-340 LED display on F-TM ServoDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 1-675 DIAG status and error display

DIAG LED	Meaning	
□ Off	Backplane bus supply of the ET 200SP not OK	
☼ Flashing	Module parameters not assigned	
■ On	Module parameters assigned and no module diagnostics	
☼ Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 138).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 1-676 RUN status and error display

RUN LED	Meaning	
□ Off	Device is not yet ready for operation	
■ On	Device is ready for operation and error-free	
☼ Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 1-677 ERR status and error display

ERR LED	Meaning
□ Off	No fault
■ On	Device has a fault and needs to be restarted. This corresponds to a serious device error or the loaded firmware cannot be operated on these device versions.

DI LED

Table 1-678 DI status and error display

DI LED	Meaning
□ Off	Input is inactive
■ On	Input is active

B LED

Table 1-679 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 1-680 STO status and error display

STO LED	Meaning
■ On	Drive ready, switch connected correctly and STO not requested
☼ flashes (0.5 Hz)	STO requested (motor is disconnected from power)

IQ LED

Table 1-681 Status and error display IQ (encoder)

IQ LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	IQ speed encoder could not be initialized IQ speed encoder has a connection problem (A/B track not connected)

Hall LED

Table 1-682 Status and error display Hall (encoder)

Hall LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated

INC LED

Table 1-683 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

LED ABS

Table 1-684 Status and error display ABS (encoder)

24..48V LED	Meaning
■ On	An absolute encoder has been configured/activated
☼ Flashes (2 Hz)	The absolute encoder has a connection problem

24..48V LED

Table 1-685 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LEDs

Table 1-686 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the TM Drive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**
  The general diagnostic information is displayed for:
  - Module
  - Module information
  - Manufacturer information
- **Diagnostics status**
  "Diagnostics status" shows the current diagnostics status of the TM Drive.
- **Active messages**
  "Active messages" displays the currently pending alarms and faults in the TM Drive module.
- **Drive diagnostics**
  The current diagnostic information of the drive is displayed for:
  - Status bits
  - Operating values
  - Encoders
  - Temperatures
  - Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE
In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1006	Braking resistor short-circuit	Overload
1019	External braking resistor/motor holding brake of the 4th phase interrupted	Wire break
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1037	Permissible temperature of the braking resistor exceeded	Overtemperature
1039	Connection to IQ encoder interrupted	Wire break
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the control electronics exceeded	Overtemperature
1044	Permissible temperature of the braking resistor exceeded The drive is switched off.	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-

Fault number	Description	S7 diagnostics alarm
1049	Zero point calibration could not be performed. The rotor may be blocked. The motor holding brake may not be open.	External error
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1051	Zero point calibration could not be performed due to a timeout. The system may be oscillating too much.	External error
1053	Overload of the brake chopper control	Overload
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1055	Motor resistance detection could not be performed	Wire break
1056	Following error during controlled system detection	Overload
1057	Position error during controlled system detection	Overload
1200	CRC checksum error in absolute encoder	Error in actuator/sensor
1201	Internal encoder error in the absolute encoder	Error in actuator/sensor
1202	No communication with absolute encoder possible or communication establishment failed.	Wire break
1203	Internal error in encoder interface	Error
1300	There is an error in the parameter assignment of the motor type.	Parameterization error
1301	Electrical time constant of the q axis is too low.	Parameterization error
1302	Electrical time constant of the d axis is too low.	Parameterization error
1303	Torque constant inconsistent	Parameterization error
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error
1999	General error	Error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The TM Drive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2005	Thermal overload of the braking resistor
2007	Switch-on delay because axis is still rotating.
2200	Encoder warning in the encoder error

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE
All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 1-687 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active

Number	Parameter	Display/unit
		• Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 1-688 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r1045	Speed setpoint of ramp generator	rpm
r0080	Torque actual value	Nm
r0079	Torque setpoint	Nm
r1538	Torque limit	Nm
r0026	Intermediate circuit voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 1-689 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Steps	-
p979[2]	Increments per revolution	-
P979[5]	Number of revolutions	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits
P979[4]	Fine resolution bits in actual value Gx_XIST2	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 1-690 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 1-691 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Technical specifications

11

11.1 Technical specifications

Technical specifications of the IQ encoder

Article number	6BK1136-6AB00-0CU0
General information	
Product type designation	F-TM ServoDrive HF
HW functional status	V1.0
Firmware version	V1.1
• FW update possible	Yes
Product description	control of EC and stepper motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	Yes
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V

Article number	**6BK1136-6AB00-0CU0**
Output current	
Current output (rated value)	5 A
Output current, max.	15 A
Output frequency	599 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
• Absolute encoder (SSI)	Yes; BiSS-C
• BiSS-C encoder	Yes
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Telegram error at SSI encoder	Yes; BiSS-C
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	Yes
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes

Article number	6BK1136-6AB00-0CU0
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	3
• SIL according to DIN EN 61800-5-2	3
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm

Article number	6BK1136-6AB00-0CU0
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	Yes

Type	IQ encoder
Output signals	2 square wave signals (A, B), 2 square wave signals inverse (nA, nB) Output differential or single ended TTL compatible, phase shifted
Number of pulses per revolution	100 (default)
Limit frequency	5 kHz
Supply voltage	+ 5 V (+/- 10 %)
Current consumption	Typ. 40 mA max. 100 mA
Permissible output current	Max. 20 mA
Permissible deviation of the pulse width from electrical 180°	+/- 90 °
Phase shift of channel A and B	Typ. 90 ° (+/- 30 °)
Output voltage (low level)	Typ. 0.25 V, max. 0.8 V (I = 20 mA at 5 V)
Output voltage (high level)	Typ. 4.25 V, max. 3.8 V (I = 20 mA at 5 V)
Permissible ambient temperature range (T_U)	-25 °C ... +105 °C
Reverse polarity protection	Occurs due to a short-circuit of the supply voltage via a protective diode, max. 200 mA continuous current permissible

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation
For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. The motor current and the output current of the outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)
When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

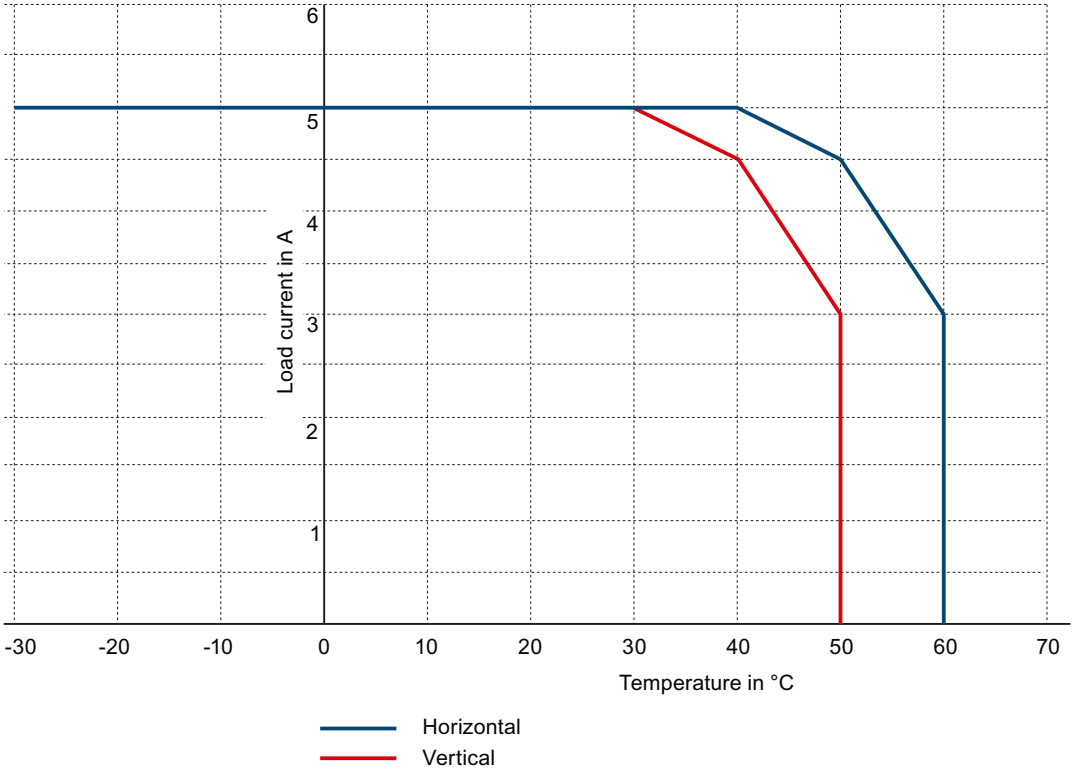


Figure 1-341 Derating of the TM Drive

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix

A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

A.2 Braking resistor and brake chopper power

The maximum continuous current of the brake chopper end stage is 5 A. The end stage can be overloaded, so that higher currents / powers are possible for a short time.

The average braking current of 5 A is monitored using an I2t model. Once the end stage has fully cooled down, a braking current of 10 A is possible for approx. 15 s, for example.

Related to 60 s, this results in a load cycle of 25%. For other current values, the load cycle can be estimated using the following figure.

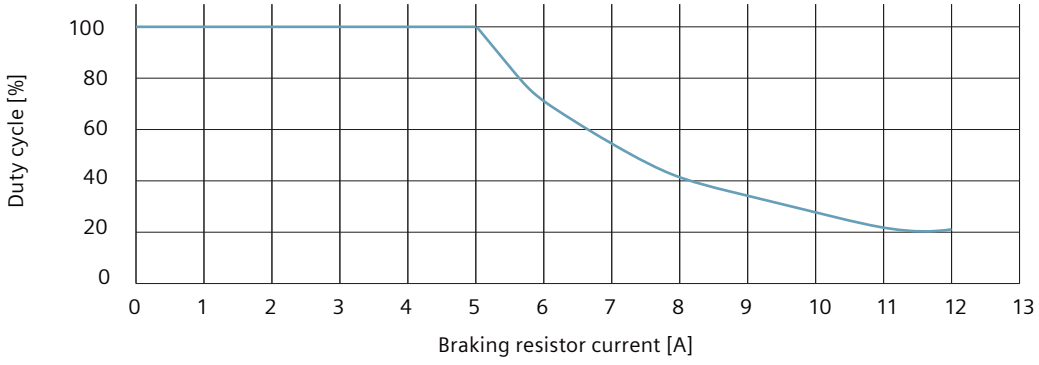


Figure 1-342 Load cycle as a function of the braking resistor current

NOTE
The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Calculation of the continuous braking power of the end stage

The continuous power of the end stage can be estimated using the following formula.

$$P_{chopper_{rated}} = 0.5 \bullet (U_{on} + U_{off}) \bullet 5A$$

Table 1-692 Examples of continuous power of the end stage

Medium intermediate circuit voltage	Continuous power
26 V	130 W
50 V	250 W

Calculation of the continuous braking power as a function of the braking resistor
The average braking power of the braking resistor depends on the braking resistance value and the intermediate circuit voltage or the switch-on and switch-off values of the brake chopper (U_{on} p6010 and U_{off} p6011). It can be estimated with the following formula.

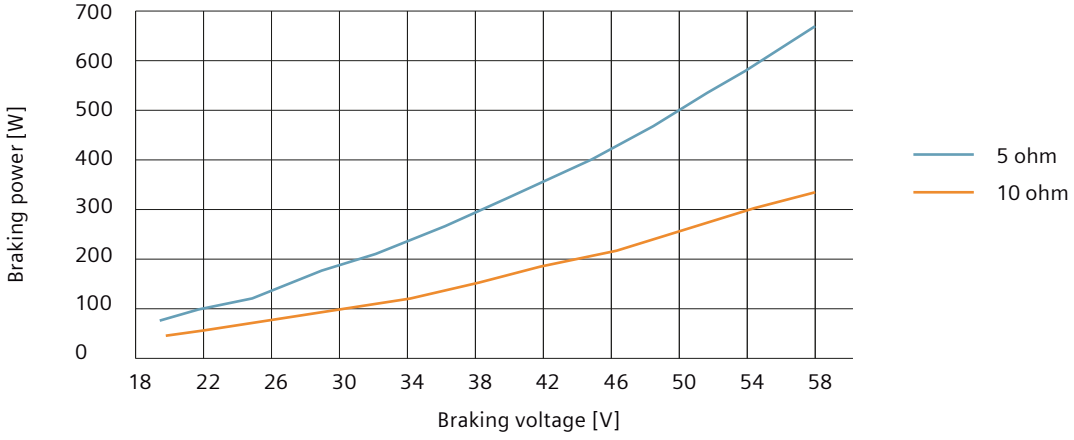
$$P_{brake\ resistor} = \frac{(0.5 \bullet (U_{on} + U_{off}))^2}{R_{brake\ resistor}}$$

Table 1-693 Examples for braking resistor line

Medium intermediate circuit voltage	Braking resistor value	Braking resistor power
26 V	5 Ω	135.2 W
	10 Ω	67.6 W
50 V	5 Ω	500 W
	10 Ω	250 W

Determination of the braking resistor peak power
In order to calculate the short-time peak power of the resistor, the configured switch-on voltage U_{on} p6010 of the brake chopper must be used.

$$P_{brake\ resistor\ max\ peak} = \frac{U_{on}^{\ 2}}{R_{brake\ resistor}}$$



It must be checked whether the braking resistor can absorb the peak power and, if needed, the continuous power expected.

A.3 Data sets

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.4 Device disposal

Recycling and disposal



For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE
The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.5 Directives and standards

SIEMENS

SIMATIC

ET 200SP
F-TM StepDrive ST 1x24..48V 5A

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Introduction

1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Purpose of the documentation

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE

The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109807362).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE

Recommendation relating to third-party products

This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.

You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 What's new?

Equipment Manual revision level	Change/new functions
03/2023	Regulated operation of stepper motors

1.2.4 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.5 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.6 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide



The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information



Figure 1-343 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 FAQ

You will find FAQs on TM Drive on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.4.2 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.



Figure 1-344 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals
- Downloads
- Compatibility tool
- Newsletter with product selection

- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.3 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC and stepper motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.
Intended use of hardware products
This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.
Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.
EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions

2

2.1 General safety instructions

⚠ WARNING

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance

Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

⚠ WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance
Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

⚠ WARNING

Electric shock if there is no ground connection
For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

⚠ WARNING

Electric shock due to connection to an unsuitable power supply
When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

⚠ WARNING

Electric shock due to equipment damage
Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

⚠ WARNING

Electric shock due to unconnected cable shield
Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

⚠ WARNING

Arcing when a plug connection is opened during operation
Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection
An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

⚠ WARNING

Electromagnetic interference due to inadequate shield support
A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

⚠ WARNING

Active implant malfunctions due to electromagnetic fields
Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

⚠ CAUTION

Symptomatic respiratory and skin reaction to chemicals
A newly purchased product might contain traces of substances that are identified as sensitizers.
Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.
Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

⚠ WARNING

Unexpected machine movement caused by radio devices or cellphones
Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

⚠ CAUTION

Radio frequency interference in residential areas
When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.
When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances
Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position
The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests
High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests
High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

⚠ WARNING

Unexpected movement of machines caused by inactive safety functions
Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings
As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge
Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

⚠ WARNING

Unsafe operating states resulting from software manipulation
Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation
2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter

3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system provides the flexibility and power required for a wide range of control applications.

The F-TM StepDrive ST is a product from the range of TM Drive modules in the ET 200SP network. In this manual, the term TM Drive is used as a synonym for F-TM StepDrive ST.

The F-TM StepDrive technology module offers you the following possible applications:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

The TM Drives have proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

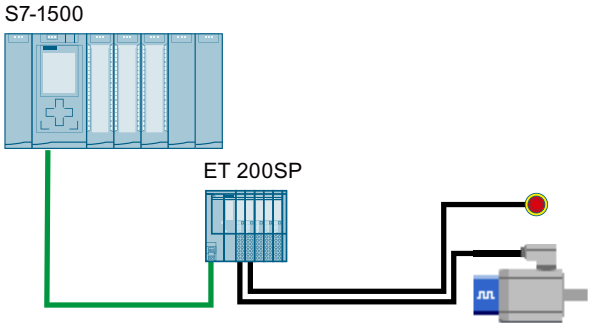


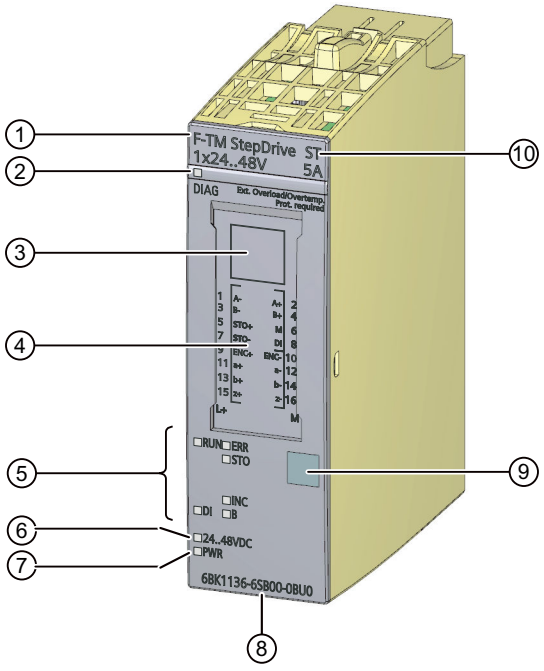
Figure 1-345 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6SB00-0BU0

View of the module



①	Module type and designation	⑥	LED for supply voltage
②	LED for diagnostics	⑦	LED for power
③	2D matrix code	⑧	Article number
④	Wiring diagram	⑨	Color coding of module type
⑤	LEDs for motor control	⑩	Function class

Figure 1-346 View of the F-TM StepDrive ST module

Properties

The F-TM StepDrive ST has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of incremental encoders (with A, B, Z track)

- 24 V digital input
- Support of individually configurable bipolar stepper motors
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 V16 or higher

Accessories

The following accessories, which are not included in the scope of delivery of this module, can be used with the module:

- Labeling strips
- Color-coded labels
- Reference identification labels
- Shield connection

A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 oder 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For more information on accessories, refer to the system manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

Unsuitable electronic fuses

Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

The TM Drive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

The TM Drive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

TheTM Drive supports the following types of communication:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.
- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.
- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.
- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 39).

Potential group

Up to a continuous input current of up to max. 10 A for each potential group, up to 3 TM Drive can be connected together to form a drive group.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (TDK Electronics 2-wire filter series B84113C) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, then it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group.
  For a potential group with only one TM Drive we recommend using an appropriate miniature circuit breaker with 6 A fuse and characteristic B.
- You must not use voltage sources with low impedances (such as supercaps) without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short circuit, it is still imperative to rectify the fault before switching it on again. Otherwise the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers
(https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

SCCR (short circuit current rating)

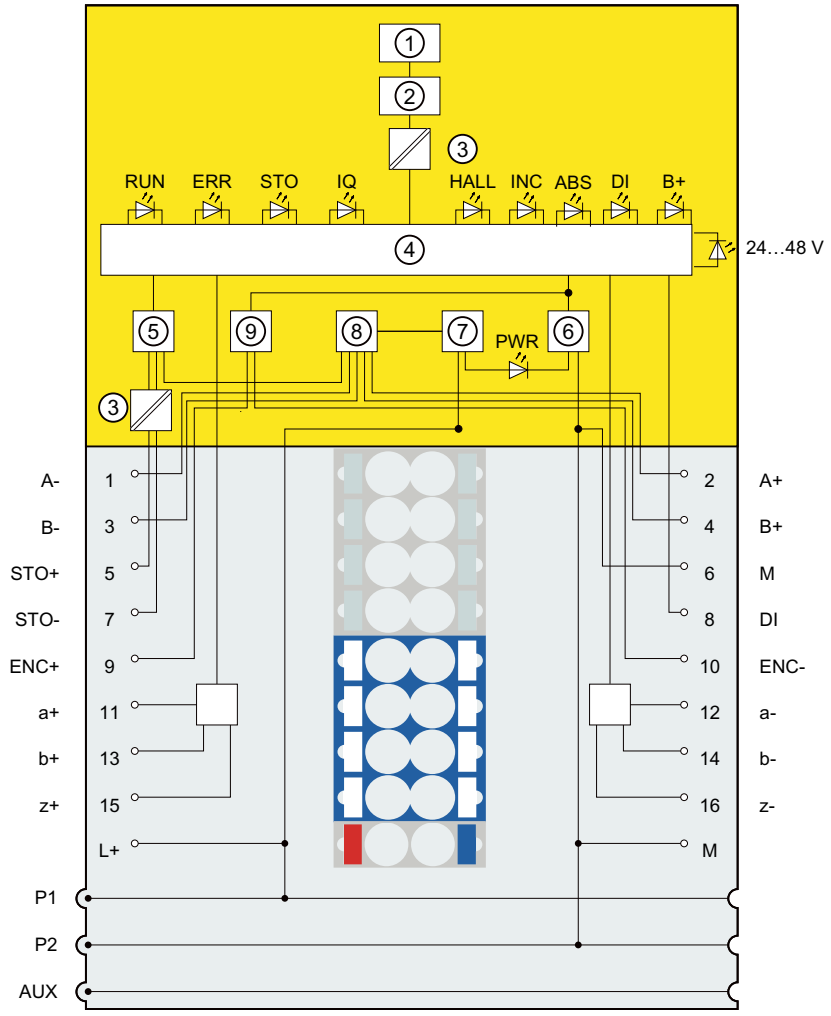
Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

⚠ WARNING

Fuse for the load circuit
In general, use a suitable overcurrent protection device to protect the TM Drive.

Schematic circuit diagram



①	Backplane bus	**Stepper motor**	
②	Backplane bus interface module of the technology controller	A-	
③	Galvanic isolation	A+	
④	Technology controller	B-	
⑤	Safe Torque Off circuitry	B+	
		Encoder supply	
⑥	Digital input circuit	ENC+	Power supply encoder 5 V

⑦	Power supply/Preparation
⑧	Reverse polarity protection
⑨	Power electronics
⑩	Encoder power supply
Power supply	
L+	Power supply 24 - 48 V
M	Power supply GND
Inputs	
STO+	STO+ input (24 V)
M	Negative terminal
STO-	Negative STO input
DI	Digital input
ENC-	Power supply encoder, negative connection
Incremental encoder	
a+	Differential encoder signal a+
a-	Differential encoder signal a-
b+	Differential encoder signal b+
b-	Differential encoder signal b-
z+	Differential encoder signal z+
z-	Differential encoder signal z-

Figure 1-347 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 1-694 Wiring rules for the interfaces

Pins	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
A+/A-/B+/B-	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
a, b, z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair
STO	Safe Torque Off	10 m	-

Permissible cable cross-sections depend on the BaseUnit used. See ET 200SP BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521)

CABLE SPEC.	Note that connected power lines must be designed according to the expected current value at maximum ambient temperature and installation type in accordance with applicable standards.

NOTE

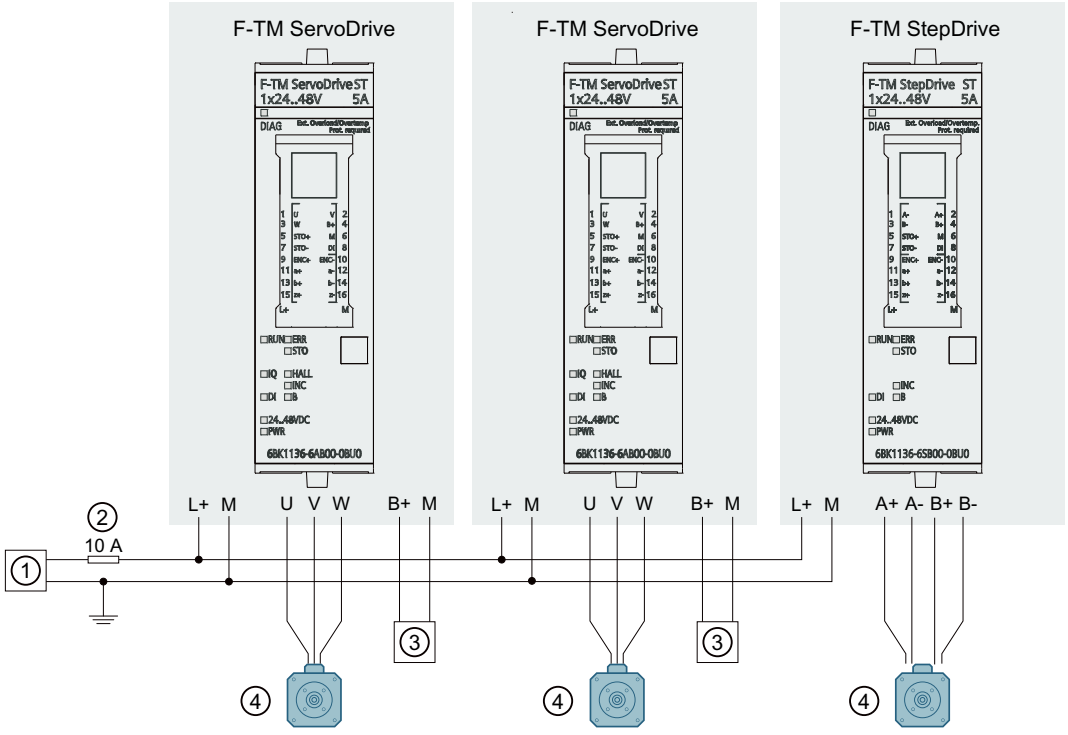
In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple TM Drive

In a potential group

You can connect multiple TM Drive to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drive to form a drive line-up



① Power supply unit
② Protective device
③ Braking resistor
④ Motor

Figure 1-348 Wiring of multiple TM Drive to form a drive line-up

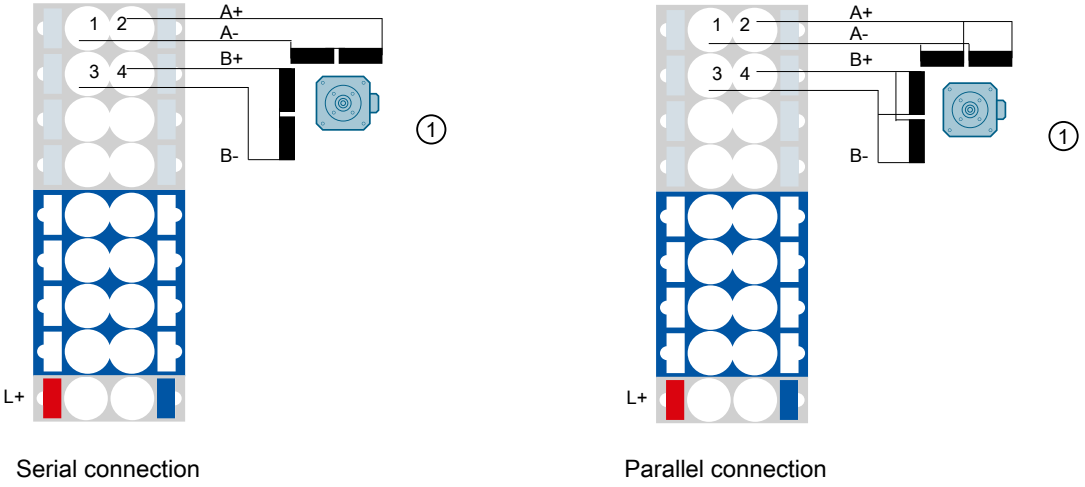
4.4 Connecting the motor

Overview

The F-TM StepDrive supports bipolar interconnected stepper motors.

4.4.1 Wiring the motor phases (stepper motor)

The following figure shows the connection of the motor phases to the BaseUnit:



①	Stepper motor
A+, A-, B+, B-	Motor phases

Figure 1-349 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	A+	Motor phase A+
2	A-	Motor phase A-
3	B+	Motor phase B+
4	B-	Motor phase B-

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

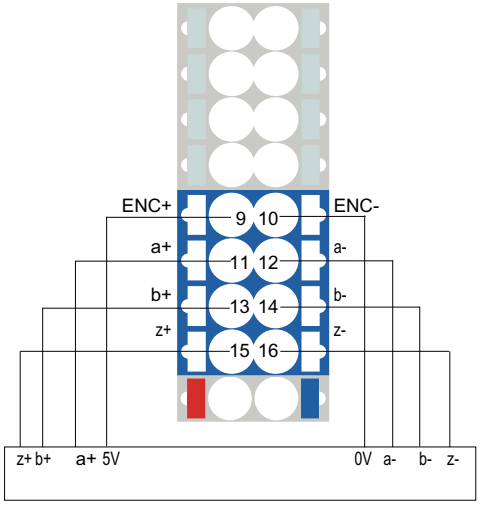


Figure 1-350 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 1-695 Power supply and signal processing conditions of the incremental encoder

Encoder circuit	Range
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V
	Low 0 V .. 1 V

*The quadrature interface results in a maximum step resolution of 2000 kHz

Encoder circuit	Range
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

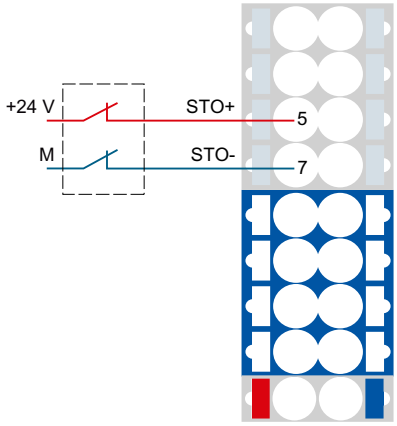
⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO



STO+ STO input 24 V
STO- STO input, negative connection

Figure 1-351 Connection of Hardware STO

NOTE
The supply voltage for the STO inputs must be different from that of the power supply.

Table 1-696 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

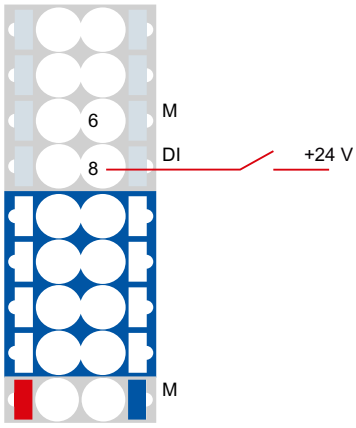
The cables of the hardware STO (STO+/STO-) must be routed separately from other cables, especially power cables.

The risk of crushing and short-circuits against earth connections must be minimized by appropriate routing.

Premature aging of the cables due to continuous UV radiation must be ruled out.

4.5.3 Connecting the 24 V digital input

Connecting a 24 V digital input



DI 24 V digital input
M Ground

Figure 1-352 24 V digital input connection

Table 1-697 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

Safety functions integrated in the drive

5

5.1 Basic safety information

5.1.1 General safety information

⚠ WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM StepDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM StepDrive documentation.
- Consider the residual risks for the risk evaluation.

⚠ WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

⚠ WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 105)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

⚠ WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 110).

Examples of safety devices and 3 F-TM StepDrive

NOTE
The supply voltage for the STO inputs must be different from that of the power supply.

The following figure shows various safety devices that are connected to 3 F-TM StepDrive.

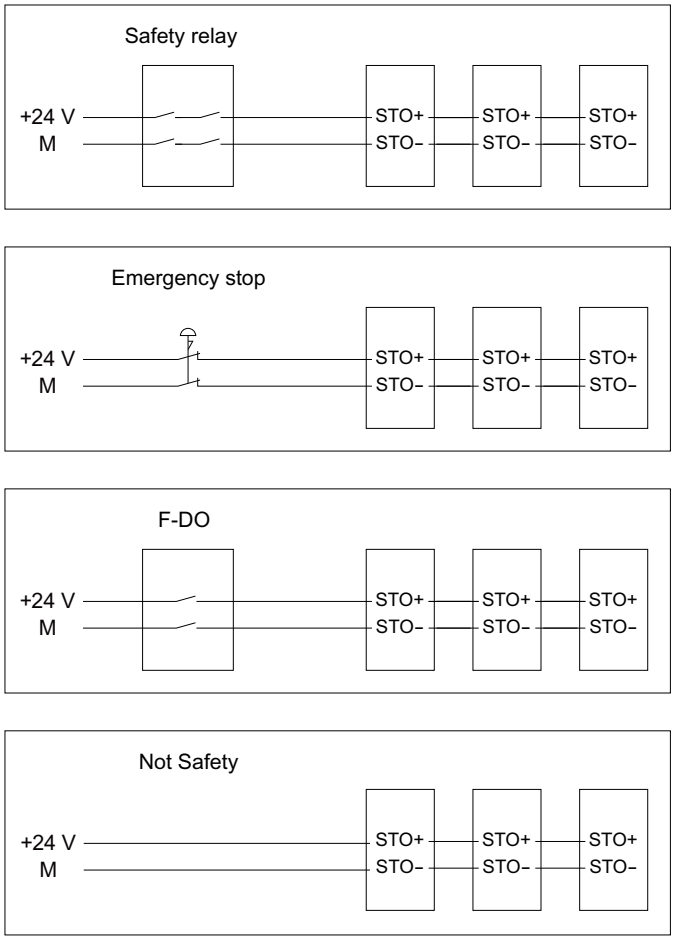


Figure 1-353 Safety devices and 3 F-TM StepDrive

NOTE
The F-TM StepDrive does not support startup protection.
Measure:
Startup protection via additional safety relay or in higher-level controller, depending on the safety requirements.

Operating voltage range

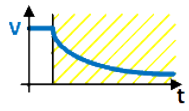
Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

Switching on again after power off

An On delay of more than 2 s must be observed between tripping and restarting the module, for example switching the power supply off and on. Otherwise the module can register an internal STO error and the module switches off in a safety-oriented manner.

5.1.4.1 Safe Torque Off (STO)



Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM StepDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

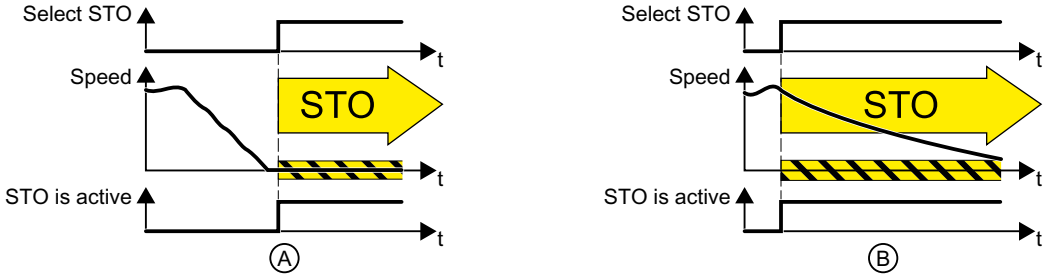


Figure 1-354 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a bipolar connected two-phase stepper motor. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

STO can be used in which the motor is already at a standstill or comes to a standstill safely due to friction in a short time.

STO allows safe working while a protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM StepDrive internally monitors the fail-safe digital input at STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM StepDrive is therefore not needed.

⚠ WARNING

Forced checking procedure

You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) as defined in the corresponding standards are a measure for the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

For functional safety of variable-speed drives, the standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies.

Function groups

The safety functions are divided into the following function groups for the F-TM StepDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM StepDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 1-698 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM StepDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM StepDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal HW fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EU machinery directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.
  See "Acceptance test" below in this section.
  For the F-TM StepDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.
  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring
Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

⚠ WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test
Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 1-699 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 1-700 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 1-701 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 1-702 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	
2.	**Switch on motor**	

No.	Description		Status
2.	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer
Professional execution of the above-stated tests and checks is confirmed.

Table 1-703 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer
The correctness of the parameter assignment documented above is confirmed.

Table 1-704 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM StepDrive drive system meet the following requirements:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM StepDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM StepDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system
  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM StepDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM StepDrive

For information on how to perform the electrical wiring for the F-TM StepDrive, refer to section Wiring (Page 27)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 34).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

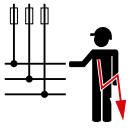
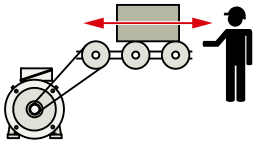
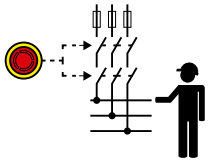
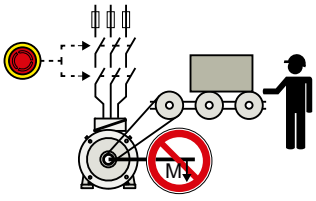
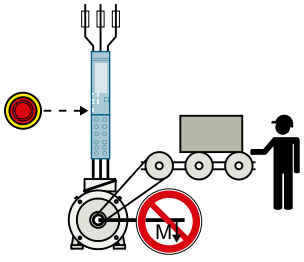
EMERGENCY OFF Risk of electric shock	**EMERGENCY STOP** Risk of unexpected movement
	

Table 1-705 Measures and solutions

Command	**EMERGENCY OFF**	**EMERGENCY STOP**
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 	Switch off the drive power supply. 
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO.  You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring

6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring a ET 200SP TM Drive.

You perform the following tasks with STEP 7 (TIA Portal), for example:

- You configure the TM Drive (insertion into the project and setting the input addresses).
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 24)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 27).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

To accept the plant, you must use the safety summary created in accordance with this manual.

Configuring a TM Drive (minimal configuration)

To configure a TM Drive , follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.
4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.

6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 1-706 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive module in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These value provide the current **actual incremental position** of the encoder system and are read cyclically, for example by the "Positioning axis" technology object and further processed accordingly (see also section 8.3 (Page 95)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the actual position value is structured as follows:

- G1_XIST1 and Gx_XIST2 are right-aligned
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.

NOTE

Dependence on the configured encoder resolution
The singleturn value ("increments / revolution") in G1_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 1-707 Structure of the encoder position actual value

User data	Contents	
Actual encoder position value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 102)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a fine resolution of 2:

Table 1-708 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 1-709 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 Encoderless / calculated

If you have set encoder (0) encoderless / calculated as encoder type, the encoder position actual value is calculated. Actual encoder position value is structured as follows.

Table 1-710 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 102)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of a "simulated encoder" with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a shift factor of 2:

Table 1-711 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 1-712 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning an TM Drive drive

⚠ CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury
Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 37) before commissioning and before operation.

⚠ WARNING

Personal injury and property damage from the falling down of a suspended axis
If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected falling down of a hanging axis can result in personal injury and property damage.
Before commissioning, it must be ensured that a cross brace is fitted to hold the suspended axis in place and prevent it from falling down unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Personal injury and property damage from the falling down of a suspended axis
An unexpected falling down of a hanging axis can result in personal injury and property damage

.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE

Performing tests
You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform configuration as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Device configuration
- Online & diagnostics
- Parameters

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Define telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):
  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:
  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM engineering.

- Drive:
  Drive data record, general settings, motor, gearbox, thermal model, brake module
- Setpoint channel:
  Reference values, application limits, speed-ramp sensor
- Open-loop/closed-loop control:
  Control type, controller settings, speed controller, current controller
- Messages/monitoring
  Motor (thermal motor model), intermediate circuit voltage, braking resistor (load), power end stage (load)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

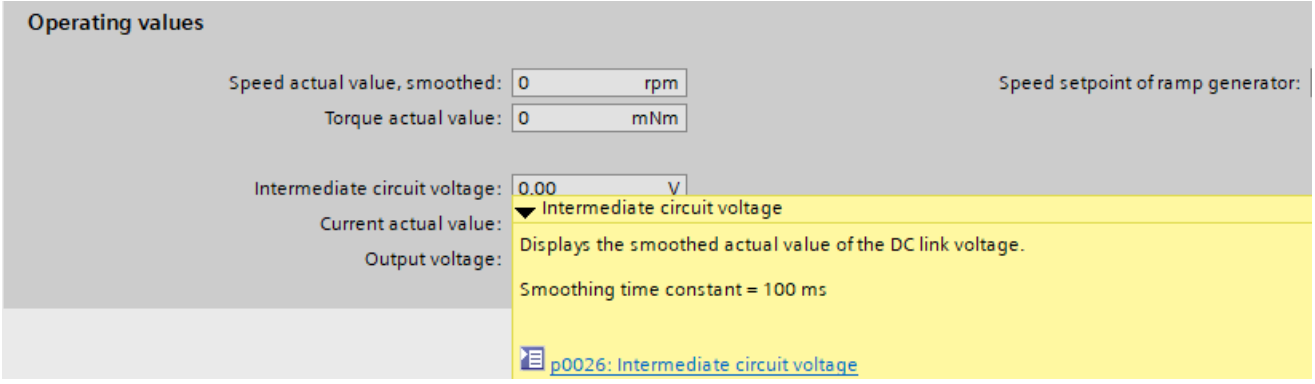


Figure 1-355 Intermediate circuit voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

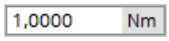
- You overwrite the current parameter value with the new value.
  Or
- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

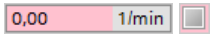
P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

	Project (offline)	Parameter value can be changed and stored in the project.
	Project (offline)	The parameter value is write-protected.
	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the TM Drive engineering:

	Drive value (online) could not be determined
	Bit parameter active (1-signal)
	Bit parameter inactive (0-signal)

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Conditions

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 27)
  - Configuring (Page 54)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Has the shielding of the motor/encoder cable been applied over a large area on the device and on the motor/encoder?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?
- Are the grounding terminals correctly attached and is the motor/encoder cable correctly connected?

Module installation and wiring

- Is the TM StepDrive plugged in / installed and firmly connected or screwed according to the assembly plan and configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the TM Drive and the motor and installed according to the guidelines?
- Is the optional digital input connected?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive .

Table 1-713 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data record	Use one of the following options in the "Configure drive data record" dialog under "Parameters > Drive": • Select pre-configured drive data record from list • Custom edit drive data record	Drive data sets (Page 64)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp generator	Setpoint channel (Page 70)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Controller settings (Page 75)
4	Configure intermediate circuit voltage monitoring and optionally the brake control module	• Define limits for the intermediate circuit voltage • Motor holding brake settings	Intermediate circuit voltage
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 84)

See also

Intermediate circuit voltage (Page 80)

7.4 Drive data sets

Introduction

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection technology, electrical safety, EMC etc., as described in this manual.

With the F-TM StepDrive ST, this also includes stepper motors which can be connected in a bipolar manner and which meet the boundary conditions explained in this manual.

Drive data record

The motor or drive of the TM Drive drive system is configured using a drive data set (DDS). A drive data record contains the settings and information for the following drive components:

- Motor
- Motor gear
- Thermal motor model

NOTE
The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive drive system supports stepper motors. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The following combinations are available:

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

(0) No encoder / calculated
The setting (0) encoderless / calculated is only supported in connection with a stepper motor. In this case, the rotor position is calculated and transferred to the control depending on the steps per revolution (p0408) or the steps per revolution (p0409).

(1) Incremental encoder (A, B, Z track)
When selecting the encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also referred to as I-track) can be connected.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 84) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Create a user-defined drive data record and configure your motor manually.

NOTE
In the TM Drive engineering, the drive parameters can only be edited in the "Parameters" > "Drive" area if you are using a user-defined drive data set.

NOTICE

After a change of the drive data record, you must adapt or optimize the parameters for the current and speed controllers, if necessary.
See section Controller settings (Page 75).

7.4.2 Using a user-defined drive data set

Create a user-defined drive data record and configure your motor manually.

You can also use this function to edit an existing drive data record.

⚠ WARNING

Avoiding incorrect parameter assignments
Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

Procedure

To freely configure the current drive data, follow these steps:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Edit drive data record by user" option.
4. Accept the configuration with "Yes".
5. Confirm that you are changing the drive data record.
6. Adjust the motor settings for your drive.

   Observe the information and notes in the help or in the tooltips of the individual parameters.

   You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

You have selected user-defined editing of the drive and adapted the settings.

See also

Motor (Page 85)

7.4.3 Drive parameters stepper motor

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0305	Nominal current	Nominal current per coil in full step mode.	A
p0312	Hold torque	Hold torque of the stepper motor in full step mode and nominal current.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0372	Connection resistance	Connection resistance of a phase	Ohm
p0376	Connection inductance	Connection inductance one phase	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
P30000	Step angle	Step angle of the stepper motor in full step mode.	-
P30001	Number of steps	The number of steps indicates the number of steps per mechanical revolution in full step mode. The value cannot be edited and is calculated from the step angle. Number of steps = 360° / step angle	-
P30014	Number of pole pairs	The number of pole pairs indicates the number of pole pairs in the motor. The value cannot be edited and is calculated from the step angle. Number of pole pairs = step angle / 4.	-
Motor gear			
P2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s

Parameter number	Name	Description	Unit
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.4 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

7.4.4.1 Encoder parameters incremental encoder and encoderless / calculated

The encoder types incremental encoder and encoderless / calculated use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder

With the incremental encoder, the increments per revolution must be set.

Encoderless / calculated

With the setting encoderless / calculated, the motor is moved at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

Encoderless / calculated with stepper motor

With the setting encoderless / calculated with stepper motor, the motor moves at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution (increments per revolution (p0408)) must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

It is recommended to set every integer multiple of the motor full step angle (p30001); a step division into partial steps (1/2, ¼, 1/8 ...) is not necessary but can improve the positioning accuracy, especially with multi-pole stepper motors. The following table shows how the corresponding step subdivisions are determined for this.

Table 1-714 Determination of the step subdivisions

Step resolution	**Steps per revolution (p0409)**	**Increments per revolution (p0408)**	**Example: Step angle = 1.8 °; Number of steps = 200; Number of pole pairs = 50**	
			Steps per revolution (p0409)	**Increments per revolution (p0408)**
Full step	1 x number of steps (p30001)	1/4 x number of steps (p30001)	200	50
½ Half step	2 x number of steps (p30001)	2/4 x number of steps (p30001)	400	100
¼ quarter step	4 x number of steps (p30001)	4/4 x number of steps (p30001)	800	200
1/8 eighth step	8 x number of steps (p30001)	8/4 x number of steps (p30001)	1600	400
.	.	.	.	.
1/64 sixty-fourth of a step	64 x number of steps (p30001)	64/4 x number of steps (p30001)	12800	3200

7.4.4.2 Assign encoder counting direction parameters

With encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting the Swap encoder counting direction parameter p0410. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows:

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

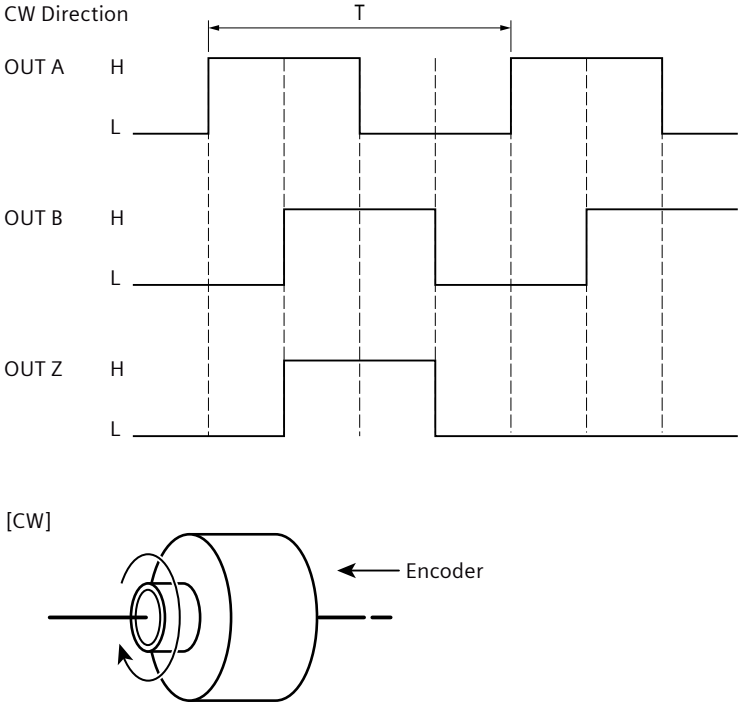


Figure 1-356 Direction of rotation for the incremental encoder

Table 1-715 **Encoder values**

Parameter number	Name	Description	Unit
p0410	Swap encoder counting direction	This setting negates the counting direction of the encoder.	-

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 71)
- Application limits (Page 72)
- Ramp generator (Page 75)

The figure below shows the processing of the speed setpoint in the drive controller.

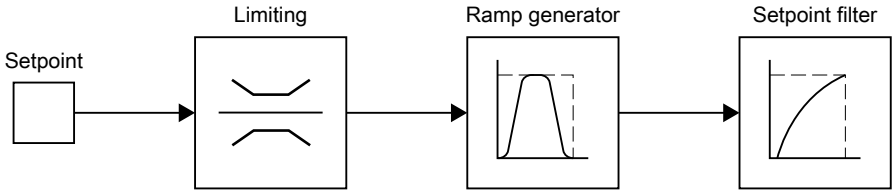


Figure 1-357 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 71).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 72).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp generator (Page 75).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.

Here, p2000 is decisive as the reference value (telegram content = 4000 hex or 4000 0000 hex for double words if the input variable has the value p2000).

Example of the normalization of the speed:

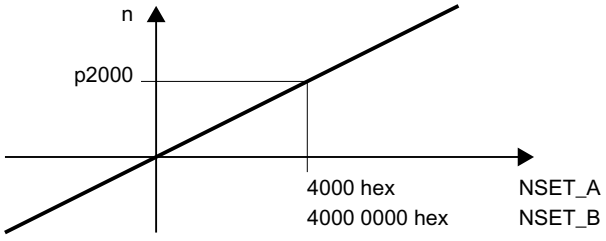


Figure 1-358 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.
Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:
   "Parameters" > "Setpoint channel" > "Reference values".

⚠ WARNING

Uncontrolled drive behavior
Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur. We therefore recommend that commissioning of the drive and thus specification of the references values be completed first before you commission the CPU and, for example, a technology object.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent speed limiting, you can define speed limits for each direction.

Torque limiting

You can specify the torque limiting as an absolute value. The limiting acts both when motoring as well as generating.

⚠ WARNING

Accuracy of torque limitation
The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor. The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.
Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Motor parameters
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses of the motor

⚠ WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment
Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.
Ensure the correct parameterization.

Standstill detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE
A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE
A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).
As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.
If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted as soon as the speed threshold for standstill detection has been undershot.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)
  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)
  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback

- "On delay time" (p2167)
  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

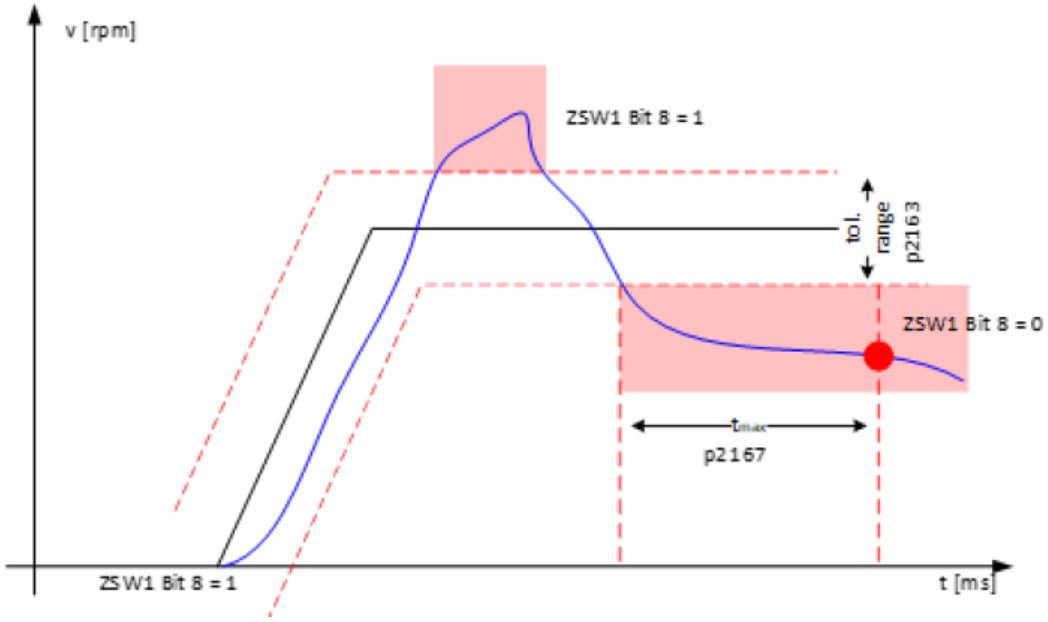


Figure 1-359 Sets the ON-delay time (p2167) and the speed threshold value 4 (p2163)

End stop detection and step loss detection with the stepper motor

If an incremental encoder and the control type [103] controlled (I = const.) are used with a stepper motor, end stop detection or step loss detection can be implemented using bit 8 in the ZSW1. The "speed threshold value 4" parameters (p2163) and the "On delay" (p2167) can be used to set the detection tolerance range.

7.5.3 Ramp generator

The TM Drive uses the speed ramp generator type "Basic ramp-function generator" p1115[0].

Speed ramp generator

The speed ramp generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

The reference value for calculating the ramps from the ramp-up and ramp-down times of the speed ramp generator is the speed specified in the "Speed" dialog box.

NOTE

On principle, the ramp-up and ramp-down times of the ramp generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.
Especially with the control type [103] controlled (I = const.), the ramp-up and ramp-down times must not be set too steep, as otherwise the rotor cannot follow the controlled rotating field.

Procedure

You enter the settings for the speed ramp generator under "Parameters" > "Parameters" > "Ramp generator":

- Rampup time
- Ramp-down time
- Speed

NOTE

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp generator ramp-up time" (p1120) and "Speed ramp generator ramp-down time" (p1121).
When using the GSD file, directly enter the values relative to 10,000 rpm.

7.6 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type.

Motor type: Stepper motor

- [103] Controlled (I = constant)

7.6.1 Controlled (I = const.)

General controller settings

In the controlled control mode (I = const.), the speed is controlled by an angle adjuster. Depending on the respective speed, the control angle of the motor is switched faster or slower in quantified steps in the desired direction of rotation.

Speed controller
It is advisable to specify speed changes along an up and down ramp, as otherwise the drive is not able to follow the specified speed.

The internal ramp-function generator (section 7.5.3) can be used as speed ramp.

Current controller
With the control mode controlled (I = const.), the current controller applies a constant current value to the motor. The motor current is specified using two current values for travel mode (p1738 run current) and standstill mode (p1739 stop current). The current values are effective values.

- Run current p1738
- Stop current p1739

The stop current is impressed on the motor while it is at a standstill and ensures a corresponding holding torque. If a speed not equal to 0 1/min is specified, the current setpoint is switched from stop current to run current. If the motor comes to a standstill from a movement, the setpoint current is switched from run current to stop current after 1 s.

In many applications, the stop current can be reduced during standstill. As a result, energy can be saved during the stop phases and the motor is subjected to less thermal stress.

For reasons of protection, the run and stop current may not be greater than 1.5 times the rated motor current (p0305).

NOTE
With the closed-loop control mode (I = const.), no distinction is made between the magnetic longitudinal inductance (for Id) and transverse inductance (for Iq) of the motor. There are therefore only current controller values for the total current.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Speed setpoint filter p1416

Additional important settings
The speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Current controller

You can either set the current controller manually or have the controller settings calculated by STEP 7.

Having controller settings calculated
To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click on the "Calculate current controller settings" button in the Controller settings area. The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Proportional gain
- Integral action time

NOTE
If you manually set the controller parameters to inappropriate values, the drive system can be damaged.
Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.2 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp generator ramp-down (p1120, p1121). If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or if a timeout is detected, the pulses are blocked after the motor brake closing time p1217 has expired. "Switching on inhibited" is activated.

Timeout
With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within 2 times of this time, the drive is de-energized and it coasts down.

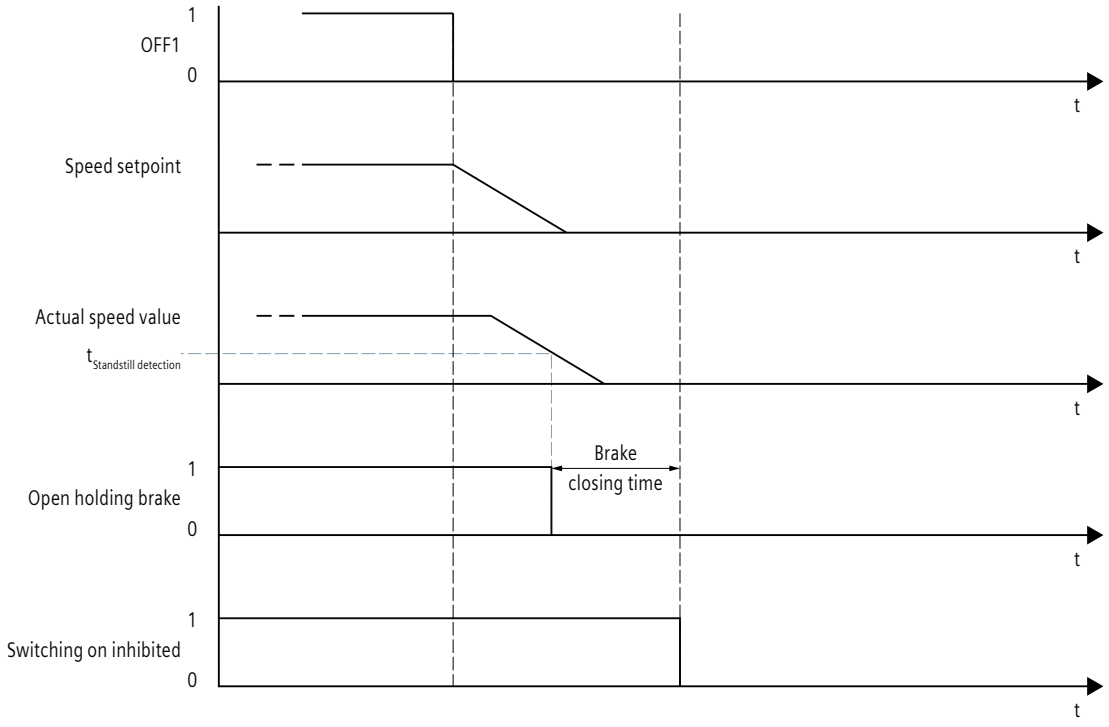


Figure 1-360 OFF1 sequence diagram

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). The pulses are immediately canceled, any parameterized motor holding brake is applied and the drive coasts down. "Switching on inhibited" is activated.

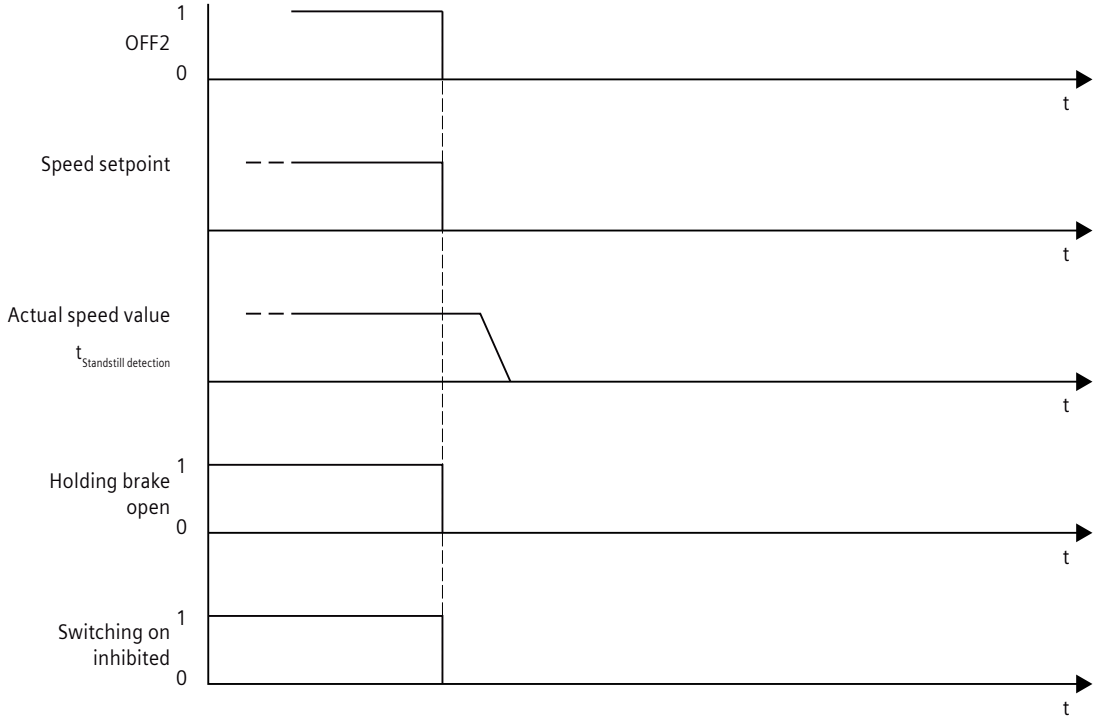


Figure 1-361 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

Timeout
The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

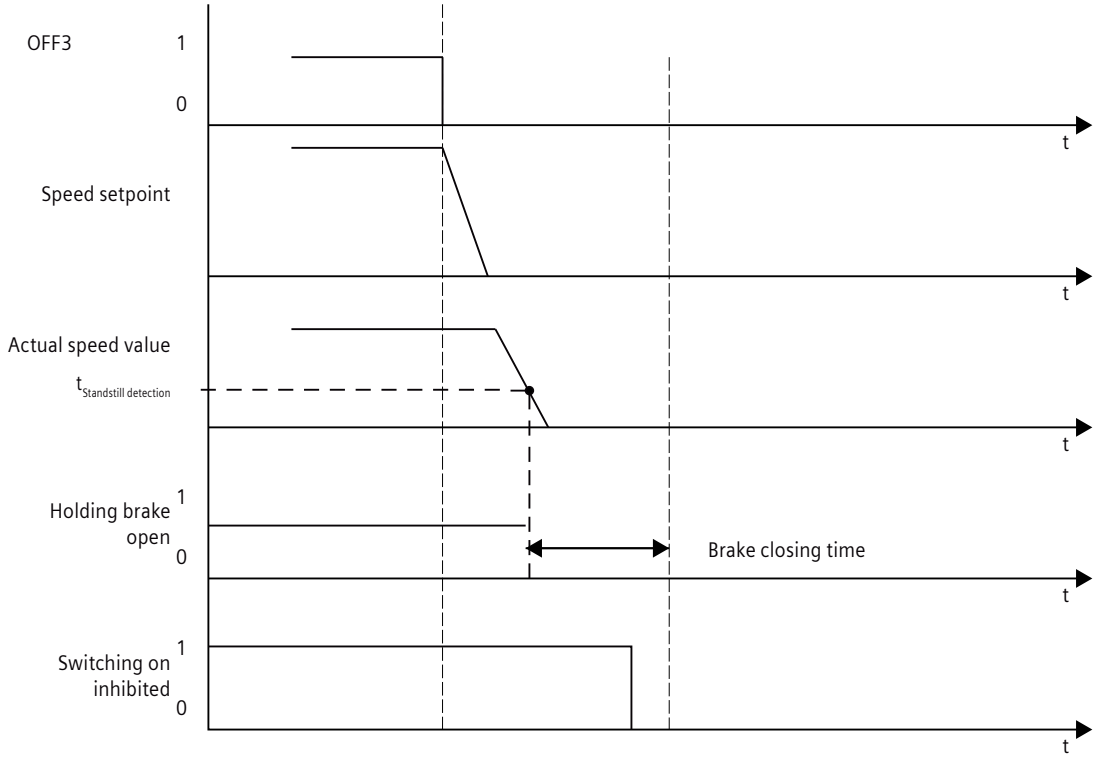


Figure 1-362 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)

7.7 Intermediate circuit voltage

The TM Drive system cyclically monitors the intermediate circuit voltage. The limit values can be set under "Alarms/Monitoring".

The following options can be selected under "Intermediate circuit voltage":

- Minimum value of the intermediate circuit voltage (p0390)
- Maximum value of the intermediate circuit voltage (p0391)

If the limit values are exceeded or not reached, the motor control is switched off. If a intermediate circuit voltage close to the limit values is detected, a corresponding warning is issued.

7.8 Brake module

The drive system TM Drive can externally control a motor holding brake via the process image using a DQ or relay module.

The following options for the stepper motor type can be selected under "Brake module":

- [0] No function
- [4] Motor holding brake externally via the process image

If stepper motors are selected, the brake chopper function cannot be used. Should a brake chopper nevertheless be required, you can install another TM Drive module with brake chopper functionality in the same potential group and connect the brake resistor there and parameterize the brake chopper.

7.8.1 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the suspended load (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the area "Parameters" > "Drive" > "Brake module".

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

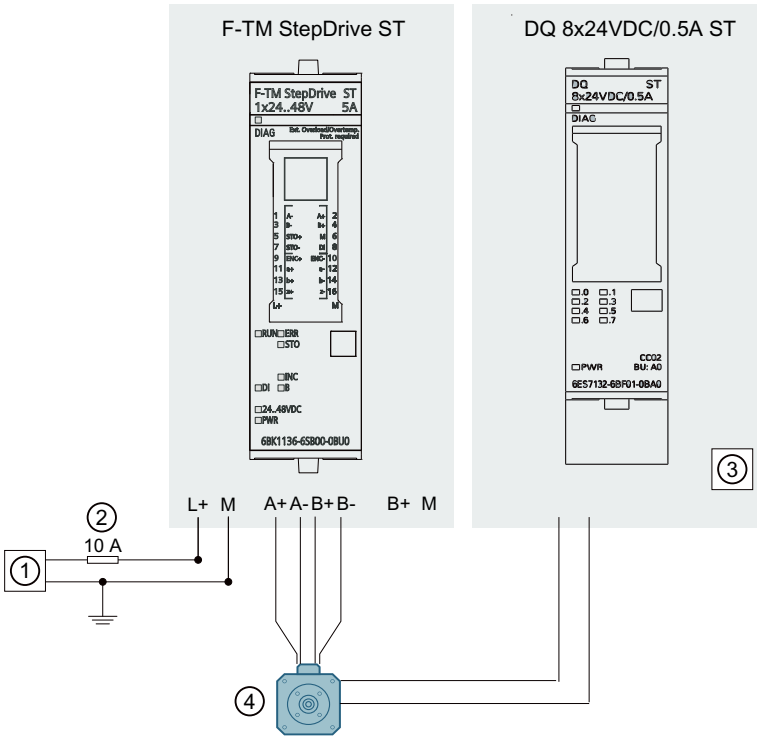
For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is parameterized, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example with a DQ module or relay module.

RC circuit of a TM Drive with DQ module and motor holding brake



① Power supply unit
② Protective device
③ DQ module
④ Motor with holding brake

Figure 1-363 RC circuit of a TM Drive with DQ module and motor holding brake

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

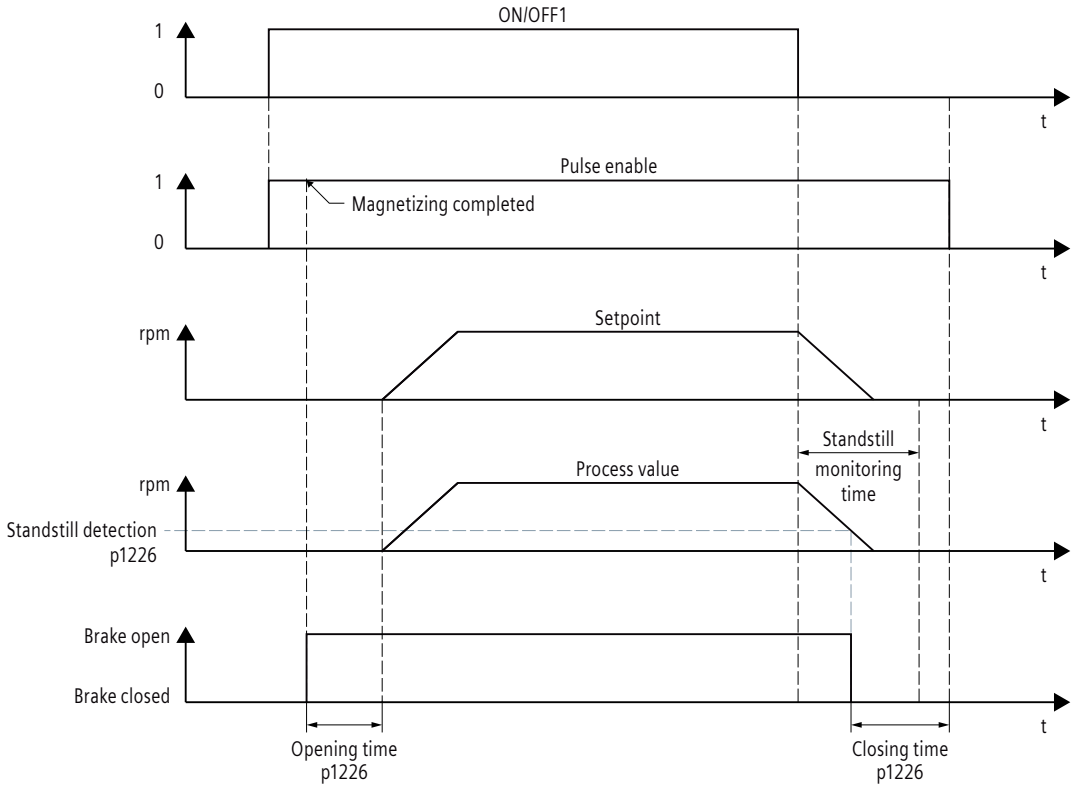


Figure 1-364 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 (Page 77) OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.9 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor monitoring

The thermal motor resistance utilization is a calculated value. The values are not saved. After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 105).

7.9.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

⚠ WARNING

Thermal motor utilization cannot be immediately determined after initialization
The thermal model is reinitialized after changing the drive data record and when switching on the device.
After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.
During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model

The I^2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

⚠ WARNING

Compliance with the ambient conditions specified by the motor manufacturer
The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.
If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.
If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.9.2 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage T_{PU}. When operating with cyclic overload, the rated power is not exceeded the by the time-averaged power (rms).

Stepper motor

With a stepper motor, a double overload of the rated current I_n cyclic for a duration of $t_{overload}$ = 3 s with a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload} \approx 0.75$ s.

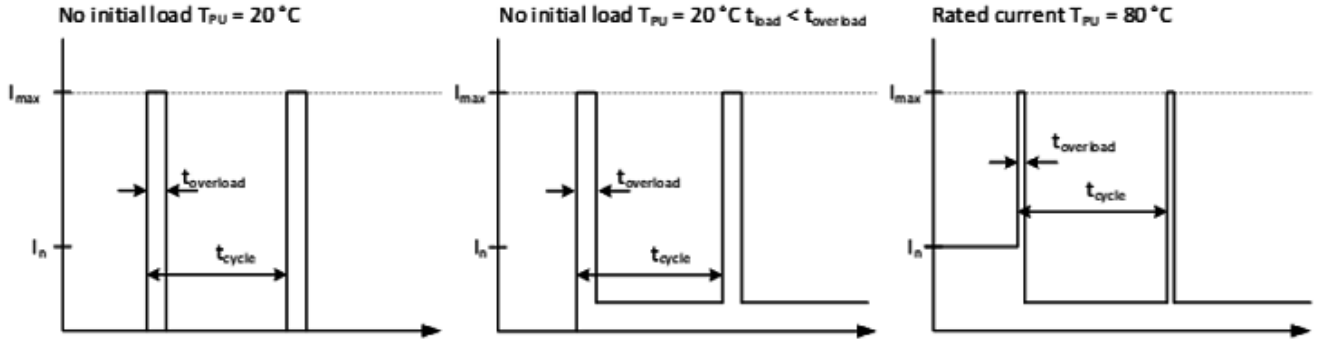


Figure 1-365 Overload behavior of TM Drive

Note the information on derating as a function of environmental conditions (e.g. temperature, mounting position) in section Derating of the ET 200SP TM Drive (Page 108).

NOTE

Overload capability of the power unit

Operation with a peak current of 10 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.9.3 Intermediate circuit voltage

Monitoring of the intermediate circuit voltage

The energy recovery in the power supply cannot be suppressed. Energy is fed back when the drive brakes and the braking chopper is not connected and configured. The energy recovery results in an increase of the intermediate circuit voltage.

You can set the limits for the intermediate circuit voltage within the permissible values.

If the limits are exceeded, the module switches off. Before the module is switched off, a warning (limit - 5%) indicates that the limit has almost been exceeded. The user is responsible for ensuring compliance with the permissible voltage limits.

Procedure

1. Open the "Intermediate circuit voltage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the minimum value (p0390) and the maximum value (p0391).

⚠ WARNING

Operation above the voltage setting range
Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and gear unit. Otherwise, the intermediate voltage may increase when the control is inactive via 60 V DC.

Programming

8

TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 88)
- Control via the SINA_SPEED (Page 94) instruction
- Control with a technology object (Page 95)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Standard telegram 1 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**

Bool	Data type	Offset
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1

Bool	Data type	Offset
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit08_NoSpeedDeviation	Bool	0.1
Bit09_ControlRequested	Bool	0.2
Bit10_SpeedComparisonValueReachedExeed	Bool	0.3
Bit11_TorqueLimitNotReached	Bool	0.4
Bit12_OpenHoldingBrake	Bool	0.5
Bit13_NoMotorOvertemperature	Bool	0.6
Bit14_ActualSpeedPositive	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2

Element	Data type	Offset
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5

Bool	**Data type**	**Offset**
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Actual encoder position value 1 (Gx_XIST1)	**DWord**	**10.0**
Actual encoder position value 2 (Gx_XIST2)	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word 1	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5

Element	Data type	Offset
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the TM Drive.
4. Control the TM Drive by setting outputs bit-by-bit. A description of how to set the outputs to control the TM Drive can be found in the PROFIdrive standard.
   You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the TM Drive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams.

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

See also

Communication telegrams (Page 55)

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive does not have an integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance

9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 1-716 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 101).

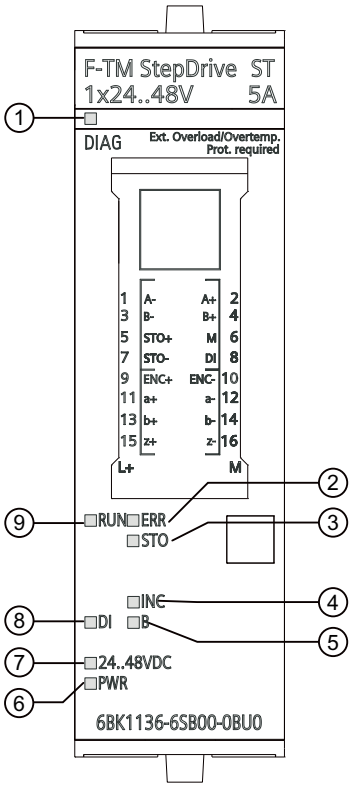
Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the TM Drive.



① DIAG (red/green)
② ERR (red)
③ STO (yellow)
Display not safety-related
④ INC (green)
⑤ B (green)
⑥ PWR (green)
⑦ 24..48V (green)
⑧ DI (green)
⑨ RUN (green)

Figure 1-366 LED display on F-TM StepDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 1-717 DIAG status and error display

DIAG LED	Meaning	
Off	Backplane bus supply of the ET 200SP not OK	
Flashing	Module parameters not assigned	
On	Module parameters assigned and no module diagnostics	
Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 101).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 1-718 RUN status and error display

RUN LED	Meaning	
Off	Device is not yet ready for operation	
On	Device is ready for operation and error-free	
Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 1-719 ERR status and error display

ERR LED	Meaning
Off	No fault
On	Device has a fault and needs to be restarted. This corresponds to a serious device error or the loaded firmware cannot be operated on this device version.

DI LED

Table 1-720 DI status and error display

DI LED	Meaning
Off	Input is inactive
On	Input is active

B LED

Table 1-721 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 1-722 STO status and error display

STO LED	Meaning
■ On	Drive ready, switch connected correctly and STO not requested
☼ flashes (0.5 Hz)	STO requested (motor is disconnected from power)

INC LED

Table 1-723 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

24..48V LED

Table 1-724 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LEDs

Table 1-725 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the TM Drive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**
  The general diagnostic information is displayed for:
  - Module
  - Module information
  - Manufacturer information
- **Diagnostics status**
  "Diagnostics status" shows the current diagnostics status of the TM Drive.
- **Active messages**
  "Active messages" displays the currently pending alarms and faults in the TM Drive module.
- **Drive diagnostics**
  The current diagnostic information of the drive is displayed for:
  - Status bits
  - Operating values
  - Encoders
  - Temperatures
  - Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE
In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the motor electronics exceeded	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1300	There is an error in the parameter assignment of the motor type.	Parameterization error

Fault number	Description	S7 diagnostics alarm
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The TM Drive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2200	Encoder warning in the encoder error

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE
All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 1-726 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 1-727 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r0080	Torque actual value	Nm
r1045	Speed setpoint in front of the ramp generator	rpm
r0026	DC link voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

NOTE

With a stepper motor and the "controlled (I = const.)" control type, the actual torque value corresponds to the current hold torque.

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 1-728 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Single-turn steps	-
p979[2]	Increments per revolution	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 1-729 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 1-730 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Technical specifications

11

11.1 Technical specifications

Technical specifications of TM Drive

Article number	6BK1136-6SB00-0BU0
General information	
Product type designation	F-TM StepDrive ST
HW functional status	V1.0
Firmware version	V1.0
• FW update possible	Yes
Product description	control of stepper motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	No
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A; at 24 V
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V

Article number	**6BK1136-6SB00-0BU0**
Output current	
Current output (rated value)	5 A
Output current, max.	10 A
Output frequency	1 000 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	No
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1

Article number	6BK1136-6SB00-0BU0
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	3
• SIL according to DIN EN 61800-5-2	3
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	No

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation
For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. In this case, the motor current and the output current of the digital outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)
When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

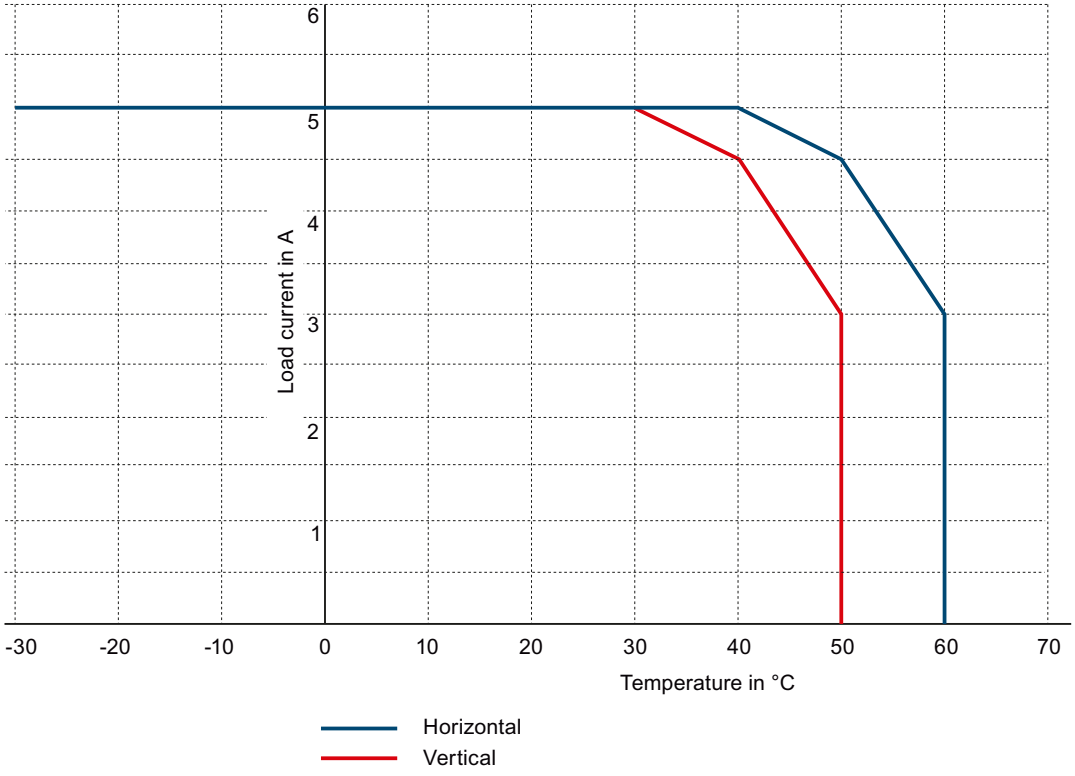


Figure 1-367 Derating the TM Drive with a stepper motor

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix

A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.2 Device disposal

Recycling and disposal



For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE

The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.3 Directives and standards

SIEMENS

SIMATIC

ET 200SP
Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Equipment Manual

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07/2013
A5E03857933-01

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Please find further information and newsletters on this subject at: (http://support.automation.siemens.com)

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Any third-party products that may be in use must also be taken into account. Please find further information at: (http://www.siemens.com/industrialsecurity)

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Documentation guide

1

1.1 Documentation Guide for Power Module F-PM-E 24VDC/8A PPM ST

Introduction

The documentation of the SIMATIC products has a modular design and includes topics concerning your automation system.

The complete documentation of the ET 200SP system consists of different modules divided into system manuals, function manuals and manuals.

The STEP 7 (online help) information system supports you in configuring and programming your automation system.

Overview of documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

The table below lists additional documents that complement this description of the F-PM-E 24VDC/8A PPM ST fail-safe power module and are available on the Internet.

Table 1-731 Documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning • Approvals • TÜV certificate
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment to verification all the way to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/safety-services).

Please send your questions to us by e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-PM-E 24VDC/8A PPM ST

Order number

6ES7136-6PA00-0BC0

View of the module

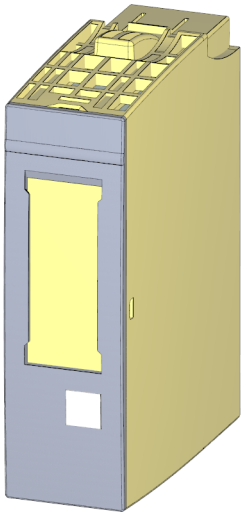


Figure 1-368 View of the F-PM-E 24VDC/8A PPM ST module

Properties

- Technical properties
  - Fail-safe digital module
  - 2 inputs (SIL3/Cat.4/PLe)
  - 1 output PM-switching or PP-switching, output current 8 A (SIL3/Cat.4/PLe)
  - 2 outputs for sensor supply
  - Sink input (P-reading)
  - Source output (PM/PP-switching)
  - Supply voltage L+
  - Suitable for connection of 2-wire sensors to IEC 61131, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms
  - Diagnostic display (DIAG red/green LED)
  - Status display for each input or output (green LED)

  - Fault display for each input or output (red LED)
  - Diagnostics, e.g., short circuit/wire break, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or passivation throughout the module
- Supported functions
  - Firmware update
  - I&M identification data
  - PROFIsafe

WARNING

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic messages (Page 57).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection

Additional information on accessories can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Safety-related shutdown of standard DQ modules by the F-PM-E 24VDC/8A PPM ST

This cost-effective solution allows for full and simultaneous shutdown of all affected outputs of the standard DQ modules when a fault is detected in the process or on the F-PM-E 24VDC/8A PPM ST power module.

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

You can use the F-PM-E 24VDC/8A PPM ST power module with all standard DQ modules within a potential group. Additional information is available in Applications for safety-related shutdown of standard modules (Page 49).

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs
If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.
Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.
One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.
The required measures are standardized for plants with product standards.
For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Connecting

3

3.1 Terminal assignment

General terminal assignment

Table 1-732 Terminal assignment for F-PM-E 24VDC/8A PPM ST

Terminal assignment for F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n • DQ-P_0: Output signal, channel 0, P-switching • DQ-M_0: Ground for output signal, channel 0, M-switching • AUX: Protective conductor connection or voltage bus for SELV/PELV circuits	C0	 CC52 6ES7193-6CP52-2MC0
3	VS_0	**4**	VS_1			
5	DQ-P_0	**6**	DQ-M_0			
7	AUX	**8**	AUX			
L+	DC24V	**N**	M			
L+	DC24V	**N**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

Make sure that you only use the power module with BaseUnit type C0 during commissioning.

Digital output

The digital output switches the voltage L+ and M using two electronic switches (see Block diagram (Page 13)). The switched voltage and chassis are conducted to the internal voltage buses P1 and P2. The switched voltage and chassis is also available at the BaseUnit at DQ-P_0 and DQ-M_0.

This results in two connection options that can be used at the same time, if desired:

- One load can be wired directly to the BaseUnit (see Applications for the output DQ/P1 and P2 (Page 34)).
- The standard modules can be supplied and switched off safety-related by means of the internal voltage buses P1 and P2. You can, in turn, connect loads to the standard modules (see Applications for safety-related shutdown of standard modules (Page 49)).

WARNING

It is no longer possible to shut down an actuator if a cross circuit has developed between L+ and DQ. To prevent cross circuits between L+ and DQ, you must route the cables used to connect the actuators in a cross-circuit proof manner (for example, as separate, sheathed cables or in separate cable ducts).

Redundant ground conductor required

WARNING

The ground conductor to the BaseUnit for F-PM-E 24VDC/8A PPM ST must be installed twice for safety reasons. Any interruption of a single ground conductor would prevent the safety-related shutdown of voltage bus P2.

Property of the individual shutdown of F-modules with fail-safe outputs

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Switching of loads with ground if the F-module is configured PM-switching

If the following two conditions are met, F-PM-E 24VDC/8A PPM ST detects a short circuit:

- If loads that have a connection between chassis and ground are switched by the F-PM-E 24VDC/8A PPM ST , for example, to improve the EMC properties.
- If chassis and ground are connected at the power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example for an F-PM-E 24VDC/8A PPM ST).

Remedy:

- Use the F-PM-E 24VDC/8A PPM ST configured as a PP-switching module.
- Increase the value of the resistance between chassis and ground at the load end to more than 100 kΩ.
- Reduce the capacitance value between chassis and ground at the load end to less than 2 µF.

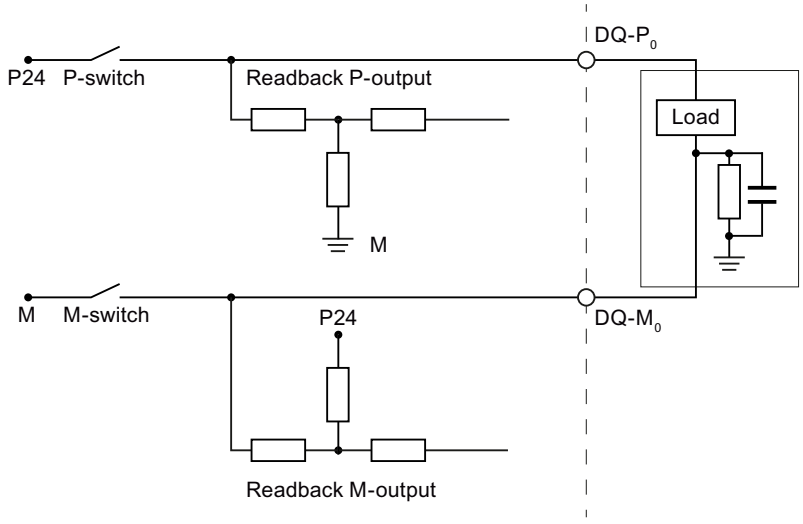


Figure 1-369 Switching of grounded loads (resistance between chassis and ground)

WARNING

During startup, the F-PM-E 24VDC/8A PPM ST carries out a switch-on test of approximately 3 ms. The capacitance between chassis and ground at the load end is charged by way of the load resistance. This low charging current may briefly trigger sensitive load circuits.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

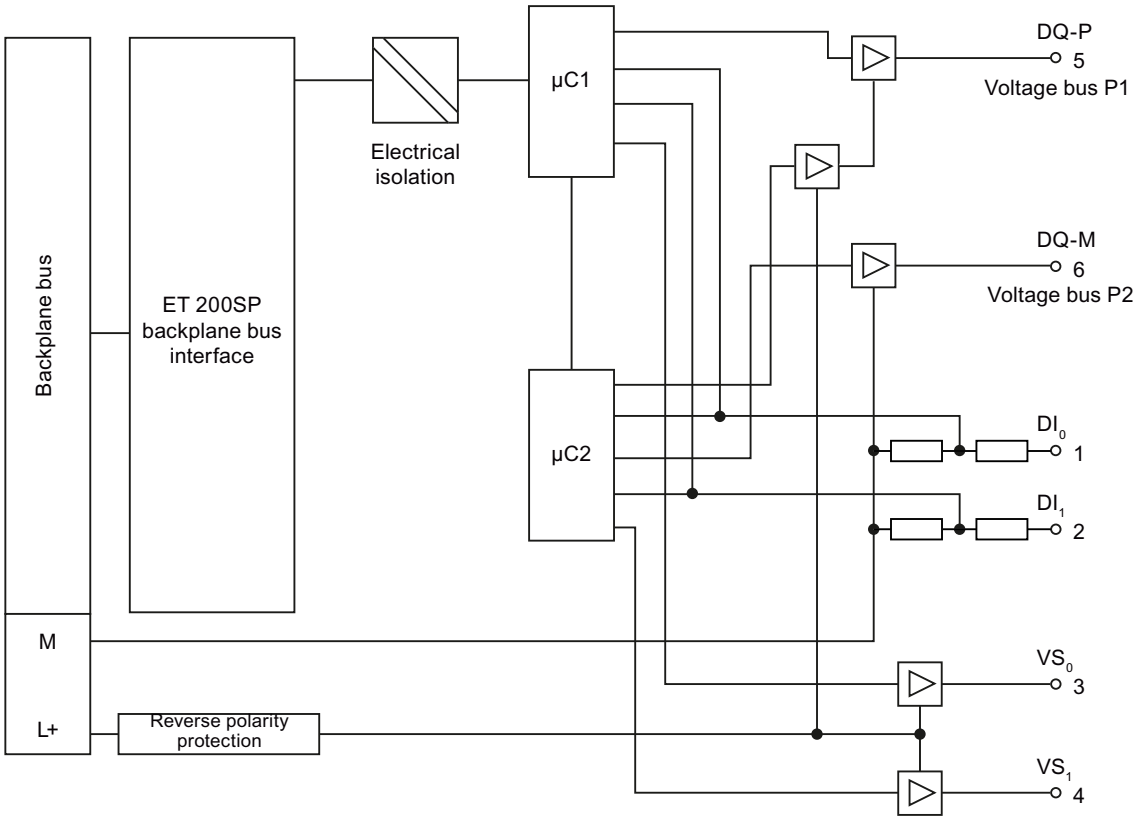


Figure 1-370 Block diagram F-PM-E 24VDC/8A PPM ST

Parameters/address space

4

4.1 Parameters

Parameters

WARNING

Diagnostic functions should be activated or deactivated in accordance with the application.

Table 1-733 Parameters for power module

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of the F-monitoring time	• disable • enable	no	Module
F-monitoring time	1 to 65535 ms	no	Module
F-source address	1 to 65534	no	Module
F-destination address	1 to 65534	no	Module
F-parameter signature (without address)	0 to 65535	no	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	no	Module
F-I/O DB manual number assignment	• disable • enable	no	Module
F-I/O DB number	—	no	Module
F-I/O DB name	—	no	Module
PM-parameters:			
Maximum test period	• 100 s • 1000 s	no	Module
Sensor supply:			
Short circuit test	• disable • enable	no	Channel
Time for short circuit test	0.5 ms to 2 s	no	Channel
Startup time of the sensors after short circuit test	0.5 ms to 2 s	no	Channel
Inputs:			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent	no	Channel pair
Discrepancy behavior	• Supply last valid value • Supply 0 value	no	Channel pair

Parameter	Value range	Parameter reassignment in RUN	Scope
Discrepancy time	5 ms to 30 s	no	Channel pair
Reintegration after discrepancy error	• Test 0-signal necessary • Test 0-signal not necessary	no	Channel pair
Activated	• disable • enable	no	Channel
Sensor supply	• Sensor supply 0 • Sensor supply 1 • External sensor supply	no	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	no	Channel
Pulse extension	• — • 0.5 s • 1 s • 2 s	no	Channel
Chatter monitoring activated	• disable • enable	no	Channel
Number of signal changes	2 to 31	no	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	no	Channel
Output:			
Activated	• disable • enable	no	Channel
Control of the output	• F-CPU • F-CPU and onboard F-DI	no	Module
Output type	• PM switching • PP switching	no	Channel
Max. readback time dark test	0.8 to 400.0 ms	no	Channel
Disable dark test for 48 hours	• disable • enable	no	Channel
Max. readback time switch on test	0.8 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

F-parameters

Information on F-parameters is available in the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.2 PM-parameters

4.2.2.1 Maximum test period

Here you specify the time within which the light and dark tests (in all combinations) should be performed throughout the module. When this time expires, the tests are repeated.

The "Maximum test period" parameter is a module parameter, which means the test cycle for the entire fail-safe output module is performed within the configured maximum test time. If the bit pattern test is not performed within the configured time (or the shortened test time of 60 seconds in case of an error), the module goes into the error state.

4.2.3 Parameters of the sensor supply

4.2.3.1 Short circuit test

Here you enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input of another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

During the execution time (Time for sensor test + Startup time of sensor after sensor test) of the short circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

4.2.3.2 Time for short circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

When assigning parameters, note that

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for sensor test" parameter.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

4.2.3.3 Startup time of sensors after short circuit test

Function

In addition to the off time ("Time for sensor test"), a startup time must be specified for performing the short circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after connecting the sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

When assigning parameters, note that

- This parameter must be greater than the transient recovery time of the employed sensor.
- Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short circuit test is enabled.

4.2.4 Parameters of the inputs

4.2.4.1 Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent

1oo2 evaluation equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One single-channel sensor
- One non-equivalent sensor
- One two-channel sensor
- Two single-channel sensors

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two single-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Achievable safety class

The following safety class can be achieved depending on the selected sensor evaluation:

- SIL3/Cat.4/PLe with "1oo2 evaluation equivalent/non-equivalent"

4.2.4.2 Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to fast response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown.. In the worst-case scenario, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

4.2.4.3 Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

4.2.4.4 Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-signal necessary"
- "Test 0-signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non equivalent"

"Test 0-signal necessary"

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non equivalent", a 0-signal must be present again at the low order channel of the channel pair.

"Test 0-signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.4.5 Activated

You hereby enable the corresponding channel for signal processing in the safety program.

4.2.4.6 Sensor supply

Here you select one of the internal sensor supplies VS_0 to VS_n or an external sensor supply.
The selection of an internal sensor supply is required for using the short circuit test.

See also

Time for short circuit test (Page 17)

4.2.4.7 Input delay

Function

To suppress stray interference, you can set an input delay for the entire channel or channel pair.
Interference pulses whose pulse time is less than the set input delay (in ms) are suppressed. Suppressed interference pulses are invisible in the PII.
A high input delay suppresses longer interference pulses, but results in a longer response time.
The values available for the input delay depend on the "Startup time of sensors after short circuit test" and the "Time for short circuit test" of the configured sensor supply.

NOTE
Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).
Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Technical specifications (Page 63)

4.2.4.8 Pulse extension

Function

Pulse extension is a function to change a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.
The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

With 1oo2 evaluation, the result of the evaluation of both sensors is used for the pulse extension.

4.2.4.9 Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

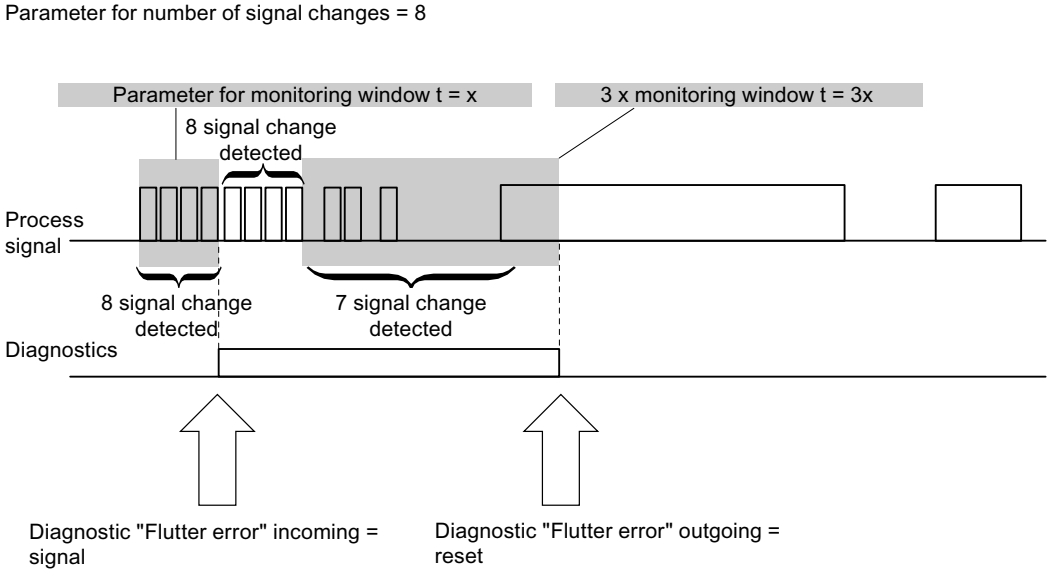


Figure 1-371 Figure chatter monitoring

Number of signal changes

Sets the number of signal changes after which a chatter error should be reported.

4.2.4.10 Monitoring window

Sets the time for the monitoring window of flutter monitoring.
You can set times of 1 s to 100 s in whole seconds for the monitoring window.
You can configure a monitoring window of 0.5 s when you set 0 s.

4.2.5 Parameters of the output

4.2.5.1 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

4.2.5.2 Controlling the output

Activates the internal evaluation.

Additional information on internal evaluation is available in the chapter "Application for internal evaluation" (Page 47).

4.2.5.3 Output type

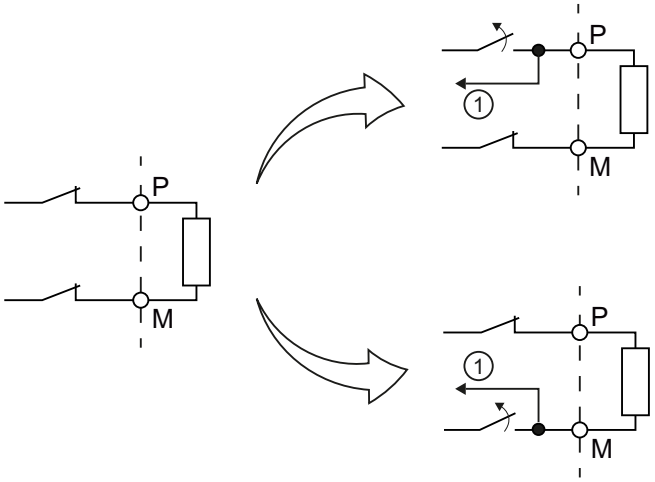
The parameter specifies if the output switches PM or PP.

4.2.5.4 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1-372 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

⚠ WARNING

Through the configured readback time dark test, short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads (Page 69).

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

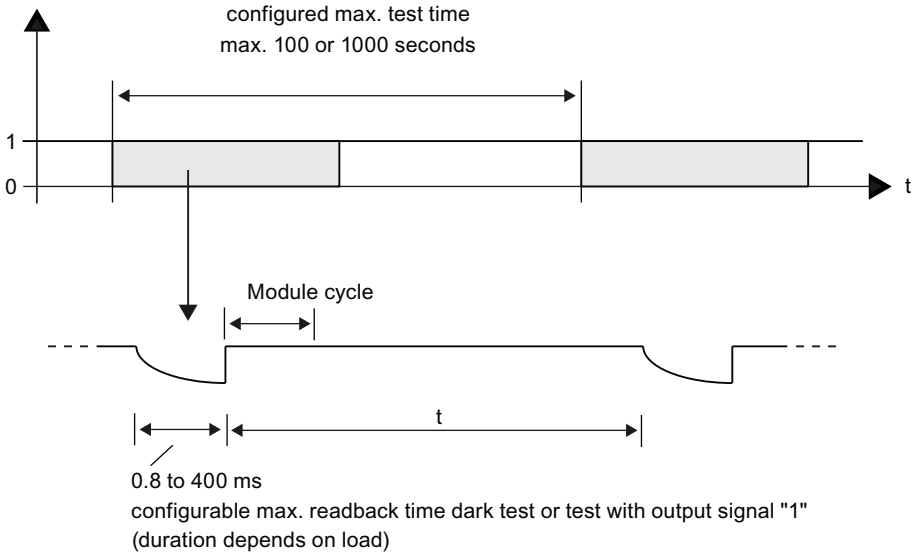


Figure 1-373 Test pulses of the dark test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 68).

4.2.5.5 Disable dark test for 48 hours

This option allows you to suppress the dark test.

If the channel is permanently active (1) for 48 hours, 2 dark test pulses (PP switching) or 3 dark test pulses (PM switching) are directed to this channel once the time has expired.

You must provide the signal change from 1 to 0 at the channel yourself within 48 hours to prevent the dark test pulse. The dark test is suspended for another 48 hours after the signal change from 0 to 1.

The dark test is permanently suppressed if the following condition is met:

- A signal change from 1 to 0 takes place before the 48 hours have expired.

⚠ WARNING

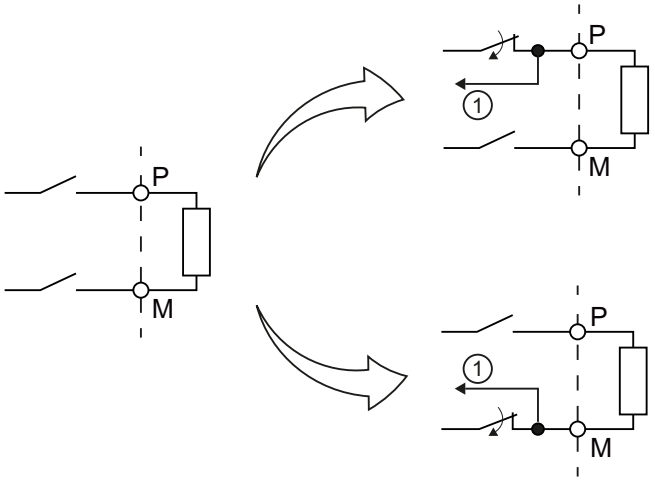
The output is passivated if an error caused by a short-circuit is recognized when the safety-function is executed (output turned off). This is necessary because a complete bit pattern test is not performed within 48 hours, which means an undetected error burst may not be ruled out.
If the channel can retain signal 0 for 48 hours and longer, the function "Disable dark test for 48 hours" must not be used.
Consult the respective requirements of your product standards regarding error detection time.

4.2.5.6 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.



① Readback

Figure 1-374 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the chapter Switching capacitive loads (Page 69).

If the capacity of the actuator is not known, it may be necessary for you to determine the required value for the readback time by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time switch on test is too small for a connected capacitive load. The charge of the capacitive load cannot take place within the configured readback time switch on test. Increase the readback time.

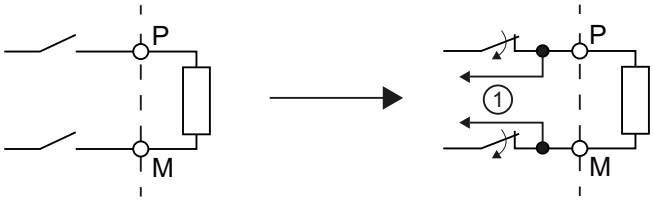
If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

4.2.5.7 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output.

For a light test, several test signals are switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.



① Readback

Figure 1-375 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

If the readback signals are incorrect, the signal is present for the configured readback time at the output channel before the fault causes passivation of the output channel.

If the signal was not read back correctly once the maximum readback time switch on test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

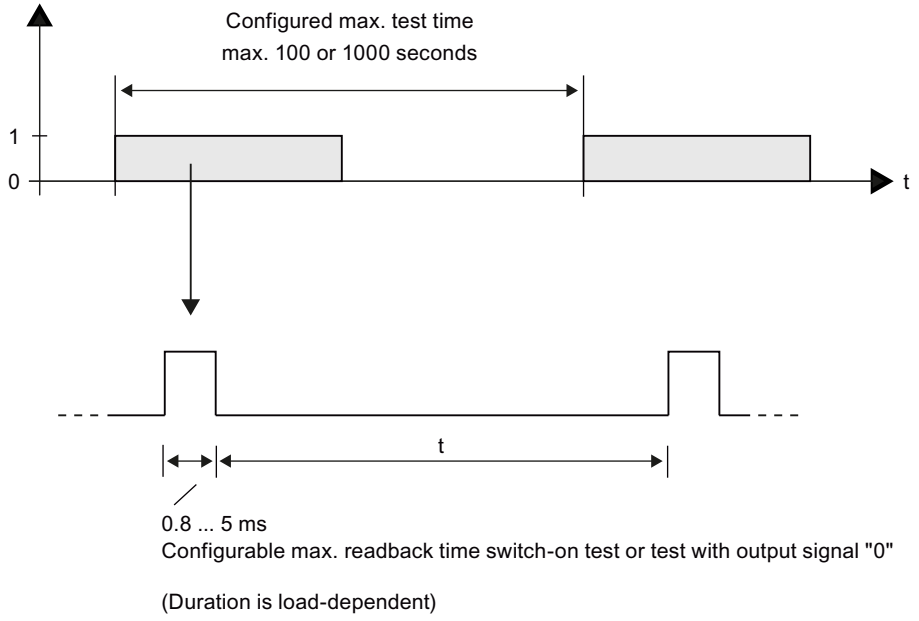


Figure 1-376 Test pulses of the light test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 68).

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after t. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.5.8 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

Wire break is signaled when the following conditions are met:

- Wiring to the actuator is interrupted.
- A module that is disabled in fail-safe mode by the F-PM module has been removed.

You also have to activate the light test to detect a wire break with an output signal "0".

4.3 Address space

Address assignment of power module F-PM-E 24VDC/8A PPM ST

The F-PM-E 24VDC/8A PPM ST power module occupies the following address areas in the F-CPU:

Table 1-734 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
In input range	**In output range**
x + 0 to x + 6	x + 0 to x + 4

x = Module start address

Address assignment of the user data and value status of power module F-PM-E 24VDC/8A PPM ST

Of the assigned addresses of power module F-PM E 24VDC/8A PPM ST, the user data occupy the following addresses in the F-CPU:

Table 1-735 Address assignment of user data **in the input range**

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status for DI_1	Value status for DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

Table 1-736 Address assignment of user data **in the output range**

Byte in the F-CPU	**Assigned bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors you may only access the low order channel in the safety program.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

See also

Value status (Page 62)

Applications of the F-I/O module

5

5.1 Applications for the output DQ/P1 and P2

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving the various safety categories.

Table 1-737 Conditions for achieving SIL/Cat./PL

F-PM-E 24VDC/8A PPM ST		Achievable safety class
Digital output DQ	Without standard DQ modules	SIL3/Cat.4/PLe
	With standard DQ modules	SIL2/Cat.3/PLd

5.1.1 Applications: Safety mode up to SIL3/Cat.4/PLe

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

5.1.1.1 Application: Wiring a load to the digital output, PM switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. They connect the load between the P-switches DQ-P_0 and the M-switch DQ-M_0. The two P-switches and the M-switch are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

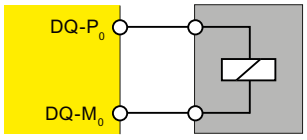


Figure 1-377 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 1-738 Parameters

Parameter	
Output type	PM switching

5.1.1.2 Application: Wiring a load to the digital output, PP switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. You connect the load between the P-switch DQ-P_0 and chassis in this case. The two P-switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

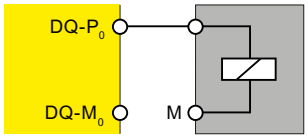


Figure 1-378 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 1-739 Parameters

Parameter	
Output type	PP switching

5.1.1.3 Application: Wiring two loads in parallel to the digital output, PM switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

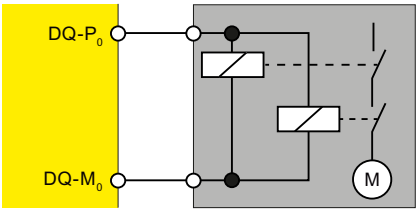


Figure 1-379 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

NOTE

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 1-740 Parameters

Parameter	
Output type	PM switching

5.1.1.4 Application: Wiring two loads in parallel to the digital output, PP switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

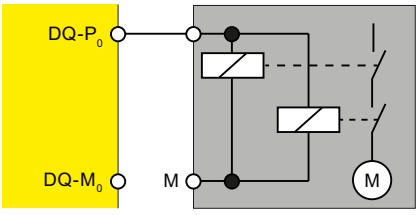


Figure 1-380 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

NOTE

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 1-741 Parameters

Parameter	
Output type	PP switching

5.2 Applications for inputs

5.2.1 Applications of the electronic module

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

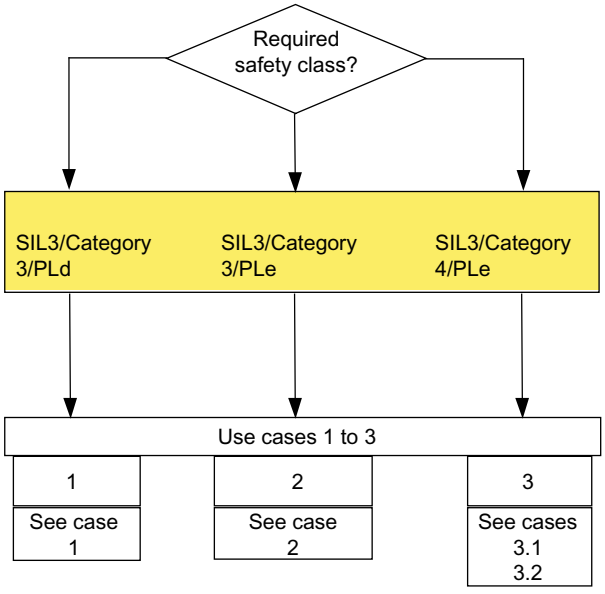


Figure 1-381 Selecting the application – digital inputs of the F-PM-E 24VDC/8A PPM ST

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 1-742 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Any	3 / 3 / d
2	1oo2 equivalent	Internal, without short circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	External/internal, with short circuit test	

Sensor requirements

Information on safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.2.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal. Any sensor supply of the module can be assigned to each input.

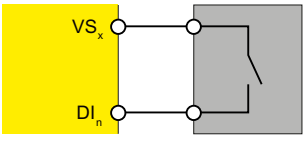


Figure 1-382 One sensor connected via one channel, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

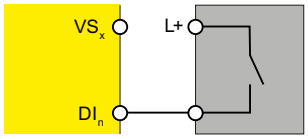


Figure 1-383 One sensor connected via one channel, external sensor supply

⚠ WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-743 Parameter assignment

Parameters	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Short circuit test	• disable • enable	disable
Sensor supply	• Sensor supply n	External sensor supply*

*) Otherwise a diagnostic message will be generated when short circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 1-744 Fault detection

Fault	Fault detection		
	Internal sensor supply and short circuit test activated	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit with other channels or other sensor supplies (short circuit with other channels is detected only if they use a different sensor supply)	yes*	no	no
Short circuit with L+ to DI$_n$	yes	no	no
Short circuit with M to DI$_n$	yes*	yes*	no

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Fault	Fault detection		
	Internal sensor supply and short circuit test activated	**Internal sensor supply and short circuit test deactivated**	**External sensor supply**
Discrepancy error	—	—	—
Short circuit with L+ to VS_n	yes	no	—
Short circuit with M to VS_n or defective	yes	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

WARNING

If the short circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the wiring between the sensor and the input channel must be short circuit proof.

5.2.3 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

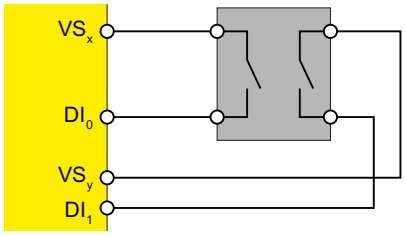


Figure 1-384 One two-channel sensor connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

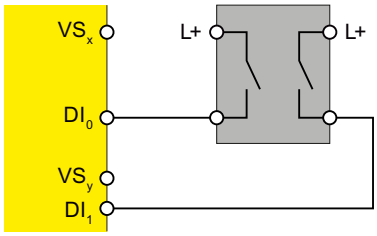


Figure 1-385 One two-channel sensor connected via two channels, external sensor supply

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

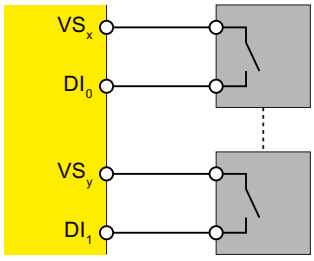


Figure 1-386 Two single-channel sensors connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

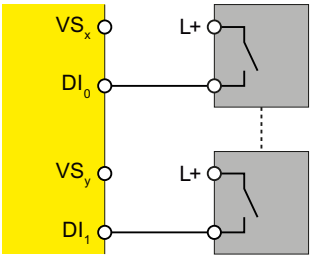


Figure 1-387 Two single-channel sensors connected via two channels, external sensor supply

⚠ WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-745 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Short circuit test	• disable • enable	disable

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 1-746 Fault detection

Fault	Fault detection	
	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit within the channel pair, with other channels or other sensor supplies	no	no
Short circuit with L+ to DI$_n$	yes*	yes*
Short circuit with M to DI$_n$	yes*	yes*
Discrepancy error	yes	yes
Short circuit with L+ to VS$_n$	no	no
Short circuit with M to VS$_n$ or defective	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor must be supplied **internally** for application 3.1 (Page 44).

The sensor can be supplied internally or externally for application 3.2 (Page 45).

Requirements for applications in machine protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short circuits.
- All short circuits listed in Fault detection and Fault detection must be detected. You only need to detect **one** short circuit because two faults are required to generate it. This means both signal cables in short circuit have an isolation fault. A multiple short circuit analysis is not required.

Procedures for locating all short circuits are also permitted if single short circuits are not located. One of the two conditions must be met for this purpose:

- Short circuits may not corrupt the read signals compared to the sensor signals.
- Short circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

5.2.4.1 Application 3.1 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected to both inputs of the power module for each process signal (1oo2 evaluation).

Supply the sensors from two different sensor supplies.

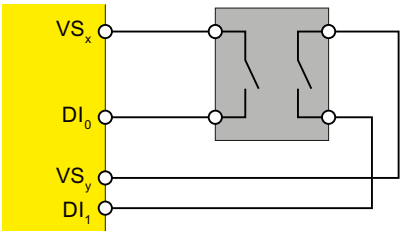


Figure 1-388 One two-channel sensor connected via two channels, internal sensor supply

You can also connect two single-channel sensors via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

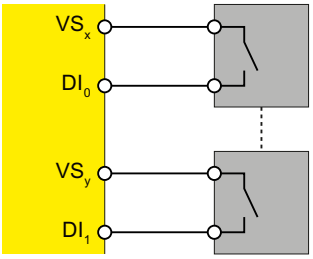


Figure 1-389 Two single-channel sensors connected via two channels, internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-747 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	1oo2 evaluation, equivalent
Short circuit test	enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 1-748 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes*
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes
Short circuit with M to VS_n or defective	yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4.2 Application 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a nonequivalent sensor nonequivalent via two channels

A nonequivalent sensor is connected nonequivalent via 2 channels to both inputs of the power module for each process signal (1oo2 evaluation, nonequivalent).

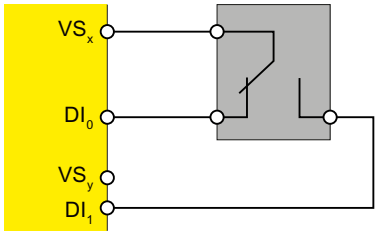


Figure 1-390 Nonequivalent sensor connected, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

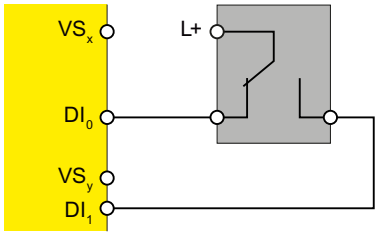


Figure 1-391 Nonequivalent sensor connected, external sensor supply

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram – connecting two single-channel sensors nonequivalent via two channels

Two single-channel sensors are connected nonequivalent to both inputs of the power module for each process signal (1oo2 evaluation).

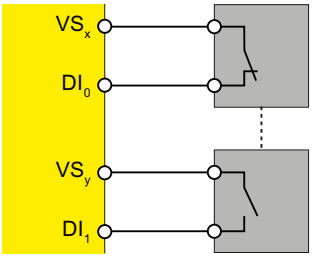


Figure 1-392 Two single-channel sensors connected nonequivalent, internal sensor supply

You can also supply the sensors by means of an external sensor supply.

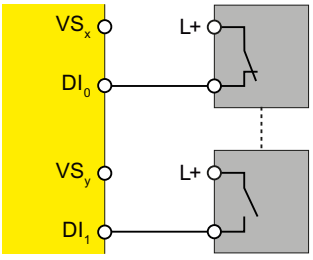


Figure 1-393 Two single-channel sensors connected nonequivalent, external sensor supply

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-749 Parameter assignment

Parameters	
Sensor evaluation	1oo2 evaluation, non equivalent
Short circuit test	• disable • enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 1-750 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes, if used
Short circuit with M to VS_n or defective	yes, if sensor supply is activated

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

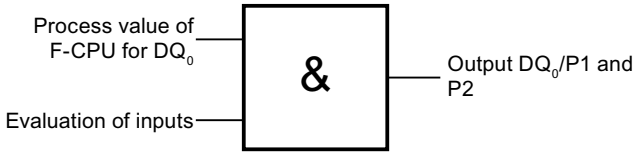
5.3 Application for internal evaluation

Function

The evaluation of the safety function takes place internally in the F-module.

You can choose between 1oo1 evaluation or nonequivalent/equivalent 1oo2 evaluation of the sensors.

- With 1oo1 evaluation, the activated inputs are logically ANDed with the process image of output DQ_0.
- With 1oo2 evaluation, the result of the inputs is logically ANDed with the process image of output DQ_0.



The acknowledgment in case of an error takes place by the safety program in the F-CPU.

Use the wiring diagrams Applications for the output DQ/P1 and P2 (Page 34) and Applications for inputs (Page 37).

You achieve SIL3/Cat.4/PLe.

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator and sensor, for example, in accordance with IEC 60947.

NOTE
If an error occurs at the inputs in this application, the F-module also outputs the error message "Safety-related shutdown" or "Safety event" for the output. Following elimination of the error at the inputs, a reintegration of the output is only possible after the bit pattern test (within the test time shortened to 60 s) has been performed.

Interconnection example

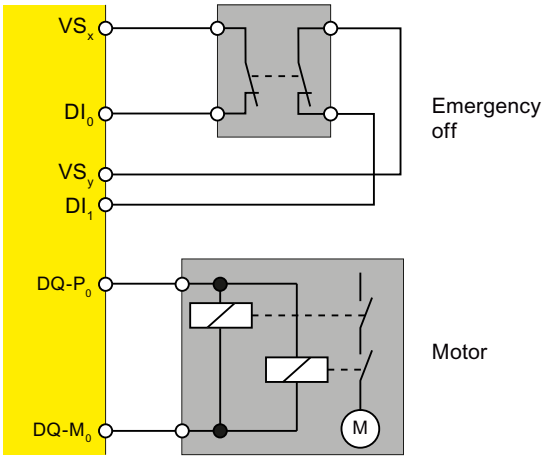


Figure 1-394 Emergency Off shutdown of a motor with equivalent 1oo2 evaluation

Parameter assignment

Assign the following parameters for the F-module:

Parameter	
Control of the output	F-CPU and onboard F-DI
Type of sensor interconnection	• 1-channel • 2-channel equivalent • 2-channel, non equivalent
Sensor supply	Sensor supply 0, Sensor supply 1, or External sensor supply

5.4 Applications for safety-related shutdown of standard modules

5.4.1 Safety-related shutdown of standard output modules, PM-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage buses P1 and P2.

Configure the power module parameters as described in section Terminal assignment (Page 10).

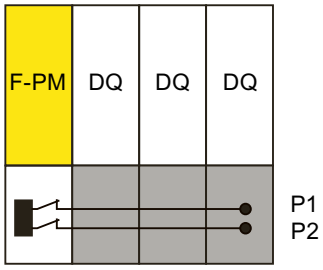


Figure 1-395 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

⚠ WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:
In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.
Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.
It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.
Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.
The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.
The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

⚠ WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

⚠ WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).
See also Terminal assignment (Page 10).

⚠ WARNING

Note the following for the "Safety-related shutdown of standard modules" application:
If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

5.4.2 Safety-related shutdown of standard output modules, PP-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage bus P1.

Configure the power module parameters as described in section Terminal assignment (Page 10).

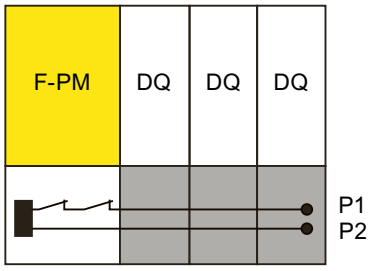


Figure 1-396 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

⚠ WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:
In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.
Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.
It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.
Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.
The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.
The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

⚠ WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

⚠ WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).
See also Terminal assignment (Page 10).

⚠ WARNING

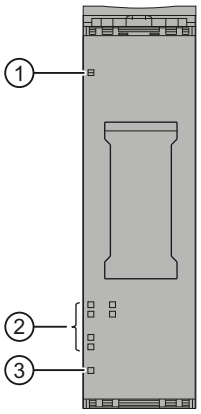
Note the following for the "Safety-related shutdown of standard modules" application:
If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display



① DIAG (green/red)
② Channel status (green), channel fault (red)
③ PWR (green)

Figure 1-397 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 57).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs and outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 1-751 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

DIAG LED

Table 1-752 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	Module parameters configured and module diagnostics

Channel status/channel fault LED

Table 1-753 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
□ Off	□ Off	Process signal = 0 and no channel diagnostics
■ On	□ Off	Process signal = 1 and no channel diagnostics
□ Off	■ On	Process signal = 0 and channel diagnostics
/ Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 1-754 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
□ Off	☼ Flashing	■ All On	The PROFIsafe address does not match the configured PROFIsafe address
☼ Flashing	☼ Flashing	□ Off	Identification of the F-module when assigning the PROFIsafe address

6.2 Interrupts

Introduction

The F-PM-E 24VDC/8A PPM ST fail-safe power module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 57).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 57).

Table 1-755 Diagnostic interrupts of the F-PM-E 24VDC/8A PPM ST

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	—	F-module	No
Parameter assignment error	16_D			
Load voltage missing	17_D			
Access to retentive storage of F-address not possible	30_D			
Different destination address (F_Dest_Add)	64_D			
Invalid destination address (F_Dest_Add)	65_D			
Invalid source address (F_Source_Add)	66_D			
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D			
"F_SIL" parameter exceeds the application-specific SIL	68_D			
"F_CRC_Length" parameter does not match the generated CRC	69_D			
Incorrect F-parameter version or F_Block_ID	70_D			
CRC1 error	71_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Internal error	256_D			
Time monitoring activated	259_D			
Internal supply voltage of the module failed	260_D			
Output short-circuited to L+	261_D		Channel	Yes
Output short-circuited to ground	262_D			
Wire break	265_D			
Incorrect/inconsistent firmware present. Firmware update required	283_D			No
Discrepancy error, channel status 0/0	768_D	2, 3		
Discrepancy error, channel status 0/1	769_D			

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Discrepancy error, channel status 1/0	770_D	2, 3	Channel	No
Discrepancy error, channel status 1/1	771_D			
Input signal could not be clearly detected	773_D	1, 2, 3		
Short circuit of internal sensor supply to L+	774_D			Yes
Overload or short circuit of internal sensor supply to ground	775_D			
No pulse detected	778_D	1		
Sensor signal chatters	784_D			
Switching frequency too high	785_D	1,2,3		No
Undertemperature	786_D		F-module	
Fault in input circuit	787_D			
PROFIsafe communication error (timeout)	792_D			
PROFIsafe communication error (CRC)	793_D			
PROFIsafe address assignment error	794_D			
Input short-circuited to L+	796_D		Channel	Yes
Output defective	797_D	—		No
Readback error	798_D			
Overload	800_D			
Supply voltage too high	802_D	1, 2, 3	F-module	
Supply voltage too low	803_D			

6.3 Diagnostic messages

Digital module error types

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 1-756 Diagnostic messages of the F-PM-E 24VDC/8A PPM ST

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 63)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_D	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open). • There is a short circuit between channels with different signals.	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.

Diagnostic message	Fault code	Meaning	Remedy
Parameter assignment error	16_D	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Load voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at BaseUnit • Check BaseUnit type
Access to retentive storage of F-address not possible	30_D	The F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Different destination address (F_Dest_Add)	64_D	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Invalid destination address (F_Dest_Add)	65_D	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Invalid source address (F_Source_Add)	66_D	The PROFIsafe driver has detected an invalid F-source address.	
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D	The PROFIsafe driver has detected an invalid watchdog time.	
"F_SIL" parameter exceeds the application-specific SIL	68_D	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
"F_CRC_Length" parameter does not match the generated CRC	69_D	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Incorrect F-parameter version or F_Block_ID	70_D	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 error	71_D	The PROFIsafe driver has detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	75_D	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Internal error	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Internal supply voltage of the module failed	260_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the electromagnetic interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Output short-circuited to L+	261_D	Short circuit to L+ can mean: • The sensor cable is short-circuited to L+. • The output cable is short-circuited to L+.	Correct the process wiring.

Diagnostic message	Fault code	Meaning	Remedy
Output short-circuited to ground	262_D	Short circuit to ground can mean: • The sensor cable is short-circuited to ground. • The output cable is short-circuited to ground. • The output signal is short-circuited to ground.	Correct the process wiring.
Incorrect/inconsistent firmware present. Firmware update required	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Discrepancy error, channel status 0/0	768_D	Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring.
Discrepancy error, channel status 0/1	769_D		
Discrepancy error, channel status 1/0	770_D		
Discrepancy error, channel status 1/1	771_D		
Input signal could not be clearly detected	773_D	An error occurred in the plausibility check of the input signal between the processors. You must eliminate the error within 100 hours. If you do not eliminate the error within 100 hours, the F-module will become inoperative. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Short circuit of internal sensor supply to L+	774_D	Possible causes: • There is a short circuit of the internal sensor supply with L+. • There is a short circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.

Diagnostic message	Fault code	Meaning	Remedy
Overload or short circuit of internal sensor supply to ground	775_D	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
No pulse detected	778_D	A pulse with a length greater than or equal to "Minimum pulse time" has not occurred within the time configured with the "Pulse monitoring window" parameter. Possible causes: • The "Pulse monitoring window" parameter setting is too low. • The "Minimum pulse time" parameter setting is too high. • There is a wire break in the process wiring.	• Check the "Pulse monitoring window" parameter. • Check the "Minimum pulse time" parameter. • Check the process wiring.
Sensor signal chatters	784_D	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Switching frequency too high	785_D	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency. (see Technical specifications (Page 63))
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 63))
Fault in input circuit	787_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate/reduce the electromagnetic interference. • Replace the F-module.
PROFIsafe communication error (timeout)	792_D	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • Bus faults are present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.

Diagnostic message	Fault code	Meaning	Remedy
PROFIsafe communication error (CRC)	793_D	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
PROFIsafe address assignment error	794_D	An error occurred during the automatic PROFIsafe address assignment.	Check the configuration.
Input short-circuited to L+	796_D	The input signal is short-circuited to L+.	Eliminate the short circuit.
Output defective	797_D	The F-module has detected an internal error. Possible causes: • Short circuit to L+ or M • The F-module is defective.	• Check the wiring. • Replace the F-module.
Readback error	798_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	If the error persists, replace the F-module.
Overload	800_D	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists.	Check the process wiring.
Supply voltage too high	802_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	803_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

In the case of a voltage dip in the supply voltage L+, the DIAG LED flashes and the module is passivated.

When the voltage has recovered (level must remain above the specified value for at least 1 minute (see Technical specifications (Page 63): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short circuit to the sensor supply

When internal sensor supply is specified and short circuit test is disabled, short circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is specified and short circuit test is enabled, short circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short circuit test and the sensor power supply. The corresponding tables for fault detection for the applications are available under Applications of the F-I/O module (Page 34).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 32).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-PM-E 24VDC/8A PPM ST

	6ES7136-6PA00-0BC0
Product type designation	F-PM-E PPM 24VDC
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V12.0
STEP 7 configurable/integrated as of version	as of V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	V2.3
PROFINET as of GSD version/GSD revision	V2.31
Operating mode	
Multi-output	No
Installation type/mounting	
Rack mounting possible	No
Front installation possible	No
Rail mounting possible	Yes; standard DIN rail
Wall mounting/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
Rated value (DC)	24 V
Low limit of permissible range (DC)	20.4 V
High limit of permissible range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; from backplane bus
Output voltage	
Rated value (DC)	24 V
Sensor supply	
Number of outputs	2
Output current	
Up to 60 °C, max.	0.3 A
Short circuit protection	Yes; electronic (response threshold 0.7 A to 2.1 A)
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short circuit protection	Yes
Output current, max.	600 mA; total current of all sensors

	6ES7136-6PA00-0BC0
Power	
Power consumption from the backplane bus	70 mW
Power loss	
Power loss, typ.	5 W
Address space	
Address space per module	
Input	7 bytes
Output	5 bytes
Digital inputs	
Number of inputs	2
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For "0" signal	-30 to +5 V
For "1" signal	+15 to +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
Assignable	Yes
For "0" to "1", min.	0.4 ms
For "0" to "1", max.	20 ms
For "1" to "0", min.	0.4 ms
For "1" to "0", max.	20 ms
For counter/technological functions	
Assignable	No
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Digital outputs	
Number of outputs	1
Digital outputs, configurable	Yes
Short circuit protection	Yes
Response threshold, typ.	> 14.8 A
Wire break detection	Yes
Response threshold, typ.	8 mA
Overload protection	Yes
Response threshold, typ.	8.8 A
Voltage induced on current interruption limited to	max 1.5 V
Switching capacity of outputs	
With resistive load, max.	8 A
With lamp load, max.	100 W
Load resistance range	
Low limit	3 Ω

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High limit	2000 Ω
Output voltage	
Type of output voltage	DC
For "1" signal, min.	24 V; L+ (-0.5 V)
Output current	
For "1" signal, rated value	8 A
For "0" signal, residual current, max.	1.5 mA; PP-switching: Max. 1.5 mA; PM-switching: Max. 1 mA
Switching frequency	
With resistive load, max.	10 Hz; symmetrical
With inductive load, max.	0.1 Hz; acc. to IEC 947-5-1, DC13, symmetrical
With lamp load, max.	4 Hz; symmetrical
Total current of outputs	
Max. current per channel	8 A; (note derating data in the manual)
Max. current per module	8 A; (note derating data in the manual)
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Interrupts/diagnostics/status information	
Fail-safe values can be switched to	No
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes, see section "Interrupts/diagnostic messages" in the manual
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	60 V DC / 75 V AC
Isolation	
Isolation test voltage	707 V DC (type test)
Standards, approvals, certificates	
SIL acc. to IEC 61508	SIL 3
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	

	6ES7136-6PA00-0BC0
Performance level according to EN ISO 13849-1	PLe
Low demand (PFD) acc. to SIL3	< 2.00E-05 1/h
High demand (PFH) acc. to SIL3	< 1.00E-09 1/h
Environmental conditions	
Operating temperature	
Min.	0 °C
Max.	60 °C
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
Dimensions	
Width	20 mm
Height	72 mm
Depth	55 mm
Weights	
Weight, approx.	70 g

Temperature characteristic values (derating)

Mounting position	Maximum temperature	Maximum output current
Horizontal	40 °C	8 A
	50 °C	6 A
	60 °C	4 A
Vertical	50 °C	4 A

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Response times

A

A.1 Response times

Introduction

The next section shows the response times of power module F-PM-E 24VDC/8A PPM ST. The response times of the fail-safe modules are included in the calculation of the F-system response time.

Times required for the calculation

Maximum internal processing time: $T_{max.}$ = 29 ms

Maximum cycle time: T_{cycle} = 14 ms

Short circuit test time for the sensor supply configured for the channel = "Time for short circuit test" + "Startup time after short circuit test"

The input delay, short circuit test times, dark test time, switch-on time, discrepancy time, and test time are configured in STEP 7.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Definition of response time for internal evaluation: Cycle time + Input delay + Short circuit test time + Maximum(readback time, switch-on time, light test time)

Maximum response time in the error-free case with 1oo1 evaluation

Maximum response time = T_{max} + Input delay + Short circuit test time for the sensor supply configured for the channel

Maximum response time in the error-free case with 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel n1)

Maximum response time with external short circuits

Maximum response time = Input delay + (n × T_{cycle}) + Sum(all short circuit test times + all startup times of sensors with activated short circuit test)

n = Number of sensor supplies with activated short circuit test

Maximum response time with discrepancy error and 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Discrepancy time + 2 × Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel 1)

Maximum response time with error and change of user data

Maximum response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test

Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Maximum response time for fail-safe digital outputs

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Maximum response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

The maximum response time for fail-safe digital outputs in the presence of an error is equal to:

Maximum response time = T_{cycle} + 2 × Maximum(dark test time, switch-on time) + interval between test pulses

A.2 Minimum distance of test pulses

The minimum interval between two test pulses depends on the activation of the light test, the configured maximum test time, and whether the output has been specified as a PM-switching or PP-switching output.

You can find the dependencies in the table below:

Assigned maximum test time	PM switching, light test not active	PM switching, light test active	PP switching, light test not active	PP switching, light test active
1000 s	62.080 s	45.147 s	82.913 s	38.137 s
100 s	5.830 s	4.238 s	7.913 s	3.521 s

Switching of loads

B

B.1 Connecting capacitive loads

If the output of power module F-PM-E 24VDC/8A PPM ST is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The figure below shows typical curves for the assignable readback times representing the correlation between load resistance and switchable load capacitance at a supply voltage of 24 V DC.

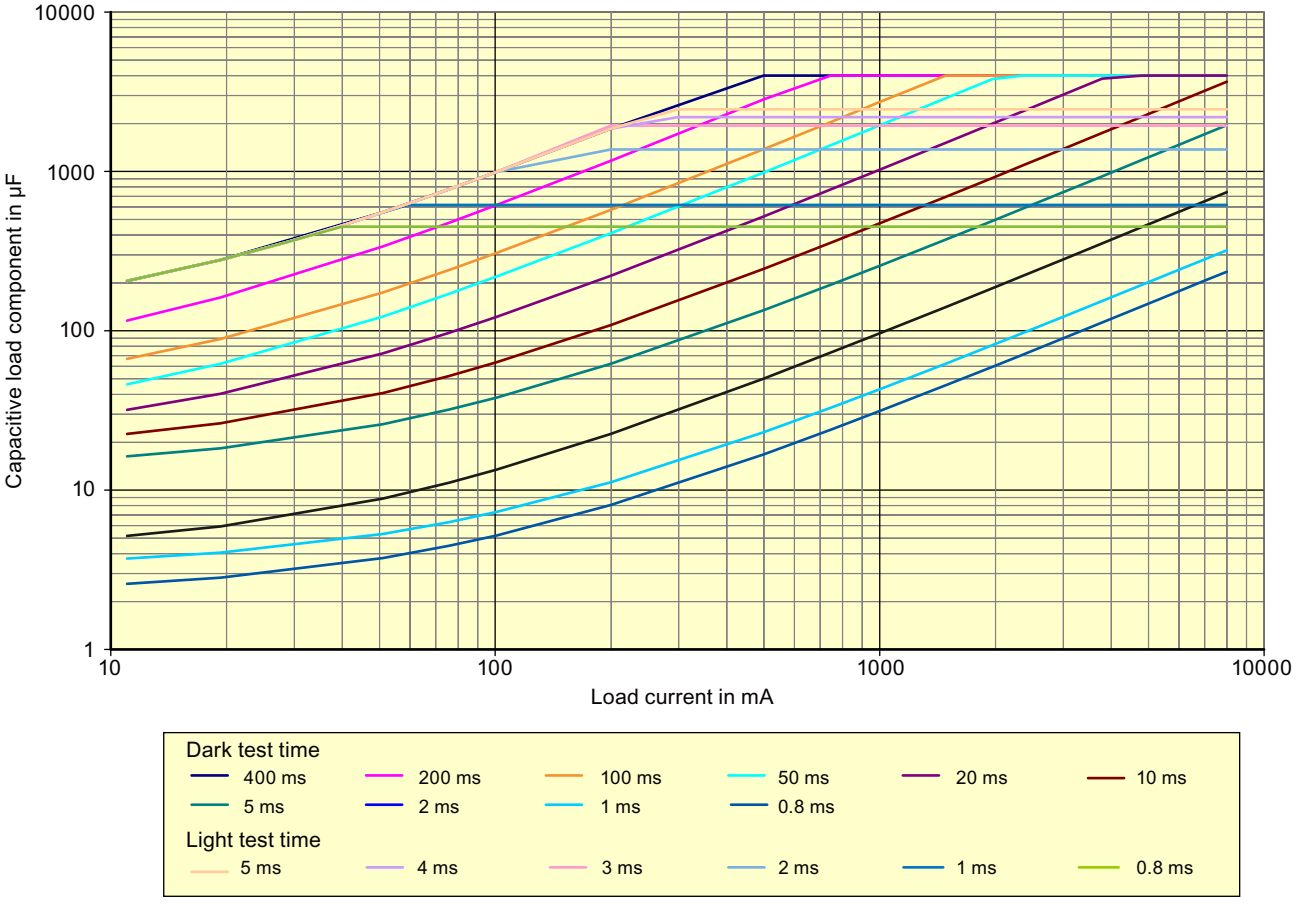


Figure 1-398 Switching of capacitive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the configured dark and light test times

The curves shown were plotted using a SIMATIC PS 307 10A power supply unit with a cable length of 25 m (cable cross-section of 1.5 mm^2) between the output of the F-PM-E 24VDC/8A PPM ST power module and the load.

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

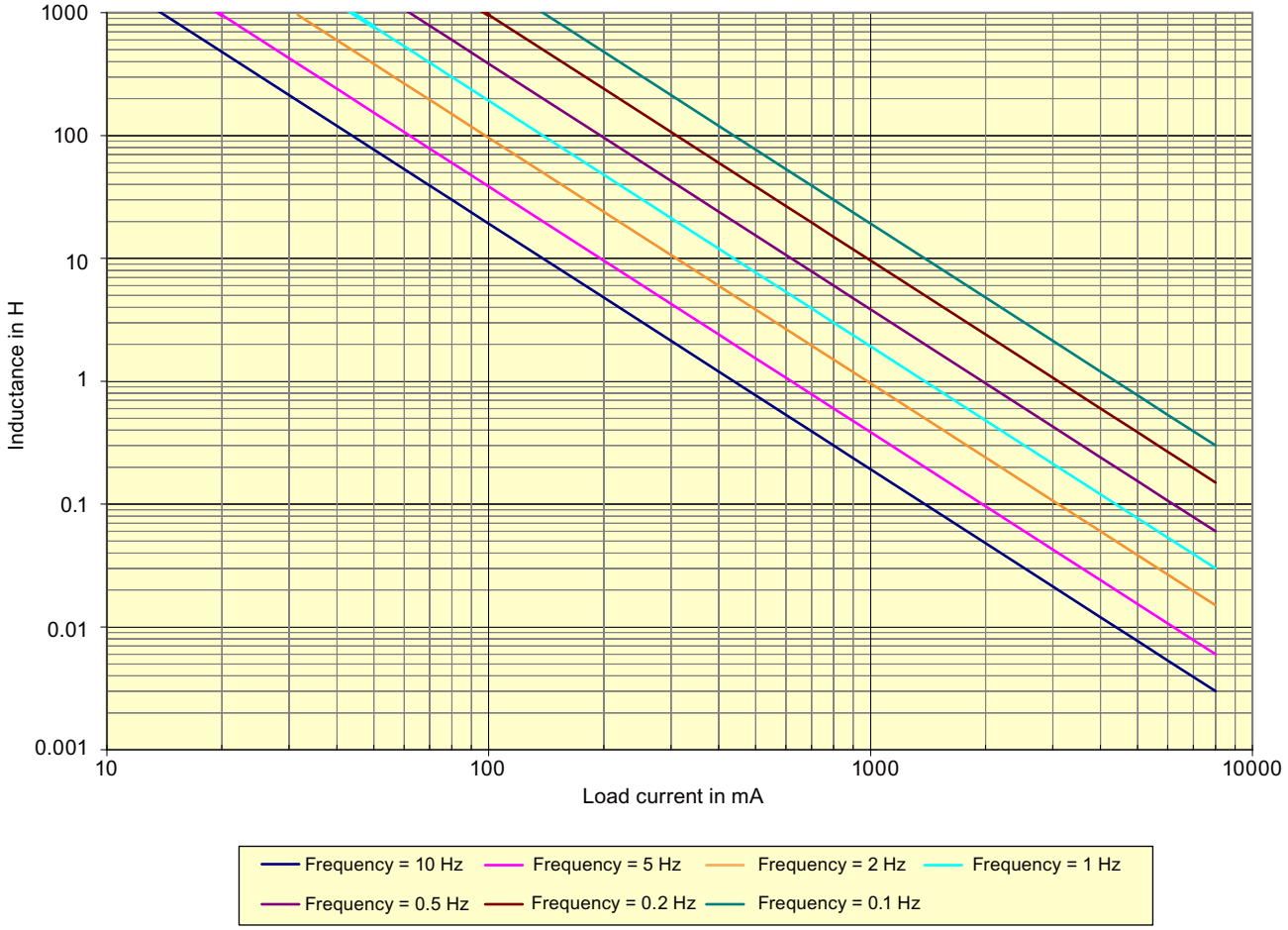


Figure 1-399 Switching of inductive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the load current and switching frequency

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Product Information for the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Product Information

Security information

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General amendments to the documentation

Content
This Product Information contains additional information and corrections relating to the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) up to and including hardware version (FS) 04.
The Product Information is part of the product supplied. The information in it should be considered more up-to-date if uncertainties arise.

Technical specifications of the F-PM-E 24VDC/8A PPM ST up to and including hardware version (FS) 04.

	6ES7136-6PA00-0BC0
Output current	
For "0" signal, residual current max.	6 mA; PP switching: typ. 1.5 mA, max. 6 mA PM switching: max. 1 mA

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Product Information for ET 200SP F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

Product Information

Introduction

Scope of the product information

This product information includes amendments and corrections to the documentation of the *ET 200SP Distributed I/O System, System Manual*. This product information also includes the addition of the ET 200SP F-TM Count 1x1Vpp sin/cos HF module (F-TM Count). The statements provided herein should be considered to be more up-to-date than other documentation if uncertainties arise.

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Incorrect counter value

Description

1. An issue has been identified which may cause the count value to be reported incorrectly or the module to enter a fatal error state. Either situation may occur when all three of the following selections are enabled:

- The encoder Signal type is set to "Sin/Cos encoder (A, B, N)".
- The "Invert direction" option is selected.
- The Reaction to signal N parameter is set to "Synchronization at signal N".

While a solution is under development, the following steps constitute a suitable workaround:

1. Swap the wiring of the SIN and COS signals on the terminal block.
2. Unselect the "Invert direction" configuration in TIA Portal.

2. An additional issue has been identified which may cause the count value to be incorrect if the N signal synchronization occurs at frequencies greater than 4 KHz. The error in the count value is proportional to the counting frequency when the N signal is processed by the counter module. The error in the count value will be most visible when the movement stops. The count error does not accumulate over multiple revolutions, but is reset each time the counter module processes an N signal.

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The issue occurs when the following selections are enabled:

- The encoder Signal type is set to "Sin/Cos encoder (A, B, N)".
- The Reaction to signal N parameter is set to "Synchronization at signal N".

While a solution is under development, a workaround is to decelerate prior to stopping. This will minimize the error in the count value.

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Product Information for the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) as of firmware version V2.0.0

Product Information

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

General amendments to the documentation

Content
This Product Information contains additional information and corrections relating to the documentation on power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) firmware version V2.0.0 and higher.
The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.
You can use the power module F-PM-E 24VDC/8A PPM ST with the standard modules listed under entry ID: 83203124 (https://support.industry.siemens.com/cs/ww/es/view/83203124) within a potential group.

Parameters

Table 1 **Parameters for power module**

Parameters	Value range	Parameter reassign-ment in RUN	Scope
Output:			
Activated	• disable • enable	no	Channel
Control of the output	• F-CPU • F-CPU and onboard F-DI	no	Module

* Firmware V2.0.0 and higher

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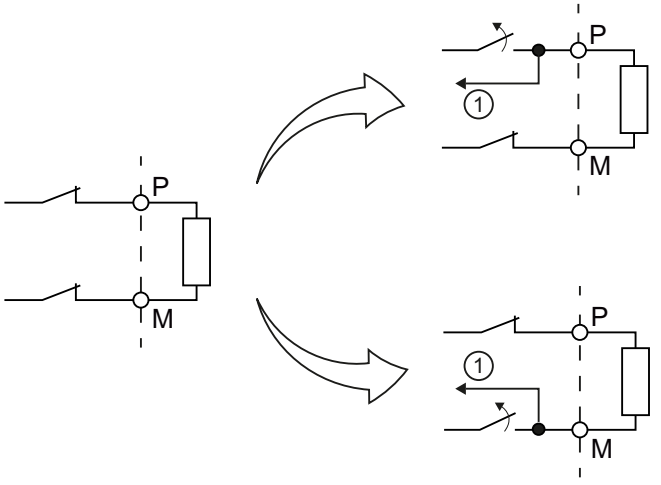
Parameters	Value range	Parameter reassignment in RUN	Scope
Output type	• PM switching • PP switching	no	Channel
Max. readback time, dark test and shutdown test	0.8 to 400.0 ms	no	Channel
Max. readback time switch on test	0.8 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel
Deactivation dark test (max. SIL2, Cat. 3, PLd) *	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

Addendum to section "Max. readback time, dark test and shutdown test" of the "Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)" manual

Function

Dark tests are switch-off tests with bit pattern test.
For "Deactivation dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.
For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.
If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

⚠ WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"
Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.
You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads.
If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.
Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "0" with a minimum duration that corresponds to the "maximum test time" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

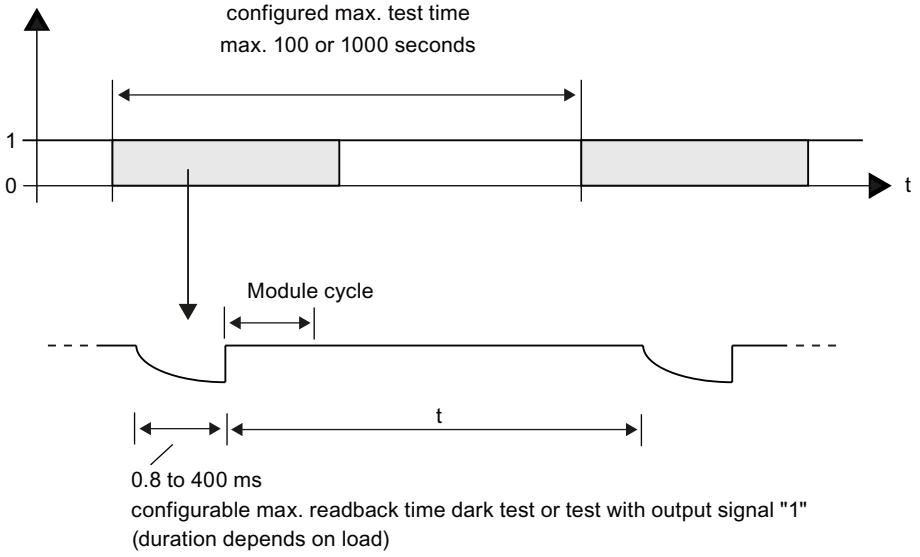


Figure 2 Test pulses of the dark test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance between test pulses.

Deactivation dark test (max. SIL2, Cat. 3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. This undesirable reaction can be, for example, a brief failure of a magnetic drive or a process value change of a digital input with very short input delay.
A capacitive load that does not meet the load curve (see section Switching capacitive loads) can result in a passivation of the output in case of a process value change, switch on test or light test, even if the dark test is deactivated.
You can reach SIL2/Cat.3/PLd with deactivated dark test.
For deactivated dark test:

⚠ WARNING

SIL2/category 3/PLd requires that there is a signal change from 1 to 0 at output DQ/P1 and P2 at least once a year. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

You achieve the following technical specifications with deactivated dark test:

XE TDB_S	6ES7136-6PA00-0BC0
Maximum achievable safety class in safety mode XE U1:1	
Performance Level to EN ISO 13849-1:2015 XE T:2	PLd
SIL according to IEC 61508 XE T:2	SIL 2
Low demand mode: PFDavg according to SIL2 XE N:2	< 2.00E-04
High demand/continuous mode: PFH according to SIL2 XE N:2	1/h; < 1.00E-08

Addendum to section 5.1 "*Applications for the output DQ/P1 and P2*"
You can reach SIL2/Cat.3/PLd with deactivated dark test.

Addendum to section 5.3 "*Application for internal evaluation*"

NOTE
If an error occurs at the inputs in this application, the F-module also outputs the error message "Safety-related shutdown" or "Safety event" for the output. Following elimination of the error at the inputs, a reintegration of the output is only possible after the bit pattern test (within the test time shortened to max. 120 seconds) has been performed.

Minimum distance of test pulses

The minimum interval between two test pulses depends on the activation of the light test, the configured maximum test time, and whether the output has been specified as a PM-switching or PP-switching output.
The minimum interval between two test pulses at a maximum test time of 100 s is at least 2 seconds, and with a maximum test time of 1000 s at least 20 seconds.

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ET 200SP
Product Information on documentation for the digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0

Product Information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial security measures that can be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

General amendments to the documentation

Content
Product Information contains supplements and corrections on the documentation for the digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0
The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Parameters

Table 1 Parameters for F-DQ 4×24VDC/2A PM HF

Parameters	Value range	Parameter reassignment in RUN	Scope
DQ parameters:			
Maximum test period	• 100 s • 1000 s	no	Module
Disable Dark Test (max. SIL2, CAT3, PLd) *	• disable • enable	no	Module
Channel parameters:			
Channel n			
Activated	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

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Parameters	Value range	Parameter reassignment in RUN	Scope
Max. readback time, dark test and switch-off test *	0.6 ms to 400.0 ms	no	Channel
Max. readback time switch-on test	0.6 ms to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnostics: Wire break	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

Disable Dark Test (max. SIL2, CAT3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive or a process value change of a digital input with very short input delay.
A capacitive load that does not meet the load curve (see section Switching capacitive loads) can result in a passivation of the output in case of a process value change, switch-on test or light test, even if the dark test is deactivated.
You can reach up to SIL2/Cat.3/PLd with disabled dark test.
For disabled dark test:

⚠ WARNING

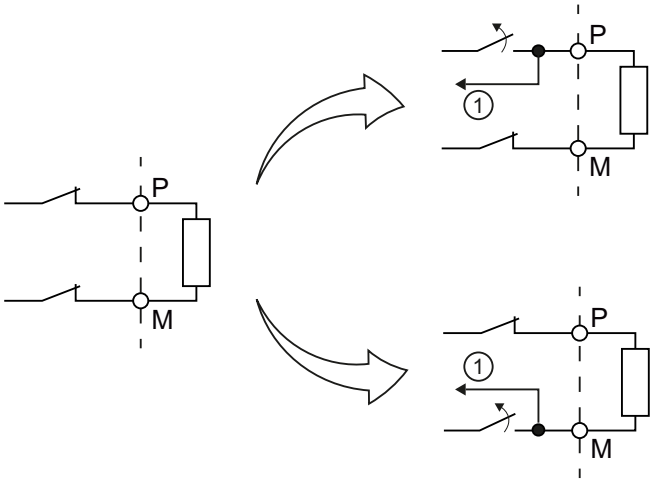
SIL2/Cat.3/PLd requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. The "0" signal must have a duration of at least 2 seconds. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

⚠ WARNING

When you use the function "Disable dark test", cross-circuits between channels with "1" signal are not detected. If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated. Also take into consideration the respective requirements of your product standards regarding error detection time.

Max. readback time, dark test and switch-off test

Function
Dark tests are switch-off tests with bit pattern test.
For "Disable dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.
For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.
If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the max. readback time, dark test and switch-off test, the output channel is passivated.
No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher max. readback time, dark test and switch-off test increases the response time of the F-module.

⚠ WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured max. readback time, dark test and switch-off test) Hz cannot be detected (50:50 sampling ratio).
Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"
Because the fault response time is extended by the max. readback time, dark test and switch-off test, we recommend that you set the max. readback time, dark test and switch-off test by trial and error as low as possible, but high enough that the output channel is not passivated.
You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads.
If the capacity of the actuator is not known, it may be necessary for you to determine the value for the max. readback time, dark test and switch-off test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "0" with a minimum duration that corresponds to the "maximum test time" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated sporadically, set a higher value for the max. readback time, dark test and switch-off test.
- If the output channel is passivated, the max. readback time, dark test and switch-off test is too small for a connected capacitive load. The discharge cannot take place within the configured max. readback time, dark test and switch-off test. Increase the max. readback time, dark test and switch-off test.

If you have set the max. readback time, dark test and switch-off test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

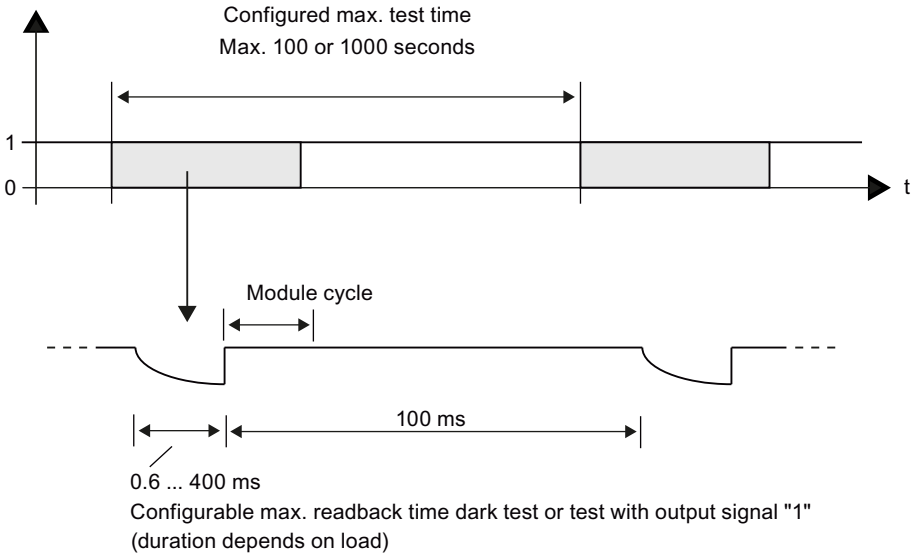


Figure 2 Test pulses of the dark test

The interval between two test pulses amounts to at least 100 ms.

Applications of the F-I/O module

Supplement to section 5 "Applications of the F-I/O module"
You can reach up to SIL2/Cat.3/PLd with disabled dark test.

Technical specifications

Technical specifications of the F-DQ 4×24VDC/2A PM HF
You achieve the following technical specifications with disabled dark test:

XE TDB_S	6ES7136-6DB00-0CA0
Maximum achievable safety class in safety mode XE U1:1	
Performance level according to EN ISO 13849-1:2015 XE T:2	PLd
Category according to EN ISO 13849-1:2015 XE T:2	Cat.3

XE TDB_S	6ES7136-6DB00-0CA0
SIL according to IEC 61508 XE T:2	SIL 2
Low demand mode: PFDavg according to SIL2 XE N:2	< 2.00E-04
High demand/continuous mode: PFH according to SIL2 XE N:2	< 1.00E-08 1/h

Response times

Introduction
The next section shows the response times of the digital output module F-DQ 4×24VDC HF. The response times of the F-DQ 4×24VDC HF digital output module are included in the calculation of the F-system response time.

Definition of response time for fail-safe digital outputs
The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation
Maximum cycle time: T_{cycle} = 15.5 ms
You assign the dark test time and switch-on time in STEP 7.

The following applies to the enabling of the dark test:

Maximum response time with no faults
The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with error and change of user data
Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test
Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

The following applies to the disabling of the dark test:

Maximum response time with no faults
The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with error and change of user data
Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)
A channel fault might not be detected until a process value change "1" to "0" takes place on the corresponding output.

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Product information for the ET 200SP fail-safe modules: Use at altitudes > 2000 m above sea level
Product Information

Introduction
This document contains important product information on the F-modules specified in the section "Validity". The product information is part of the product supplied. This product information should be considered more up-to-date than other documentation if uncertainties arise.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Validity
The statements in this product information apply to the F-modules listed below for operating altitudes > 2000 m above sea level:

Table 1 Validity

Designation	Article number	Version	Max. operating altitude
ET 200SP F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	FS04 or higher	4000 m above sea level
ET 200SP F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	FS04 or higher	
ET 200SP F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	FS01 or higher	
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	FS05 or higher	
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0CA1	FS01 or higher	
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	FS01 or higher	

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Effects on the availability of modules
The higher cosmic radiation present during operation at altitudes over 2000 m above sea level will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases this can result in a transition of the module into the safe state, especially for safety modules. However, the functional safety of the module is fully retained.

Currently valid markings and approvals

NOTE

Information on the components of the ET 200SP automation system:
The markings and approvals printed on the components of the ET 200SP automation system are currently based on an operating altitude of up to 2000 m above sea level. The fail-safe modules are certified for use in safety mode up to the maximum operating altitude listed in Table 1 (according to IEC 61508:2010, EN ISO 13849-1:2015 and IEC 62061:2005/A2:2015).

F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

Shipping and storage conditions
The following information applies to the fail-safe module F-DI 8x24VDC HF.

Table 2 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions
The following information applies to the fail-safe module F-DI 8x24VDC HF.

Table 3 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 4 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level		
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m
	Maximum ambient temperature		
Horizontal	60 °C	54 °C	48 °C
Vertical	50 °C	45 °C	40 °C

The normative basis for the derating is IEC 61131-2:2017.

Comments
Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values
The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)

Shipping and storage conditions
The following information applies to the fail-safe module F-DQ 4x24VDC/2A PM HF.

Table 5 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions
The following information applies to the fail-safe module F-DQ 4x24VDC/2A PM HF.

Table 6 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 7 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	6 A
	50 °C	45 °C	40 °C	5 A
	60 °C	54 °C	48 °C	4 A
Vertical	50 °C	45 °C	40 °C	4 A

The normative basis for the derating is IEC 61131-2:2017.

Comments
Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE
Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values
The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

Shipping and storage conditions
The following information applies to the fail-safe module F-DQ 8x24VDC/0.5A PP HF.

Table 8 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions
The following information applies to the fail-safe module F-DQ 8x24VDC/0.5A PP HF.

Table 9 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 10 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	3 A
	50 °C	45 °C	40 °C	2.5 A
	60 °C	54 °C	48 °C	2 A
Vertical	50 °C	45 °C	40 °C	2 A

The normative basis for the derating is IEC 61131-2:2017.

Comments
Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE
Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values
The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Shipping and storage conditions
The following information applies to the fail-safe module F-PM-E 24VDC/8A PPM ST.

Table 11 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions
The following information applies to the fail-safe module F-PM-E 24VDC/8A PPM ST.

Table 12 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 13 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	8 A
	50 °C	45 °C	40 °C	6 A
	60 °C	54 °C	48 °C	4 A
Vertical	50 °C	45 °C	40 °C	4 A

The normative basis for the derating is IEC 61131-2:2017.

Comments
Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE
Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values
The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1) and F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

Shipping and storage conditions
The following specifications apply to the fail-safe modules F-AI 4xI 0(4)..20mA 2-/4-wire HF and F-AI 4xU 0..10V HF.

Table 14 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions
The following specifications apply to the fail-safe modules F-AI 4xI 0(4)..20mA 2-/4-wire HF and F-AI 4xU 0..10V HF.

Table 15 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 16 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level		
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m
	Maximum ambient temperature		
Horizontal	60 °C	54 °C	48 °C
Vertical	50 °C	45 °C	40 °C

The normative basis for the derating is IEC 61131-2:2017.

Comments
Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE
Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values
The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

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Product Information for the Documentation of ET 200SP Fail-safe Modules

Product Information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
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General amendments to the documentation

This Product Information contains amendments and corrections to the documentation of the ET 200SP fail-safe modules. The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Validity of the Product Information
The following information supplements the equipment manual of the ET 200SP fail-safe module:

- ET 200SP Digital Output Module F-DQ 8x24VDC/0.5A PP HF (https://support.industry.siemens.com/cs/ww/en/view/109747998)

Section 5.5 "Application: Connection of the ET 200SP digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)"
For the operation of the digital output module F-RQ 1x24VDC/24..230VAC/5A from FS 04 on, the use of the following readback times is required: Channel parameter "Max. readback time light test / dark test" with the default value "0.8 / 1.0 ms".

Validity of the Product Information
The following information supplements the equipment manuals of the ET 200SP fail-safe modules:

- ET 200SP Digital input module F-DI 8x24VDC HF (https://support.industry.siemens.com/cs/us/en/view/78589499)
- ET 200SP Digital output module F-DQ 4x24VDC/2A PM HF (https://support.industry.siemens.com/cs/us/en/view/78645789)
- ET 200SP Power module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/us/en/view/78645796)

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Section 6.3 "Interrupts/diagnostic alarms" – Table 6-6

Diagnostic alarm	Error code	Meaning	Remedy
Supply voltage too high	801_D	The supply voltage is too high.	Check the supply voltage and then test the safety application.
Supply voltage too low	802_D	The supply voltage is too low.	Check the supply voltage and then test the safety application.

Supply voltage outside the nominal range
If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the F-module is passivated.
When the voltage has recovered (level must remain within the specified value range for at least 1 minute (see section 7 "Technical specifications", subsection "Voltages, currents, potentials)), the DIAG LED stops flashing. The F-module remains passivated.

NOTICE

When an undervoltage or overvoltage event is detected (supply voltage too high/low – outside nominal range), it must be assumed that components may not execute their correct function properly after the supply voltage has returned to the nominal operating range. You can identify these components using a function check.
Therefore, we recommend that you always perform a full function check of the machine/plant or in any case a check of the safety functions directly after an undervoltage or overvoltage event before re-commissioning.

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Product Information on fail-safe modules with GSD configuration

Product Information

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
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Introduction

Observe the following notes and explanations for PROFINET IO during parameterization of fail-safe modules with GSD file in the PROFIsafe profile 2.4 (BP mode).

NOTE

When using fail-safe modules with the GSD file on an F-host, note that the warnings, information and references to other manuals contained in the F-module equipment manuals are still valid.
Please also observe the F-host specifications.

Implementation of the Device_Fault bit in BP (Basic Protocol) mode of the fail-safe modules

PROFIsafe 2.4 with automatic reintegration:
In this mode, the F-host is responsible for module-wide passivation in the event of a channel fault. This means that if an individual channel reports a fault, the F-host performs passivation of all channels within an F-module. Notification of the F-CPU about faults and the consequent reaction of the F-CPU takes place via PROFIsafe status and control bits.
Reintegration of an F-module with faults in this mode takes place automatically after all channel faults have been completely eliminated.
After all pending faults have been corrected, the F-module returns to the normal state and process values are updated cyclically again.

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PROFIsafe 2.4 with operator acknowledgment for reintegration:
This is the same mode as before, but the reintegration can only be completed after a pending operator acknowledgment signal is released by the F-host (i.e. operator acknowledgment is handled by the F-host).
From the operator's perspective, waiting for the operator acknowledgment signal is indicated by specific LED flashing (red-green). This means that, after pending faults of an affected channel have been eliminated, the value status is set to "good" and the LED flashing will show optically that the channel is ready to finish reintegration.
After all channel faults have been eliminated, the F-module checks whether operator acknowledgment from the F-host is pending by evaluating the PROFIsafe control bit **OA_Req**. As long as this control bit is set to "true", the channel shows "Waiting for reintegration" through flashing LEDs. In this state, note that the value status bits for the channels have already been set to "good" and the F-module is ready to function normally. For this reason, the received operator acknowledgment only affects the LED flashing.

Summary of failure and reintegration from the perspective of the F-module

1. Fault occurs and is detected.
2. Device_Fault is sent to the F-host.

NOTE

This can be viewed as an implicit request for an operator acknowledgment.

3. Channel fault is corrected, Device_Fault=0 is sent to the F-host and the F-module is reintegrated
4. Operator acknowledgment via the PROFIsafe control bit OA_Req is received by the F-host and the alternating flashing of the LEDs is switched off.

Restart
After all channel faults have been corrected (all I/O self-tests are completed successfully), the process values are automatically output or supplied again.

⚠ WARNING

Manual reintegration must be realized on the F-host side
You can find a description of suitable measures in the technical specification PROFISafe Version 2.6, Annex C, subsection *"C.1.4.2 Prevent unintentional restart by application measures"*.

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Product information on the ET 200SP fail-safe modules
Product Information

Affected modules

ET 200SP F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

ET 200SP F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)
Modules with firmware versions V1.0.1 and V1.0.3
(Production period up to and including 2015 with the serial numbers: S C-D..., S C-E..., S C-F1... to S C-F9..., S C-FO... and S C-FN...)

Security information

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In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

Important note for maintaining the operational safety of your system - Upgrade to firmware version >= V1.0.5

This product information contains important details on maintaining the operational safety of your system. The product information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Measures for maintaining operational safety in the event of undervoltage/overvoltage events
To maintain the operational safety, you must install a firmware version >= V1.0.5.

Reason:
Within the scope of internal quality assurance measures and continuous market observations, output characteristics of 24 V DC switched-mode power supplies on the market have been detected which significantly differ in their quality from the voltage curves for the supply of programmable controllers specified by IEC/EN 61131-2.
Switched-mode power supplies can maintain the output voltage at less than 50% of the nominal output voltage when an overload or short-circuit occurs and then return to the rated value.

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The fail-safe modules ET 200SP F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) and ET 200SP F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) passivate themselves in the event of undervoltage and thereby guarantee safety in the machine/system. Once the fault is eliminated and the supply voltage returns to the nominal voltage range for at least 1 minute, the modules can be acknowledged, depassivated and reintegrated into the system.
In rare cases, due to the above-mentioned characteristics of switched-mode power supplies, the modules may erroneously indicate correct operation. Correct operation can be restored with an OFF/ON of the 24 V DC supply voltage or pulling/plugging the modules.
In order to ensure that the modules are acknowledged or depassivated and normal operation is resumed, install a firmware version >= V1.0.5 for the affected output versions of the two modules.
In general, we recommend that you always observe the following warning and implement the described measures:

⚠ WARNING

When an undervoltage or overvoltage event is detected (supply voltage too high/low – outside nominal range), it must be assumed that components may not execute their correct function properly after the supply voltage has returned to the nominal operating range. You can identify these components using a function check.
Therefore, we recommend that you always perform a full function check of the machine/plant or in any case a check of the safety functions directly after an undervoltage or overvoltage event and before re-commissioning.

See also

Firmware update for ET 200SP F-DI 8x24VDC HF (https://support.industry.siemens.com/cs/ww/en/view/99086745)
Firmware update for ET200SP F-PM-E PPM DC24V (https://support.industry.siemens.com/cs/ww/en/view/109479266)

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Product Information for the Documentation of ET 200SP Fail-safe Modules

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

General amendments to the documentation

This Product Information contains amendments and corrections to the documentation of the following ET 200SP fail-safe modules.

- Digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)
- Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)
- Digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)
- Digital output module F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)
- Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)
- Digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)
- Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)
- Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)
- Counter module F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.
You can use the Power Module F-PM-E 24VDC/8A PPM ST with the standard modules listed under entry ID: 83203124 (https://support.industry.siemens.com/cs/ww/en/view/83203124) **within a potential group.**

Supplement to the section "Response times" of the Equipment Manual "Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)"
The discrepancy time is included in the calculation of the maximum response time (T_{WCDT}) and can therefore be set to 0 in the SIMATIC STEP 7 response-time table.

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Amendment to chapter 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", 5.1.1.4 "*Application: Wiring of two parallel loads to the digital output, PP switching*" and 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ WARNING

The light test must be activated if the output channel can permanently carry the "0" signal for 100 hours or more. Consult the respective requirements of your product standards regarding error detection time.

Addendum to section 5.1 "*Applications for the output DQ/P1 and P2*" and 5.4 "*Applications for the safety-related shutdown of standard modules*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ WARNING

A defective F-module can result in cyclic "1" signals with the duration of the "Max. readback time switch on test" at the output DQ/P1 and P2.

Correction of section 3.1 "*Terminal assignment*" of the manual "Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

The warning in the section "Redundant ground conductor required" is being omitted, and being replaced by the new warning in section 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", section 5.1.1.4 "*Application: Wiring two loads in parallel to the digital output, PP switching*" and section 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*".

Amendment to chapter 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", section 5.1.1.4 "*Application: Wiring two loads in parallel to the digital output, PP switching*" and section 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

⚠ WARNING

In this application, you have to connect two ground cables to the BaseUnit for safety reasons. Otherwise, the maximum residual current at signal "0" (specified in the technical specifications) cannot be maintained if a single ground cable is interrupted.

Amendment to chapter 5.2 "*Application 1: Safety mode SIL3/Cat.3/PLd*" of the Equipment Manual "Digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)" and section 5.2.2 "Application 1: Safety mode SIL3/Cat.3/PLd" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

NOTE

SIL3/Cat.3/PLd can be achieved through cross-circuit proof wiring and for the sensor, through application of the principle of positive opening operation.

Unsupported parameters

The "Pulse stretching" and "Disable dark test for 48 hours" parameters are not supported.

Dependencies between the "Discrepancy time" and "Input delay" parameters

The configured discrepancy time must be greater than the configured input delay.

Dependencies between the "Startup time of the sensors after short circuit test" and "Time for short circuit test" parameters
The startup time of the sensor after a short-circuit test must amount to at least 1% of the time for the short-circuit test.

Switching on the supply voltage L+ for the ET 200SP F-modules and IM
Make sure that the F-module as well as the IM were de-energized at the same time before you switch on the supply voltage L+ for an F-module. You do not have to observe a switch-on sequence.

Cyclic reading of I&M data
Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Wire break detection for F-DQ 4x24VDC/2A PM HF fail-safe module up to and including hardware revision level 02
The response threshold of the wire break detection is < 15 mA.

T_{DAT} acknowledgment time

F-Module	T_{DAT} acknowledgment time
Digital input module F-DI 8x24VDC HF	23 ms
Digital output module F-DQ 4x24VDC/2A PM HF	31 ms
Power module F-PM-E 24VDC/8A PPM ST	30 ms

Technical specifications
The information on "Permitted potential difference between different circuits" is no longer part of the technical specifications.

Technical specifications, digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)

Voltage induced on current interruption limited to	-2*47 V, typical

Technical specifications, power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Voltage induced on current interruption limited to	max. -1.5 V

Block diagram F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

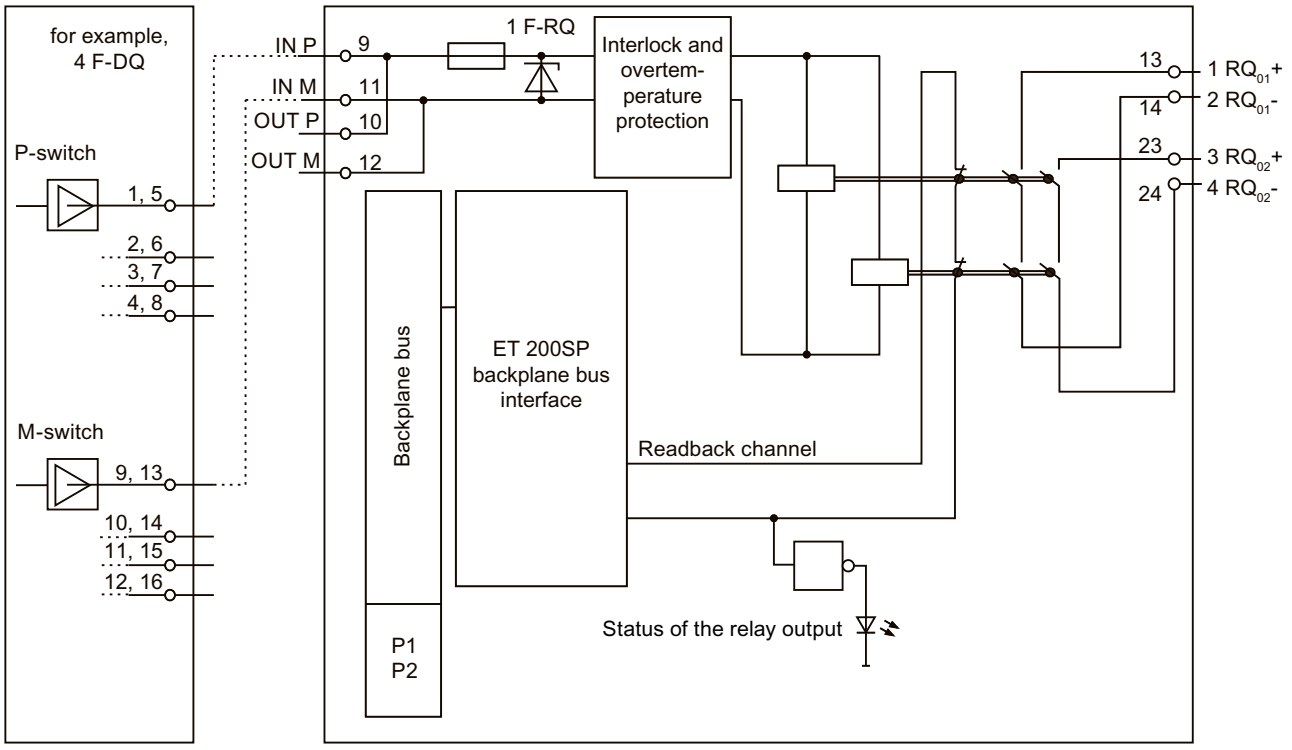


Figure 1 Block diagram F-RQ 1x24VDC/24..230VAC/5A

Amendment to section 5.1 "Application 1: Safety mode SIL2/Cat.3/PLd with two-wire connection, 1oo1 evaluation" of the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Amendment to section 5.3 "Application 3: Safety mode SIL2/Cat.3/PLd with four-wire connection, 1oo1 evaluation" of the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

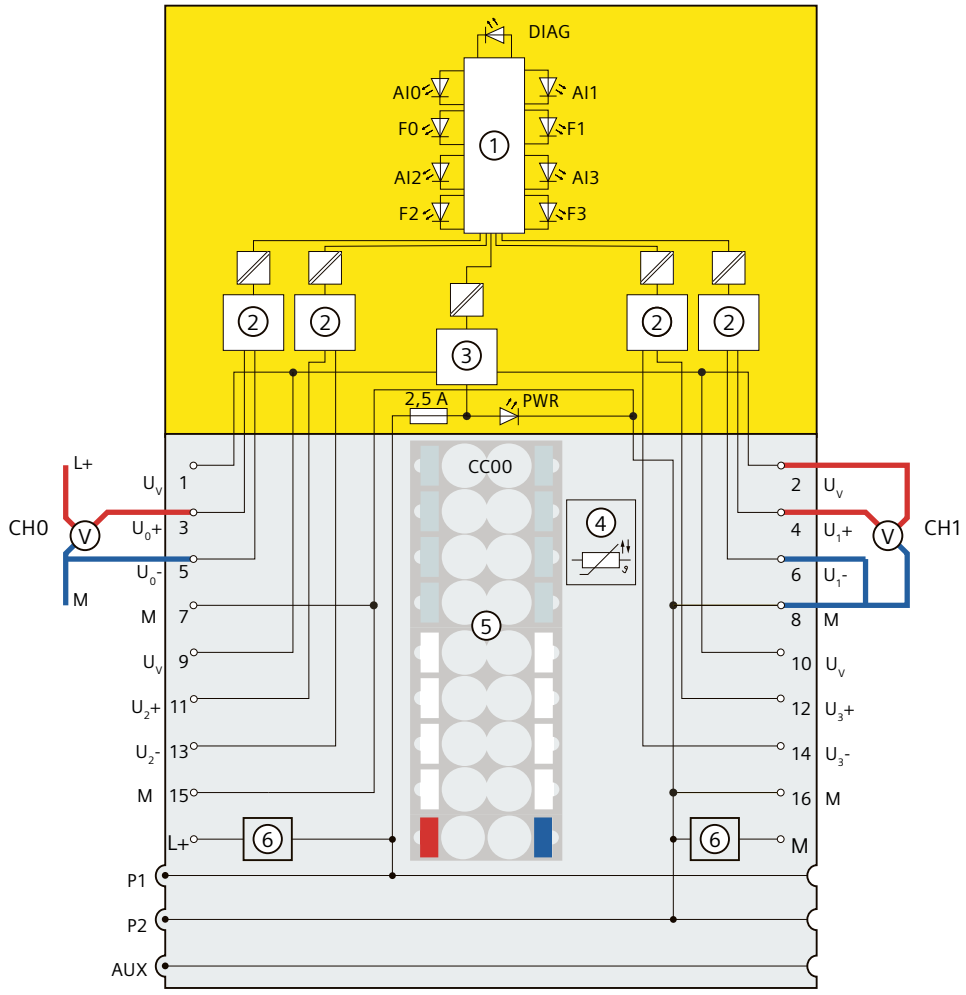
⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

New section 5.5 "Application 5: Safety mode SIL2/Cat.3/PLd with 3-wire connection, 1oo1 evaluation" in the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

Voltage measurement 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2 1oo1 evaluation

⚠ WARNING

To achieve SIL2/Cat.3/PLd when using this wiring, you must use a suitably qualified sensor.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

⚠ WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.
For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Assignable parameters for Application 5

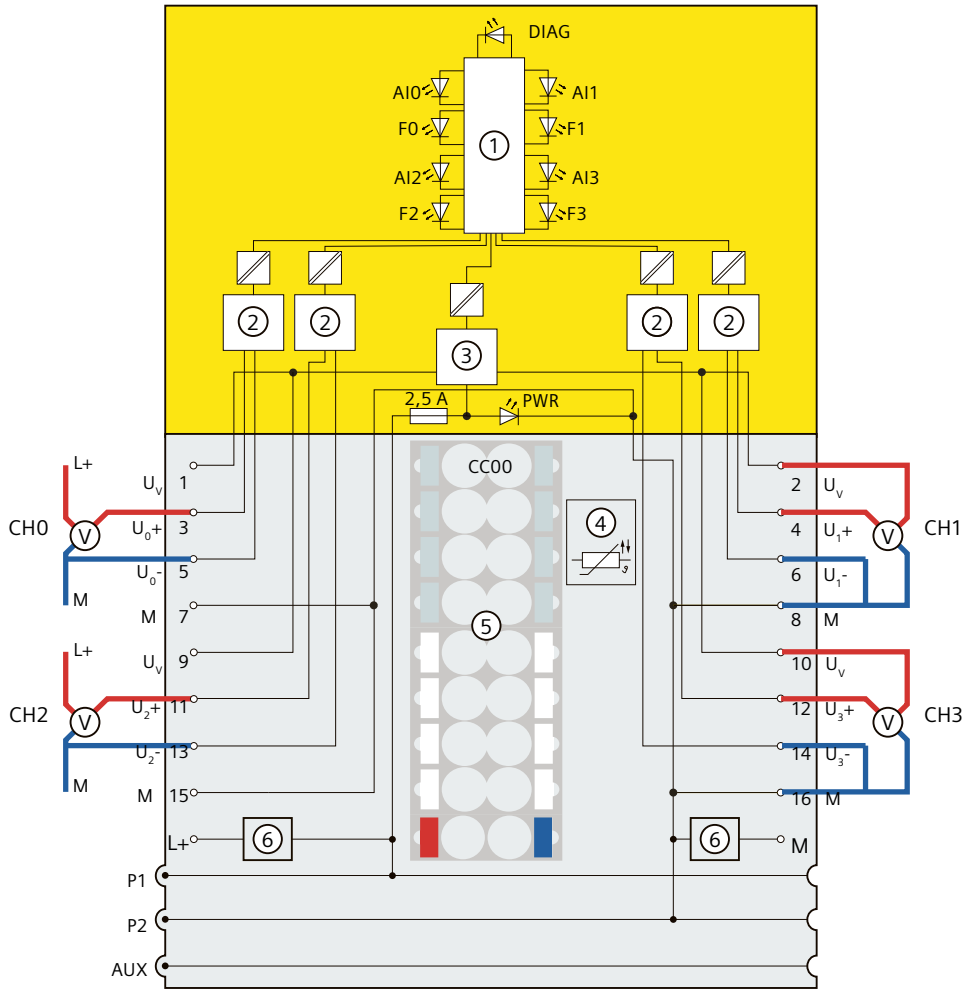
Table 1 Parameters for Application 5 of the F-AI 4xU 0..10V HF

Parameter	Value range in safety mode
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo1 evaluation (max. SIL2/Cat.3/PLd)
Measuring range	0 to 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

New section "5.6 Application 6: Safety mode SIL3/Cat.4/PLe with 3-wire connection, 1oo2 evaluation" in the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 3 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe with this wiring, you must use suitably qualified sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for Application 6

Table 2 Parameters for Application 6 of the F-AI 4xU 0..10V HF

Parameter	Value range in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	0 to 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

Amendment to section 5.1 "Application 1: Safety mode SIL3/Cat.3/PLd with 2-wire transducer" of the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Amendment to section 5.3 "Application 3: Safety mode SIL3/Cat.3/PLd with 4-wire transducer" of the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

New section 5.5 "Application 5: Safety mode SIL3/Cat.3/PLd with 3-wire measuring transducer" in the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

Introduction

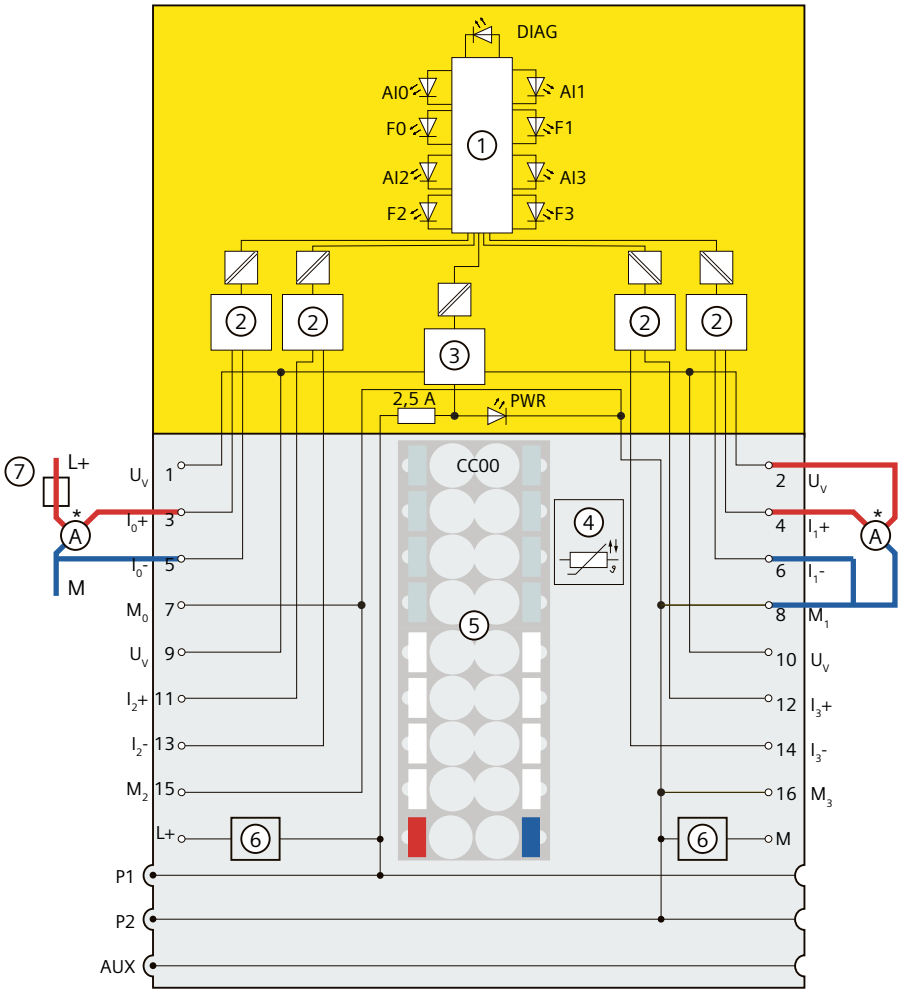
The following section describes the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 5: Safety mode SIL3/Cat.3/PLd, 1oo1 evaluation with 3-wire measuring transducer.

Possible diagnostic messages, the error causes and possible corrective measures are specified in the section "Diagnostic messages".

Current measurement 0/4 to 20 mA, 3-wire measuring transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)

⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 4 1oo1 evaluation

WARNING

To achieve SIL3/Cat.3/PLd with this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Assignable parameters for Application 5

Table 3 Parameters for Application 5 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameter	Value range in safety mode
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

New section 5.6 "Application 6: Safety mode SIL3/Cat.4/PLe with 3-wire measuring transducer" in the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

Introduction

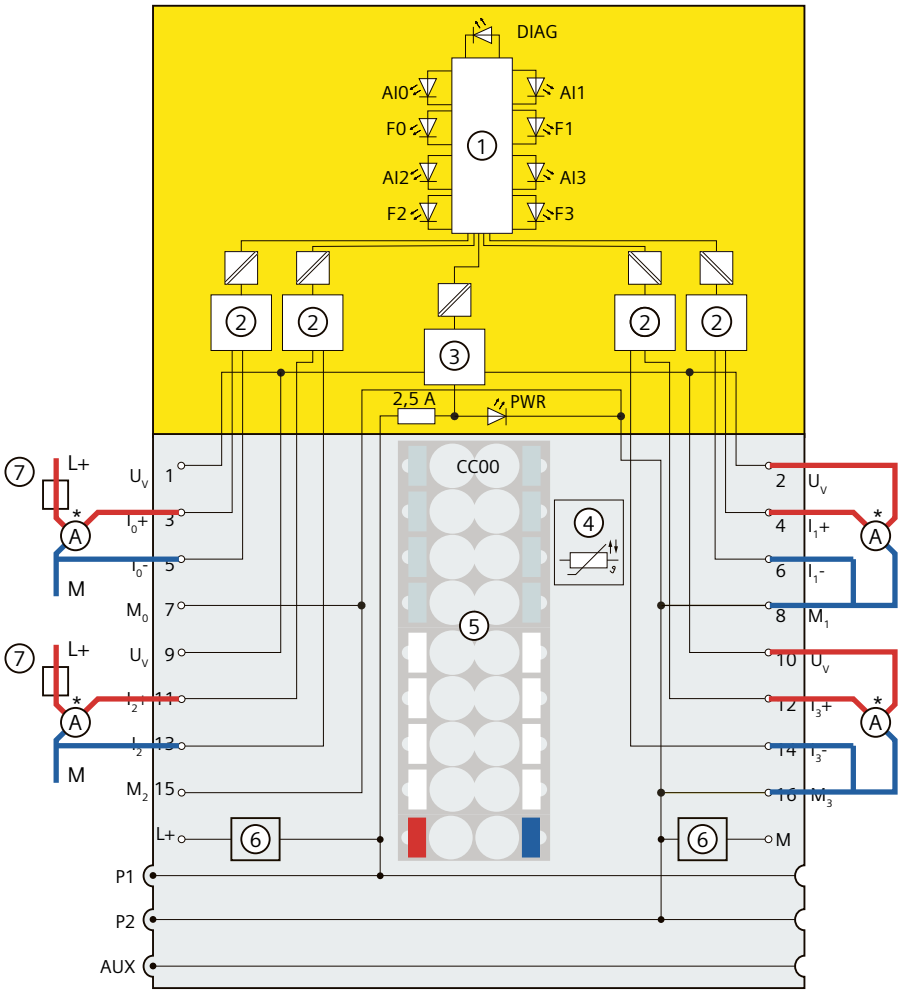
The following section contains the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire for

- Application 6: Safety mode SIL3/Cat.4/PLe, 1oo2 evaluation with 3-wire measuring transducer

Possible diagnostic messages, their error causes and possible corrective measures are specified in the section "Diagnostic message".

Current measurement 0/4 to 20 mA, 3-wire measuring transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.



①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 5 1oo2 evaluation

⚠ WARNING

To achieve SIL3/Cat.4/PLe with this wiring, you must use suitably qualified sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for Application 6

Table 4 Parameters for Application 6 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameter	Value range in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

Use of radio devices and cell phones

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Supplement to the Attachment "Reaction times" of the Manuals "Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)" and "Digital Input Module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)"

Digital output of the Power Module F-PM-E 24VDC/8A PPM ST

Definition of response time for fail-safe digital outputs
The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Following applies to activation of the dark test:
Maximum response time with no faults
The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)
Maximum response time in case of error with detection by readback (change of user data)
Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)
Maximum response time in case of error with detection by bit pattern test
Max. response time = Configured test period

The following applies to deactivation of the dark test:
Maximum response time with no faults
The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)
Maximum response time in case of error with detection by readback (change of user data)
Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)
A channel fault may not be detected until process value change 1 to 0 takes place at the output DQ/P1 and P2.

Digital inputs of Power Module F-PM-E 24VDC/8A PPM ST and fail-safe module F-DI 8x24VDC HF

Definition of the response time for fail-safe digital inputs
The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Maximum response time with external short-circuits
F-PM-E 24VDC/8A PPM ST:
Max. response time = T1 + T_{cycle} + (n * T_{cycle}) + Sum[x=0...1](Tsx) + MAX(T_{cycle}, T2)

F-DI 8x24VDC HF:
Max. response time = T1 + T_{cycle} + (n * T_{cycle}) + Sum[x=0...7](Tsx) + MAX(T_{cycle}, T2)

Tsx sum term:
(T2x + T3x) < T_{cycle} → Tsx = T_{cycle}
(T2x + T3x) >= T_{cycle} → Tsx = MAX(T2x, T_{cycle}) + T3x
For deactivated sensor supplies or sensor supplies with deactivated short-circuit test, enter the value of 0 in the formula for Tsx.

T1 = Input delay for the considered channel
T2 = Short-circuit test time for the considered channel

x = activated sensor supply
T2x = Time for the short-circuit test
T3x = Startup time of sensors after the short-circuit test
n = Number of sensor supplies with activated short-circuit test

Examples

The following section contains an example for the calculation of the maximum response time with external short-circuits at an F-DI 8x24VDC HF with a maximum cycle time T_{cycle} of 11.5 ms with the default parameter assignment.

Channel	T1 [ms]	Short-circuit test	T2 [ms]	T3 [ms]	T_{cycle} [ms]	T2 + T3 < T_{cycle}	Ts [ms]	MAX(T_{cycle}, T2) [ms]	Max. response time with external short-circuits [ms]
0	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
1	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
2	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
3	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
4	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
5	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
6	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
7	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2

Sample calculation: Sum term Ts = (4.2 ms + 4.2 ms) < 11.5 ms → Tsx = T_{cycle}

The following section shows an example for the calculation of the maximum response time with external short-circuits at an F-DI 8x24VDC HF with a maximum cycle time T_{cycle} of 11.5 ms depending on the parameter assignment.

Channel	T1 [ms]	Short-circuit test	T2 [ms]	T3 [ms]	T_{cycle} [ms]	T2 + T3 < T_{cycle}	Ts [ms]	MAX(T_{cycle}, T2) [ms]	Max. response time with external short-circuits [ms]
0	0.4	Enable	0.5	0.5	11.5	YES	11.5	11.5	5465.3
1	0.8	Enable	4.2	10	11.5	NO	21.5	11.5	5465.7
2	1.6	Enable	20	4.2	11.5	NO	24.2	20	5475.0
3	3.2	Enable	100	100	11.5	NO	200	100	5556.6
4	0.4	Disable	-	-	11.5	-	0	11.5	- *)
5	0.8	Enable	100	4.2	11.5	NO	104.2	100	5554.2
6	1.6	Enable	500	500	11.5	NO	1000	500	5955.0
7	3.2	Enable	2000	2000	11.5	NO	4000	2000	7456.6

*) With short-circuit test deactivated, external short-circuits are not detected.

Sample calculation: Sum term Ts = (4.2 ms +10 ms) >= 11.5 ms → Tsx = MAX(4.2 ms, 11.5 ms) + 10 ms

Diagnostic messages

Table 5 Diagnostic messages of the F-PM-E 24VDC/8A PPM ST

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	• An excessively high temperature was measured in the F-module. • The PWM function of a load causes interference signals in the supply voltage of the F-module.	• Operate the F-module within the specified temperature range (see Technical specifications) Once the fault has been eliminated, the F-module must then be pulled and plugged, or the power switched OFF and ON. • Decouple the supply voltages of the load using the PWM function and the F-module.

SIEMENS

SIMATIC
ET200
Product Information for ET200SP F-TM Count Firmware Update V1.0.2

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Description

Description
The firmware update V1.0.2 for the ET 200SP F-TM-C module is now available that fixes these issues.

- The maximum firmware cycle time of this fail-safe module has been increased from 5ms to 6ms. Each firmware cycle is not permitted to reach or exceed 6ms.
- An issue has been identified which can cause an internal counter diagnostic to bring the module to a safe state. This can be caused by the following conditions:
  - Using the module in the consistent presence of external electrical noise
  - Placing encoder signal wires in the same tray with AC power wiring or high-energy, rapidly-switched DC wiring
  - Using unshielded encoder cables or improper shielded encoder cables

Refer to the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/109793497) for more information about the ET 200SP product family. Refer to the description on the Internet (https://support.industry.siemens.com/cs/ww/en/view/58649293) of how to perform a firmware update for the SIMATIC ET 200SP F-TM Count.

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Options for the firmware update
The following options are available for updating firmware:

- Online in STEP 7 through Online & Diagnostics
- Online in STEP 7 through accessible devices (PROFINET)
- Online with the MultiFieldbus Configuration Tool (MFCT)
- Using a SIMATIC memory card (possible for CPU and central I/O modules)
- Through the integrated Web server (possible for CPU, as well as centralized and distributed I/O modules)
- Online through the SIMATIC Automation Tool

NOTE

Firmware update of I/O modules
The L+ supply voltage must be present on the module at the start of and during the firmware update.

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, always check that the version is approved for use in the module in question. The attachments of the certificate for SIMATIC Safety (https://support.automation.siemens.com/WW/view/en/49368678/134200) specify the approved firmware version.

The table below provides an overview of the media that can be used to update the firmware of a specific module.

Table 1 Overview of firmware update options

Firmware update	CPU	Interface module	I/O module
STEP 7 (TIA Portal)	✓	✓	✓
Accessible devices	✓	✓	✓
MFCT	--	✓	✓
SIMATIC memory card	✓	--	✓
Web server of the CPU	✓	--	✓
SIMATIC Automation Tool	✓	✓	✓

SIEMENS

Industrial Controls

ET 200SP Motor starter (3RK1308-0**00-0CP0)

Equipment Manual

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Introduction

1

Purpose of the documentation

This Equipment Manual describes the non-fail-safe and the fail-safe ET 200SP motor starters with firmware version V1.0.0 or higher.

This Equipment Manual supplements the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293). Functions affecting the system in general are described in the System Manual. There, you will also find information on installation, connection and the installation conditions of the ET 200SP motor starter.

The information provided in this Equipment Manual, the System Manual and the function manuals enables you to commission the ET 200SP distributed I/O system.

Basic knowledge required

A general knowledge of the following areas is needed in order to understand this manual:

- Industrial controls
- Digital circuit logic
- Automation technology
- Safety functions
- PROFINET and PROFIBUS bus topology
- TIA Portal

Definition

In the manual, "ET 200SP motor starter" is used as a synonym for all non-fail-safe and fail-safe variants of the ET 200SP motor starter.

1.1 Responsibility for system configuration and functionality

The products described here have been developed to carry out safety-related functions as part of a complete plant or machine. In general, a complete safety system consists of sensors, evaluation units, signaling devices and methods for safe tripping. It is the responsibility of the manufacturer to ensure that the system or machine is functioning properly as a whole.

Siemens AG, its subsidiaries, and associated companies (hereinafter referred to as "Siemens") are not in a position to guarantee every characteristic of a complete plant or machine not designed by Siemens.

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1.2 Change documentation

Release number	Changes
03/2025	Incorporation of new firmware functions V1.2.2 such as chatter monitoring and "5-life"

1.3 Siemens Industry Online Support

Information and service

At Siemens Industry Online Support you can obtain up-to-date information from our global support database:

- Product support
- Application examples
- Forum
- mySupport

Link: Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en)

Product support

You can find information and comprehensive know-how covering all aspects of your product here:

- **FAQs**
  Answers to frequently asked questions
- **Manuals/operating instructions**
  Read online or download, available as PDF or individually configurable.
- **Certificates**
  Clearly sorted according to approving authority, type and country.
- **Characteristics**
  For support in planning and configuring your system.
- **Product announcements**
  The latest information and news concerning our products.
- **Downloads**
  Here you will find updates, service packs, HSPs and much more for your product.
- **Application examples**
  Function blocks, background and system descriptions, performance statements, demonstration systems, and application examples, clearly explained and represented.
- **Technical data**
  Technical product data for support in planning and implementing your project

Link: Product support (https://support.industry.siemens.com/cs/ww/en/ps)

mySupport

The following functions are available in your personal work area "mySupport":

- **Support Request**
  Search for request number, product or subject
- **My filters**
  With filters, you limit the content of the online support to different focal points.
- **My favorites**
  With favorites you bookmark articles and products that you need frequently.
- **My notifications**
  Your personal mailbox for exchanging information and managing your contacts. You can compile your own individual newsletter in the "Notifications" section.
- **My products**
  With product lists you can virtually map your control cabinet, your system or your entire automation project.
- **My documentation**
  Configure your individual documentation from different manuals.
- **CAx data**
  Easy access to CAx data, e.g. 3D models, 2D dimension drawings, EPLAN macros, device circuit diagrams
- **My IBase registrations**
  Register your Siemens products, systems and software.

1.4 Siemens Industry Online Support app

Siemens Industry Online Support app

The Siemens Industry Online Support app provides you access to all the device-specific information available on the Siemens Industry Online Support portal for a particular article number, such as operating instructions, manuals, data sheets, FAQs etc.

The Siemens Industry Online Support app is available for Android and iOS:

Android

iOS

1.5 Support Request

After you have registered, you can use the Support Request form in the online support to send your question directly to Technical Support:

Support Request:	Internet (https://support.industry.siemens.com/My/ww/en/requests)

1.6 Recycling and disposal

These devices can be recycled thanks to their low pollutant content.

NOTE

For environmentally friendly recycling and disposal of your old device, contact a company certified for the disposal of electronic waste and dispose of the device in accordance with the regulations in your country.

Cybersecurity information

2

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In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Information about third-party software

3

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Product-specific safety instructions

4

4.1 General safety notes

⚠ DANGER

Hazardous voltage.
Will cause death or serious injury.
Turn off and lock out all power supplying this device before working on this device.

NOTICE

Damage caused by electrostatic charge
The motor starter can become damaged by an electrostatic charge if the unoccupied pins of the motor starter are contacted.
When handling and installing the ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.
It is only permitted to connect ET 200SP motor starters after disconnection of the electronic power supply (PELV and SELV) and of the line power supply (500 V AC).

⚠ WARNING

Use of radio devices or cell phones
Malfunctions are possible when using radio devices or cell phones in the immediate vicinity of fail-safe I/O. This can cause death, serious physical injury or material damage.
If you scan the 2D matrix code/ID link or use the "SIEMENS Industry Support App" when the fail-safe I/O is switched on, deactivate all wireless connections of the radio/cell phone beforehand. Alternatively, switch off the fail-safe I/O before scanning.
Switch off radio devices in the immediate vicinity of fail-safe I/O.

4.2 Safety information for hazardous areas

⚠ WARNING

Explosion hazard in Class I and Class II Hazardous Locations.
Can cause death or serious injury.
The fail-safe motor starter is permitted for the operation of device group II, Cat (2), area G D.
The fail-safe motor starter itself must not be located in the hazardous area.

4.3 Safety instructions for safety-related applications

⚠ WARNING

Hazardous voltage.
Will cause death or serious injury.
To avoid an electric shock, observe the following safety measures when working on the plant and the device:

- Turn off and lock out all power supplying this device before working on this device.
- Make sure that the device cannot be switched back on.
- Verify that the equipment is not live.
- Ground the plant.
- Cover adjacent live parts or erect barriers around them.

⚠ WARNING

Hazardous Voltage
Work on live parts of the ET 200SP motor starter system can result in death or serious injury. The device is only allowed to be commissioned and operated by qualified personnel. For the purpose of the safety information in this documentation, a "qualified person" is someone who is authorized to energize, ground, and tag equipment, systems, and circuits in accordance with established safety procedures.

NOTICE

Loss of the safety function
For the fail-safe ET 200SP motor starter, the key safety values apply in the case of a function test interval (state change of the outputs) ≤ 1 month.
To check functioning of the switching elements, switch the motor on or off at least once every month. For additional information on checking the switching elements, see chapter"Operating motor starters (Page 33)".

⚠ WARNING

Loss of the safety function with incorrect wiring
If wiring is incorrect, the motor starter cannot shut down in the event of a fault and the motor will continue to run. There is a risk of severe injury or death. Material damage is also possible.
To ensure the safety function, in the case of a single-phase load route the phase and the neutral conductor through the motor starter. You will find additional information next to the connection examples in chapter "Single-phase motor (Page 149)". In the case of a three-phase load, do not connect the neutral conductor to the star point of the load.

NOTICE
Electromagnetic interference To ensure interference immunity of the motor starter, ground PELV/SELV power supply units in accordance with regulations. (Please also note the documentation for the respective power supply unit in this regard.)

4.4 Intended use

⚠ WARNING
Improper use of hardware products. **Serious damage to property, can cause death or serious injury.** This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens. Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults. EU note: Commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed complies with the stipulations of the Directive 2006/42/EC.

4.5 Current information about operational safety

Important note for maintaining operational safety of your system

⚠ DANGER
Hazardous voltage **Can cause death, serious injury or property damage** **Please take note of our latest information!** Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. We therefore also provide information in the newsletters Industrial controls (https://new.siemens.com/global/en/products/automation/industrial-controls/forms/newsletter.html) and Safety Integrated (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/newsletter.html) about new products, further technical developments as well as standards and guidelines.

4.6 Declaration of conformity

The manufacturer declares that the safety components of the fail-safe ET 200SP motor starter series in the designs marketed by us comply with the applicable basic health and safety requirements of the EC Directives stated (including amendments), and that the stated standards were applied in their design and construction.

You can download the entire EC Declaration of Conformity: Declaration of Conformity (http://www.siemens.com/sirius/approvals).

Standards

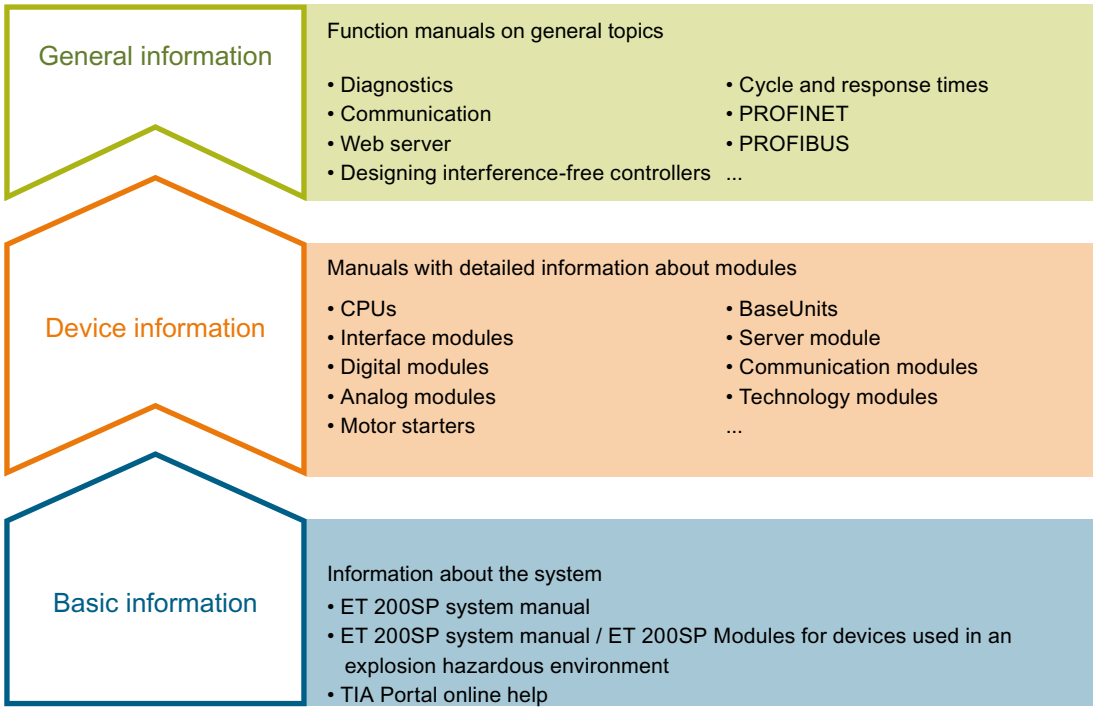
The table below shows the standards that each of the ET 200SP motor starters comply with:

Standard	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
IEC 60947-4-2:2011-05	x	x	x	x
IEC 60947-4-3:2011-07	x	-	-	-
EN 62061: 2005	-	-	x	x
EN ISO 13849-1:2015	-	-	x	x
IEC 61508-1:2010	-	-	x	x
IEC 61508-2:2010	-	-	x	x
IEC 61508-3:2010	-	-	x	x

ET 200SP Documentation Guide

5

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information
The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information
Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information
The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product features

6

6.1 Article numbers, properties, accessories

Article numbers

Short code	Article number
Direct-on-line starter	
DS 0.1 - 0.4 A HF	3RK1308-0AA00-0CP0
DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0AE00-0CP0
Reversing starter	
RS 0.1 - 0.4 A HF	3RK1308-0BA00-0CP0
RS 0.3 - 1 A HF	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0BE00-0CP0
Fail-safe direct-on-line starters	
F-DS 0.1 - 0.4 A HF	3RK1308-0CA00-0CP0
F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0
F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0CE00-0CP0
Fail-safe reversing starters	
F-RS 0.1 - 0.4 A HF	3RK1308-0DA00-0CP0
F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0
F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0DE00-0CP0

Views of the ET 200SP motor starter

The ET 200SP motor starter is a 30-mm-wide compact device with hybrid technology. The ET 200SP motor starter has electronic overload protection for switching of three-phase asynchronous motors and single-phase AC motors up to 5.5 kW (at 500 V) during normal operating conditions. Fail-safe variants of the motor starter are also available.

The figure below shows an ET 200SP HF motor starter:



Figure 1-409 View of the ET 200SP motor starter with mounted 3DI/LC module (optionally available)

The figure below shows a fail-safe ET 200SP motor starter:



Figure 1-410 View of the fail-safe ET 200SP motor starter with mounted 3DI/LC module (optionally available)

Properties of the ET 200SP motor starter

The ET 200SP motor starter has the following technical properties:

- Switching and protection device for three-phase asynchronous motors and single-phase AC motors
- Integrated short-circuit and overload protection
- Direct-on-line or reversing start function

Fail-safe motor starters additionally support safety-related disconnection (Safe Torque Off). The fail-safe variants of the motor starter are therefore suitable for the following uses:

- Safety-related applications up to SIL 3 to EN 61508, PL e/Cat. 4 to EN ISO 13849-1
- Overload protection of motors in hazardous areas

You can find all the functions supported by the ET 200SP motor starter in Chapter Functions (Page 45)

The following system functions of the ET 200SP family remain supported:

- I&M data
- Firmware update
- Maintenance
- PROFIenergy

You will find the descriptions of these functions and also rules and regulations for commissioning in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

Accessories of the ET 200SP motor starter

You can order the following accessories separately:

- BaseUnit with width of 30 mm (3RK1908-0AP00-0xx0)
- Labeling strips in various versions:
  - 500 units light-gray on a roll (6ES7193-6LR10-0AA0)
  - 500 units yellow on a roll (6ES7193-6LR10-0AA0)
  - 1000 units light-gray on DIN A4 sheets (6ES7193-6LA10-0AG0)
  - 1000 units yellow on DIN A4 sheets (6ES7193-6LA10-0AG0)
- 160 reference identification labels (6ES7193-6LF30-0AW0)
- 3DI/LC module (3RK1908-1AA00-0BP0)
- Fan (3RW4928-8VB00); is already included with all 4-12 A motor starters

NOTICE
Blowing direction of the fan Observe the blowing direction of the fan when mounting. The air flow must be directed into the inside of the motor starter. The correct blowing direction is indicated by arrows on the bottom of the fan. See ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en), "Installing fans" section.

- Mechanical bracket for BaseUnit (3RK1908-1EA00-1BP0)
- Cover for an empty BaseUnit (3RK1908-1CA00-0BP0)
- Touch protection for infeed bus (3RK1908-1DA00-2BP0); is already provided with all BaseUnits with 500 V AC infeed

You can find further information on accessories in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en) in the Appendix "Accessories/spare parts".

See also

Introduction (Page 6)

6.2 Electromagnetic compatibility

Definition of EMC

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Designing interference-free motor starters

For interference-free operation of the ET 200SP station in accordance with standard IEC 60947-4-2, use a dummy module before the first motor starter. No dummy module is necessary to the right of the motor starter.

Note the following mounting rules:

Use the following dummy module on the standard mounting rail between the previous module and the ET 200SP motor starter:

BU cover 15 mm: 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0

For operation of the ET 200SP station with an unused BaseUnit, a cover must be provided for the open BaseUnit plug contacts (power connector, power bus connector, and backplane bus connector).

The cover protects the plug contacts against dirt. The BU cover can be ordered as an accessory.

NOTE

Use of interference suppressors with hybrid switchgear

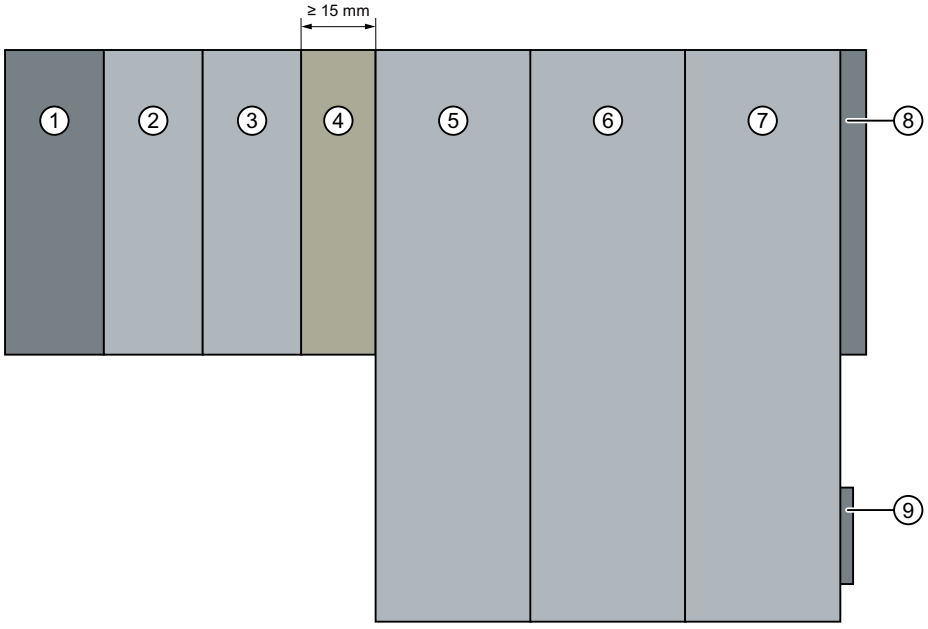
No EMC protective wiring (e.g. RC element or varistor interference suppression module) is ever necessary with the ET 200SP motor starter. Observe the following section in this context Designing motor starters in conjunction with electromechanical switching devices (Page 28).

Under normal operating conditions, the motor is always switched off in current zero due to the specific properties of the hybrid switching technology. As result, no critical states in terms of EMC ever arise in the surrounding environment.

If EMC interferences nevertheless arise, an RC element can be connected to the motor (see section Designing motor starters in conjunction with electromechanical switching devices (Page 28), figure "Use of RC elements for reducing voltage peaks").

Mounting the dummy module

The figure below provides a schematic representation of how to implement measures for improving interference immunity.



① Interface module
② Digital input module
③ Digital output module
④ Dummy module
⑤ Motor starter
⑥ Motor starter
⑦ Motor starter
⑧ Server module
⑨ Infeed bus cover

NOTICE

Ensuring interference immunity
You must not plug any other module into the BaseUnit of the dummy module, otherwise interference immunity is no longer ensured.

NOTE

Using a dummy module
The dummy module cannot be configured in all versions of TIA Portal.
In this case, leave this slot unoccupied in TIA Portal.

6.3 Designing motor starters in conjunction with electromechanical switching devices

NOTICE
Use of motor starters in series with mechanical switching devices, e.g. line contactors When using motor starters in series with mechanical switching devices, e.g. line contactors, ensure that voltage peaks are prevented by means of the mechanical shutdown of small motors (high inductance). You can achieve this with a corresponding shutdown sequence or through the use of RC elements.

One advantage of the hybrid motor starters is, among other things, the shutdown in the current zero point, which has the advantage that no voltage peaks or arcing occur in the power circuit. Thus, electromagnetic interferences no longer exists due to the shutdown.

Switching an inductive load, in particular of motors with an output of < 1 kW with correspondingly high inductance, e.g. with a contactor, can cause an inductive voltage of several 1000 V with steep voltage edges, depending on the switching time. This can also occur multiple times due to the bouncing of the contactor contacts and the resultant arcs. For a contactor, this leads to increased contact erosion (wear) and to high electromagnetic load on other components due to coupling into other electric lines.

If a line contactor is also connected upstream or downstream of a motor starter, the shutdown of the line contactor when the motor is running generates a counter-acting self-induction voltage, which can reach a voltage of several 1000 V with a very steep voltage rise.

The motor starter is protected against overvoltage by internal varistors. If, however, the voltage peaks are significantly higher and/or they occur more frequently or in rapid succession (due to contactor bouncing), the varistors become overloaded and can no longer limit the voltage peaks. The voltage peaks are then present directly on the electronic switching element of the motor starter and can ultimately lead to damage and a defective device.

Remedial measures

- Delayed shutdown of the line contactor by the motor starter shutting down before the contact (in current zero point). These voltage peaks do not occur at all and the contactor can be shut down (de-energized) approx. 100 ms later. This also results in an increased service life of the contactor, because it always switches without load.
- Use of RC elements on the 3 motor phases. As a consequence, the voltage peaks and also the steep voltage rise are reduced.

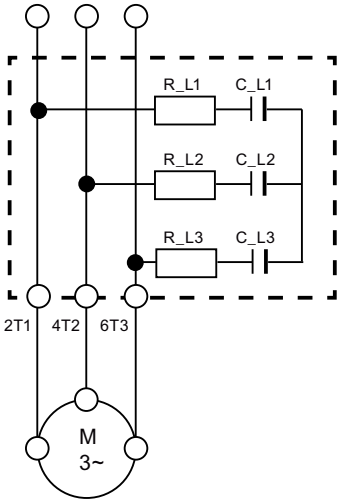


Figure 1-411 Use of RC elements for reducing voltage peaks

The following RC elements are suitable:

- 3RK1911-6EA00 for the direct mounting on standard mounting rail
- 3RK1911-6EB00 for direct attachment to the motor terminal board
- RC elements for direct attachment on the S00 contactor (3RT2916-1P*). RC elements for load contactors larger than size S00 must be obtained through third-party manufacturers.

NOTICE
Connected motors Observe the dimensioning of the connected motors.

If other regenerative components (FU, motors, transformers, etc.) are connected to the motor starter, the FAQ "EMC interference with fail-safe ET 200SP motor starter with a device fault (https://support.industry.siemens.com/cs/us/en/view/109818881)" must be observed.

6.4 Applications

You can use the ET 200SP motor starters wherever you want to switch and protect drives up to 5.5 kW with an ET 200SP system.

The ET 200SP motor starters are used for the following, for example:

- Conveyor technology
- Logistics systems
- Production machines
- Machine tools
- Gas discharge lamps

Fail-safe motor starters are designed exclusively for the switching and protection of motor loads.

6.5 Permissible ambient temperatures up to 1000 m above sea level.

General supplementary conditions

You can install the motor starter in two mounting positions:

- Horizontal mounting position
- Vertical mounting position

The mounting position depends on the position of the standard mounting rail. The following maximum permissible ambient temperatures apply depending on the mounting position:

- Horizontal mounting position: 60 °C
- Vertical mounting position: 50 °C

Observe the following general conditions when using the motor starters:

- Parameterized rated operational current I_e
- Current of the infeed system (500 V AC)
- Current of the power bus (24 V DC)
- Fan operation; the fan switches itself on and off automatically depending on the temperature in the motor starter.

Stand-alone installation

You can operate motor starters equipped with fans with the max. parameterizable I_e within the specified temperature limits.

Use of fans in group configuration (side by side)

1) Operation with infeed system (500 V AC) up to 27 A
See the table below for the cases in which you must use a fan depending on the ambient temperature during operation with a infeed system (500 V AC) up to 27 A:

Set operational current I_e	Direct-on-line starter		Reversing starter	
	Horizontal mounting position	Vertical mounting position	Horizontal mounting position	Vertical mounting position
	Ambient temperature			
1 A	45°... 60 °C [1]	40°... 50 °C [1]	45°... 60 °C [1]	40°... 50 °C [1]
3 A	45 ... 60 °C [1]	40°... 50 °C [1]	45°... 60 °C [1]	40°... 50 °C [1]
5 A	40°... 60 °C [1]	35 ... 50 °C [1]	37°... 60 °C [1]	32°... 50 °C [1]
7 A	35 ... 60 °C [1]	30°... 50 °C [1]	32 ... 60 °C [1]	27°... 50 °C [1]
9 A	30°... 60 °C [1]	25 ... 50 °C [1]	25°... 55 °C [1]	20°... 50 °C [1]
> 9 A	Up to max. 50 °C [1] [2]	Up to max. 50 °C [1] [2]	Up to max. 50 °C [1] [2]	Up to max. 50 °C [1] [2]
> 10 A	Up to max. 45 °C [1] [2]	Up to max. 45 °C [1] [2]	Up to max. 45 °C [1] [2]	Up to max. 45 °C [1] [2]

1) In operation with an infeed system up to 32 A, the maximum usage temperature is reduced by 10 K.

2) Fans are included in the scope of supply

NOTICE
Loadability of the power bus The power bus (24V DC) can only be loaded with up to 7 A when used with the motor starters.

2) Current of the infeed system (500 V AC) in accordance with UL/CSA requirements

NOTICE
A fan is absolutely necessary In this type of operation you always have to use a fan.

See the table below for the maximum ambient temperature at which you can run the motor starter when operating it with a infeed system (500 V AC) in accordance with UL/CSA requirements:

Set operational current I_e	**Direct-on-line starter, reversing starter**	
	Horizontal mounting position	**Vertical mounting position**
	Ambient temperature	
1 A	Up to max. 60 °C	Up to max. 50 °C
3 A	Up to max. 60 °C	Up to max. 50 °C
5 A	Up to max. 60 °C	Up to max. 50 °C
> 5 A	Up to max. 50 °C	Up to max. 50 °C
> 9 A	Up to max. 45 °C [1)]	Up to max. 45 °C [1)]

1) Fans are included in the scope of supply

NOTICE
Loadability of the power bus The power bus (24V DC) can only be loaded with up to 7 A when used with the motor starters.

6.6 Permissible ambient temperatures at more than 1000 m above sea level.

Current derating as a function of the installation altitude is applicable for devices with and without fans.

Possible restrictions through current derating at installation altitudes above 1000 m above sea level can be compensated for by using a fan.

The following table shows the current derating as a function of the altitude of the installation location:

Installation altitude h in m	I_e in %	Max. ambient temperature (vertical/horizontal installation)
1000 m	100 % (see above)	
2000 m	92 %	+ 60 °C ... + 50 °C
3000 m	85 %	+ 54 °C ... + 45 °C
4000 m	78 %	+ 48 °C ... + 40 °C

The I_e values can be interpolated on the basis of the available altitude specifications.

NOTICE

Derating of the nominal/rated data for the insulation coordination beyond specific altitudes above sea level

- Up to an elevation of 2000 m above sea level, operation is possible without derating of the nominal/rated data for the insulation coordination.
- With an installation altitude higher than 2000 m and below 4000 m above sea level, observe the following:
  - Line connection / E-bus: the permitted overvoltage category is reduced from III to II
  - Power bus (24 V power supply): only SELV / PELV supply permitted

NOTICE

Extension of the application range for fail-safe SIMATIC ET 200SP motor starters at installation altitudes of up to 4000 m above sea level

For information on this, please refer to the current product release Extension of the application range for fail-safe SIMATIC ET 200SP motor starters up to an installation altitude of 4000 m (https://support.industry.siemens.com/cs/ww/en/view/109778836).

6.7 Device versions

Current ranges

The table below shows the switchable motor powers depending on the primary voltage, according to DIN EN 60947-4-1: Table G.1. The stated current ranges are valid for the ET 200SP motor starters.

	0.1 ... 0.4 A		0.3 ... 1 A		0.9 ... 3 A		2.8 ... 9 A		4 ... 12 A	
	0.1 A	0.4 A	0.3 A	1 A	0.9 A	3 A	2.8 A	9 A	4 A	12 A
230 V AC	< 0.06 kW	0.09 kW	< 0.06 kW	0.18 kW	0.18 kW	0.55 kW	0.55 kW	2.20 kW	0.75 kW	3.0 kW
400 V AC	< 0.06 kW	0.12 kW	< 0.09 kW	0.25 kW	0.37 kW	1.10 kW	1.50 kW	4.00 kW	1.5 kW	5.5 kW
500 V AC	< 0.06 kW	0.18 kW	< 0.12 kW	0.37 kW	0.55 kW	1.50 kW	1.50 kW	4.00 kW	2.2 kW	5.5 kW

The assignments of the motor currents to the motor powers are recommended values. Due to the introduction of energy-efficient motors (IE3, IE4) to the market, rated currents are falling for any given power. At the same time, the start-up currents rise.

NOTICE

Dimensioning instructions

Take the current characteristics of the connected motor and motor starter into account when dimensioning. The following characteristic values are relevant:

- Ratio of rated current to motor starting current
- The maximum starting current of the motor may deviate from the values specified by the manufacturer by 20% in accordance with EN 60034-1.
- Maximum permissible current range of the motor starter: The permissible current range can be found in the graphic in Chapter "Device protection model (Page 70)".

You will find more information on dimensioning switching devices for IE3/IE4 motors in the Switching devices application manual (http://support.automation.siemens.com/WW/view/en/94770820).

6.8 Operating motor starters

Hardware and software requirements

Fail-safe ET 200SP motor starters are supported by IM155-6PN BA interface modules with firmware V3.2 or higher, IM155-6PN ST with firmware V3.1 or higher, IM155-6PN HF with firmware V3.1 or higher and IM155-6DP HF with firmware V3.0 or higher.

You require SIMATIC STEP 7 V14 or higher for configuring and programming fail-safe ET 200SP motor starters. No additional safety software (e.g. F-Configuration Pack) is required for configuring and programming the fail-safe ET 200SP motor starter.

NOTE

Requirements for manual bus mode

The device firmware V1.2.0 or higher is required for manual bus mode of the ET 200SP motor starter.

NOTE
Configuration of the ET 200SP motor starters with the TIA Portal software SIMATIC STEP 7 V13 or higher is possible with a GSD file (GSDML).

Checking switching elements

The switching elements (semiconductors, relays) are checked automatically when the motor is switched off and on via the motor starter.

The switching elements cannot be checked in the following operating states:

- During operation (Motor ON)
- In the switched-off state (Motor OFF)

Therefore ensure that the switching elements are regularly checked by the following actions:

- Monthly self-test of the motor starter if the motor starter has been switched off for more than a month:
  - Self-test by switching the motor on and off

  or alternatively
  - Commissioning of the entire system
- If the motor is operated continuously, disconnect it from the power supply at least once monthly by way of the motor starter.
- In the case of reversing starters, check the switching elements for both directions of rotation: To do this, start the motor once in the clockwise direction and once in the counter-clockwise direction.

The switching on and off routines must be run through without errors. This means:

- Current must flow.
- The motor starter must not display any errors.
- The supply voltage must be stable.

The switching on or off routine is canceled as soon as an error is detected. The motor starter assumes the safe OFF state. Observe to the diagnostic messages in DS72 logbook - Read device error (Page 128). Depending on the error message, you can reset the error by switching off the 24 V supply voltage and then switching it on again.

If you switch on when the line voltage is interrupted or a load is missing, the following messages are generated:

- Residual current detected
- Residual current disconnection

This message can be acknowledged by the Trip Reset / Reset pushbutton.

If the supply voltage is interrupted during switching on or off, this may lead to a device fault (entry 308 in data set 92 (Page 133)). In addition, the following entries in DS72 logbook - Read device error (Page 128) are possible:

- 20017 "Residual current detection during switching on/off routine or bypass element does not close"
- 20018 "Error in switching element diagnostics in the switching off process"

You can reset these faults and subsequently continue operating the motor starter following a fault-free test cycle as described above. If the faults recur, this indicates that the motor starter is defective in spite of the fact that the supply voltage conditions are stable. Replace the motor starter in this case.

Replacing the fail-safe motor starter

When replacing a fail-safe motor starter, pay attention to the commissioning specifications for fail-safe systems.

Fail-safe input F-DI on the BaseUnit

The fail-safe input on the BaseUnit is designated as follows in the manual with "F-DI".

In the case of safety-related applications, control the F-DI on the BaseUnit from a safe output.

NOTICE

Connection of the F-DI input of the BU-30-MS5 to BU-30-MS10 BaseUnits to surge filters
If your equipment makes it necessary to protect the contact against overvoltage, you have to connect the F-DI input of the BU-30-MS5 to BU-30-MS10 BaseUnits to surge filters!
Refer to Chapter "Electromagnetic compatibility" in ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

⚠ WARNING

Safety-related shutdown via the F-DI
Depending on peripherals used, the shutdown takes place via one or two output channels (terminals):

- PM switching: The shutdown takes place via two output channels.
- PP switching: The shutdown takes place via one output channel.

Shutdown via one output channel (PP switching) achieves SILCL 3 according to EN 62061, PL e/Cat. 4 according to EN ISO 13849-1 if steps are taken to ensure that the cables are installed in such a way that they are protected against a cross-circuit/line-to-line fault.
For the BU-30-MS7 to BU-30-MS10 F-DI forwarding BaseUnits, only PP switching is possible.
For the single F-DI BaseUnits BU-30-MS5 and BU-30-MS6, PM and PP switching are possible.

Bright and dark tests

With bright and dark tests, safety relays such as ET 200SP F-PM-E (6ES7136-6PA00-0BC0) or SIRIUS 3SK check whether their safe outputs can still be activated and deactivated. The bright and dark tests are run cyclically. The ET 200SP motor starter is intended for operation with an F-PM-E or 3SK connected upstream and is adapted to the bright and dark test times of these devices.

You can find more information on the operating principle and parameter assignment of bright and dark tests in the respective device manual.

To avoid an unintentional response of the fail-safe motor starter during the bright and dark test, these tests must not exceed a certain time. Due to component aging, the permissible read-back time can also decrease throughout the motor starter's service life. The voltage of the power supply unit also has an influence on the permissible read-back time. Increase the power supply unit's output voltage to minimize the risk of incorrect deactivation during dark tests.

By trial and error, set the read-back time as low as possible, but so high that the output channel is not deactivated.

⚠ WARNING
Inadvertent starting of the motor if the bright test lasts too long The motor can start if the bright test lasts more than 10 ms. There is a risk of severe injury or death. Material damage is also possible. Make sure that the bright test lasts less than 10 ms on devices that are connected upstream of the motor starter.

Power supply

In the case of a 24 V DC power supply, observe the following safety measures:

- Ensure safe electrical separation and separate routing of cables.
- Ensure increased insulation of the extra-low voltage (SELV/PELV) from circuits with hazardous potentials in accordance with IEC 60364-4-41.
- To deactivate safely via the 24 V power bus, use a suitable power supply in compliance with the requirements of the safety classification used.
- In corner-grounded delta networks, ensure increased insulation of the extra-low voltage (SELV/PELV) from circuits with hazardous potentials in accordance with NFPA 79.

Current consumption of the ET 200SP motor starters in the electric torque

NOTICE
Brief current peak possible In the electric torque of the 24 V DC power supply, a brief current peak can occur depending on the number of motor starters. Ensure an appropriate layout of your voltage source, taking this current peak into consideration.

Selection of a SITOP power supply including selective load circuit monitoring for an ET 200SP station with fail-safe I/O modules and motor starters:
See FAQ ET 200SP motor starter + fail-safe I/O + SITOP including selectivity (https://support.industry.siemens.com/cs/ww/en/view/109781189) in Industry Online Support.

Peak current in the start-stop torque

Number of motor starters	Current in A	Time in ms (until 8 A rated current is reached)
1	25	0.145
2	47	0.24
3	64	0.32
4	78	0.36
5	91	0.42

Number of motor starters	Current in A	Time in ms (until 8 A rated current is reached)
6	101	0.46
7	111	0.51
8	119	0.56
9	127	0.61
10	134	0.67
11	140	0.71
12	145	0.78
13	150	0.85
14	155	0.90
15	159	0.97
16	162	1.05
17	165	1.10
18	168	1.20
19	170	1.30
20	172	1.40
21	174	1.50
22	176	1.60
23	178	1.80
24	179	2.10
25	180	2.50
26	181	3.20
27	182	4.00
28	183	5.00
29	184	6.90
30	186	9.00

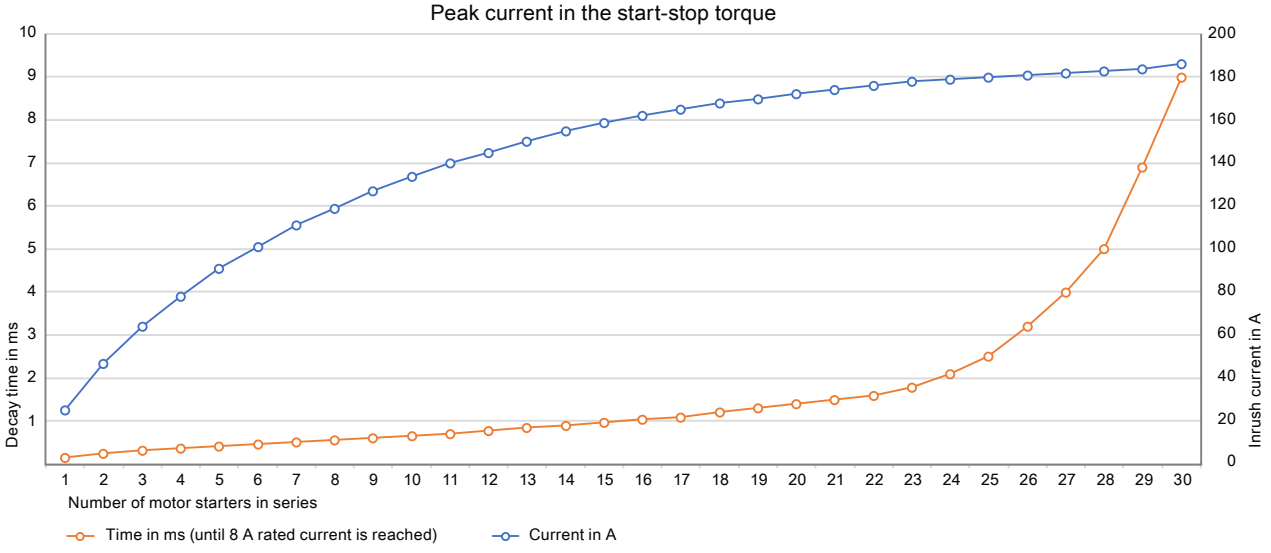


Figure 1-412 Peak current in the start-stop torque

Connecting and operating motor brakes

ET 200SP motor starters can be operated for the following braking applications:

- Variant 1: High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 400 V brake
- Variant 2: High Feature DOL starter or reversing starter with 230 V brake
- Variant 3: High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 230 V brake without connection to the neutral conductor

Variant 1. High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 400 V brake

The current for the braking device is drawn from two phases.

NOTICE
Current drain for the braking device Note that the current for the braking device may only be taken from terminals T1 and T3. Otherwise, the motor starter may be damaged.

The connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

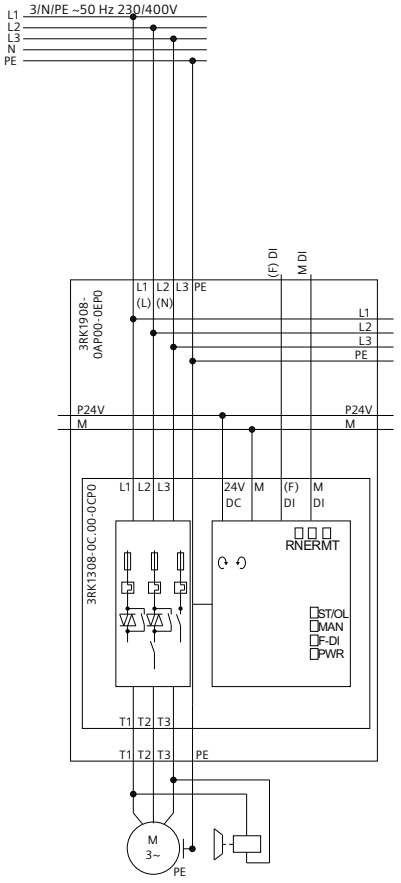


Figure 1-413 Connection of a 400 V brake to an ET 200SP motor starter

Variant 2. High Feature DOL starter or reversing starter with 230 V brake

The current for the braking device is drawn from only one switched phase. Connection is via T1.

The single-phase connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

NOTICE

Using this mode

This operating mode is **not** suitable for 3RK1308-0C and fail-safe 3RK1308-0D motor starters as there is a connection to the neutral conductor.

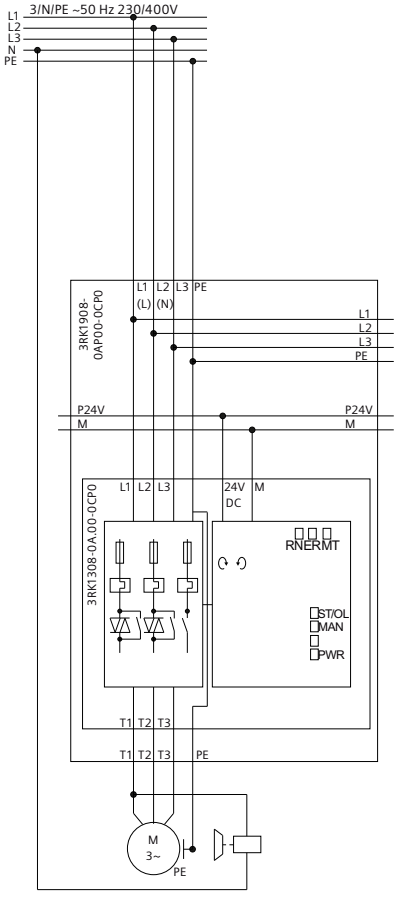


Figure 1-414 Connection of a 230 V brake with connection to the neutral conductor to an ET 200SP motor starter

Variant 3. High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 230 V brake without connection to the neutral conductor

The current for the braking device is drawn from only one switched phase. Connection is via T1. The second connection of the braking device is made at the neutral point of the motor windings and there is **no** connection to the neutral conductor.

The single-phase connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

NOTICE
Using this mode This operating mode is **also** suitable for fail-safe 3RK1308-0C and 3RK1308-0D motor starters as there is no connection to the neutral conductor.

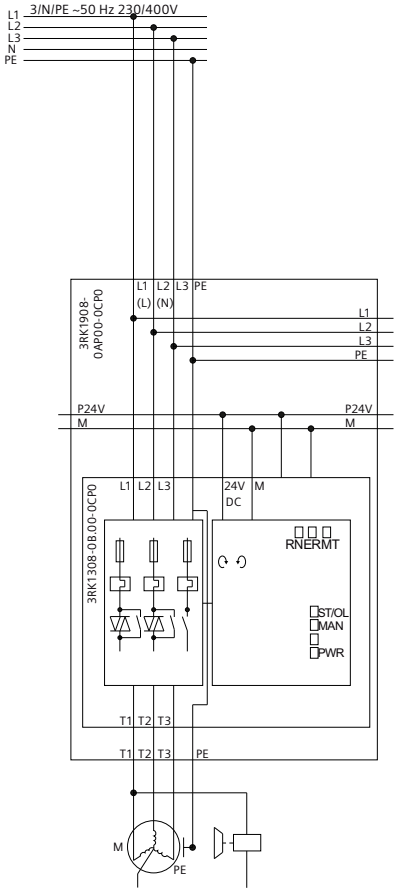


Figure 1-415 Connection of a 230 V brake in star connection and connection to the neutral point on an ET 200SP motor starter

Overview

The table below shows which motor starters can be operated with which of the three variants (✓ = permissible; - = not permissible):

Version	**1** **400 V brake**	**2** **230 V brake with connection to the neutral conductor**	**3** **230 V brake with connection to the neutral point**
Motor connection	Star or delta connection	Star or delta connection	Star connection only
Brake closing time 1)	Long	Very short	Medium
High Feature DOL starter	✓	✓	✓
High Feature reversing starter	✓	✓	✓
High Feature F DOL starter	✓	-	✓
High Feature F reversing starter	✓	-	✓

NOTICE
Brake properties The brake properties vary depending on the type of connection. Please observe the information provided by the motor manufacturer.

NOTE

1)

The brake closing time is influenced accordingly by the type of connection and the selected braking device.

For detailed information, see the documentation provided by the motor manufacturer. The brake configurations described can result in a time response that deviates from the specifications of the motor manufacturer.

Checking the settings

Always check the safety-related parameters during acceptance of the system. Also always check the parameters if a parameter has been changed or if you are commissioning the system for the first time.

Example of the correct engineering of a motor starter

NOTICE
Maximum current-carrying capacity Note that the sum of the starting current of the motor and the inrush current of the brake must not exceed the maximum current-carrying capacity of the selected motor starter.

- Rated motor current I_{rated}: 2.45 A
- Braking current I_B: 0.50 A
- Setting value on motor starter: $I_e = I_{rated} + I_B = 2.95$ A
- Motor starting current factor: I_{St}/I_{rated} 8-fold
- Brake inrush current factor: 8-fold
- Motor starting current: $I_{St} = I_{rated} * I_{St}/I_{rated} = 2.45$ A * 8 = 19.6 A
- Maximum brake inrush current: $I_B * 8 = 0.5$ A * 8 = 4 A
- Motor starting current + brake inrush current: 19.6 A + 4 A = 23.6 A

- Maximum current-carrying capacity of 3 A motor starter (3RK1308 - 0AC00-0CP0): 30 A; see also data sheet (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq))
- **Result:** The maximum current-carrying capacity is 23.6 A. It is below 30 A for this application. This means that you can use the ET 200SP motor starter (3RK1308 - 0AC00-0CP0) for this application.

Operation by experienced users only

⚠ WARNING

Qualified personnel required
All work involved in connecting, commissioning, operation and maintenance must be carried out by **qualified, responsible** personnel.
Failure to follow proper procedures may result in **personal injury and damage to property**.

ATEX-certified motor overload protection

Fail-safe ET 200SP motor starters are approved under device group II, Category 2) in the "GD" area. This means that the fail-safe motor starters can protect motors that are located in hazardous gas, vapor, mist and air mixtures and also combustible dust.

⚠ WARNING

The motor starter is not suitable for installation in hazardous areas.
Due to the increased danger in hazardous areas, observe the following standards:

- EN 60079-14 / VDE 0165-1 Explosive atmospheres - Part 14: Electrical installations
- EN 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance
- EN 50495 Safety devices required for the safe functioning of equipment with respect to explosion risks

See also

FAQ ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq)

Functions

7

7.1 Overview of functions

The table below shows the functions of the various versions of ET 200SP motor starters:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Basic function/basic parameter (Page 48)				
• Rated operational current (Page 48)	x	x	x	x
• Load type (Page 49)	x	--- (Only 3-phase possible)	x ("1-phase" not possible for ATEX applications)	---
Motor control (Page 50)				
• Electronic switching technology (hybrid switching technology) (Page 50)	x	x	x	x
• Control function (Page 53)	---	x	---	x
• Operating modes (Page 54)	x	x	x	x
Overload protection (Page 55)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
Substation monitoring (Page 65)				
• Response to residual current detection (Page 65)	x	x	--- (Only "Deactivate" possible)	--- (Only "Deactivate" possible)
• Upper/lower current warning limit (Page 69)	x	x	x	x
• Upper/lower current limit (Page 69)	x	x	x	x
• Substation monitoring (Page 65)	x	x	x	x
• Blocking time and blocking current (Page 70)	x	x	x	x
• Blocking time and blocking current (Page 70)	x	x	x	x
• Asymmetry monitoring (Page 73)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
• Short-circuit protection (fuses) (Page 74)	x	x	x	x
Response to CPU/master STOP (Page 76)	x	x	x	x
Group fault diagnostics/group warning diagnostics (Page 76)	x	x	x	x
TEST/RESET button (Page 119)	x	x	x	x

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Emergency start (Page 84)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)
Trip RESET (Page 88)	x	x	x	x
Cold start (Page 88)	x	x	x [1)]	x [1)]
PROFIenergy (Page 91)	x	x	x	x
Logbook (Page 90)	x	x	x	x
Maintenance (Page 122)	x	x	x	x
Parameter start interlock [1)]	x	x	x	x
Manual bus [1)]	x	x	x	x
Diagnosis "Supply voltage too low"	x	x	x	x

1) From FW Version 1.2.0

The following functions are available when using the 3DI/LC module via the inputs:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Inputs (Page 76)	x	x	x	x
Manual local (local control) (Page 81)	x	x	x	x
Trip without restart (Page 81)	x	x	x	x
Trip with restart (Page 82)	x	x	x	x
Trip emergency end position CW (Page 82)	x	x	x	x
Trip emergency end position CCW (Page 84)	x	x	x	x
Group warning (Page 84)	x	x	x	x
Emergency start (Page 84)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)
Motor CW (Page 85)	x	x	x	x
Motor CCW (Page 85)	---	x	---	x
Quick Stop direction-independent (Page 86)	x	x	x	x
Quick Stop clockwise (Page 87)	x	x	x	x
Quick Stop counter-clockwise (Page 88)	---	x	---	x
Trip RESET (Page 88)	x	x	x	x
Cold start (Page 88)	x	x	x [1)]	x [1)]
Operational trip end position CW (Page 89)	x	x	x	x
Operational trip end position CCW (Page 90)	x	x	x	x

1) From FW Version 1.2.0

The following functions are safety-related:

	Fail-safe direct-on-line starter	Fail-safe reversing starter
Response to safety-related tripping (Page 74) (STO = Safe Torque Off)	x	x
Ex motor application (Page 75)	x	x
Rated operational current (Page 48)	x (ATEX application only)	x (ATEX application only)
Overload protection (Page 55)	x (ATEX application only)	x (ATEX application only)

NOTE

Restrictions in relation to monitoring and input functions
When you activate safety-related functions, parameterization of the monitoring or input functions may be restricted.

7.2 Intrinsic protection

The ET 200SP motor starter protects itself against overload. Intrinsic device protection cannot be parameterized or switched off. You can find more information on the permissible ambient temperatures in chapter Permissible ambient temperatures up to 1000 m above sea level. (Page 30).

If the intrinsic protection becomes active, the follow responses occur:

- The motor trips.
- Emergency starting is not possible in the case of tripping due to intrinsic device protection.
- The diagnostic message "Switching element overload" is output in DS92 Read device diagnostics (Page 133).
- The entry "Number of switching element overload trips" in DS95 Read statistics (Page 137) is incremented by 1.

As of device firmware V1.2.0, the value of the device protection model can be read out via the DS94 Read measured values (Page 137).

If the intrinsic device protection was active, the device's diagnostics function indicates a device fault.

NOTICE

Damage due to operation of capacitive loads possible
When capacitive loads are used, the switching components in the ET 200SP motor starter can be destroyed by high inrush currents.

NOTICE
Material damage due to operation with frequency converters possible Operation in series with a frequency converter is not allowed. The switching components in the motor starter can be destroyed when operating an ET 200SP motor starter in series with a frequency converter.

7.3 Basic function/basic parameter

7.3.1 Basic functions/parameters during first commissioning

The default settings listed in the following two chapters apply to first commissioning and as defaults for the programming devices (exception: rated operational current). When a motor starter is set to the commissioning mode again, it uses the values that were valid when the technology supply voltage was last lost.

7.3.2 Rated operational current

This parameter is used to set the rated operational current that the feeder can carry without interruption. Usually, the rated operational current of the motor is specified on the rating plate of the motor. The adjustment range depends on the performance class of the ET 200SP motor starter.

NOTE

Rated operational current

The rated operational current is one of the key parameters.

You cannot disable motor protection completely. However, you can prevent the shutdown of the motor by selecting the parameter Overload protection (Page 55).

In this case, motor protection must be ensured by other measures (e.g. a thermistor in the motor).

NOTE

Functional switching

Observe the minimum loads for the ET 200SP motor starters.

The minimum loads are specified in the technical specifications of the relevant device. You can find more information on the minimum loads in chapter "Minimum load current (Page 52)".

Current motor current

The latest current in the motor starter is returned via the process image for analysis. In addition, you can read out the latest current with phase precision in data set 94.

The current is measured in two phases. The current for the third phase is calculated. The highest of the three values is determined. The returned 6-bit value specifies the motor current ratio I_{curr} / I_{rated} (I_{rated} = parameterized rated operational current).

The value is represented by one digit before the decimal point (DI 1.5) and five digits after the point (DI 1.0 to DI 1.4). This results in a maximum ratio for I_{curr} / I_{rated} of 1.96875 (approx.

197 %).
The resolution is 1/32 per bit (3.125 %).

DI 1.5	DI 1.4	DI 1.3	DI 1.2	DI 1.1	DI 1.0	
2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	
1	0.5	0.25	0.125	0.0625	0.03125	Sum = 1.96875
0	0	0	0	0	0	$I_{curr} = 0$
1	0	0	0	0	0	$I_{curr} = I_{rated}$ x 1
1	0	1	1	0	0	$I_{curr} = I_{rated}$ x 1.375
1	1	1	1	1	1	$I_{curr} = I_{rated}$ x 1.96875

I_{curr} = rated operational current I_{rated} x value (DI 1.0 to DI 1.5)
I_{rated} = rated current of the motor

Default setting

- In the ET 200SP motor starter, the rated operational current is preset at the factory to the maximum value. In the event of renewed parameterization, the parameters last set apply.
- Due to the engineering systems, the rated operational current is preset to the minimum value for safety reasons. You must therefore parameterize this value when you configure the system. The ET 200SP motor starter may otherwise trip due to overload on first starting.

Settings

Table 1-781 Settings for actual motor current

Device parameters	Default settings	Setting range
Rated operational current	• In the motor starter: maximum value or last parameterization • In engineering systems: minimum value	• 0.1 A ... 0.4 A • 0.3 A ... 1 A • 0.9 A ... 3 A • 2.8 A ... 9 A • 4 A ... 12 A Increment: 0.01 A

The setting range depends on the device type.

7.3.3 Load type

This is where you select whether the motor starter should protect a single-phase or a three-phase load.

NOTE

Reversing starter
1-phase loads are not permissible on the reversing starter. 1-phase operation is also not permissible after activation of the "EX motor" parameter in the case of fail-safe direct motor starters.

Settings

Table 1-782 Settings for load type

Device parameters	Default setting	Setting range
Load type	3-phase	• 3-phase • 1-phase

3-phase operation
In 3-phase operation, you can operate a 3-phase asynchronous motor at the connections of the motor starter.

To ensure motor protection, do not connect more than one motor to one motor starter.

Do not operate several single-phase motors on one motor starter in three-phase operation.

1-phase operation
In 1-phase operation, you can operate a 1-phase asynchronous motor at the connections of the motor starter. 1-phase operation is only possible when using a direct-on-line starter. The relevant three-pole tripping characteristics apply to single-phase operation.

Feed in the line voltage on terminals L1 and L2(N) only and connect the single-phase motor to the terminals T1 and T2 only.

An ATEX application in 1-phase operation is not possible with the motor starter.

7.4 Motor control

7.4.1 Electronic switching technology (hybrid switching technology)

The ET 200SP motor starter combines the advantages of semiconductor technology and relay technology.

The ET 200SP motor starter switches the load in phases L1 and L2 via semiconductors and bypass relays. Phase L3 is always switched via a relay.

⚠ DANGER

Hazardous Voltage
Can Cause Death or Serious Injury
If the line voltage is applied at the infeed bus of the motor starter, a hazardous voltage may be active at the output of the motor starter even without a motor ON command. When working on the feeder, you must ensure disconnection from the power, e.g. by the position "Parking position/OFF".
You will find further information on the "Parking position/OFF" in the System Manual.

This combination is known as hybrid switching technology. Hybrid switching technology in the ET 200SP motor starter is characterized by the following properties:

Switching on

The inrush current in the case of motorized loads is conducted briefly via the semiconductors.

Advantage: The relay contacts are protected. Longer service life is achieved thanks to reduced wear and tear.

Current routing

The continuous current is routed via relay contacts.

Advantage: Relay contacts cause lower thermal losses than semiconductors.

Switching off

Switching off is implemented via the semiconductors.

Advantage: The contacts are not stressed with arcs when switching via the semiconductors. This results in increased service life.

Schematic circuit diagram

The following figures show schematic circuit diagrams of the High Feature version and of the fail-safe version of the ET 200SP motor starter (direct-on-line starter version):

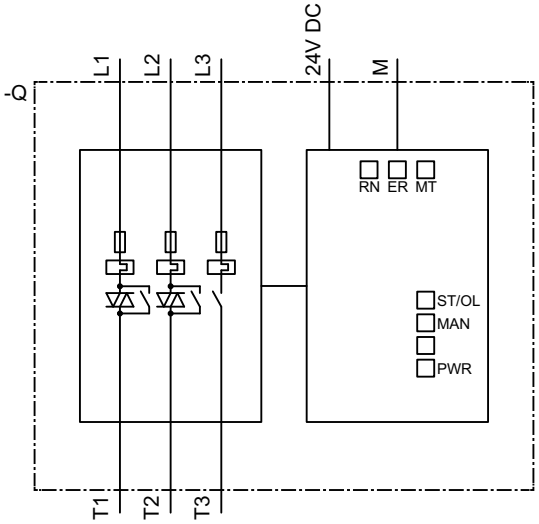


Figure 1-416 Schematic circuit diagram of HF direct-on-line starter

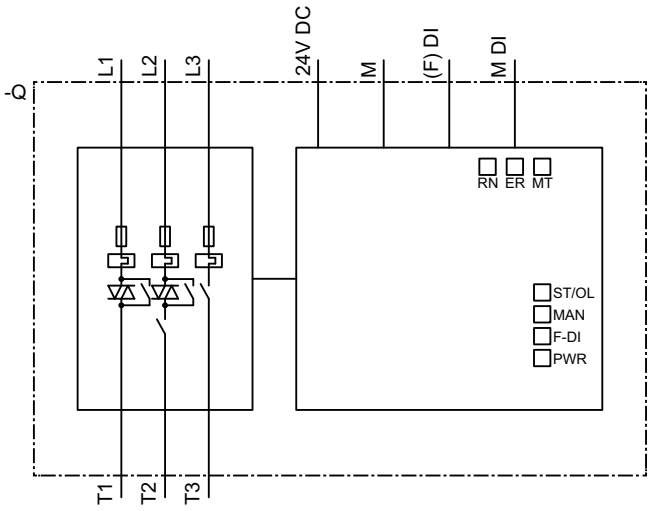


Figure 1-417 Schematic circuit diagram of fail-safe direct-on-line starter

The ET 200SP motor starters do not possess any galvanic isolation of the switching elements in the main circuits. The isolating function in compliance with EN 60947-1 is only warranted in the parking position.

See also

ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293)

7.4.2 Minimum load current

The minimum load current is 20% of the set motor current, but at least the absolute minimum current specified in the tables below.

The minimum load current differs between the ET 200SP motor starters and the fail-safe ET 200SP motor starters:

Load current	0.1 ... 0.4 A	0.3 ... 1 A	0.9 ... 3 A	2.8 ... 9 A	4 ... 12 A
Motor/ohmic load of motor starter	0.05	0.15	0.18	0.56	0.8
Motor load of fail-safe motor starter	0.05	0.15	0.45	1.4	2

As soon as the minimum current limit is undershot during operation, the fault detection (residual current detection) picks up.

Disconnection or a warning is triggered depending on the setting of the "Response to residual current detection" parameter.

Residual current detection cannot be parameterized to "Warn" in the case of fail-safe motor starters.

See also

DS72 logbook - Read device error (Page 128)
DS92 Read device diagnostics (Page 133)

7.4.3 Control function

The motor starter controls the direction of rotation of motors with the control function. Internal logic prevents you from activating both directions of rotation simultaneously.

The graphic below shows the reaction times of the motor starter to control commands. The reaction times when restarting and changing direction of rotation are identical.

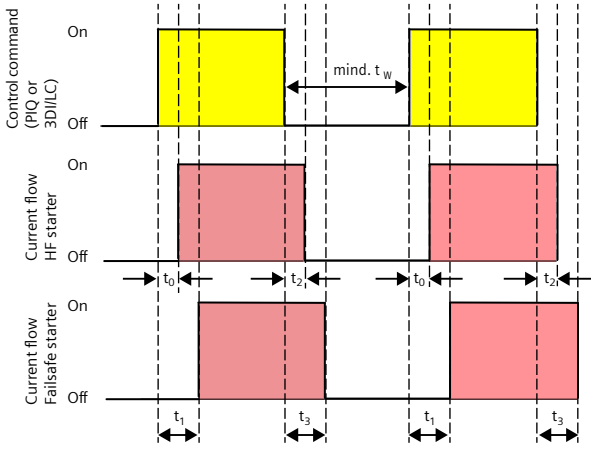


Figure 1-418 Control command reaction times

Timing:

Times t_0 to t_3 for the PIQ include a time dependency on the clock of the fieldbus and the station topology of +5 ms jitter.

For the 3DI/LC modules, a debounce time of 10 ms is included.

Timing (worst case) PIQ

- t_0: Time until current flow after the switch-on command for the HF starter: 30 ms (up to V1.2.0 25ms)
- t_1: Time until current flow after the switch-on command Safety starter: 40 ms (up to V1.2.0 30ms)
- t_2: OFF delay after switch-off command HF starter: 35 ms
- t_3: OFF delay after switch-off command Failsafe starter: 50 ms
- t_W: Recovery time: Time that must elapse due to an internal interlocking time until a repeat switch-off command is accepted after a switch-off command:
  - HF starter 195 ms
  - Failsafe starter: 215 ms

Timing (worst case) 3DI/LC

- t_0: Time until current flow after the switch-on command for the HF starter: 35 ms (up to V1.2.0 30 ms)
- t_1: Time until current flow after the switch-on command Safety starter: 45 ms (up to V1.2.0 35 ms)
- t_2: OFF delay after switch-off command HF starter: 40 ms

- t_3: OFF delay after switch-off command Failsafe starter: 55 ms
- t_W: Recovery time: Time that must elapse due to an internal interlocking time until a repeat switch-off command is accepted after a switch-off command:
  - HF starter 200 ms
  - Failsafe starter: 220 ms

7.4.4 Operating modes

The following modes are available (in ascending order of priority):

- Operating mode: Automatic (lowest priority)

  The motor starter can only be controlled with the PLC via the fieldbus.

  Automatic mode is activated automatically when communication with the interface module or the higher-level CPU is established.
- Operating mode: Manual bus: Controlling the motor starter by means of software, e.g. TIA Portal V16, via fieldbus is possible [1)]
- Operating mode: Manual local via the 3DI/LC module (highest priority)

  The motor starter can be controlled as follows:
  - Set the "Local Control" (LC on the 3DI/LC module) input to activate manual local mode.
  - Also set a digital input on the 3DI/LC module (1, 2 or 3, depending on the parameterization) to "Motor CW" or "Motor CCW", for example.

Using the LED "MAN", the message bits in the Address space (Page 113) and the DS92 Read device diagnostics (Page 133), you detect which control source currently has control priority:

- Operating mode: Automatic ("MAN" LED off)
- Operating mode: Manual local ("MAN" LED on)

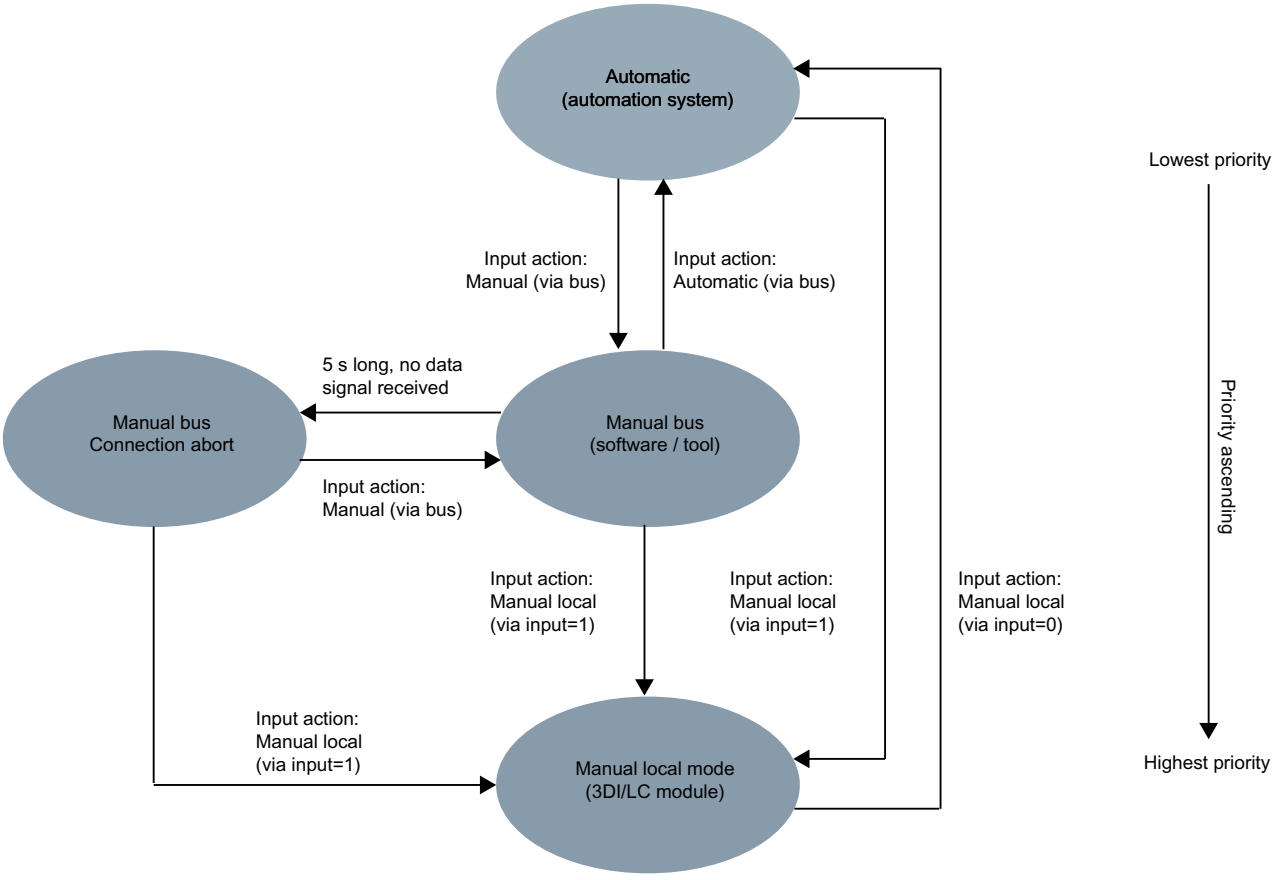


Figure 1-419 Operating modes

1) possible as of firmware version 1.2.0

7.5 Overload protection

Description

The approximate temperature of the motor is calculated using the measured motor currents and device parameters "Rated operating current" and "Tripping class". This indicates whether the motor is overloaded or is functioning in the normal operating range.

NOTE

Ensuring overload protection

Do not connect multiple motors to one motor starter due to overload protection, mutual interference between the motors, etc.

Response of the thermal motor model on restart

You set the response of the thermal motor model on restart with this parameter:

- Retention of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply, the thermal motor model is at the same motor temperature rise state when the power supply is restored as it was before disconnection. This behavior protects the motor against overload in the case of brief failures of the 24 V power supply. With this setting, you can therefore specify that the motor starter retains the thermal motor model when the power supply is restored.
- Deletion of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply for a longer period, for maintenance purposes, for example, the saved values can result in an incorrect interpretation of the motor state. With this setting, you can therefore specify that the motor starter deletes the thermal motor model when the power supply is restored.

In ATEX operation, fail-safe motor starters can only be parameterized to "Retention of the thermal motor model on restart", however.

Principle of operation

The electronics continuously calculate a model of the thermal load on the motor dependent on the operating time and the current load. The motor memory model charges when the motor is switched on. The motor memory model discharges after the motor is switched off.

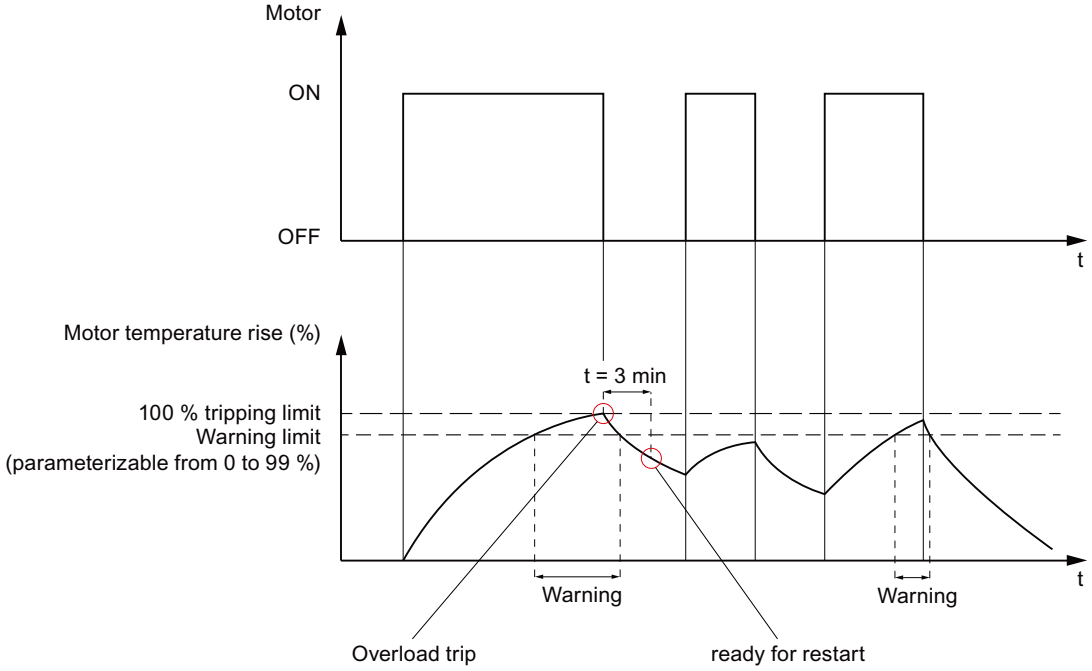


Figure 1-420 Principle of operation

Following an overload tripping operation, the motor memory model is fully discharged after approximately three minutes. You must wait for this cooling time to elapse before you can acknowledge the fault. If the control supply voltage fails, the motor starter can store the remaining cooling time if the relevant parameters have been set. When the control supply

voltage is restored, the remaining cooling time elapses before the load can be switched on again.

If you initiate a restart within a very short time after switching off the motor, it may be that the motor memory model has not yet fully discharged. This can result in an extremely fast overload trip after the restart. In continuous operation (partially charged motor memory model), the tripping times are reduced depending on the pre-charge.

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit.

This function is deactivated with a warning limit for motor temperature rise of 0%.

If the warning limit for motor heating is exceeded, a group warning and the "Thermal motor model overload" maintenance alarm are output.

Response to overload - thermal motor model

You use this device parameter to specify how the motor starter is to respond to overload:

- Trip without restart
- Trip with restart

⚠ WARNING

Hazardous Voltage.
Can Cause Death, Serious Injury, or Property Damage.
When the cooling time has expired following an overload trip, and a RESET takes place, or automatic restart has been parameterized, the machine starts up immediately if a control command is active. People in the danger area may be injured.
Make sure that the danger area of the machine is kept clear of people.

- Warning: a general warning is set.

In ATEX operation, you can only parameterize fail-safe motor starters to "Trip without restart".

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2 x the setting current (motor protection to IEC 60947-2).

The tripping characteristics represent the time to trip as a function of the current multiple. The continuous black line in the following diagrams illustrates the tripping characteristic curve for three-pole symmetrical loads and for single-phase loads. The continuous red line illustrates the tripping characteristic curve for three-pole loads when one phase fails.

The following diagram shows the overload protection for CLASS OFF:

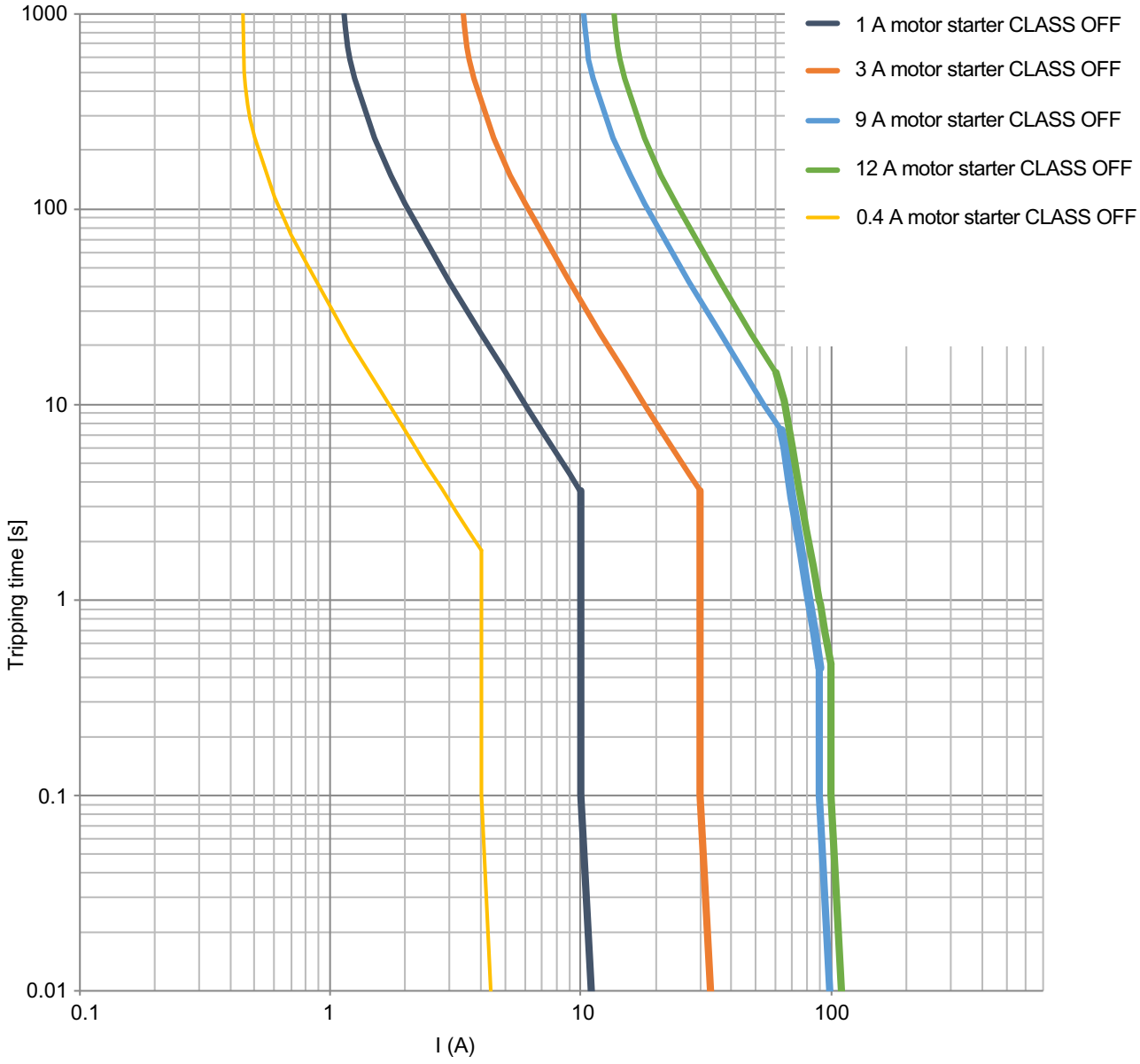


Figure 1-421 CLASS OFF overload protection

The following diagram shows the overload protection for CLASS 5:

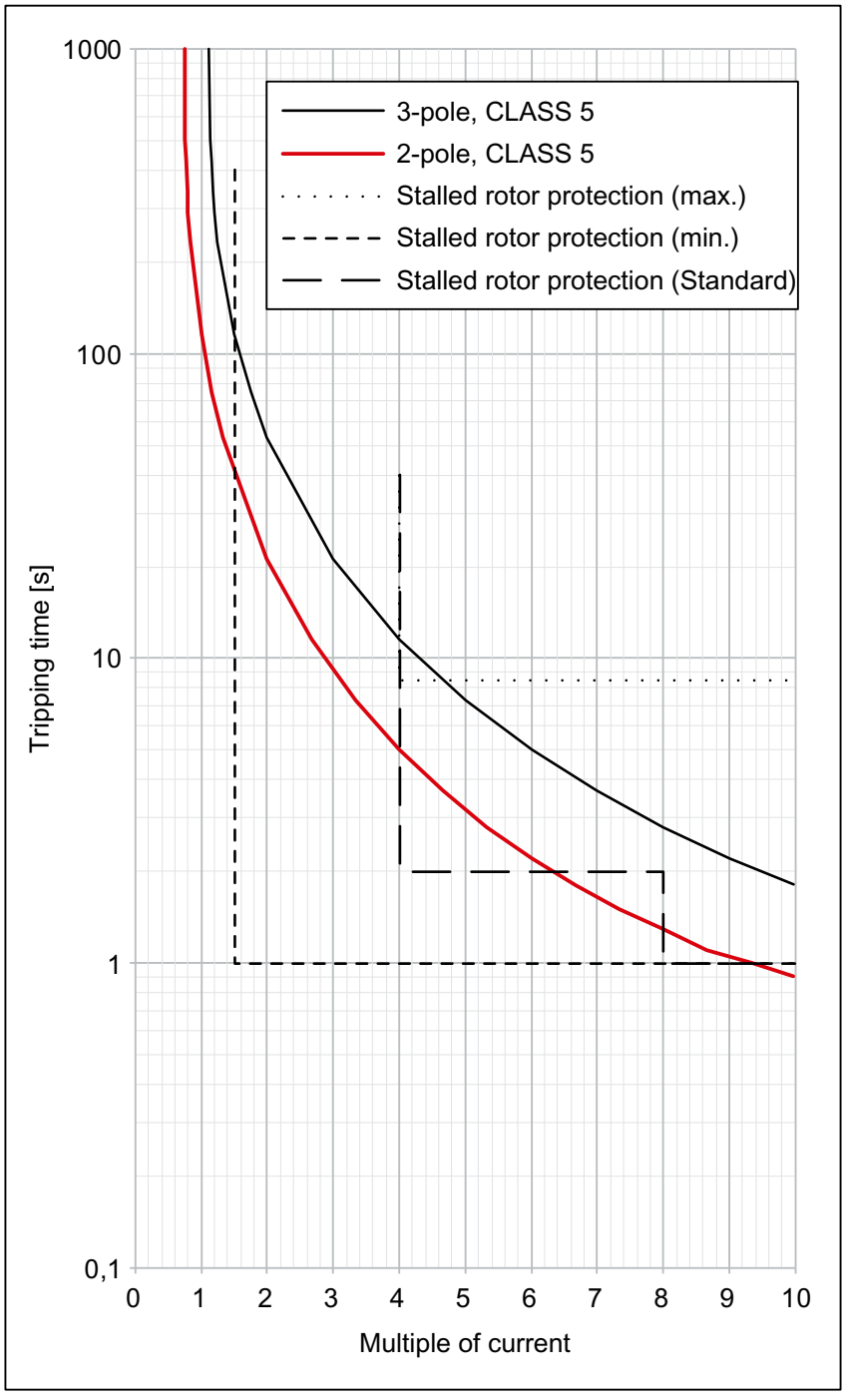


Figure 1-422 CLASS 5 overload protection

The following diagram shows the overload protection for CLASS 10:

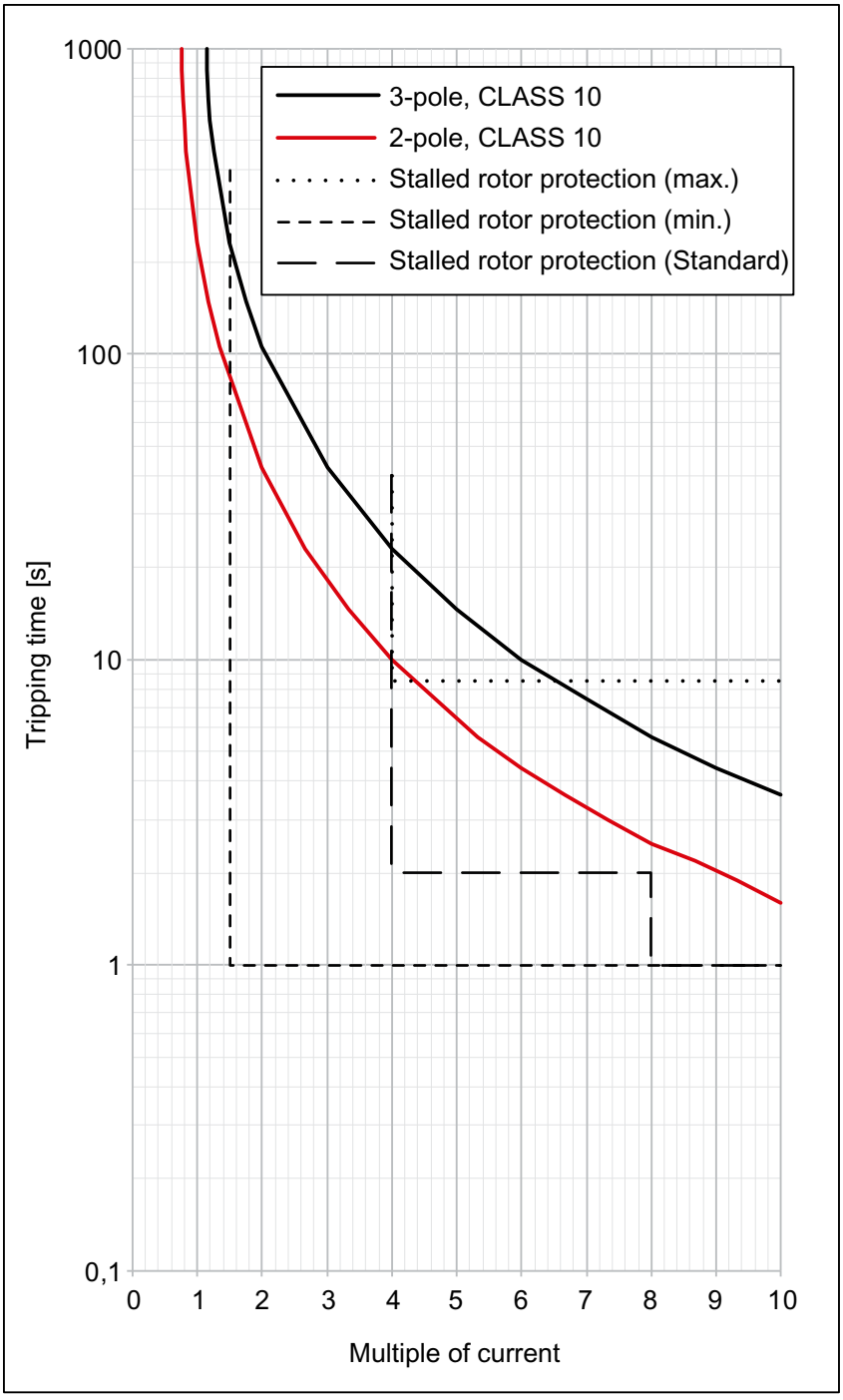


Figure 1-423 CLASS 10 overload protection

You can find out how to calculate the switching cycles in chapter Calculating switching cycles (Page 61).

The following trip classes can be parameterized according to IEC 60947-4-2:

- CLASS OFF
- CLASS 5 (10 A)
- CLASS 10

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. At overload currents greater than 65 A, shutdown becomes effective earlier than with the motor protection function (intrinsic device protection model).

The setting range of the overload protection is 1:3.

You can find more information about intrinsic device protection in chapter Device protection model (Page 70).

7.6 Calculating switching cycles

The switching cycles attainable by the ET200 SP motor starter are determined by the root-mean-square of the motor current I_{rms_motor}. The switching cycle considered is admissible if the following criterion is met:

$I_{rms_motor} \leq I_e * 1.05$

I_{rms_motor} is determined on the basis of the root-mean-squares of the motor currents during the startup time and the motor operation time taking the motor OFF time into account. In the following formula, I_e corresponds to the rated current of the connected motor.

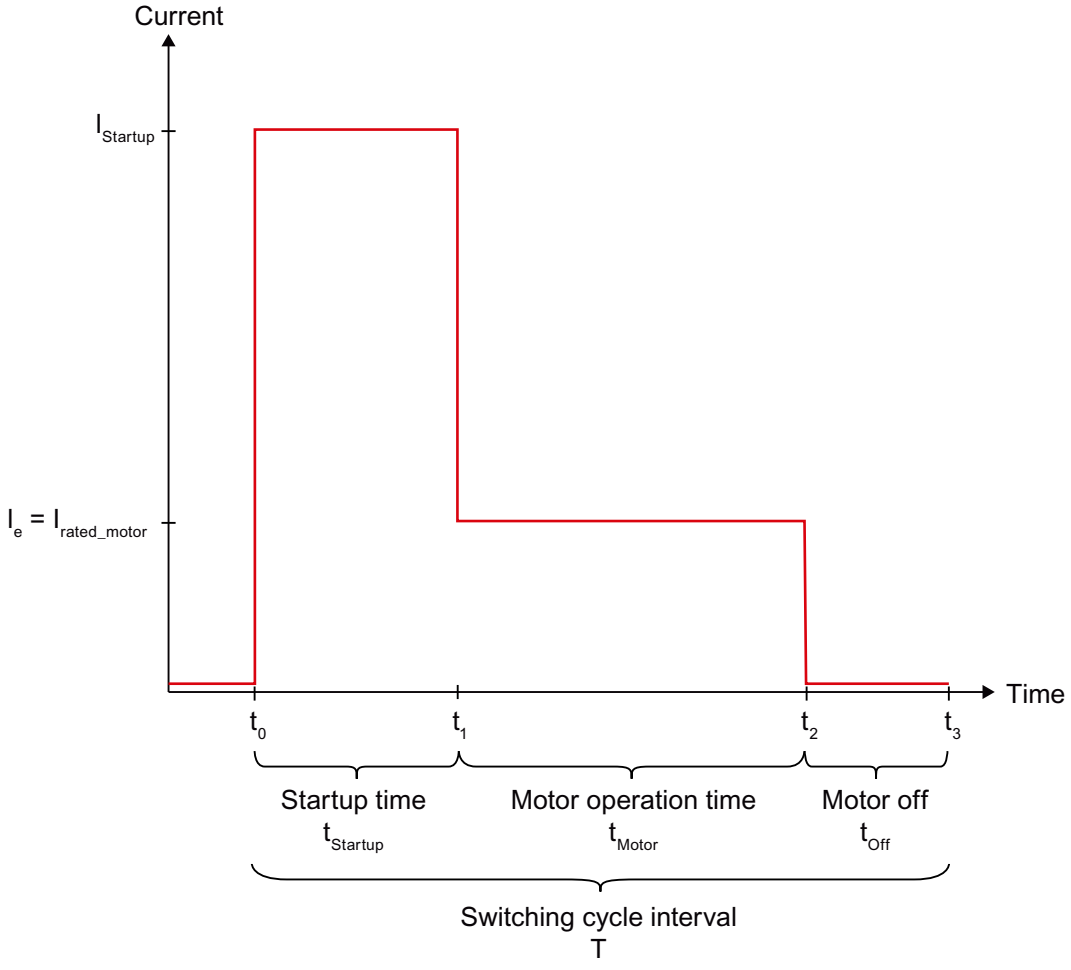
x = starting current factor $I_{Startup}/I_e$

Table 1-783 Switching frequency per hour of the 3RK1308 motor starter for the switch-on duration of 0.5 s:

Current setting [A]		0.4	1	3	9	10	12
x = starting current factor $I_{Startup}/I_e$	Startup time [s]	Number of starting operations per h					
2.5	0.1	4131	4131	4131	4131	4131	4131
2.5	0.3	1377	1377	1377	1377	1377	1377
2.5	0.5	826	826	826	826	826	826
2.5	0.7	590	590	590	590	590	590
2.5	2	207	207	207	207	207	207
4	0.1	1446	1446	1446	1446	1446	1446
4	0.3	482	482	482	482	482	482
4	0.5	289	289	289	289	289	289
4	0.7	207	207	207	207	207	207
4	2	72	72	72	72	72	72
6	0.1	620	620	620	620	620	620
6	0.3	207	207	207	207	207	207
6	0.5	124	124	124	124	124	123
6	0.7	89	89	89	89	89	86
6	2	31	31	31	31	31	25
8	0.1	344	344	344	339	292	75
8	0.3	115	115	115	108	93	20
8	0.5	69	69	69	62	53	8
8	0.7	49	49	49	43	36	0

8	2	17	17	17	9	6	0
10	0.1	219	219	219	51	54	0
10	0.3	73	73	73	12	13	0
10	0.5	44	44	44	0	0	0
10	0.7	31	31	31	0	0	0
10	2	11	11	11	0	0	0

$$I_{rms_motor} = \sqrt{\frac{1}{T}\left[(x * I_e)^2 * t_{Startup} + I_e^{\,2} * t_{Motor}\right]}$$



Switching cycle parameters

The following table shows all the parameters that you have to consider for calculation of the permissible switching cycle:

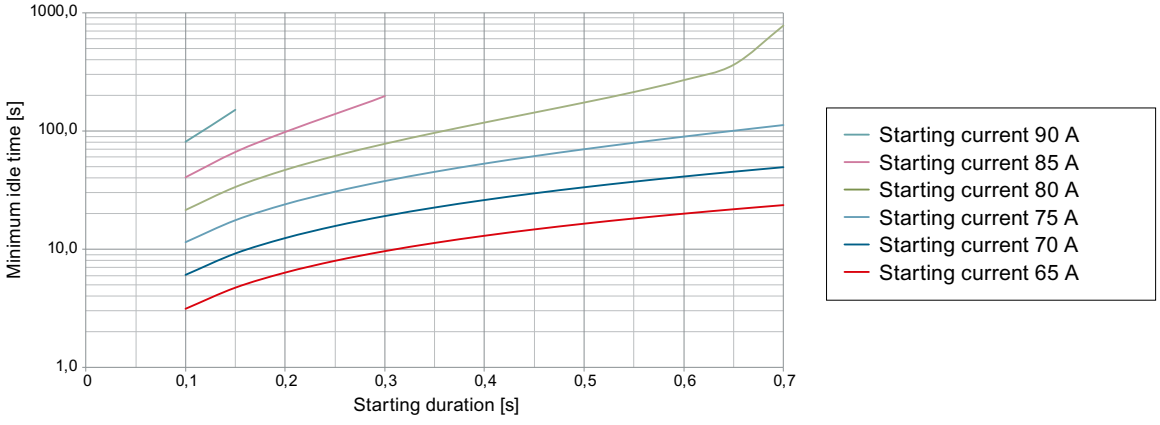
Parameters		Description	Conditions
Starting time	$t_{Startup}$ [s]	Time during which the motor accelerates up to its operating speed from standstill	The maximum is determined by the parameterized tripping class and the intrinsic device protection (see also Overload protection (Page 55)).
Starting current	$I_{Startup}$ [A]	Root-mean-square of the motor current that flows during the starting time. It is considered as a multiple x of the rated value of the motor I_{rated_motor} or of the parameterized rated operational current I_e. $I_{Startup}$ [A] = x * I_e [A]	The maximum is the permissible current of the relevant device class. Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics). (Also see: Overload protection (Page 55) and the example graphics)
Motor operation time	t_{Motor}[s]	Time in which the motor is in operation after startup.	-
Rated operational current	I_e [A]	Root-mean-square of the motor current in the operating phase after the starting time or the parameterized value I_e of the motor starter	The permissible I_e is determined by the adjustment range of the motor starter used and its ambient temperature (see also: Overload protection (Page 55)).
Motor OFF time:	t_{Off} [s]	Idle time of the motor within the switching cycle	Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics).
Switching cycle interval	T [s]	Total of t_{Off}, t_{Motor} and $t_{Startup}$	The maximum time is 300 s.

You use the switching cycle interval time to determine the permissible starting frequency per hour as follows:

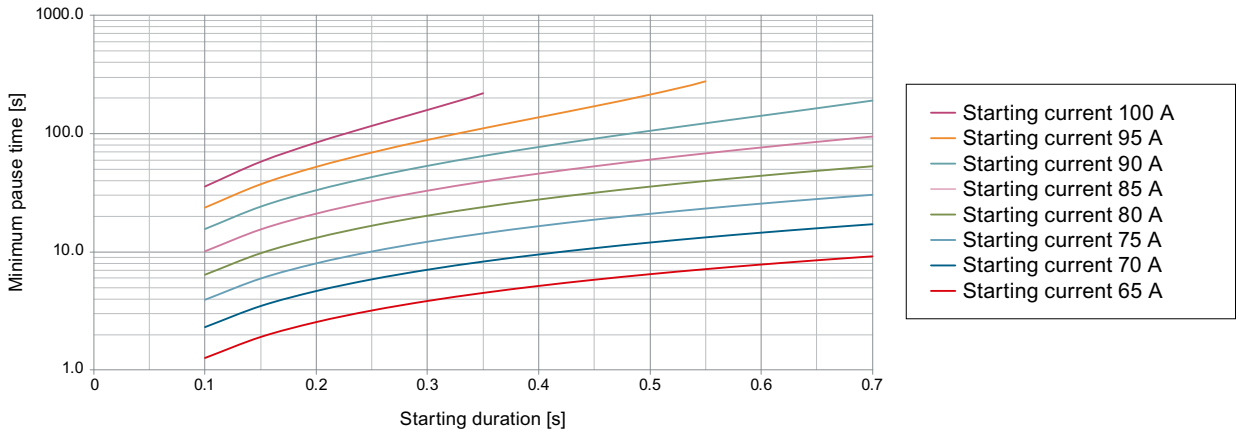
$$\text{Switching cycles [1/h]} = \frac{1}{T} * 3600$$

As from a starting current of 65 A in the case of the 9 A and 12 A motor starters, consider the device protection model for calculation of the switching cycles. The following graphics show the minimum idle time depending on the starting current:

Minimum idle time (T_{Off}) 9 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8



Minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8



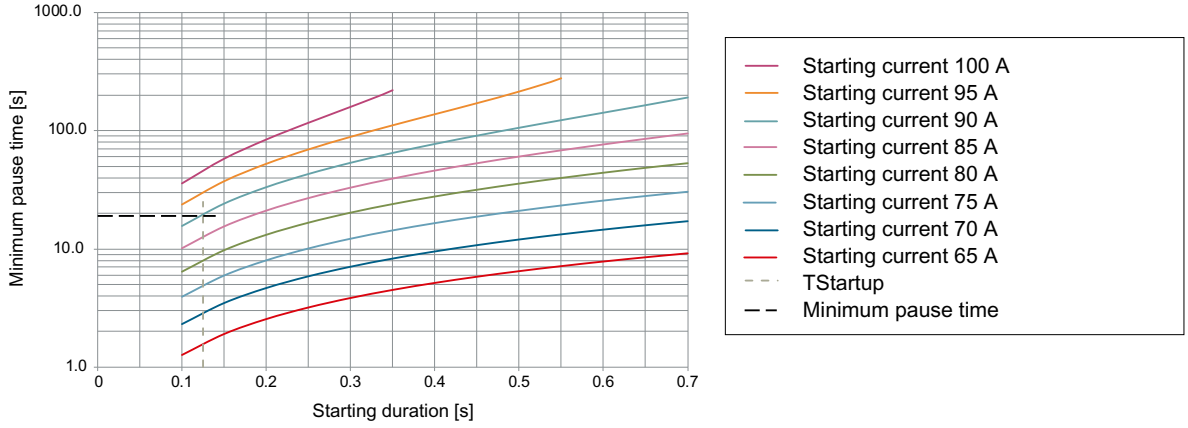
Example for the minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated}$ = 8

The graphic below shows the minimum idle time of a 12 A motor starter with the following parameters:

I_{rated_motor} = 10.4 A

$I_{startup/Irated_motor}$ = 8.6; thus: $I_{Startup} \approx 89$ A

$T_{Startup}$ = 0.125 s $T_{Off} \geq 19$ s



7.7 Substation monitoring

You can determine various system states with the help of the motor current and the current limits.

System state	Current value	Protection by:
Motor operates more sluggishly, e. g. due to bearing damage	Current is higher than normal	Upper current limit Upper current warning limit
Motor operates more smoothly, e. g. because the system has run out of processing material.	Current is lower than normal	Lower current limit Lower current warning limit
Motor is blocked	Very high current flowing	Blocking protection
• Open circuit • Defective fuse • Motor idling • Power failure • No load connected	Very low current flowing Minimum load undershot	Residual current detection

7.7.1 Response to residual current detection

If the motor current drops to under 20% from the set operational current or below the minimum load limit in one of the phases, residual current detection responds. You use this device parameter to specify how the motor starter is to behave in the event of residual current being detected:

- Warning (not in the case of fail-safe motor starters)
- Tripping

NOTE

When the motor is switched on, residual current detection is suppressed for approximately 1 s.

This does not apply to fail-safe motor starters.

Residual current detection for motor starters with 0.1 ... 0.4 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.1 to 0.4 A:

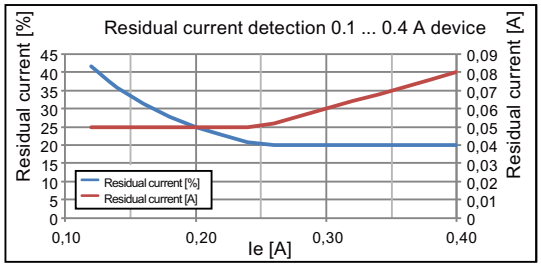


Figure 1-424 Residual current detection 0.1-0.4 A device

Residual current detection for motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

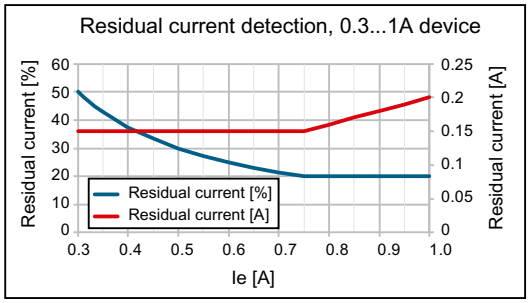


Figure 1-425 Residual current detection 0.3-1 A device

Residual current detection for motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

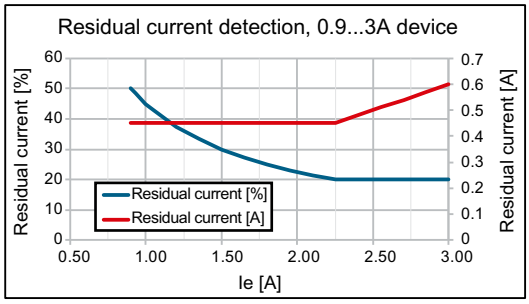


Figure 1-426 Residual current detection 0.9-3 A device

Residual current detection for motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

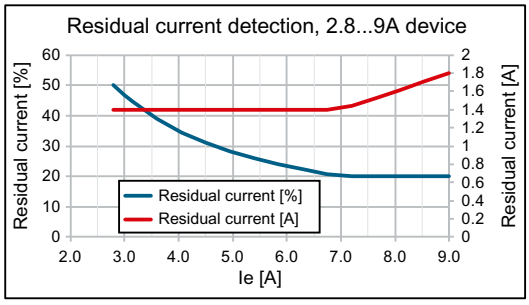


Figure 1-427 Residual current detection 2.8-9 A device

Residual current detection for motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

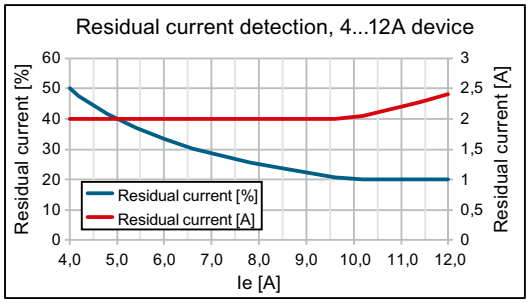


Figure 1-428 Residual current detection 4-12 A device

Residual current detection for fail-safe motor starters with 0.1 ... 0.4 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.1 to 0.4 A:

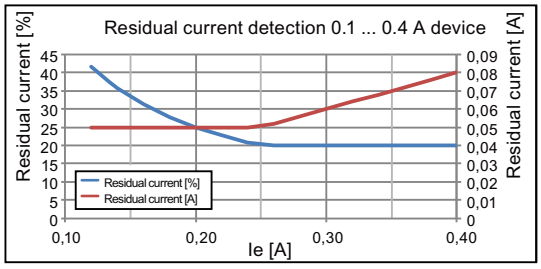


Figure 1-429 Residual current detection 0.1-0.4 A device

Residual current detection for fail-safe motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

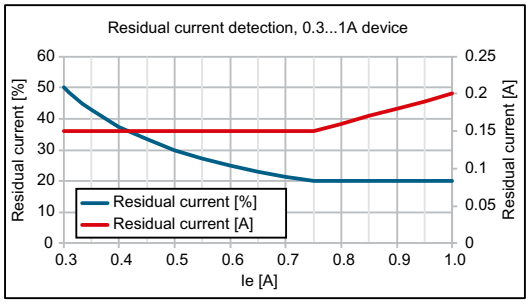


Figure 1-430 Residual current detection 0.3-1 A device

Residual current detection for fail-safe motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

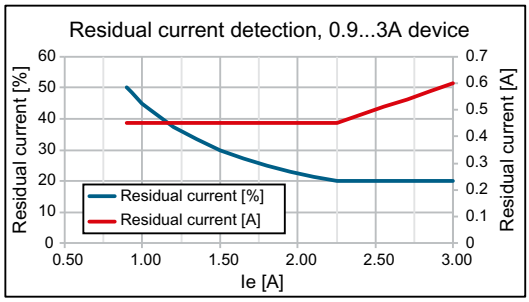


Figure 1-431 Residual current detection 0.9-3 A device

Residual current detection for fail-safe motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

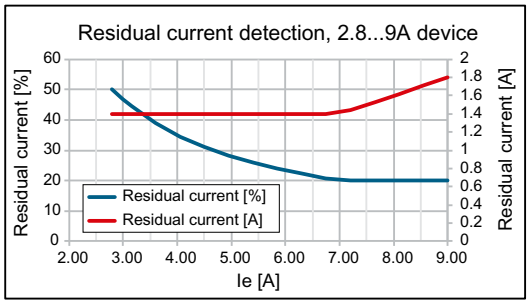


Figure 1-432 Residual current detection 2.8-9 A device

Residual current detection in the case of fail-safe motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

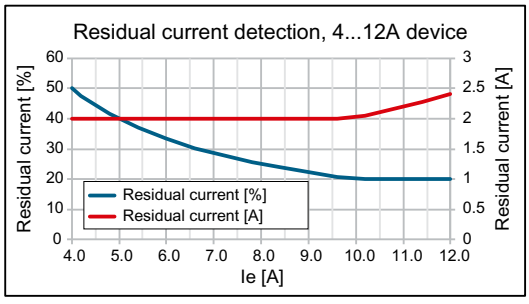


Figure 1-433 Residual current detection 4-12 A device

7.7.2 Upper/lower current warning limit

You can enter an upper and/or a lower current warning limit value. If the current warning values are exceeded or undershot, the motor starter responds with a warning message without tripping. The warning message is acknowledged as soon as the warning threshold is exceeded or undershot by 5%.

NOTE

The current warning thresholds are activated by default. You can deactivate the current warning thresholds, however. The current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current warning limit	21.875%	• 18.75 ... 100% of I_e • 0% (= deactivated) Increment: 3.125%
Upper current warning limit	112.5%	• 50 to 400% of I_e • 0% (= deactivated) Increment: 3.125%

7.7.3 Upper/lower current limit

You can enter an upper and/or a lower current limit. The current limits are deactivated by default. If the current limits are overshot or undershot, the motor starter responds by tripping. The "I_e upper limit value violation" or "I_e lower limit value violation" message is issued. If the current exceeds the maximum rated operational current by a factor of ten, the motor starter shuts down the motor even if the current limit values are deactivated. An entry in the logbook (data set 73 (Page 131)) is generated.

Example

The following example shows an application for the upper and lower current limit:

- The viscosity of the mixed mass is too high, that is, the upper current limit has been overshot.
- No load because drive belt is broken. In other words, the lower current limit has been violated.

NOTE

The parameterized current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current limit	Deactivated	• 18.75 ... 100 % of I_e • 0 % (= deactivated) Increment: 3.125 %
Upper current limit	Deactivated	• 50 to 400 % of I_e • 0 % (= deactivated) Increment: 3.125 %

7.7.4 Blocking time and blocking current

The blocking current specifies how much current is consumed by the motor (at rated voltage) when the drive is blocked.

If the motor current exceeds 400 % of the set motor current I_e for a time > 1 s after the motor ramps up, the blocking protection is tripped and a trip command is generated.

After the motor is switched on, the parameterized values for the blocking current and blocking time apply. A switchover to the fixed values (400 %, 1 s) takes place depending on the set motor protection class (CLASS 5/ 10 A → 5 s, CLASS 10, off → 10 s).

- The "Tripping due to motor blocking" and "Group fault" diagnostic messages are generated
- The statistic "Number of motor overload trips" is incremented by 1

If the parameter "Group fault diagnostics" is set to "Enabled", a corresponding diagnostic interrupt is set if blocking protection responds.

Setting ranges

The table below shows the possible setting range for the blocking current and the blocking time:

Device parameters	Default setting	Setting range
Blocking current	800 %	150 ... 1500 % of I_e Increment: 50 %
Blocking time	1 s	1 ... 7.5 s Increment: 0.5 s

7.7.5 Device protection model

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. The device protection model consists of the relay protection model (dotted line) and the thermal motor model (continuous line) with the highest permissible current setting. The device protection is active 20 ms after the ON command. This means that, in the case of ET 200SP motor starters, an overload trip may occur in the upper current range before the motor protection trips. The device protection is active even when the overload protection is set to "Warn" and the "Response of the thermal motor model on restart" parameter is set to "Delete".

The motor starter operates within a permissible current range. The following graphic shows the permissible current range:

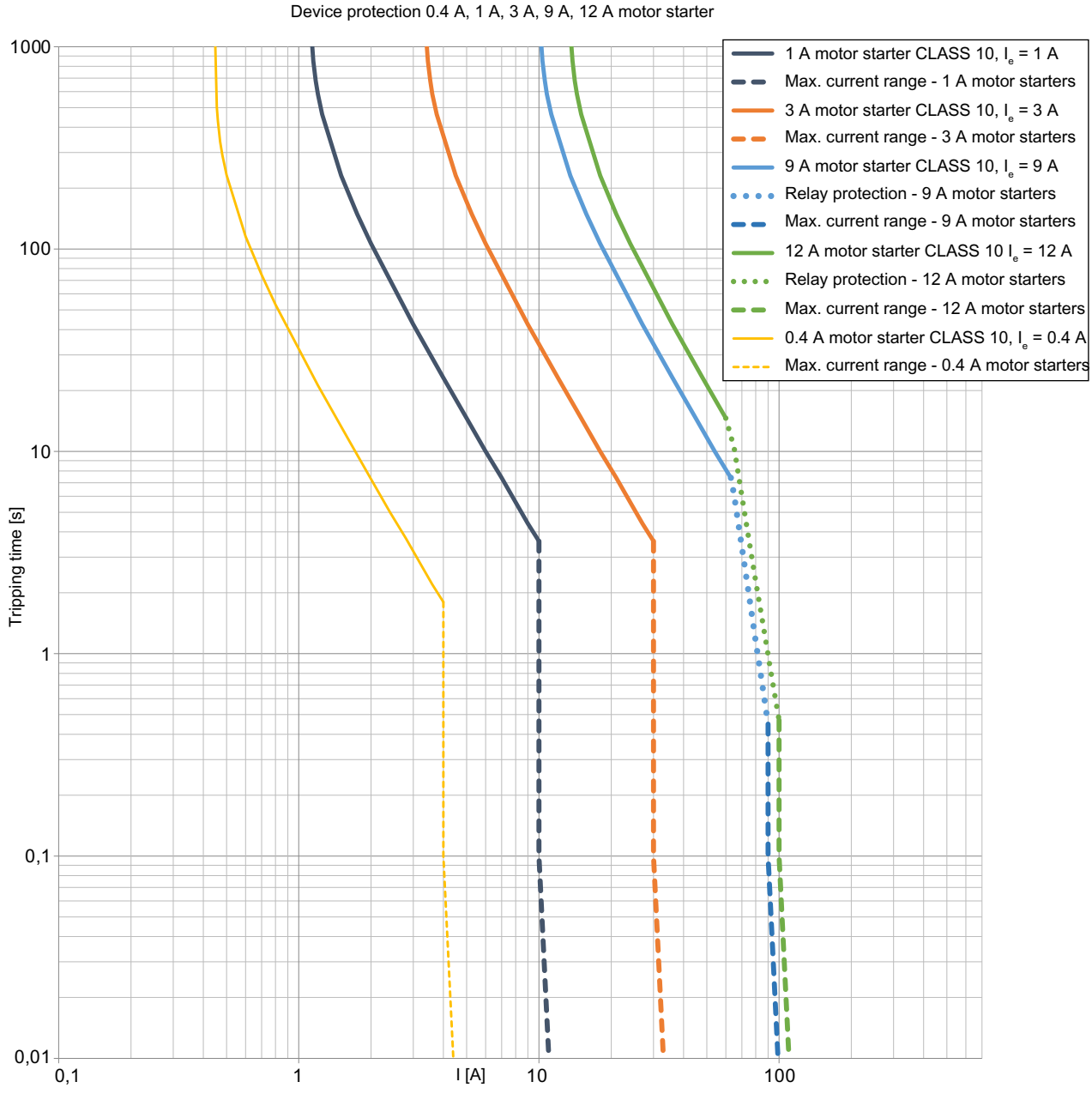


Figure 1-434 Device protection

How the motor starter's device protection works is described below.

Shutting down the motor starter within the permissible current range

The motor starter switches off in the following cases:

- The motor starter is too hot.
- The CLASS 10 tripping characteristic for the maximum current setting has been exceeded.
- The relay protection characteristic in the case of 9 A and in the case of 12 A motor starters has been exceeded.

Wait at least three minutes after shutting down the motor starter. Then trigger a trip reset. The motor starter is operable again.

Violation of the permissible current range

Switching elements may be damaged if the permissible current range (represented by the vertical line in the graphic) is exceeded. The motor starter switches off. The "Current measuring range overshot" message is issued. 9 A and 12 A motor starters switch off without the support of the semiconductors. This is referred to as "hard switching" and is output as a fault diagnosis.

To prevent response of the device protection, a motor's maximum starting current must not be higher than the motor starter's max. permissible current range.

NOTICE
Violation of the permissible current range **Fail-safe motor starters** are defective after overshoot of the permissible current range and cannot be activated again. Reactivation of **non-fail-safe motor starters** is possible. The service life of a non-fail-safe motor starter is, however, limited.

7.7.6 Temperature monitoring

The motor starter has an internal temperature monitoring function. If the motor starter exceeds its internal temperature warning threshold, the "Switching element hot" alarm is issued in data set 75 (Page 132). The motor starter switches off if the temperature continues to rise. The "Switching element overload" diagnostic message (object number 309) is issued in data set 92 (Page 133) if temperature monitoring responds.

You can trigger trip reset on the motor starter after a cooling time of at least three minutes. You can activate the motor starter again once it has sufficiently cooled down.

Fan control

The fan is controlled temperature-based by the internal temperature monitoring function. The thermal device protection model can also lead to the activation of the fan.

7.7.7 Asymmetry monitoring

Description

Three-phase asynchronous motors respond to slight asymmetries in the supply voltage with a higher asymmetric current consumption. As a result, the temperature in the stator and rotor windings of the drive increases. The ET 200SP motor starter protects the load against overload by issuing a warning or by tripping. You can parameterize whether a warning is output or tripping occurs.

NOTE
When the motor is switched on, asymmetry evaluation is suppressed for approx. 0.5 s.

Asymmetry limit

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Tripping

Settings

Table 1-784 Settings for asymmetry monitoring

Device parameters	Default setting	Setting range
Response to asymmetry	Tripping	• Warn • Tripping

7.7.8 Short-circuit protection (fuses)

Description

The ET 200SP motor starter is equipped with integrated safety fuses as short-circuit protection. Short-circuit protection is implemented both between a phase and ground (= ground fault), and between two phases.

Switching performance

The ET 200SP motor starter switches off short-circuits in the motor or in the cables. The ET 200SP motor starter complies with the requirements of type of coordination 1 (IEC 60947-4-2).

On tested assemblies, the type of coordination defines the permissible condition of devices following a short-circuit. Type of coordination 1 means that the load feeder is non-operational after a short circuit has been cleared.

Messages and actions

After the fuse responds, the "Residual current detection" message is output in the case of non-fail-safe motor starters. The "Switching element defective" message is issued in the case of fail-safe motor starters. Then replace the starter.

7.8 Safety-related functions

7.8.1 Self-test

ET 200SP fail-safe motor starters run a self-test of the switching elements every time they are switched on and off.

Ensure a stable line power supply. An unstable power supply may lead to a situation in which the motor starter incorrectly signals a fault.

7.8.2 Response to safety-related tripping

The STO (Safe Torque Off) function is the safety function integrated in the fail-safe motor starter. It ensures the safe disconnection of torque-generating energy on the motor. Safety Torque Off prevents unintentional start-up in compliance with EN 60204-1, Section 5.4. The drive is safely free from torque. This state is monitored in the motor starter.

Safety-related tripping is achieved for the fail-safe motor starters thanks to the special arrangement and checking of the switching elements.

Safety-related tripping is performed by a low level ("0" signal) at the F-DI. As an alternative, safety-related tripping can be achieved by removing the 24 V supply voltage from the power bus.

In the case of fail-safe ET 200SP motor starters, the OFF state is defined as the safe state (Safety torque off). ET 200SP Failsafe motor starters are self-monitoring. A diagnostic message can be sent to the controller in the event of tripping via F-DI.

The signal (F-DI) is provided via the corresponding BaseUnit with F-DI-infeed or F-DI forwarding.

Settings

Table 1-785 Response to safety-related tripping

Device parameters	Default setting	Setting range
Response to safety-related tripping	No warning	• No warning • Warning

7.8.3 Ex motor application

Set the "Ex motor application" parameter if the fail-safe motor starter is to switch and protect an explosion-proof motor.

NOTE

ATEX Ex II (2) G D zones

You can use the fail-safe motor starter for explosion-proof motors that are situated in ATEX Ex II (2) G D zones.

An ATEX approval is not possible with the motor starter when it is used in 1-phase operation.

An ATEX approval is possible by means of further measures such as thermoclick.

NOTE

It is not possible to set the motor protection to Class OFF in EX operation.

Settings

Table 1-786 Settings for Ex motor application

Device parameters	Default setting	Setting range
Ex motor application	No	• No • Yes

The maintenance alarm 0x1036, "New safety-related parameters received", is issued if you have activated the "EX motor" parameter. Before the "EX motor" parameter is accepted, you must confirm it on the device with the blue button.

See also

Setting safety-related parameters (Page 106)

7.9 Response to CPU/master STOP

With this parameter, you set the response of the PIQ following a CPU STOP:

- Retain last value
  The last received and valid value of the process image of the outputs is retained.
- Switch substitute value 0
  The process image of the outputs is assigned the value "0". "Switch substitute value 0" is active even if the header module of the ET 200SP station is deenergized.

NOTE

The response to CPU/master STOP is only relevant in "Automatic" mode.

7.10 Group fault diagnostics/group warning diagnostics

You can use these parameters to determine whether diagnostics are enabled or disabled. If you set the group diagnostics parameter to "Disable", no diagnostic messages are output to the CPU. If you set the group warning diagnostics parameter to "Disable", no maintenance alarms are output.

You will find the requirements for the use of maintenance alarms in an Maintenance FAQ (https://support.industry.siemens.com/cs/ww/en/view/109485777).

Settings

Table 1-787 Settings for group fault/group warning diagnostics

Device parameter	Default setting	Setting range
Group fault diagnostics	Enable	• Disable • Enable
Group warning diagnostics	Disable	• Disable • Enable

7.11 Inputs

If you use the optional 3DI/LC module (3RK1908-1AA00-0BP0), the motor starter can execute various actions with the "Inputs" device function. The actions are parameterizable. The signals are evaluated on the 3DI/LC module for this purpose. Inputs 1 to 3 (DI 0.4 to 0.6) can be connected directly with contact elements or sensors.

The bit 2.5 in the process image of the inputs indicates whether a 3DI/LC module is inserted.

The signal states are transferred in parallel via the process image. In addition, the signal states in DS92 Read device diagnostics (Page 133) can be read out. The input actions of the individual digital inputs affect the motor starter functions independently of one another.

The input LC (local control) switches over to manual local mode. You cannot change the parameterization of the input. This input is always implemented as an NO contact. You can detect whether or not manual local is active if bits 0.7 and 1.6 are active in the process image input.

For information on this topic, see Chapter "Connecting the 3DI/LC module for the motor starter" in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

Inputs for commissioning
To ensure operation of a motor in the unparameterized state of the ET 200SP motor starter with the aid of the 3DI/LC module, the input parameters in data set 201 are permanently assigned the following values by default:

- DI1: Motor CW
- DI2: Motor CCW
- DI3: Cold start (fail-safe motor starters as of V1.2.0)

This pre-parameterization is overwritten when the ET 200SP motor starter is parameterized.

Response to sensor supply overload

The supply voltage for the digital inputs is short-circuit proof. The current is limited to a maximum of 100 mA. If a short-circuit or overload situation occurs in the sensor supply, the switching elements (motor) are shut down and a group fault is output. Acknowledge the fault with Trip Reset.

⚠ WARNING

The digital inputs (1 to 4) are not isolated. The reference potential is M (5), and therefore SELV/PELV. Only supply the inputs with the 24 V DC output (6).
Do not connect any temperature sensors for winding control of motors if they do not have protective separation. Otherwise, in the event of a fault, a dangerous voltage may be transmitted to the sensor cables and thus to the SELV/PELV circuits. If these cables are then touched, it can lead to death, serious injury and enormous material damage.
You will find more information in chapter Connecting 3DI/LC module (Page 155).

Response to removal of the 3DI/LC module:

Bit 2.5 is reset in the process image input if you remove the 3DI/LC module during operation. You can evaluate the bit and thus indicate unintentional removal. The inputs are not open-circuit-proof.

⚠ WARNING

The motor can continue to run with the corresponding parameterization
When you remove the 3DI/LC module, the motor can continue to run with the appropriate parameterization.

Input signal delay

The input signal delay is fixed at 10 ms.

Input n signal

You can use this device parameter to determine whether or not the input level of the inputs is to be saved.

- Retentive, i.e. latching mode (edge evaluation)
  Regardless of the input signal present, the action can only be deactivated again by a further event and remains active even after cancellation until it is overwritten by another action (e.g. process image of the outputs).
- Non-retentive, that is, jog (level evaluation)
  This input action is active as long as the input is active.

Input n level

You use this device parameter to specify the input logic:

- NC contact
- NO contact

NOTE

Parameterization only as NO contact.
For "Input n action": "Emergency start", "Motor CW", "Motor CCW", "Cold start" and "Trip reset", "Input n level" can only be parameterized as an NO contact.

NOTE

Change from NC contact to NO contact
If "Input n level" is changed from a normally closed contact to a normally open contact and the associated "Input n action" is parameterized as "Trip without restart", the "Input tripping" message bit is set and shut down accordingly in the case of an open input due to the input delay!

NOTE

Applied input voltage
If input voltage is applied (input active), the value "1" is transferred to the controller regardless of the "Input n level" parameter.

Input n action

Different actions can be triggered when an input signal is present. You can parameterize the following actions dependent on "Input n level", "Input n signal" and "Mode".

NOTE

If "Input n-signal" = retentive, and "Input n-action" = motor CW/CCW, at least one input must always be parameterized with input action "Tripping ..." or "Quick Stop". If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

Table 1-788 Input n action

Input n action	Input n level	Input n signal	Operating mode	Description
No action	NO/NC	n. ret./ret.	All	No direct action on the motor starter. Evaluation und further processing possible using the process image.
Trip without restart	NO/NC	n. ret.	All	• Results in tripping of the motor. • Must be acknowledged once the cause of the tripping has been rectified (initial status).
Trip with restart (AUTO RESET)	NO/NC	n. ret.	All	• Results in tripping of the motor. • Acknowledged automatically after the cause of the trip has been rectified (initial status).
Trip end position CW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CCW"
Trip end position CCW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CW"
Group warning	NO/NC	n. ret./ret.	All	• The diagnosis "Group warning" is output. • The motor starter is not switched off.
Emergency start	NO	n. ret.	All	• Starts the load when an ON command is issued despite the fact that an internal trip command is present. • Intrinsic device protection of the motor starter remains active and prevents the device from being destroyed. • Only allowed as an NO contact • Not parameterizable when the "EX motor" parameter is active.
Motor CW Motor CCW (with reversing starters only)	NO	n. ret./ret.	Manual local mode	• The motor starter must be in "manual local" mode for these actions. • Motor CW: Switching the motor on or off • Motor CCW: Switching the motor on or off • Only allowed as an NO contact • n. ret. The input action is active while the input signal is pending. • ret.: The action becomes active by means of the rising edge of the input and remains active regardless of the level. The action is reset by the input action "Quick Stop" or "group fault".
Quick Stop	NO/NC	n. ret./ret.	All	• Motor is switched off direction-independently without group fault. • "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
Quick Stop clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CW" without group fault. • "Quick Stop" takes priority over "Motor CW"

Input n action	Input n level	Input n signal	Operating mode	Description
Quick Stop counter-clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CCW" without group fault. • "Quick Stop" takes priority over "Motor CCW" • The action is only available for reversing starters.
Trip RESET	NO	n. ret.	All	• "Trip RESET" is triggered once. • "Trip RESET" is only possible as NO contact.
Cold start	NO	n. ret.	All	Enables switch-on without main power. If the main power supply is nevertheless present (current flowing), an internal trip command is generated. For fail-safe motor starters as of firmware version V1.2.0
Operational trip end position CW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CCW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostic message is set in data set 92.
Operational trip end position CCW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostic message is set in data set 92.
NO: NO contact NC: NC contact ret.: Retentive n. ret.: non-retentive (activation and deactivation of the input action follows the status of the input signal (= jog))				

Settings

Table 1-789 Settings for inputs

Device parameters	Default setting	Setting range
Input signal delay	• 10 ms	-
Input 1 level	• NO contact	• NC contact • NO contact
Input 2 level		
Input 3 level		
Input 1 action	• Motor CW	• No action • Trip without restart • Trip with restart
Input 2 action	• Motor CCW (RS) • No action (DS)	

Device parameters	Default setting	Setting range
Input 3 action	• Cold start	• Trip end position CW • Trip end position CCW • Group warning • Emergency start • Motor CW • Motor CCW • Quick Stop (direction-independent) • Quick Stop clockwise • Quick Stop counter-clockwise • Trip RESET • Cold start • Operational trip end position CW • Operational trip end position CCW
Input 1 signal	• Non-retentive	• Retentive • Non-retentive
Input 2 signal		
Input 3 signal		

7.12 Manual local (local control)

Manual local control with the ET 200SP motor starter is only possible when the 3DI/LC module is inserted. A digital input is permanently assigned the function "Manual local" (LC connection). If the digital input is active, that is, "manual local" is requested, the ET 200SP motor starter changes to manual local mode even in the case of motor ON. To exit manual local mode, the manual local input must be inactive and the motor must be switched off via the DI module. That is, with active input action "Motor CCW" or "Motor CW", the ET 200SP motor starter remains in manual local mode and thus in the "Motor ON" state as long as the input action is not interrupted.

NOTE

Removal during operation

If the 3DI/LC module is removed from the ET 200SP motor starter during manual local mode, this results immediately in shutdown of the running motor and then to exiting of manual local mode.

If a removed 3DI/LC module is plugged onto the ET 200SP motor starter while "manual local" is active, a changeover is made to manual local mode.

The motor starter assumes automatic mode when manual local mode is ended, i.e. the motor starter switches to the control priority of the CPU. The motor can start immediately when CW or CCW command is pending via the process image of the outputs.

7.13 Trip without restart

The action "Trip without restart" results in the following behavior:

- The motor is tripped. Acknowledge disconnection via Trip Reset after remedying the cause of tripping. You can then switch on the motor again.
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

7.14 Trip with restart

The action "Trip with restart" results in the following behavior:

- The motor is tripped.
- Acknowledged automatically after the cause of the trip has been rectified (input status).
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

7.15 Trip emergency end position CW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CW" is reported as outgoing (DS92 entry is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CW" is issued in the case of trip end position CW DI static "1", an incoming diagnostic message "trip end position CW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CW direction of rotation (emergency start deactivated).

The action "Trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CW can be overridden by emergency starting.

Example

The following example shows the "trip end position CW" with digital input 1 parameterized to "Trip end position CW":

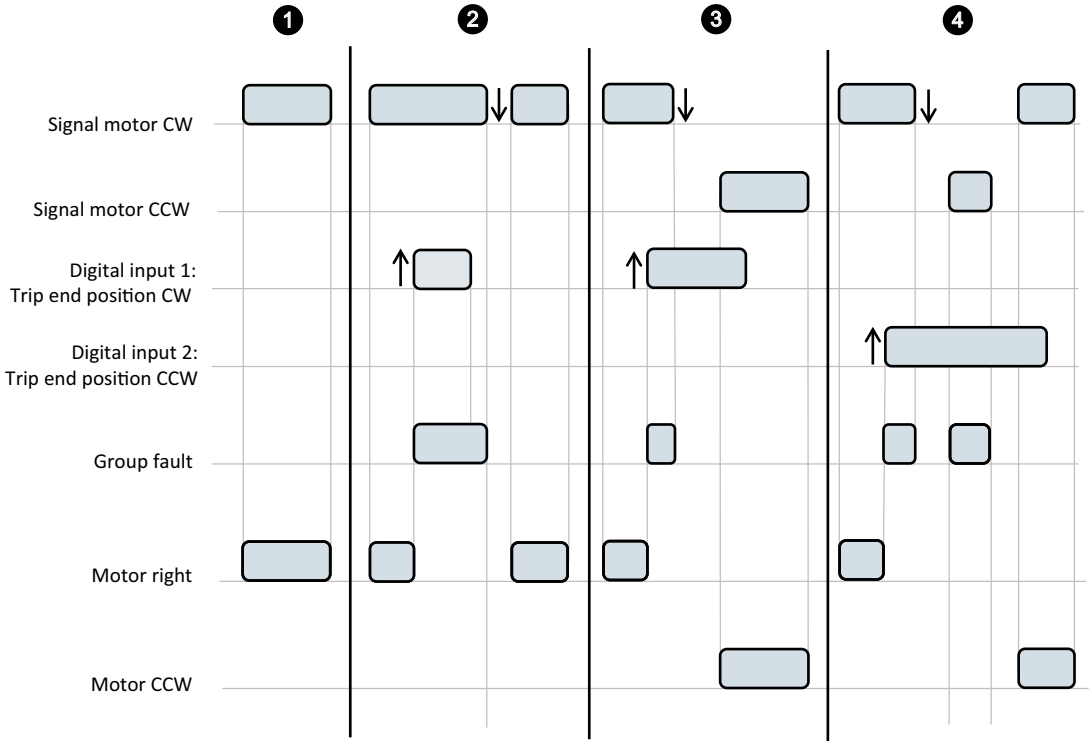


Figure 1-435 Example of trip end position CW

① You switch the motor on by means of "Motor CW". The motor is running.

② You switch the motor on by means of "Motor CW". The motor is running. The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. To switch the motor back on again, digital input 1 and the signal "Motor CW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

③ You switch the motor on by means of "Motor CW". The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. While digital input 1 is set, you can only run the motor counter-clockwise. The group fault is deleted when the signal "Motor CW" is canceled.

④ You switch the motor on by means of "Motor CW". The motor is also switched off by setting the digital input 2 (parameterized to input action 1 = Trip end position CCW). A group fault is generated at the same time by the starter. While digital input 2 is set, you can only run the motor clockwise. To switch the motor back on again, digital input 2 and the signal "Motor CW" or "Motor CCW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

7.16 Trip emergency end position CCW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CCW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CCW" is reported as outgoing (entry 92 is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CCW" is issued in the case of trip limit CCW DI static "1", an incoming diagnostic message "trip end position CCW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CCW direction of rotation (emergency start deactivated).

The action "Trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CCW can be overridden by emergency starting.

7.17 Group warning

The action "Group warning" results in the following behavior:

- A "group warning" is generated.
- An entry with the object number 304 (byte 0, bit 7) is generated in the DS92 Read device diagnostics (Page 133).
- A logbook entry is created in the DS75 logbook - Read events (Page 132).
- The motor is not tripped.
- A maintenance alarm is generated when group warning diagnostics is enabled.

7.18 Emergency start

Description

Emergency start enables restart despite an internal trip command. Emergency start is possible if there is an ON switching command for the motor. The motor is switched on despite a pending trip cause. At a limit trip, the motor starts in the opposite direction.

Emergency starting is not possible in the following situations:

- When you are using a fail-safe motor starter in ATEX operation
- If a device fault is active
- If there is no switched/unswitched 24 V DC supply voltage, or if the supply voltage is outside the specified range.
- The blocking protection has responded
- If a process image error is active

You can activate the function "Emergency start" as follows:

- PIQ 0.4 "Emergency start"
- Via the 3DI/LC module
- Via manual bus mode
- In manual bus mode via DS68

Messages and actions

Table 1-790 Messages and actions emergency start

Message	Action
Emergency start active	Remains pending while emergency start is active, even if the motor is switched off.

7.19 Motor CW

In automatic mode, the motor is activated or deactivated in the CW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.0 "Motor CW" in the process image of the outputs is ignored in manual local mode.

The parameter can only be implemented as an "NO contact".

If "Input n-signal" = retentive, and "Input n-action" = Motor-CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

7.20 Motor CCW

In automatic mode, the motor is activated or deactivated in the CCW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.1 "Motor CCW" in the process image of the outputs is ignored in manual local mode.

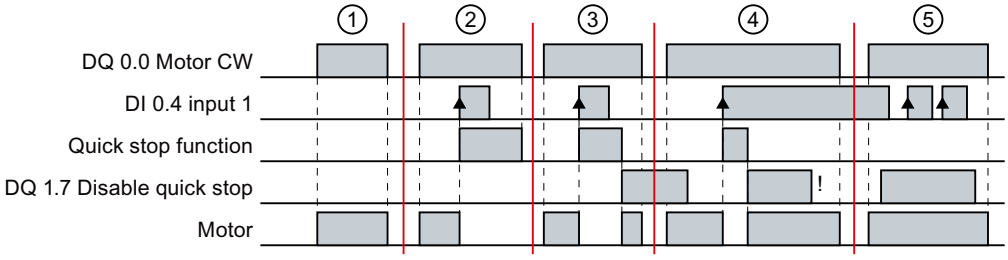
The parameter can only be implemented as an "NO contact".

If "Input n-signal" = retentive, and "Input n-action" = Motor-CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

7.21 Quick Stop direction-independent

- Motor is tripped without group fault.
- "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
- The input action responds to the active edge of the input signal, which means that deactivation is possible when the static input signal "Quick stop" is present.
- The input trigger is reset through cancelation of the "Motor CW" and "Motor CCW" control commands, or by means of "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.
- The motor is tripped regardless of the direction of rotation.

Example 1: Input 1 signal = retentive/edge-triggered



① The motor is switched on by "Motor CW".

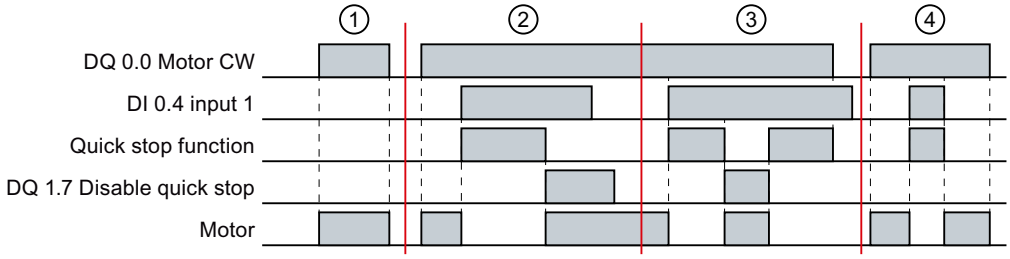
② Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1 (parameterized to input action 1 = Quick Stop). By revoking the "Motor CW" command, the Quick Stop function is reset.

③ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again until the "Motor CW" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again. Although the static digital input signal 1 (DI2) is still present, the motor continues to run and is only reset by revoking the "Motor CW" command.
Reason: The input action is edge-triggered.

⑤ Motor is switched on by "Motor CW" and continues to run uninterrupted since Disable quick stop continuously overwrites the edges of the signal of digital input 1 (DI2).

Example 2: Input 1 signal = non-retentive



① The motor is switched on and off by "Motor CW".

② The motor is switched on by "Motor CW", then switched off by the level at digital input 1 (parameterized with input action 1 = Quick Stop). The Quick Stop function is reset by Disable quick stop. The motor is switched on again since "Motor CW" is still active.

③ The motor is switched off by the level at digital input 1. The "Quick Stop" function is reset by setting "Disable quick stop". As the level "Motor CW" is still active, the motor runs "CW" again until the "Disable quick stop" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the level at digital input 1. While the "Quick Stop" function is active, the motor remains switched off and starts up again when "Quick Stop" is revoked until "Motor CW" is switched off.

7.22 Quick Stop clockwise

The action "Quick Stop CW" results in the following behavior:

- The motor is switched off with pending signal "Motor CW" without group fault
- The motor is not switched off with pending signal "Motor CCW"
- "Quick Stop CW" takes priority over "Motor CW"
- The input action responds to the active edge of the input signal, which means deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the control commands "Motor CW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

7.23 Quick Stop counter-clockwise

The action "Quick Stop CCW" results in the following behavior:

- The motor is switched off with pending signal "Motor CCW" without group fault
- The motor is not switched off with pending signal "Motor CW"
- "Quick Stop CCW" takes priority over "Motor CCW"
- The input action responds to the active edge of the input signal, Deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the commands "Motor CCW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

NOTE

No quick stop CW in the case of direct-on-line starters
You cannot use quick stop CCW in combination with direct-on-line starters.

7.24 Trip RESET

"Trip RESET" acknowledges all the errors/faults that are currently active and that can be acknowledged. An error/fault can be acknowledged if its cause has been rectified or if it is no longer present.

Trip RESET is triggered by:

- Loading a valid parameterization
- Remote RESET via PLC (PIQ bit 0.3 Trip RESET)
- Remote RESET via input actions (if parameterized)
- TEST/RESET button on the ET 200SP motor starter
- Power-on reset (switching off and on again of the 24 V supply voltages on the device)

NOTE

TRIP RESET as input n signal
The "Trip Reset" action is only possible as an "input n signal" (non-retentive).

7.25 Cold start

Description

The "cold start" function enables control of a motor without error messages. The motor starter responds here as if the main power supply were connected to the system. Thus, in the commissioning phase, for example, the relevant control commands are accepted from the controller and the relevant messages are sent.

The "cold start" function enables activation of the motor starter without a main power supply. The motor starter responds here as if the main power supply were connected to the system. The error message "Residual current detection/tripping" is suppressed. Thus, in the

commissioning phase, for example, the relevant control commands are accepted from the controller and the relevant messages are sent.

NOTE
The "cold start" function is not possible for the command "Motor on" in an ATEX configuration.

NOTE
If the main power supply is nevertheless present (current flowing), an internal trip command is generated.

NOTE
The "cold start" action is only permissible as an "input n level" (NO contact) and only as an "input n signal" (non-retentive).

You can activate the "cold start" function as follows:

- PIQ 0.7 "Cold start"
- Via the 3DI/LC module
- In manual bus mode via DS68

7.26 Operational trip end position CW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CW direction of rotation.

The action "Operational trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostic message is set in data set 92.
- Operational trip end position CW cannot be overridden by emergency start.

7.27 Operational trip end position CCW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CCW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CCW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CCW direction of rotation.

The action "Operational trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostics message is set in data set 92.
- Operational trip end position CCW cannot be overridden by emergency start.

7.28 Chatter monitoring

- The following two events trigger the chatter monitoring (it does not matter which channel is used for the switch-on command):
  - There is a new switch-on command within 500 ms after the last switch-on command.
  - There is a switch-on command within the interlock time (standard: 55 to 170 ms after switch-off command, safety: 95 ms to 195 ms after switch-off command).
- The number of new switch-on commands within 500 ms is stored in the statistics data (Page 137).
- 0x311 is sent as a diagnostic interrupt (frequency too high).
- The warning 0x311 (frequency too high) is canceled if no further switch-on command has occurred within 1.5 s.

7.29 Logbook

Description

The logbooks contain a chronological list of device faults, trips and events that are assigned a time stamp, thus creating a log. The log is stored internally so that the causes can be evaluated at a later stage.

Logbooks

Three logbooks that can be read as a data set are available:

- DS72: DS72 logbook - Read device error (Page 128)
- DS73: DS73 logbook - Read triggering operations (Page 131)
- DS75: DS75 logbook - Read events (Page 132)

The operating hours (see Chapter DS95 Read statistics (Page 137)) of the device in seconds are used as a time stamp. You can find the object numbers of the relevant messages in the

relevant data sets. The last 21 entries are stored in the logbooks. You can read out the entries with the relevant data sets. The logbook is designed as a circular buffer. After 21 entries, the oldest entry is overwritten. The latest entry is at the first location.

In case of a retentive error "Fail-safe motor starter defective" (see DS72 logbook - Read device error (Page 128), "Assignment of object number to device fault message" table), the DS72, DS73 and DS75 logbooks are frozen when the supply voltage (24 V DC) is removed, i.e. no further entries are permitted.

Logbook - Read device errors

The logbook "Read device errors" contains all device errors/faults. The object numbers of the actual fault causes are entered, e.g. object number 476, "Current measurement defective".

Logbook - Read trips

The logbook "Read trips" contains all group faults. The object numbers of the actual fault causes are entered, e.g. "Switching element defective".

Logbook - Read events

The logbook "Read events" contains all warnings as well as certain actions. Incoming events are reported as incoming. In addition, some events are also reported as outgoing. Incoming entries are marked "+". Outgoing events are marked "-".

7.30 PROFIenergy

7.30.1 What is PROFIenergy?

PROFIenergy supports the following two functions:

- Energy saving function

  Supports targeted shutdown of loads during idle times.
- Measured value function

  Energy management is an instrument which is ideally suited to reducing energy consumption and thereby energy costs within a company both systematically and on a long term basis. The aim of energy management is to optimize the use of energy in a company - from the purchasing of energy through to the consumption of energy - economically and ecologically. The measured value function provides the measured values required for optimization.

7.30.2 PROFIenergy in the motor starter

The ET 200SP motor starter supports the "Energy saving function" and "Measured value function" for the motor current. These are identified as commands, since they trigger reactions in the ET 200SP motor starter.

In addition, the ET 200SP motor starter also provides so-called services that provide information on the status of the motor starter as defined in PROFIenergy. These can then be evaluated and further processed in the user program.

Using PROFIenergy with the ET 200SP motor starter

SIEMENS provides two function blocks for using PROFIenergy:

- PE_START_END (FB815) supports the switch to an energy-saving mode.
- PE_CMD (FB816) supports the reading out of measured values and the switch to an energy-saving mode

You will find further information in the document entitled "Common Application Profile PROFIenergy, Technical Specification for PROFINET Version V1.1 Edition 2, Dec. 2013, Order Number 3802" published by PROFIBUS International (PI).

NOTE

PROFIenergy is not possible with PROFIBUS interface modules.

NOTE

The PROFIenergy function is available with firmware version V3.3 of the interface modules.

Commands

The following tables show the supported commands:

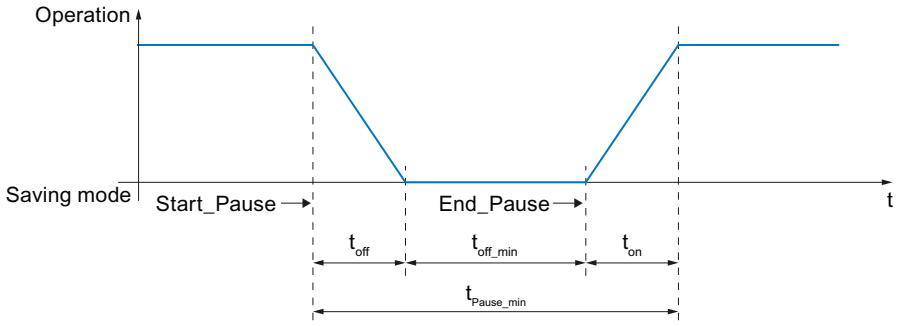
Control commands	
Start_Pause	The starter switches to energy-saving mode.
Start_Pause_with_time_response	The starter switches to energy-saving mode and signals its minimum idle times.
End_Pause	The starter switches back to operating mode.

Status commands	
PE_Identify	Provides a list of supported PROFIenergy commands/functions.
PEM_Status	Returns the current mode.
PEM_Status_with_time_response	Returns the extended status of the current mode.
Query_Modes	
List_Energy_Saving_Modes	Provides a list of supported energy-saving modes.
Get_Mode	Provides the parameter values with which the energy-saving function works.
Query_Version	Shows the implemented PROFIenergy profile.
Query_Measurement	
Get_Measurement_List	Provides a list of supported measured values.

Status commands	
Get_Measurement_List_with_object_-number	Provides a list of supported measured values and the associated object number.
Get_Measurement_Values	Provides the requested measured values.
Get_Measurement_Values_with_obje-ct_number	Provides the requested measured values together with the object number.

The ET 200SP motor starter operates with the following PROFIenergy modes (PE modes):

PE_Mode_ID = 255	Ready to operate
PE_Mode_ID = 01	Energy-saving mode



t_{off}	Time_to_Pause	Time the starter requires in order to change to energy saving mode. With the ET 200SP motor starter, this time is always 100 ms.
t_{off_min}	Time_min_length_of_stay	Minimum time that the device spends or should spend in saving mode. For the ET 200SP motor starter: 150 ms
t_{on}	Time_to_operate	Time that will elapse before the starter changes back to the operating state. For the ET 200SP motor starter: 100 ms (due to startup sequence)
t_{Pause_min}	Time_min_Pause	Time that is compared with t_{Pause} (is transferred together with the "Start_Pause" command to the motor starter); if $t_{Pause} \geq t_{Pause_min}$, the device switches to saving mode.

"Measured value function" command

Measured values for energy need to be supplied for efficient energy management. The PROFIenergy specification offers various measured values from which to choose, each of which is assigned a measured value ID. The ET 200SP motor starter supports the instantaneous values of the phase current and the mean value of the phase currents as measured values.

The measured values are uniquely identified by IDs. The following measured value IDs 7, 8, 9, and 33 are supported:

- ID = 7: Current rms value of the phase current a (L1)
- ID = 8: Current rms value of the phase current b (L2)
- ID = 9: Current rms value of the phase current c (L3)
- ID = 33: Mean value of the three phase currents (a+b+c)/3

The current values are transferred with the following tolerances:

- Domain = 0x03 → IEC 61557-12
- Class = 0x0B → 5 %

The result is that the measured values are transferred with an accuracy of 5 % relative to the maximum configurable rated operational current I_e.

Reaction of the starter when energy-saving mode is activated

Shutdown of the motor by suppression of the PIQ bits (Motor CW, Motor CCW). The other PIQ bits (e.g. Trip RESET) remain active.

Interactions with the various operating modes

- PROFIenergy is operative only in Automatic mode
- Manual local mode is not influenced by PROFIenergy; it is still possible to switch to manual mode and thereby to control the motor manually
- Both cyclic and acyclic data transmission (PIQ, PII, data sets, diagnostics, alarms, etc.) to and from the motor starter are still possible

Prerequisites for the starter to switch to energy-saving mode (min. idle time, etc.)

The changeover to "Pause" energy-saving mode only becomes effective when the idle time sent is greater than the device-specific minimum idle time. This means that a switch is only performed when the pause is longer than the motor starter requires to switch the main energy for the load off and on again.

The switch to energy-saving mode is recorded in the "Events" logbook. Entry: "Energy saving mode active"

See also

Application example (https://support.industry.siemens.com/cs/ww/en/view/109478388)

PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127)

7.31 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions). You update the firmware of the motor starter with the help of firmware files.

NOTE

Note the preconditions for a firmware update/downgrade
You can find the preconditions for a firmware update/downgrade in the Siemens Industry Online Support under the entry Firmware update for ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/view/109486088).

Loading and installing a firmware update

- Click "Product Support" on the Siemens Industry Online Support (https://support.industry.siemens.com/) page.
- In the product tree selection field, select "Automation engineering → Automation systems → SIMATIC industrial automation systems → Controllers → IO systems → ET 200 systems for the control cabinet → ET 200SP".

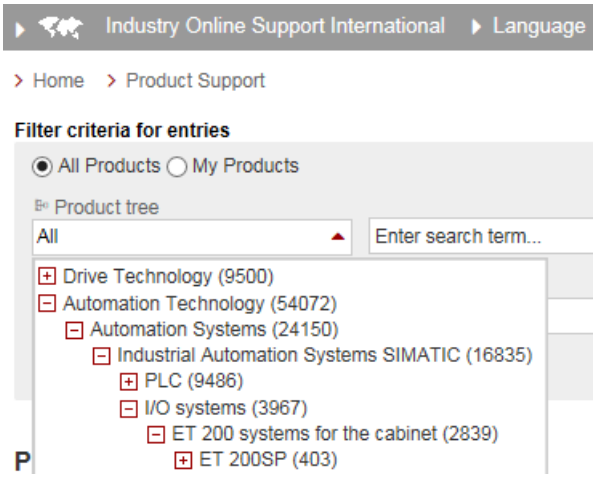


Figure 1-436 ET 200SP in the product tree

- Navigate to the specific type of module that you want to update.
- Under "Product information → Support", click on the "Software downloads" link.
- Download the required firmware update files.

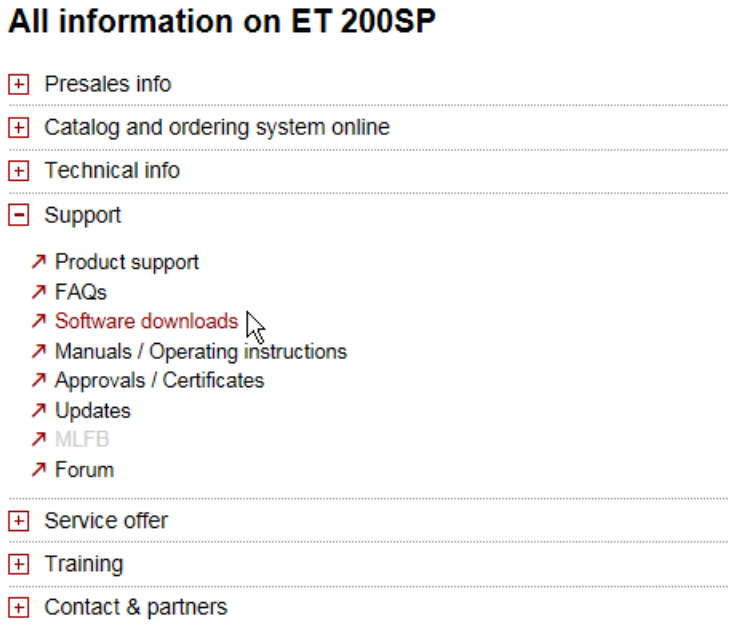


Figure 1-437 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.

NOTICE
Firmware update for fail-safe motor starters In the case of fail-safe motor starters, the firmware update is permissible only if the motor starter is the only module on a rack. Make sure before a firmware downgrade of fail-safe motor starters with a F-DI BaseUnit (MS5-MS10) that the associated F-DI is on 1-signal (=value of "1"). Also make sure that the motor starter is only connected to the device on which the firmware is being updated (e.g. PG/PC or CPU).

NOTICE
Loss of the safety function after an incorrect firmware update The safety functions can be lost if you inadvertently install a firmware update on a motor starter for which the update was not intended. Make sure that the PG/PC or the CPU is exclusively connected to the motor starter on which the firmware is being updated.

NOTE

Securing the supply voltage

On starting, and during the firmware update, the 24 V DC supply voltage must be applied at the header module and the motor starter.

NOTE

Interrupted firmware update

If a firmware update has been interrupted, remove and reconnect the affected module before a renewed firmware update.

⚠ WARNING

Risk of impermissible system states

The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure due to a firmware update can cause an unpredictable motor starter state. After completion of the update, the current PIO and the input actions take effect again.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to property damage.

Before installing the firmware update, ensure that the motor starter, the CPU and the interface module are not executing an active process.

More options for the firmware update

The following options are available for updating firmware:

- Online via PROFINET IO/PROFIBUS DP (with STEP 7), see below
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules), see below
- With the TIA Portal:
  - Non-fail-safe ET 200SP motor starter, SIMATIC STEP 7 V13 SP1 or higher with installed HSP
  - Fail-safe ET 200SP motor starter, SIMATIC STEP 7 V14 or higher with installed HSP
- Via a SIMATIC memory card, see below
- With SIMATIC STEP 7 Version V5.5 SP4 or higher

Procedure using STEP 7

Proceed as follows to perform an online firmware update with STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

NOTE

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure using a SIMATIC memory card
Proceed as follows to perform a firmware update via the SIMATIC memory card:

1. Insert a SIMATIC memory card into the SD card reader of your programming device / computer.
2. To save the update file on the SIMATIC memory card, mark the SIMATIC memory card in the project navigator under "Card reader/USB memory".
3. In the "Project" menu, select the command "Card Reader/USB memory → Create firmware update memory card".
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card containing the firmware update files in the CPU.

Procedure using the Web server
The procedure is described in the Function Manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).

Behavior during the firmware update

Note the following behavior during the firmware update of the motor starter:

- The LEDs flash as described in chapter "Status and error displays (Page 115)".
- The motor starter powers up again after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the thermal motor type and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module. A successfully loaded firmware update is activated immediately.

If a fail-safe motor starter is in "Manual local" mode during the firmware update, the motor starter switches to Commissioning mode (Page 100) after the successful firmware update operation. You must first confirm ATEX parameters before you can perform manual local control (see Configuring ATEX operation (Page 107)).

Online help for STEP 7

You can find more information on the procedure in the STEP 7 online help.

Parameters/address space

8

8.1 Parameter assignment

When configuring an ET 200SP motor starter, the full parameterization scope is set and automatically transferred to the motor starter. When parameterizing in the user program, the parameters are transferred to the module via the data sets with the statement "WRREC". If the CPU initiates a new parameter assignment, e.g. if communication breaks down, the parameterization is overwritten by the system parameterization via the user program.

The modules of the ET 200SP distributed I/O system support the full parameterization scope of the ET 200SP motor starters.

NOTE

List of supported ET 200SP header modules

You will find a list of the compatible ET 200SP header modules in the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109485777).

NOTE

Reduction to default parameters

In the following cases, the full scope of parameterization is reduced by the configuring software to the standard parameters (DS201) for system reasons:

- Activated DPV0 alarm mode (in the case of PROFIBUS IMs)
- Activated option handling (in the case of PROFIBUS IMs)
- When configuring using a GSD (for parameters, see Read/write DS201 device parameter 1 (Page 139))

NOTE

Trip RESET

When you send valid parameters to the motor starter, a trip RESET is triggered. Acknowledgeable active faults are deleted.

Parameters for ET 200SP motor starter

The effective range of the adjustable parameters depends on the type of configuration. The following configurations are possible:

- Centralized operation with an ET 200SP CPU and the ET 200SP Open Controller
- Distributed operation on the PROFINET IO in an ET 200SP system
- Distributed operation on the PROFIBUS IO in an ET 200SP system

When you assign parameters in the user program, transfer the parameters to the module via the data sets with the "WRREC" statement.

The parameters that can be set can be found in the Appendix in Read/write DS201 device parameter 1 (Page 139) and Read/write DS202 device parameter 2 (Page 141).

You will find an explanation of the parameters in Chapter Declaration of parameters (Page 103).

NOTE
Changing the parameters during operation
If parameters are modified during operation, they will be overwritten by the parameters configured in the hardware configuration during a restart of the control system.
If this is not desired, a command must be issued to disable parameterization.

You set the parameter block in theDS93 Write command (Page 136).

8.2 Commissioning mode

Commissioning mode is available for fail-safe ET 200SP motor starters.

When setting up a system, you can test the wiring without the functioning PROFINET or PROFIBUS connection. Perform the test in commissioning mode.

The motor starter switches to commissioning mode in the following cases:

- After the power supply has been activated, the motor starter does not receive any parameterization via the backplane bus.
- The DI module's "Local Control" switch is activated.
  As soon as Local Control is active, the parameterization saved last is used when the power supply is activated. Control via the DI module is possible after confirmation via the TEST/RESET button.

To switch to commissioning mode in the case of fail-safe motor starters, confirm the change with the blue button. During ATEX operation, additionally confirm the current parameters, as described in chapter "Configuring ATEX operation (Page 107)".

If the motor starter receives valid parameterization via the backplane bus in commissioning mode, the parameterization is placed in intermediate storage. The parameterization becomes active when "Local Control" is terminated (motor OFF). The commissioning mode is exited.

Inputs for commissioning
To ensure operation of a motor in the unparameterized state of the ET 200SP motor starter with the aid of the 3DI/LC module, the input parameters in data record 201 are permanently assigned the following values by default:

- DI1: Motor CW
- DI2: Motor CCW
- DI3: Cold start (fail-safe motor starters as of V1.2.0)

This pre-parameterization is overwritten when the ET 200SP motor starter is parameterized.

8.3 Parameterization using a GSD file

For the ET 200SP-IM155 interface module of the ET 200SP system, there are two different GSD files, one for operation with PROFINET and one for operation with PROFIBUS. The GSD and GSDML files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

If you configure the ET 200SP motor starter in the PROFIBUS environment with GSD, and the standard values in data set 202 have to be changed, then you create data set 202 via the user program on initial commissioning of the starter. Transfer the data set to the PLC.

Parameterization with the PROFINET GSDML file

The ET 200SP motor starter can be fully configured with all parameters with the GSDML file for PROFINET.

Parameterization with the PROFIBUS GSD file

Two parameter data sets (DS201 and DS202) are used for configuring the ET 200SP motor starter. Only data set DS 201 is ever transferred as the startup data set when using a PROFIBUS GSD.

8.4 Slot rules

You can find further information on the structure of a system with an ET 200SP motor starter in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

8.5 Data plausibility check

Check of the incoming parameters in the "Automatic" and "Manual bus" modes

The motor starter checks all incoming parameters for validity and plausibility, provided manual local mode is not active. The valid parameters are stored in data set 203 and 204.

In the case of incorrect parameters during startup (after power ON):

- The diagnoses "Group fault" and "Invalid parameter value" are set in the DS92 Read device diagnostics (Page 133).
- The motor remains shut down.
- An "Invalid parameter value" logbook entry (object number 365) is created in DS73 logbook - Read triggering operations (Page 131).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 142). Incorrect parameters can be read back and verified in the Read/write DS201 device parameter 1 (Page 139).

In the case of incorrect parameters from the user program and when the motor is switched off:

- The "Group warning" and "Invalid parameter value" diagnoses are set and the number of the invalid parameter is entered in DS92 Read device diagnostics (Page 133).
- A logbook entry is created in the DS75 logbook - Read events (Page 132).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 142). Incorrect parameters can be read back and verified in data set 201.

For parameters when the motor is running:

- The parameters are not accepted by the starter.
- The "Parameters cannot be changed in ON state" maintenance alarm is set if the maintenance alarm is enabled in the current parameterization.
- The "Group warning" and "Invalid parameter value" entries are set in DS92 Read device diagnostics (Page 133) and the number of the invalid parameter is entered.
- The motor is not switched off.
- A logbook entry is created in the DS75 logbook - Read events (Page 132).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 142). Incorrect parameters can be read back and verified in the Read/write DS201 device parameter 1 (Page 139).

Checking incoming parameters in "Manual local" mode

The incoming parameters are checked as follows in "Manual local" mode:

- When the motor is switched off:

  The motor starter saves the parameter and accepts it only when the motor starter has switched over to "Automatic" mode again. Only after changing to "Automatic" are the parameters checked.
- When the motor is running:
  - The parameters are not accepted by the motor starter, even if the motor starter changes later to "Automatic" mode.
  - The diagnosis "Parameters cannot be changed in ON state" is set in the DS75 logbook - Read events (Page 132).
  - The diagnosis "Group warning" is set.
  - The motor is not switched off.
  - A logbook entry is created
  - The currently valid parameter values are retained.

Checking incoming parameters in "Manual bus" mode

The incoming parameters are not accepted and saved in "Manual bus" mode.

8.6 Declaration of parameters

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2x the setting current (motor protection to IEC 60947).

For more information, see Chapter Overload protection (Page 55).

Rated operational current I_e

This is where you can enter the rated operational current that the branch (switchgear and motor) can carry without interruption. The setting range depends on the relevant device's rating class.

For more information, see Chapter Rated operational current (Page 48).

Blocking current

If the blocking current is overshot, the motor starter detects stalling.

For more information, see Chapter Blocking time and blocking current (Page 70).

Blocking time

The blocking time is the time a motor block can be permitted without tripping the motor. If the blocking time expires and the system is still stalled, the motor starter switches off.

For more information, see Chapter Blocking time and blocking current (Page 70).

Diagnosis Electronics supply voltage too low

With this device parameter, you define whether a message is to be displayed if the supply voltage is too low (as of firmware V1.2.0).

Input n action

Different actions can be triggered when an input signal is present.

You can find out which actions you can parameterize depending on "Input n level", "Input n signal" and "Mode" in chapter Inputs (Page 76).

Input n level

You use this device parameter to specify the input logic.

For more information, see Chapter Inputs (Page 76).

Input n signal

You use this device parameter to determine whether or not the input level of the digital inputs is to be saved.

For more information, see Chapter Inputs (Page 76).

Load type

Here, you can specify whether the motor starter must protect a 1-phase load (direct-on-line starters only) or a 3-phase load.

For more information, see Chapter Load type (Page 49).

Upper/lower current limit

You can enter a lower and/or an upper current limit value.

NOTE
The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

For more information, see Chapter Upper/lower current limit (Page 69).

Upper/lower current warning limit

You can enter a lower and/or an upper current warning limit value.

NOTE
The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

For more information, see Chapter Upper/lower current warning limit (Page 69).

Group error diagnostics

You use this parameter to determine whether diagnostics via PROFINET or PROFIBUS DP (fault type) are enabled or disabled.

For more information, see Chapter Group fault diagnostics/group warning diagnostics (Page 76).

General warning diagnostics

You use this device parameter to determine whether or not a maintenance alarm is forwarded to the higher-level CPU.

For more information, see Chapter Group fault diagnostics/group warning diagnostics (Page 76).

Thermal motor model (response to overload)

You use this device parameter to determine how the motor starter is to respond to overload.

For more information, see Chapter Overload protection (Page 55).

Response to CPU/master STOP

Determines the module's response to CPU STOP.

For more information, see Chapter Response to CPU/master STOP (Page 76).

Response to residual current detection

You use this device parameter to specify how the motor starter is to respond to residual current detection.

For more information, see Chapter Response to residual current detection (Page 65).

Response to asymmetry

You use this device parameter to determine how the motor starter is to behave in the event of asymmetry.

For more information, see Chapter Asymmetry monitoring (Page 73).

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit. At a warning limit of 0 %, the function is deactivated.

For more information, see Chapter Overload protection (Page 55).

8.7 Assigning fail-safe motor starter parameters

8.7.1 Explanation of safety-related parameters

Ex motor

The motor starter can switch and protect loads in an EX protection zone (see Ex motor application (Page 75)).

Response to safety-related tripping

The motor starter can send a warning to the CPU if tripping has been triggered through the fail-safe input (see Response to safety-related tripping (Page 74)).

8.7.2 Setting safety-related parameters

Fail-safe motor starters possess the following safety-related parameters:

- Ex motor
- Rated operational current
- Trip class

Response to modified safety-related parameters

If modified safety-related parameters are received during run-up, the parameters are displayed. Confirm the modified parameters by pressing the Reset button twice before continuing work.

If modified safety-related parameters are received after run-up has been completed, the motor starter responds as follows depending on its status:

- Motor OFF in automatic mode

  The motor starter accepts the new parameters. The parameters are indicated by the LEDs' flashing sequence. To activate the parameters, confirm them with the blue button. The motor cannot be switched on before the parameters are activated.
- Motor ON in automatic mode and in manual local mode

  The motor starter rejects the parameters. The "Parameter changes not allowed in motor ON state" message is issued. As communication is not secure, the motor starter does not respond to the modified parameters. Depending on the parameterization, entries in data set "DS92" or diagnostic interrupts are generated. The entries in data set "DS92" are deleted as soon as the modified parameters are active.
- Manual local mode

  The motor starter accepts the new parameters and saves them. As soon as manual local mode is ended, the parameters are activated and indicated by means of the LEDs' flashing sequence. Confirm the parameters with the blue button. The motor cannot be switched on before the parameters are activated.
- Manual bus mode

  The motor starter accepts the new parameters. The parameters are indicated by the LEDs' flashing sequence. To activate the parameters, confirm them with the blue button. The motor cannot be switched on before the parameters are activated.

The motor starter remains in the safe state (STO) until you have confirmed the parameters. Before you have confirmed the parameters, they can already be read out in data set "DS203". Data set "DS201" is accepted. A group warning in the DS92 Read device diagnostics (Page 133) and in the process image input is triggered. Moreover, a maintenance alarm, "New safety-related parameters received" (0x1036), can be generated.

Response to invalid parameterization

If inconsistent or invalid parameterization is detected, the applicable parameters are discarded. Entries in data set "DS92" or diagnostic interrupts are generated. To narrow down the invalid parameterization, compare the parameter values from the data sets "DS201" and "DS203" or "DS202" and "DS204".

Reading back the data sets "DS201" and "DS202" returns the last correctly transferred data set, even if it is rejected later due to inadmissible content.

Data sets with incorrect lengths are rejected and discarded. The starter continues to operate with the last valid parameter.

8.7.3 Configuring ATEX operation

ET 200SP fail-safe motor starters protect motors in an ATEX environment. The following parameters are considered to be safety-related in ATEX operation:

- Rated operational current (I_e)
- Trip class

You set the parameters via the data sets or using the engineering software.

Before the new safety-related parameters are accepted, however, check and confirm the new parameters. The parameter settings are indicated by means of a flashing sequence of the LEDs on the fail-safe motor starter. As soon as you have ensured with the aid of the LEDs that all parameters are correctly set, confirm the new parameters on the device by means of the blue button. The parameters are not accepted until you have confirmed and the motor starter is "Ready for motor ON". Changes to parameters that are not safety-related do not require confirmation.

LED flashing sequence

The following graphic shows the order in which the LEDs flash:

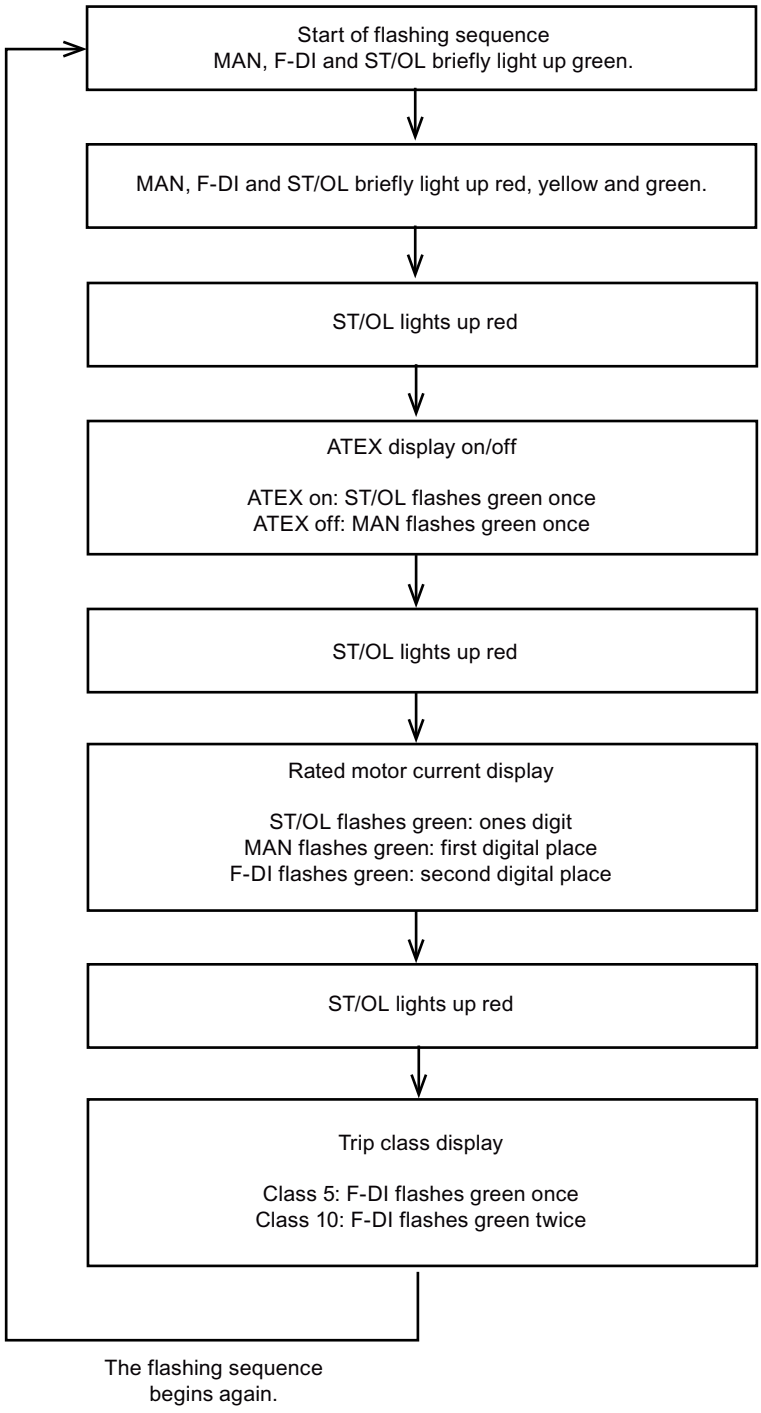


Figure 1-438 Flashing sequence during ATEX operation

The start of the flashing sequence is indicated by the "MAN", "F-DI" and "ST/OL" LEDs, which light up briefly in green all at the same time. The multi-colored LEDs then light up in red and yellow. Lighting up also serves to verify that all LEDs are functioning correctly.

To signal display of the next parameter, the "ST/OL" LED briefly lights up in red between every flashing signal for a set parameter.

The flashing sequence ends as soon as you press the blue button twice and confirm the set parameters.

NOTE

Receiving several parameter assignments

If safety-related parameters are received during a flashing sequence, conform the first parameters (or reject them) first. Only then are the parameters that have been sent last indicated. The motor cannot be started until the parameters last sent are valid and you have confirmed them.

NOTE

ATEX operation is not possible in connection with an activated parameter block

If the parameter block is activated and an ATEX parameter assignment is received, the device fault 461 and the diagnostic interrupt 0x1095 are output.

Disable the parameter block of the corresponding motor starter before you send ATEX parameters.

Rejecting ATEX parameterization

Proceed as follows if you want to reject the set parameterization:

1. Press the blue button for longer than five seconds.

   A group fault is output and the "Invalid parameter value" diagnostic message in data set 92 is set. A logbook entry is also created in data set 73. The diagnostic interrupt 0x1095 is also triggered if group fault diagnostics is enabled. In this state you cannot trigger any of the other functions.
2. Send the correct parameterization via the data set "DS201".
3. Confirm the correct parameterization.

Displaying ATEX parameters

To display the safety-related parameter settings during normal operation, press the TEST/RESET button for at least five seconds.

8.7.4 Examples of LED flashing sequences

Below you see a few examples of the LED flashing sequence.

Example of I_e = 5 A and CLASS 10

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 5 A and CLASS 10:

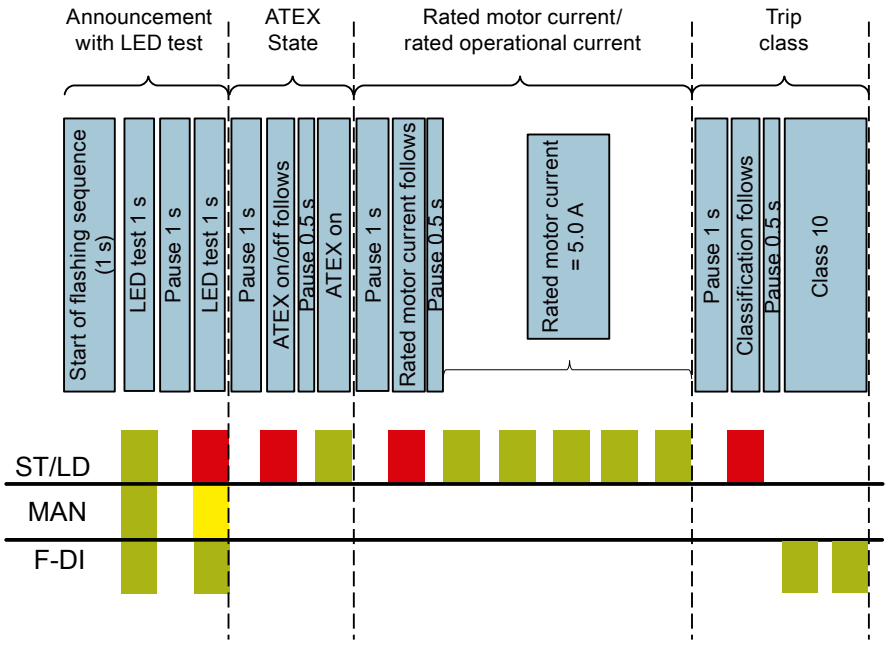


Figure 1-439 Display example I_e = 5.0 A CLASS 10

Example of I_e = 0.34 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 0.34 A and CLASS 5:

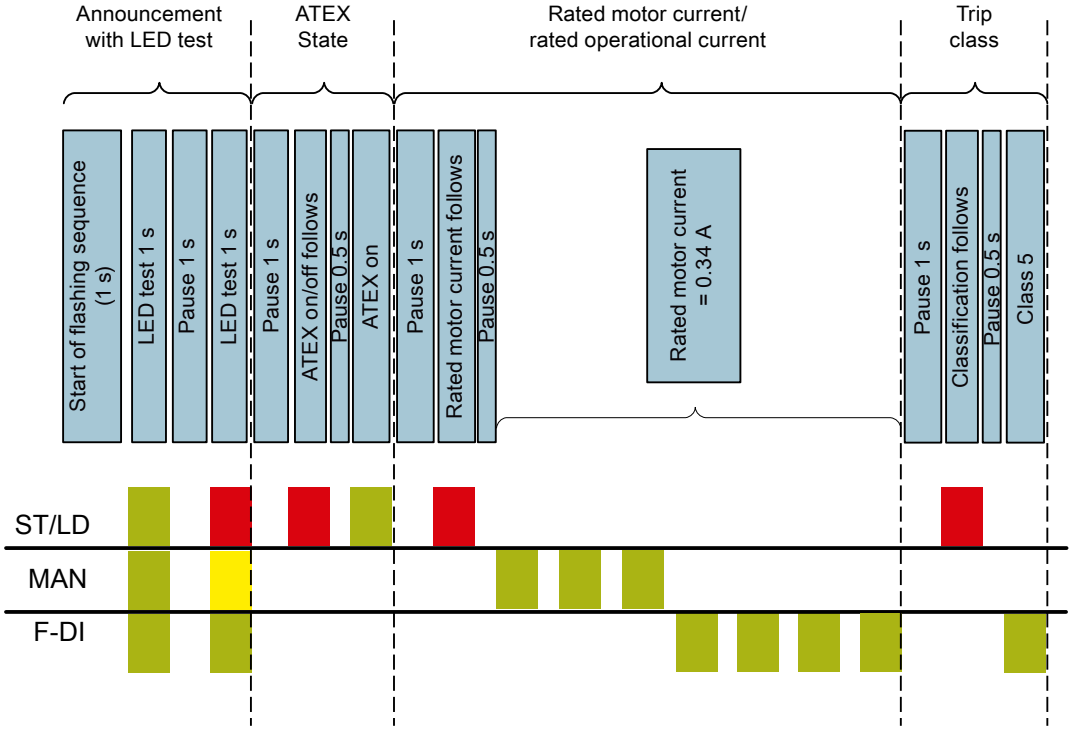


Figure 1-440 Display example I_e = 0.34 A CLASS 5

Example of I_e = 11.4 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 11.4 A and CLASS 5:

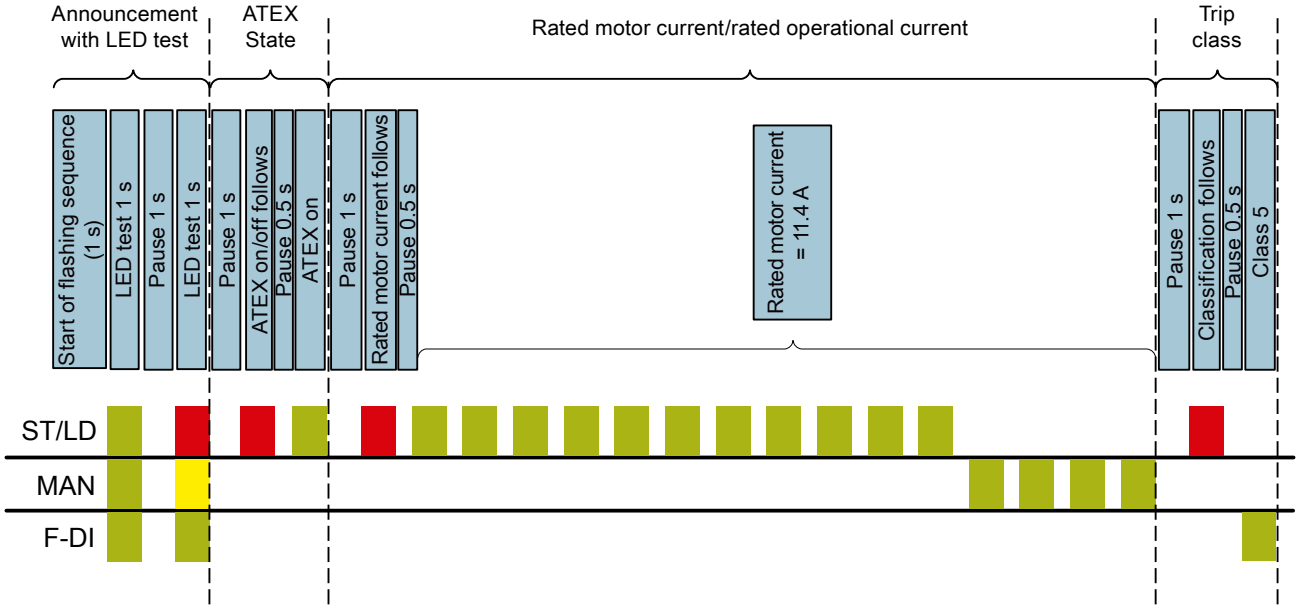


Figure 1-441 Display example 11.4 A CLASS 5

Example of I_e = 3.75 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 3.75 A and CLASS 5:

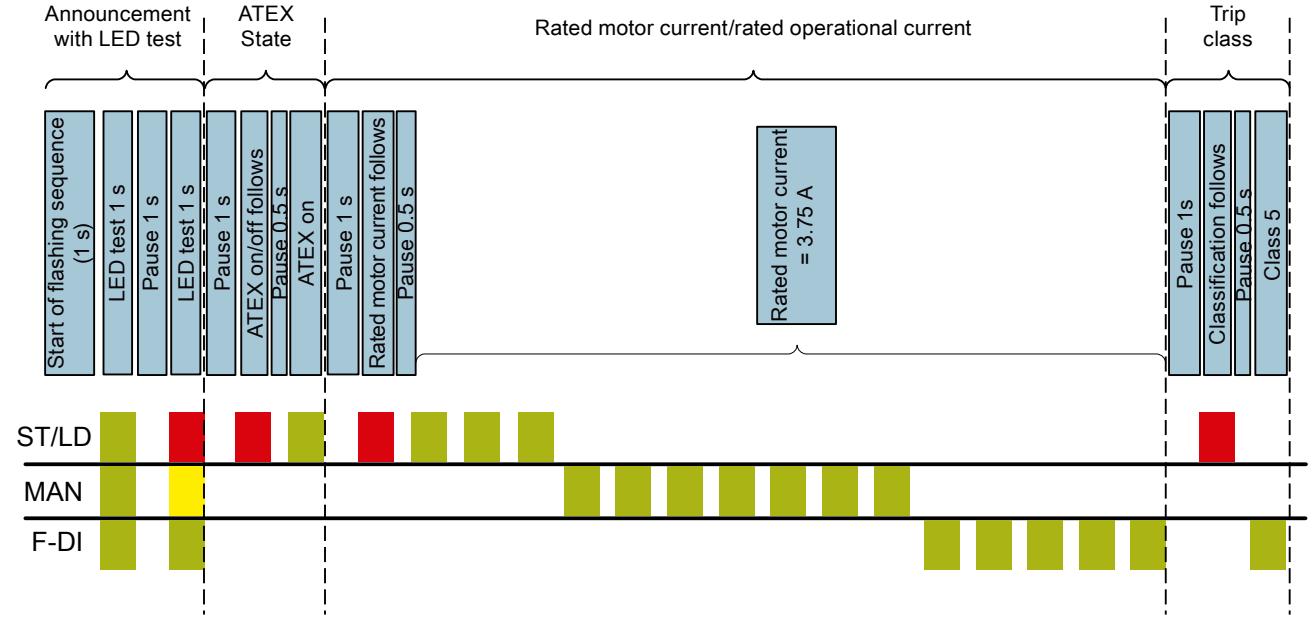


Figure 1-442 Display example Ie = 3.75 A CLASS 5

ATEX off display

The following figure shows the LED flashing sequence when ATEX operation for a fail-safe motor starter is deactivated:

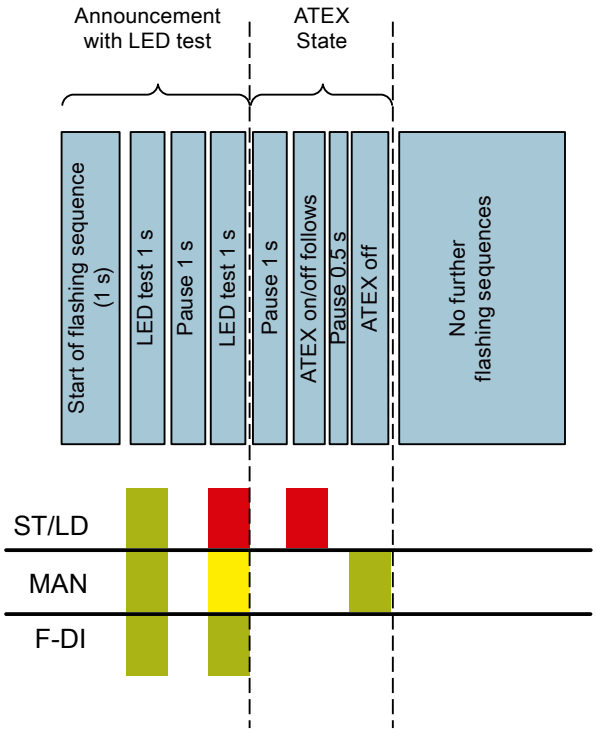


Figure 1-443 ATEX off display

8.8 Address space

Process image of the outputs

Table 1-791 Contents of process image of the outputs (in bytes 0 to 1)

Process data	Meaning	Relevant for
DQ 0.0	Motor CW	All
DQ 0.1	Motor CCW	Reversing starters only
DQ 0.2	-	-
DQ 0.3	Trip RESET	All
DQ 0.4	Emergency start	All (except activate "EX motor" parameter)
DQ 0.5	-	-
DQ 0.6	-	-
DQ 0.7	Cold start	All
DQ 1.0	-	-
DQ 1.1	-	-
DQ 1.2	-	-
DQ 1.3	-	-

Process data	Meaning	Relevant for
DQ 1.4	-	-
DQ 1.5	-	-
DQ 1.6	-	-
DQ 1.7	Disable quick stop	All

Process image of the inputs

Table 1-792 Process image of the inputs (in bytes 0 to 3)

Process data	Meaning	Relevant for
DI 0.0	Ready (automatic)	All
DI 0.1	Motor ON	All
DI 0.2	Group fault	All
DI 0.3	Group warning	All
DI 0.4	Input 1	All (with 3DI/LC module)
DI 0.5	Input 2	All (with 3DI/LC module)
DI 0.6	Input 3	All (with 3DI/LC module)
DI 0.7	Input LC	All (with 3DI/LC module)
DI 1.0	Motor current I_{curr} [%] bit 0	All
DI 1.1	Motor current I_{curr} [%] bit 1	All
DI 1.2	Motor current I_{curr} [%] bit 2	All
DI 1.3	Motor current I_{curr} [%] bit 3	All
DI 1.4	Motor current I_{curr} [%] bit 4	All
DI 1.5	Motor current I_{curr} [%] bit 5	All
DI 1.6	Manual local mode	All (with 3DI/LC module)
DI 1.7	-	-
DI 2.0	Ready to start for motor ON	All
DI 2.1	Motor ON - RIGHT	All
DI 2.2	Motor ON - LEFT	Reversing starters only
DI 2.3	Quick stop active	All
DI 2.4	Energy saving mode active	All
DI 2.5	DI module inserted	All
DI 2.6	Explosion protection of the motor active	Fail-safe starters only
DI 2.7	Parameter block active	All [1)]
DI 3.0	Thermal motor model overload	All
DI 3.1	-	-
DI 3.2	I_e current limit tripping	All
DI 3.3	F-DI status	Fail-safe starters only
DI 3.4	Residual current detected	All
DI 3.5	Asymmetry detected	All
DI 3.6	Overtemperature	All
DI 3.7	-	-

1) From FW Version 1.2.0

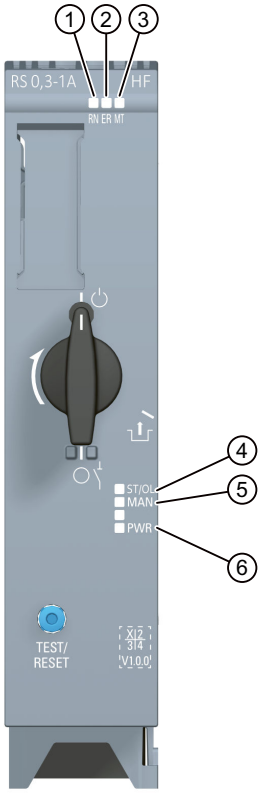
Alarms/diagnostic messages

9

9.1 Status and error displays

LED display

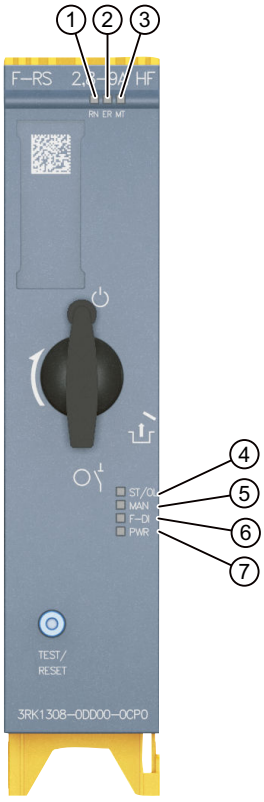
The figure below shows the LED display on the ET 200SP motor starter:



①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	PWR	(green)	- Power

Figure 1-444 LED display on the ET 200SP motor starter

The figure below shows the LED display on the fail-safe ET 200SP motor starter:



①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	F-DI	(green)	- Fail-safe digital input
⑦	PWR	(green)	- Power

Figure 1-445 LED display on the ET 200SP Failsafe motor starter

Meaning of the LEDs

The tables below give the meanings of the status and fault displays:

RN/ER/MT LED

Table 1-793 RN/ER/MT status and error displays

LEDs			Meaning	Explanation
RN (RUN)	ER (ERROR)	MT (MAINT)		
■ On	Not relevant	Not relevant	Operating state "RUN", the ET 200SP motor starter is in a "normal" application and executes the control commands. The current operating mode is not relevant.	-
☼ Flashes	Not relevant	Not relevant	Startup (Cfg + Par.) Self-test Module deactivated Parameterization error	System operating state "System startup" A parameterization fault during startup prevents exiting of this state. The SIMATIC ET 200SP motor starter reports a fault.
				Wait until the ET 200SP motor starter is ready.
				Firmware update
				The module has been deconfigured.
Not relevant	Not relevant	■ On	Maintenance demanded (warning)	Group warning At least one Maintenance demanded alarm has been transferred to the controller. Possible causes: • Motor model has exceeded warning limit • Current value has exceeded or undershot warning limit • Start disabled, ET 200SP motor starter too warm (without ON command)
Not relevant	☼ Flashes at ≥ 2 Hz	Not relevant	Error	Group fault At least one Error alarm has been transferred to the controller. Possible causes: • Electronics supply voltage too low or too high • Motor protection disconnection • Thermal overload of the ET 200SP motor starter • Missing load voltage, phase failure/missing load • The mechanical rotary interlock is not in the READY position.
■ On	OFF	☼ Flashes	PROFIenergy active	-
☼ Flashes	OFF	☼ Flashes	Action required	Ex motor (ATEX): New safety-related parameters are available for release.

ST/OL (STATE/OVERLOAD) LED

Table 1-794 Status display ST/OL

ST/OL LED	Motor operating state	Meaning
■ On	Operation	ON command for motor active
□ Off	STOP	The motor is switched off. It is not known whether the motor is still rotating or not.
☼ Flashes at 0.5 Hz	Overload	The thermal motor model or device protection model has tripped.

MAN (MANUAL) LED

Table 1-795 Status display MAN

MAN LED	Meaning	Remedy
□ Off	Manual local mode deactivated	-
■ On	Manual local mode activated	-
☼ Flashes at 1 Hz	Connection abort in manual bus mode	-

PWR (POWER) LED

Table 1-796 Status display PWR

PWR LED	Meaning	Remedy
□ Off	Supply voltage not present or too low	Check the supply voltage.
■ On	Supply voltage present	-

LED F-DI for fail-safe motor starters

Table 1-797 Status display F-DI

LED F-DI	Meaning	Remedy
□ Off	LOW level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-
■ On	HIGH level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-

LED combinations

Table 1-798 Status displays ST/OL/MAN/PWR

LEDs			Meaning	Explanation
ST/OL (State/Over-load)	MAN (Manual)	PWR (Power)		
Lights up for 4 s	Lights up for 4 s	Lights up for 4 s	LED/fan test	All LEDs are switched on for 4 s (triggered by pressing the blue button).
Flashes	Flashes	Lights up	Firmware update active or canceled	-
OFF	OFF	OFF	No supply voltage	No supply voltage available A detected undervoltage (in the case of still functioning electronics) is not reported as power OFF, but as a fault.
Flashes at 1 Hz	Flashes	Lights up	Device fault	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the wiring and, if necessary, replace the device.

9.2 TEST/RESET button

The RESET button has the following functions:

Designation	Tripping	Description
LED/fan test	Press of a button for less than two seconds	The LED/fan test is activated. All LEDs (ST/OL, MAN, PWR) light up and the fan is switched on for 4 s. An LED/fan test is not possible in the case of fail-safe motor starters with F-DI deactivated (safety-related shutdown by low level).
RESET function	Press of a button	If a group fault is active, you can acknowledge this fault using the blue button. You can acknowledge device faults in principle only via ON/OFF of the control voltage. Note: If a fault is active, you cannot execute the LED/fan test.

Additional functions in the case of fail-safe motor starters

Confirming ATEX parameters	Press of a button	You confirm display of the parameters via an LED flashing sequence by pressing the RESET button twice.
Discarding ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you discard newly set ATEX parameters and you return to the original parameterization.
Displaying ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you can display the currently set ATEX parameters during operation.
Switching to commissioning mode	Press of a button	In "Manual local" mode, confirm the change to commissioning mode by the fail-safe motor starter by pressing the button.

9.3 Interrupts

The ET 200SP motor starter supports diagnostic interrupts and maintenance. You can read out the diagnoses of the motor starter in the following data sets:

- DS72 logbook - Read device error (Page 128)
- DS73 logbook - Read triggering operations (Page 131)
- DS75 logbook - Read events (Page 132)
- DS92 Read device diagnostics (Page 133)

A diagnostic message is output for each diagnostics event and the ER LED flashes on the module when group fault diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You can evaluate the error codes via the user program. The following table shows the individual diagnostic messages:

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
0003_h (3_{dec})	Overvoltage	1407	Cause: The supply voltage is above the tolerance limit. Remedy: Change the power supply.
1000_h (4096_{dec})	Zero current after ON command	338	No current flow is detected in the motor feeder after an ON command. Possible cause: main circuit interrupted (energy supply missing, internal fuse defective, load missing)
1021_h (4129_{dec})	Phase unbalance	340, 341	The limit value for phase unbalance has been exceeded. Phase unbalance can cause an overload. Possible causes: Failure of the phase, fault in the motor windings Remedy: Check the motor feeder and the motor.
1022_h (4130_{dec})	Thermal motor model overload	327, 328	The motor feeder has been overloaded. The motor temperature rise has exceeded a limit. Remedy: Please check the motor and the applications that are being driven by the motor. After a trip, you can switch the motor on again after the cooling time has expired, or after the thermal motor model has been deleted.
1036_n (4150_{dec})	Parameters for EX motor protection received	1537	Parameters for the EX motor protection have been received. Remedy: Remedy: Confirm the correctness of the parameters directly on the device.
1040_h (4160_{dec})	Threshold I exceeded	334, 1541	The current has exceeded a limit. Remedy: Please check the application that is being driven by the motor.
1041_h (4161_{dec})	Threshold I undershot	335, 1542	The current has undershot a limit. Remedy: Please check the application that is being driven by the motor.
1093_h (4243_{dec})	Sensor supply overload	354	The output driver for the sensor supply is overloaded. Remedy: Check the cabling and the sensor.
$104C_h$ (4172_{dec})	Motor blocking	339	The maximum motor current has exceeded a limit for blocking protection. Possible cause: The motor is blocked. Remedy: Please check the application that is being driven by the motor.

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
1080_h (4224_{dec})	Device fault	308, 338, 381,456, 458, 460, 476, 480, 490, 1414, 1417, 1466, 1467, 1482, 20010, 20011, 20012, 20013, 20015, 20018, 20017 (up to V1.2.0)	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the logbook entries. Check the wiring and, if necessary, replace the device.
1083_h (4227_{dec})	Switching element overload	309, 1580	Switching element (switching contact, power semiconductor) too hot. Check the ambient conditions linked to cooling. You might have to take derating into consideration. Check the number of switching operations. Also check whether the fan is working properly.
1084_h (4228_{dec})	Electronics supply voltage too low	317	The supply voltage is below the permissible value. Remedy: Check the power supply (load measurement, voltage range)
1088_h (4232_{dec})	No switching element supply voltage	333	No supply voltage has been detected or the mechanical rotary interlock is not in the READY position. Remedy: Check the power supply to the switching elements and the cabling or turn the mechanical rotary interlock to the READY position.
1095_h (4245_{dec})	Parameter error	365, 366, 384, 461	The module is not yet parameterized or is incorrectly parameterized or the safety-related parameters have been rejected. Remedy: Correct the parameterization.
1096_h (4246_{dec})	Process image error	355	The process image output (PIQ) contains invalid control bit combinations (e.g. control bits for clockwise and counter-clockwise set simultaneously). Remedy: Check and correct the process image output (PIQ).
$10A5_h$ (4261_{dec})	Residual current	337, 338	No current flow is detected in the motor feeder after an ON command. Possible causes: Phase failure, fault in the motor winding, fuse in the device defective Remedy: Check the motor feeder (main circuit) and the motor. Clear the short-circuit in the system and replace the device.
$100A_h$ (4106_{dec})	Test mode current flow	1406	Current is flowing in the motor feeder although the motor feeder is in test mode or the test position. Possible causes: The main circuit is not interrupted in test operation. The cold start function of the ET 200SP motor starter is activated. Remedy: Check the wiring or deactivate the cold start function
$109D_h$ (4253_{dec})	Input Action	348, 351	A warning or trip signal is active on at least one input. Remedy: Check the application.
$109E_h$ (4254_{dec})	Emergency end position CW	349	The "CW" emergency end position has been passed. Remedy: Check the end position of the drive.
$001F_h$ (31_{dec})	Channel temporarily unavailable		Wait until the firmware update is completed.

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
$109F_h$ (4255_{dec})	Emergency trip end position CCW	350	The "CCW" emergency end position has been passed. Remedy: Check the end position of the drive.
$134B_h$ (4939_{dec})	Trip Reset not possible		Trip reset is currently not possible (e.g. because the cooling phase is in progress). Remedy: Repeat the action later (e.g. after the cooling time has elapsed).
1080_h		20013, 1466, 1417, 20010, 1467 (as of V1.2.2)	When the error occurs for the 1st to 4th time. On the 5th occurrence, error type channel diagnostics 1080_h is reported again.

9.4 Maintenance

A maintenance alarm is output for each group warning and the MT LED lights up on the module when group warning diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You read the maintenance alarms in data set 75 (Page 132) of the motor starter.

Extended maintenance

You will find general information on extended maintenance in "Diagnostics" in the SIMATIC PROFINET Function Manual
(https://support.industry.siemens.com/cs/de/de/view/49948856/en).

The PROFINET interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET according to the standard IEC 61158-6-10. The aim is early detection and correction of potential faults. The motor starter's full functionality (maintenance) is available with firmware version V3.3 of the interface module.

The maintenance information is generated in STEP 7 with the following system messages:

- Maintenance request - symbolized by a yellow screwdriver.
- Faults - symbolized by a red screwdriver

See also

SIMATIC ET 200SP System Manual
(http://support.automation.siemens.com/WW/view/en/58649293)

Technical data

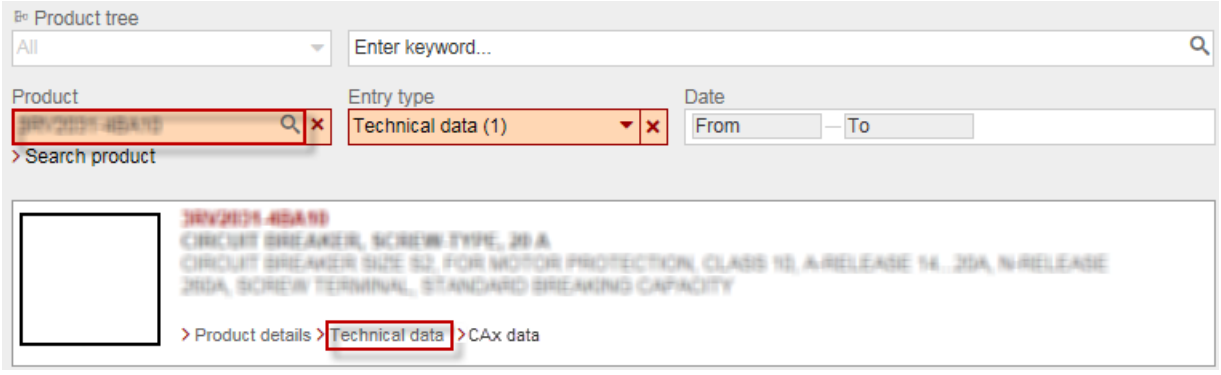
10

10.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data" link.



10.2 Final conditions for safety-related parameters

Safety-related parameters

The safety-related parameters in the data sheet have been determined on the basis of the following final conditions:

- Side-by-side mounting at rated current I_n
- 100% ON period of electronics
- 40 °C ambient temperature
- DIN EN 60721-3-7 noxious gas environment: class 3C2

B10d value

NOTICE
Consider the B10d value stated for the motor starter in your application. The maximum number of operating cycles (B10d) may not be exceeded within the mission time T1. If the expected number of operating cycles exceeds the B10d value during the device's service life, you must set correspondingly shorter replacement intervals.

You can calculate the maximum service life of the device as follows: T10D = B10d / nop;
nop: Operating cycles/year

Validity of safety engineering data

The safety engineering data specified in the data sheet is valid under the following prerequisites:

The specified PFH/PFD value is valid until the electrical endurance (B10) or the mission time has been reached. Replace the device if either the electrical endurance or the mission time has been exceeded. The application is outside of the specification if the maximum number of starting operations is exceeded.

NOTE

Definition of "number of starting operations"

The "number of starting operations" stands for the frequency of switching of the main conducting path switching elements, i.e. switching on and off of the connected motor and not requesting of STO via the power supply or the fail-safe digital input.

NOTICE
Use of ET 200SP motor starters at installation altitudes higher than 2000 m above sea level Refer to the current product information for use at an altitude higher than 2000 m above sea level (Extension of the application range for fail-safe SIMATIC ET 200SP motor starters up to an installation altitude of 4000 m (https://support.industry.siemens.com/cs/ww/en/view/109778836)).

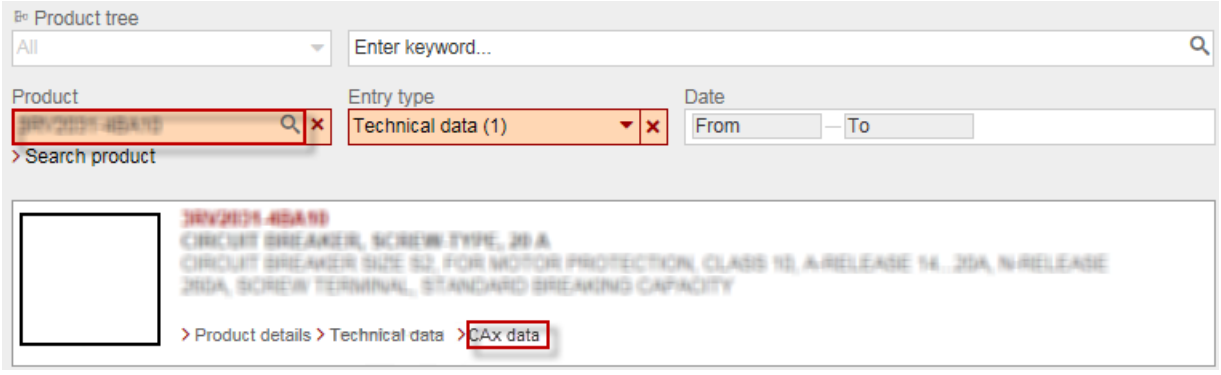
CAx data

11

11.1 CAx data

You can find the CAx data in the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "CAx data link.



Data sets

A

A.1 Reading and writing of data records

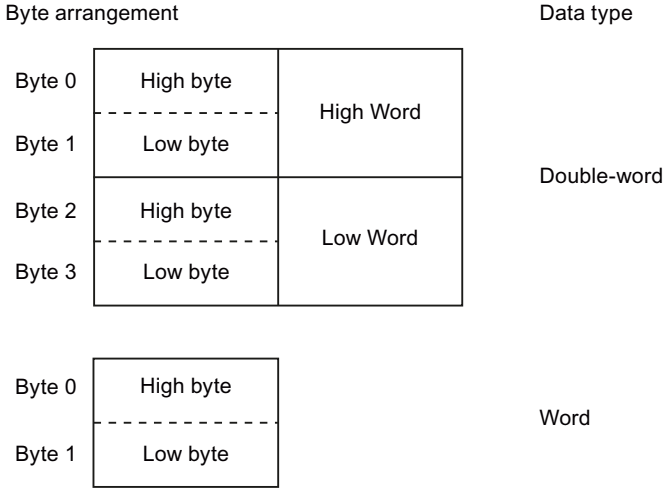
You can access the data sets of the motor starter from STEP 7:

- Writing data sets by calling SFB 53 "WRREC"
- Reading data sets by calling SFB 52 "RDREC"

You will find further information about the SFB in the STEP 7 online help.

A.2 Byte arrangements

When data longer than one byte is stored, the bytes are arranged as follows ("big endian"):



A.3 DS68 Read/write process image output

NOTE

Please note that data set 68 is overwritten by the cyclic process image in automatic mode!

Byte	Content	Value / value range	Meaning
0	Coordination	0x21	Write via acyclic bus channel (PLC)
1	Reserved	0x00	-
2	Reserved	0x00	-
3	Reserved	0x00	-

Byte	Content	Value / value range	Meaning
Process image of the outputs			
4	Process data	DQ 0.0 to DQ 0.7	See table below
5	Process data	DQ 1.0 to DQ 1.7	See table below

Table 1-799 Content of process image of the outputs (in bytes 4 and 5)

Byte.Bit	Encoding	Process data	Meaning	Relevant for
4.0	Bit (1 = active)	DQ 0.0	Motor CW	All
4.1		DQ 0.1	Motor CCW	Reversing starters only
4.2		DQ 0.2	-	-
4.3		DQ 0.3	Trip reset	All
4.4		DQ 0.4	Emergency start	All [1]
4.5		DQ 0.5	-	-
4.6		DQ 0.6	-	-
4.7		DQ 0.7	Cold start	All [2]
5.0	Bit (1 = active)	DQ 1.0	-	-
5.1		DQ 1.1	-	-
5.2		DQ 1.2	-	-
5.3		DQ 1.3	-	-
5.4		DQ 1.4	-	-
5.5		DQ 1.5	-	-
5.6		DQ 1.6	-	-
5.7		DQ 1.7	Disable quick stop	All

1) Not for EX motor

2) F starter as of FW V 1.2.0

A.4 DS69 Read process image input

Byte	Content	Value / value range	Meaning
0	Process data	DI 0.0 to DI 0.7	See table below
1	Process data	DI 1.0 to DI 1.7	See table below
2	Process data	DI 2.0 to DI 2.7	See table below
3	Process data	DI 3.0 to DI 3.7	See table below

Table 1-800 Process image input (in bytes 0 and 3)

Byte.Bit	Encoding	Process data	Meaning	Relevant for
0.0	Bit (1 = active)	DI 0.0	Ready (automatic)	All
0.1		DI 0.1	Motor ON	All
0.2		DI 0.2	Group fault	All
0.3		DI 0.3	Group warning	All
0.4		DI 0.4	Input 1	All
0.5		DI 0.5	Input 2	All
0.6		DI 0.6	Input 3	All

Byte.Bit	Encoding	Process data	Meaning	Relevant for
0.7	Bit (1 = active)	DI 0.7	Input 4	All
1.0	Bit (1 = active)	DI 1.0	Motor current I_{act}-bit0	All
1.1		DI 1.1	Motor current I_{act}-bit1	All
1.2		DI 1.2	Motor current I_{act}-bit2	All
1.3		DI 1.3	Motor current I_{act}-bit3	All
1.4		DI 1.4	Motor current I_{act}-bit4	All
1.5		DI 1.5	Motor current I_{act}-bit5	All
1.6		DI 1.6	Manual local mode	All
1.7		DI 1.7	-	-
2.0	Bit (1 = active)	DI 2.0	Ready to start for motor ON	All
2.1		DI 2.1	Motor CW	All
2.2		DI 2.2	Motor CCW	Reversing starters only
2.3		DI 2.3	Quick stop active	All
2.4		DI 2.4	Energy saving mode active	All
2.5		DI 2.5	DI module inserted	All
2.6		DI 2.6	Ex motor active	F starters only
2.7		DI 2.7	Parameters disabled CPU/master active	All
3.0	Bit (1 = active)	DI 3.0	Thermal model overload	All
3.1		DI 3.1	-	-
3.2		DI 3.2	I_e current limit tripping	All
3.3		DI 3.3	F-DI status	F starters only
3.4		DI 3.4	Residual current detected	All
3.5		DI 3.5	Asymmetry detected	All
3.6		DI 3.6	Overtemperature	All
3.7		DI 3.7	-	-

A.5 DS72 logbook - Read device error

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (= latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	1
Entry 2 (= second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
10 - 11	Signed 16	Object number	0 ... ±32767	1
... ...				
Entry 21 (last, oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	1

The data set call "Logbook device fault" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete logbooks yourself.

The supported object numbers and their meanings are shown in the table below: In the case of HF motor starters, you can acknowledge faults by switching off the supply voltage and by switching it on again. Replace the motor starter if the fault occurs again.

NOTE

In the case of fail-safe motor starters, there are some faults that you cannot acknowledge. If the relevant message in the "Fail-safe motor starter defective" column is marked with an "x", you can reset this error a maximum of 5 times. After that, the motor starter must be replaced.

Table 1-801 Assignment of error types to device faults

Object No.	Device fault messages	Fail-safe motor starter defective	5-life Error	F	Unit	Comment
308	Switching element defective	x	-	x	x	-
417	Stack overflow	-	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 381 "Error during self-test". The failure type defined there also applies.
418	Stack underflow	-	-	x	x	
423	Invalid command	-	-	x	x	
434	Error in system software	-	-	x	x	
437	Watchdog overflow	-	-	x	x	
456	EEPROM: memory defective	x	-	x	x	
458	EEPROM: CRC error "Device parameter"	x	-	x	x	
460	EEPROM: Contains invalid data	x	-	x	x	
462	EEPROM: Invalid pointer for device parameter buffer	x	-	x	x	
464	ROM error	x	-	x	x	
465	RAM error	x	-	x	x	
476	Current measuring defective	x	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
478	Bypass element does not close	-	-	x	x	
479	Bypass element does not open	x	-	x	x	
480	Bypass element protection has opened unintentionally during operation	- [2)]	-	x	x	

Object No.	Device fault messages	Fail-safe motor starter defective	5-life Error	F	Unit	Comment
486	Program execution check: Sequential program execution error	-	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 381 "Error during self-test". The failure type defined there also applies.
487	Program execution check: Logical programming error	-	-	x	x	
490	Incorrect power section detected	x	-	x	x	-
1414	Switching element short-circuited	x	-	x	x	-
1417	Bypass element defective	- [1) 4)]	**x**	x	x	-
1466	Contact 1 failed	- [4)]	**x**	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
1467	Contact 2 failed	- [4)]	**x**	x	x	
381	Error during self-test		-	x	x	-
1407	Electronics supply voltage too high	-	-	x	x	Previously in D73
1482	Current measuring range overshot	x [3)]	-	x	x	Previously in D73
20010	Direct-on-line or reversing relay defective	- [4)]	**x**	x	-	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
20011	12 V supply defective	x	-	x	-	
20012	F-DI defective	x	-	x	-	
20013	Hard switching of relays	- [4)]	**x**	x	-	
20015	Relay control defective feedback message	x	-	x	-	
20018	Bypass relay hard switched in the permissible current range (< 1 A at 0.4 A, < 3 A at 1 A MS and 3 A MS, < 8 A at 9 A MS and 12 A MS)	-	-	x	-	

[1)] Defective fail-safe ET200 SP motor starters up to V1.0.1 with error code 1417 can be reset once to V1.0.2 by means of a firmware update.

[2)] The error is present if the bypass relay could no longer be closed during the on/off routine of the fail-safe motor starter.

[3)] In case of error 1482, the last measured current value is stored in data set 95 as object number 608 as of firmware version V1.2.0.

[4)] **Defective fail-safe ET200 SP motor starters as of V1.0.1 can be reset to V1.2.2 by means of a firmware update. These errors are now tolerated 4 times.**

A.6 DS73 logbook - Read triggering operations

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 ... ±32767	
... ...				
Entry 21 (last, oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	

The data set call "Logbook trips" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.
Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

The supported object numbers and their meaning are shown in the table below:

Table 1-802 Assignment of object number to trips message

Object No.	Trips message	Comment
305	Safety-related tripping	Fail-safe motor starters only
309	Switching element overload	-
317	Electronics supply voltage too low	-
328	Motor overload trip	Tripping of the thermal motor model
333	Mechanical rotary interlock is not in the READY position	-
334	I_e upper limit violation	-
335	I_e lower limit violation	-
338	Residual current tripping	-
339	Tripping due to motor blocking	-
341	Asymmetry tripping	-
348	Input tripping	-
349	Input trip CW	-
350	Input trip CCW	-
354	Sensor supply overload	
355	Process image error	-
365	Invalid parameter value	Group fault only on startup

Object No.	Trips message	Comment
384	No external startup parameters received	-
1406	Cold start tripping	For all motor starters
20016	Insufficient temperature	-

A.7 DS75 logbook - Read events

Byte	Data type	Meaning	Range of values	Increment
User data (technology data)				
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 ... ±32767	
... ...				
Entry 21 (oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	

The data set call "Logbook events" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.
Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

The supported object numbers and their meaning are shown in the table below:

Table 1-803 Assignment of object number to event message

Object No.	Event messages	Comment
Warnings		
327	Thermal motor model overload	In the case of a group fault, the message "Motor overload trip" is also queued.
337	Residual current detected	-
340	± Asymmetry detected	-
351	Input warning	-
365	Invalid parameter value	Not in the case of startup since it is a group fault
366	Parameters cannot be changed in ON state	-
1541	± I_e warning threshold exceeded	-

±: Event is entered as "incoming" (+) and "outgoing" (-) event. Other messages are entered only as "incoming" messages

Object No.	Event messages	Comment
1542	± I_e warning threshold undershot	-
	Actions	
310	± Emergency start active	-
357	Automatic mode	Enter at the time of changeover
358	Manual bus mode	Enter at the time of changeover
359	Manual local mode	Enter at the time of changeover
360	Manual bus mode	Connection abort
368	± Parameters block CPU/master active	-
376	Firmware update successful	-
378	Firmware update has errors	-
454	Internal communication fault	-
1520	± Energy-saving mode active	-
1580	Switching element hot	-

±: Event is entered as "incoming" (+) and "outgoing" (-) event. Other messages are entered only as "incoming" messages

A.8 DS92 Read device diagnostics

Object number	Byte.Bit	Meaning	Relevant for
		User data (technology data) Switching/controlling	
301	0.0	Ready (automatic) The device is ready for operation via the controller. There is no connection to the mechanical rotary interlock.	All
306	0.1	Motor CW	All
307	0.2	Motor CCW	Reversing starter
309	0.3	Switching element overload	All
308	0.4	Switching element defective	All
310	0.5	Emergency start active	All
302	0.6	Group fault	All
304	0.7	Group warning	All
-	1.01.7	Reserved	-
		Protection function (motor, cable, short-circuit)	
-	2.0-2	Reserved	
327	2.3	Thermal motor model overload	All
328	2.4	Overload tripping	All
-	2.5	Reserved	-
330	2.6	Cooling time active	All
305	2.7	F-DI status	Fail-safe motor starters
-	3.0-1	Reserved	-
333	3.2	Mechanical rotary interlock is not in the READY position	All
-	3.3-6	Reserved	-
352	3.7	Input control	All
340	4.0	Asymmetry detected	All

Object number	Byte.Bit	Meaning	Relevant for
341	4.1	Asymmetry tripping	All
334	4.2	I_e upper limit violation	All
335	4.3	I_e lower limit violation	All
-	4.4	-	-
337	4.5	Residual current detected	All
338	4.6	Residual current tripping	All
339	4.7	Tripping due to motor blocking	All
344	5.0	Input 1	All
345	5.1	Input 2	All
346	5.2	Input 3	All
347	5.3	Input LC	All
348	5.4	Input tripping	All
349	5.5	Input trip CW	All
351	5.6	Input warning	All
350	5.7	Input trip CCW	All
-	6.0-1	Reserved	-
353	6.2	Quick stop active	All
354	6.3	Sensor supply overload	All
-	6.4-6	Reserved	-
317	6.7	Electronics supply voltage too low	All
Communication			
-	7.0	Reserved	-
356	7.1	CPU or master STOP	All
357	7.2	Automatic mode	All
358	7.3	Manual bus mode	All
359	7.4	Manual local mode (local control)	All
	7.5	Reserved	-
360	7.6	Connection abort in manual mode	All
-	7.5-6	Reserved	-
355	7.7	Process image error	Reversing starter
-	8.0	Reserved	-
358		Manual bus mode	All
365	8.1	Invalid parameter value • During operation • During starting • Rejected safety-related parameters	All
366	8.2	Parameters cannot be changed in ON state	All
368	8.3	Parameters disabled CPU/master active	All
384	8.4	No external startup parameters received	All
-	8.5-7	Reserved	-
-	9.0-1	Reserved	-
381	9.2	Error during self-test	Fail-safe motor starters only
-	9.3-7	Reserved	-
367	10-11	Incorrect parameter number (as word)	All

Object number	Byte.Bit	Meaning	Relevant for
	12-13	Reserved	All
Device functions			
1405	14.0	Cold start active	All; F starters as of V1.2.0
1406	14.1	Cold start tripping	All; F starters as of V1.2.0
-	14.2-7	Reserved	-
-	15-18	Reserved	-
Switching/controlling			
1407	19.0	Electronics supply voltage too high	All
1470	19.1	Ready for motor ON	All
1414	19.2	Switching element short-circuited	All
1417	19.3	Bypass element defective	All
-	19.4-7	Reserved	-
1422	20.0	Thermal motor model deactivated	All
-	21.0-1	Reserved	-
Protection function			
1482	21.2	Current measuring range exceeded [1)]	All
-	21.3-7	Reserved	-
Communication (operating modes)			
357	22.0	Automatic mode (redundant to bit 7.2)	All
-	22.1-2	Manual bus mode (redundant to bit 7.3)	All, as of Firmware V1.2.0
359	22.3	Manual local mode (redundant to bit 7.4)	All
-	22.4-7	Reserved	-
-	23	Reserved	-
Prewarnings			
-	24-25	Reserved	-
Maintenance			
-	26-31	Reserved	-
Quick Stop			
1508	32.0	Quick Stop 1 - direction-independent	All
1509	32.1	Quick Stop 1 - clockwise	All
1510	32.2	Quick Stop 1 - counter-clockwise	Reversing starter
-	32.3-7	Reserved	-
-	33	Reserved	-
End position			
1507	34.0	Input operational trip - end position CW	All
1506	34.1	Input operational trip - end position CCW	All
-	34.2-7	Reserved	-
-	35	Reserved	-
Energy saving function			
-	36.0-5	Reserved	-
1522	36.6	Start_Pause command is pending	All
1520	36.7	Energy saving mode active	All

Object number	Byte.Bit	Meaning	Relevant for
-	37	Reserved	-
Operating states			
-	38-49	Reserved	-
Ex motor protection			
1535	50.0	Explosion protection of the motor active	Fail-safe motor starters only
-	50.1	Reserved	-
1537	50.2	New safety-related parameters received	Fail-safe motor starters only
-	50.3-7	Reserved	-
-	51	Reserved	-
Warnings			
1580	52.0	Switching element hot; as of firmware version V1.2.1	-
1573	52.3	Chatter monitoring	All
1541	52.4	I_e warning limit exceeded	All
1542	52.5	I_e warning limit undershot	All
-	52.6-7	Reserved	-
-	53	Reserved	-

1) As of Firmware version V1.2.0. If the starting current exceeds the maximum current measuring range (see technical data sheet), this bit is set and the measured value is stored in data set 95.

A.9 DS93 Write command

Write structure of data set 93 command

Byte	Content	Value / value range	Meaning
0	Coordination	0x21	Write via acyclic bus channel
1	Reserved	0x00	-
2	Reserved	0x00	-
3	Reserved	0x00	-
Command			
4	Number of commands	0 ... 1	Number of subsequent valid commands
5	Command 1	Command number	Optional; for meaning see the following table
6	Reserved	Reserved	Reserved
7	Reserved	Reserved	Reserved
8	Reserved	Reserved	Reserved
9	Reserved	Reserved	Reserved

Assignment of command to command number and their meaning (byte 5 to 9)

Object number	Command number	Command	Meaning
0	0	Reserved	No function
703	1	Trip reset	Resets and acknowledges error messages
709	4	Automatic mode	Transition to automatic mode (control by DP master)

Object number	Command number	Command	Meaning
711	5	Manual bus mode	Transition to manual mode. The motor starter switches to manual bus mode depending on the interface via which the command is received.
707	10	Parameters disabled CPU/master ON	Parameterization by parameterizing master not possible, or its parameters are ignored
708	11	Parameters disabled CPU/master OFF	Parameterization by parameterizing master is possible

A.10 DS94 Read measured values

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
	Measured values (volatile)				
504	0	Unsigned 8	Phase current I_{L1} (%)	0 ... 796 %	3.125 %
505	1	Unsigned 8	Phase current I_{L2} (%)	0 ... 796 %	3.125 %
506	2	Unsigned 8	Phase current I_{L3} (%)	0 ... 796 %	3.125 %
-	3 ... 6	0x00	Reserved	-	-
503	7	Unsigned 8	Unbalance	0 ... 255 %	1 %
502	8 ... 9	Unsigned 16	Motor heating	0 ... 1,000 %	1 %
518	10, 11		Switching element heating	0 ... 1,000 %	1 %
-	12 ... 27	0x00	Reserved	-	-
513	28 ... 31	Signed 32	Phase current $I_{L1(rms)}$	±0 ... 20,000 A	0.01 A
514	32 ... 35	Signed 32	Phase current $I_{L2(rms)}$	±0 ... 20,000 A	0.01 A
515	36 ... 39	Signed 32	Phase current $I_{L3(rms)}$	±0 ... 20,000 A	0.01 A
516	40 ... 41	Unsigned 16	Electronics supply voltage	0 ... 1,500 V	0.1 V
-	42 ... 43	0x00	Reserved	-	-
531	44 ... 47	Signed 32	I_{max} current motor switch-on cycle	±0 ... 20,000 A	0.01 A (as of V.1.2.1)
-	48 ... 63	0x00	Reserved	-	-

A.11 DS95 Read statistics

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
-	0	0	Reserved	-	-
-	1.0-5	0	Reserved	-	-
-	1.6-7	11_B	Bit 6 operating hours resolution 1 second Bit 7 operating hours selection 1 operating hour - device	11 (fixed)	1
-	2 ... 3	0x00	Reserved	-	-
682	4 ... 7	Unsigned 32	Device operating hours in seconds	0 ... (2^{32}-1)	1 s

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
603	8 ... 11	Unsigned 32	Number of motor CW starts	0 ... (2^{32}-1)	1
604	12 ... 15	Unsigned 32	Number of starts motor CCW	0 ... (2^{32}-1)	1
605	16 ... 17	Unsigned 16	Number of motor overload trips Is incremented on tripping by: • Blocking current monitoring • Overload protection	0 ... (2^{16}-1)	1
20051	18	Unsigned 8	Number of chatter monitoring errors	0 ... (2^{8} - 1)	1 [1)]
-	18 ... 19	0x00	Reserved	-	-
609 [2)]	20 ... 23	Signed 32	Motor current $I_{max\ (rms)}$	±0 ... 20 000	0.01 A
608 [3)]	24 ... 27	Signed 32	Last tripping current $I_{A\ (rms)}$	±0 ... 20 000	0.01 A
602	28 ... 31	Unsigned 32	Motor operating hours in seconds	0 ... (2^{32}-1)	1 s
615	32 ... 49	0x00	Reserved	-	-
616	50 ... 51	Unsigned 16	Number of switching element overload trips	0 ... (2^{16}-1)	1
2013 [4)]	52 ... 53	Unsigned 16	Number of hard switching operations of the relay	0 ... (2^{16}-1)	1
-	54 ... 89	0x00	Reserved	-	-
20050	54	Unsigned 8	Number of 5 life errors	0 ... 5	1 [1)]

[1)] As of firmware version V1.2.2

[2)]The motor current $I_{max\ (rms)}$ shows the maximum rms value present in a phase over the operating period (min/max pointer function). It is calculated every 10 ms. Excluded are the first 20 ms after start (inrush current).

[3)] The last tripping current $I_{A\ (rms)}$ is updated for each trip, irrespective of the magnitude of the current that was present there beforehand (no min/max pointer function).

[4)] Previously, the object number could only contain a maximum of "1". Now the motor starter can be reset for values from "1" to "4". The starter should only be replaced at "5"

Up to firmware version V1.2.0 the value is entered if

- the motor is blocked,
- the maximum value of the motor model is exceeded,
- the maximum value of the device or relay model is exceeded.

As of firmware version V1.2.0, an additional entry is made if a measured value is exceeded or if hard switching occurs with the fail-safe motor starter.

NOTE

Operating hours counter

The operating hours counter runs as soon as the motor starter is supplied with 24 V.

A.12 Read/write DS201 device parameter 1

DS201 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS201, these incorrect parameters will also be reported back when reading DS201. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults for factory settings of the motor starter appear in italics in the Value range column. In the engineering system, a distinction is made between the default values of the input actions and the current range of the defaults of the motor starter.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 49)
2209	0.2-0.3	*[0]: No* [1]: Yes	EX motor application (ATEX operation)	Ex motor application (Page 75)
6	0.4 - 0.7	[3]: CLASS 5 (10a) [0]: CLASS 10 [15]: CLASS OFF (not in ATEX mode) [1)]	Trip class [1)]	Overload protection (Page 55)
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Tripping with restart (not during ATEX operation) [2]: Warning (not during ATEX operation)	Response to overload - TMM	Overload protection (Page 55)
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart (not during ATEX operation)	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 55)
20000	1.3	*[0]: No warning in the case of safety-related tripping [0019H]* [1]: Warning in the case of safety-oriented tripping	Response to safety-related tripping with F-DI	Response to safety-related tripping (Page 74)
34	1.4	*[0]: Switch substitute value* [1]: Retain last value	Response to CPU/master STOP	Response to CPU/master STOP (Page 76)
19	1.5	[0]: Warning (not in the case of fail-safe motor starters) *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 65)
20	1.6	[0]: Warning (not during ATEX operation) *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 73)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
317	1.7	Diagnosis Supply voltage too low [1)]	[0] released (default) [1] block	Diagnosis supply voltage too low (Data plausibility check (Page 101))
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 76)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 76)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 76)
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 76)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 76)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 76)
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 76)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 76)
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning [7]: Emergency start (not during ATEX operation) *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start (not during ATEX operation) [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW	Input 1 action	Inputs (Page 76)
195	4	See input 1 - action *[9]: Motor CCW (default for reversing starters)*	Input 2 action	Inputs (Page 76)
196	5	See input 1 - action *[13]: Cold start (default for HF motor starters)*	Input 3 action	Inputs (Page 76)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
2	6 - 7	0.1 ... 12 A/10 mA *The maximum current is preset.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 48)
15	8	18.75 ... 100%/3.12-5% [6 ... 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 69)
16	9	50 ... 400%/3.125% [16 ... 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 69)

1) As of Firmware version V1.2.0

A.13 Read/write DS202 device parameter 2

DS202 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS202, these incorrect parameters will also be reported back when reading DS202. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults appear in italics in the Value range column.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1* ... 7.5 s/0.5 s [2 ... 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 70)
-	0.4 - 0.7	[0]: Reserved	Reserved	-
2210	1	0 ... 99 %/1 % [0 ... 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 55)
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1500 %/50 % [3 ... 20] *Default value is [16]: 800 %* As of firmware version V1.2.0	Blocking current	Blocking time and blocking current (Page 70)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 ... 100 %/3.125 % [6 ... 32] [0]: Deactivated *Default value is [7]: 21.875 %*	Lower current warning limit	Upper/lower current warning limit (Page 69)
2214	9	50 ... 400 %/3.125 % [16 ... 128] [0]: Deactivated *Default value is [36]: 112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 69)

A.14 Read DS203 device parameter 1

DS203 contains the second part of the incorrect parameter with which the motor starter is working. The defaults appear in italics in the Value range column.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 49)
2209	0.2--0.3	*[0]: No* [1]: Yes	EX motor application (ATEX operation)	Ex motor application (Page 75)
6	0.4 - 0.7	[3]: CLASS 5 (10a) [0]: CLASS 10 [15]: CLASS off (as of firmware version V1.2.0)	Trip class [1)]	Overload protection (Page 55)
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Tripping with restart (not during ATEX operation) [2]: Warning (not during ATEX operation)	Response to overload - TMM	Overload protection (Page 55)
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart (not during ATEX operation)	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 55)
20000	1.3	*[0]: No warning in the case of safety-related tripping [0019H]* [1]: Warning in the case of safety-related tripping [0019H]	Response to safety-related tripping with F-DI	Response to safety-related tripping (Page 74)
34	1.4	*[0]: Switch substitute value* [1]: Retain last value	Response to CPU/master STOP	Group fault diagnostics/group warning diagnostics (Page 76)
19	1.5	[0]: Warning (not in the case of fail-safe motor starters) *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 65)
20	1.6	[0]: Warning (not during ATEX operation) *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 73)
317	1.7	Diagnosis Supply voltage too low (all motor starters as of firmware version V1.2.0)	[0] released (default) [1] block	-
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 76)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 76)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 76)
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 76)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 76)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 76)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 76)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 76)
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning [7]: Emergency start (not during ATEX operation) *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start (not during ATEX operation) [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW	Input 1 action	Inputs (Page 76)
195	4	See input 1 - action *[9]: Motor CCW (default for reversing starters)*	Input 2 action	Inputs (Page 76)
196	5	See input 1 - action *[13]: Cold start (default for HF motor starters)*	Input 3 action	Inputs (Page 76)
2	6 - 7	0.1 ... 12 A/10 mA *The maximum current is preset.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 48)
15	8	18.75 ... 100 %/3.125 % [6 ... 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 69)
16	9	50 ... 400 %/3.125 % [16 ... 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 69)

A.15 Read DS204 device parameter 2

DS204 contains the second part of the incorrect parameters with which the motor starter is working.

The defaults appear in italics in the Value range column.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1* ... 7.5 s/0.5 s [2 ... 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 70)
-	0.4 - 0.7	[0]: Reserved	Reserved	-

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
2210	1	0 ... 99 %/1 % [0 ... 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 55)
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1500 %/50 % [3 ... 20] *Default value is [16]:* *800 %* As of firmware version V1.2.0	Blocking current	Blocking time and blocking current (Page 70)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 ... 100 %/3.125 % [6 ... 32] [0]: Deactivated *Default value is [7]:* *21.875 %*	Lower current warning limit	Upper/lower current warning limit (Page 69)
2214	9	50 ... 400 %/3.125 % [16 ... 128] [0]: Deactivated *Default value is [36]:* *112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 69)

A.16 I&M data

A.16.1 I&M data

The following I&M data (Identification & Maintenance function) are supported by all ET 200SP motor starters:

Number	Name	Comment
I&M 0	Device identification	This is stored in the device on initialization
I&M 1	Equipment identifier	These are entered in the engineering system.
I&M 2	Installation	
I&M 3	Description	

NOTE

With PROFINET, the I&M data can be accessed via data sets 0xAFF0 - 0xAFF3 (PNO).
With PROFIBUS, the I&M data can be accessed via data set 255.

A.16.2 I&M 0: Read device identification

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0020	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M0 data block 0			
6 ... 7	Unsigned16	MANUFACTURER_ID	42 = Manufacturer ID SIEMENS
8 ... 27	Char[20]	ORDER_ID	Article number (MLFB)
28 ... 43	Char[16]	SERIAL_NUMBER	Serial number
44 ... 45	Unsigned16	HARDWARE REVISION	Hardware revision or product version
46 ... 49	Char	SOFTWARE_REVISION	Firmware version
50 ... 51	Unsigned16	REV_COUNTER	Provides information about the parameterized changes on the module. The "REV_ COUNTER" is incremented after each change.
52 ... 53	Unsigned16	PROFILE_ID	Gives information about the PROFIBUS profile supported by the device and the line of products belonging to the device.
54 ... 55	Unsigned16	PROFILE_SPECIFIC_TYPE	Used to supplement the object "PROFILE_ID" and contains further information on the profile.
56 ... 57	Unsigned16	IM_VERSION	Provides information about the version of the identification data (01 01hex = Version 1.1).
58 ... 59	Unsigned16	IM_SUPPORTED	Provides information about the available identification data (Index 2 to 4).

A.16.3 I&M 1: Read/write equipment identifier

The following data are saved:

Byte	Length	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0021	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 1			
6 ... 37	Char[32]	TAG FUNCTION	Plant identifier Fill unused positions with blanks (0x20)
38 ... 59	Char[22]	TAG LOCATION	Location designation Fill unused positions with blanks (0x20)

A.16.4 I&M 2: Read/write installation

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0022	Block type
2 ... 3	Unsigned16	0x0012	Block length = 18
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 2			
6 ... 21	Char[16]	IM_DATE	Specification of an input date (YYYY-MM-DD HH:MM)

A.16.5 I&M 3: Read/write description

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0023	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 3			
6 ... 59	Char[54]	IM_DESCRIPTOR	Comment Fill unused positions with blanks (0x20)

Circuit examples

B

B.1 Connection examples for motor starters

B.1.1 Connecting and operating motor brakes

See Chapter Operating motor starters (Page 33).

B.1.2 Example of the correct engineering of a motor starter

See Chapter Operating motor starters (Page 33).

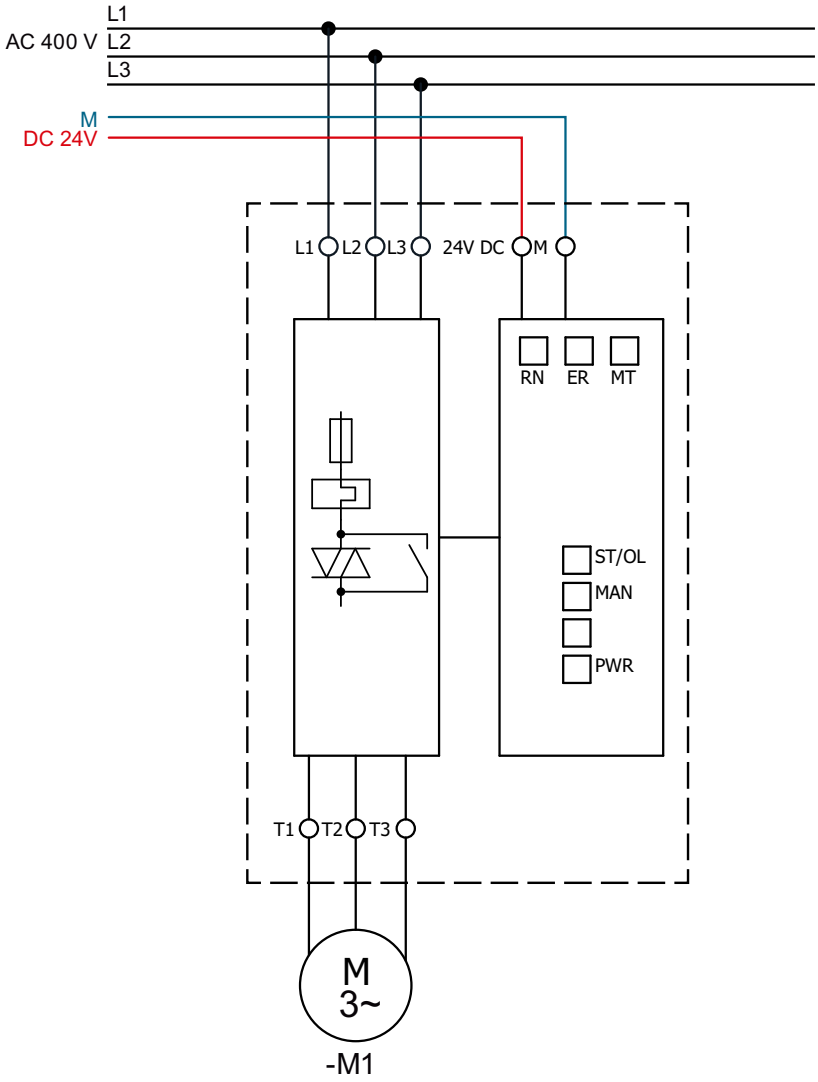
B.1.3 Induction machine

Direct-on-line starter
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0A*00-0CP0

Reversing starter
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0B*00-0CP0

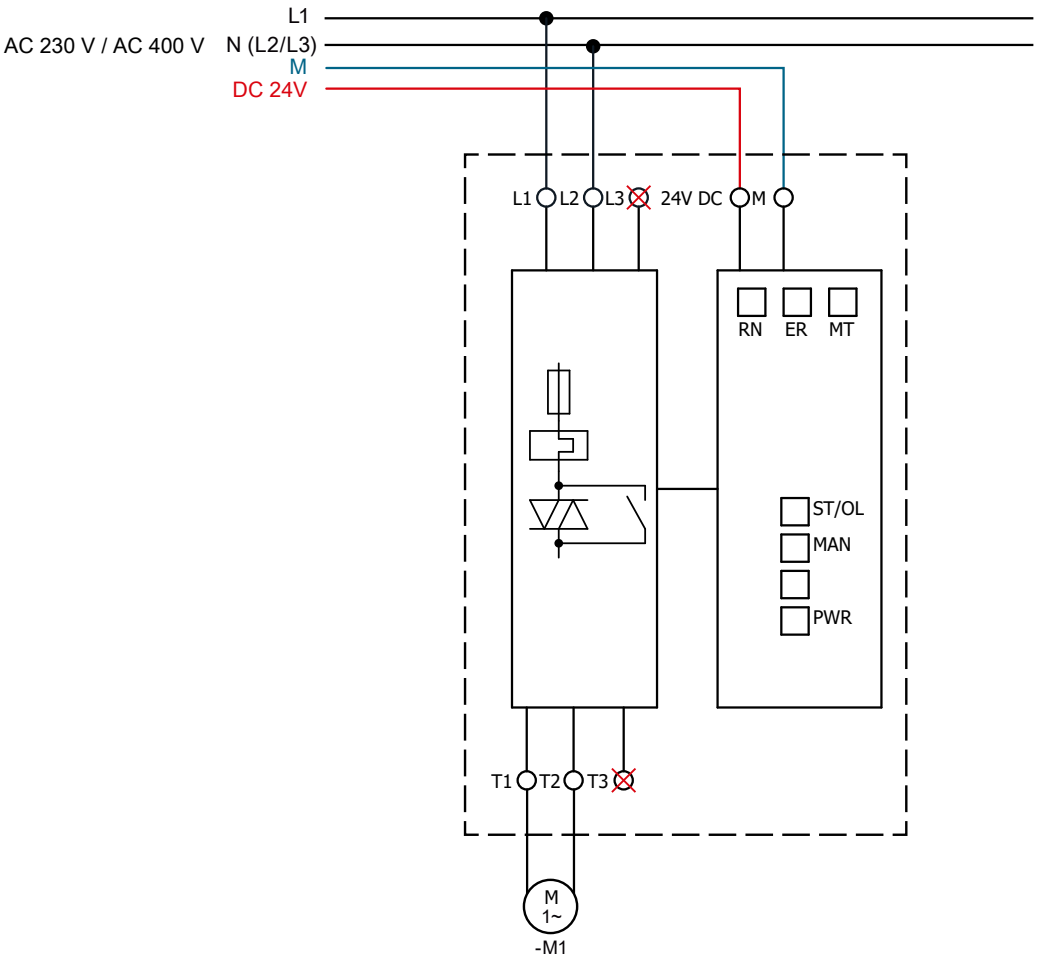


In the multi-pole representation, the N and PE conductors are not shown separately.
Do not connect PE or N to the neutral point.

B.1.4 Single-phase motor

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0.
- Alternatively, this wiring can also be performed using a fail-safe 3RK1308-0C*00-0CP0 direct starter.



In the multi-pole representation, the PE conductor is not shown separately.

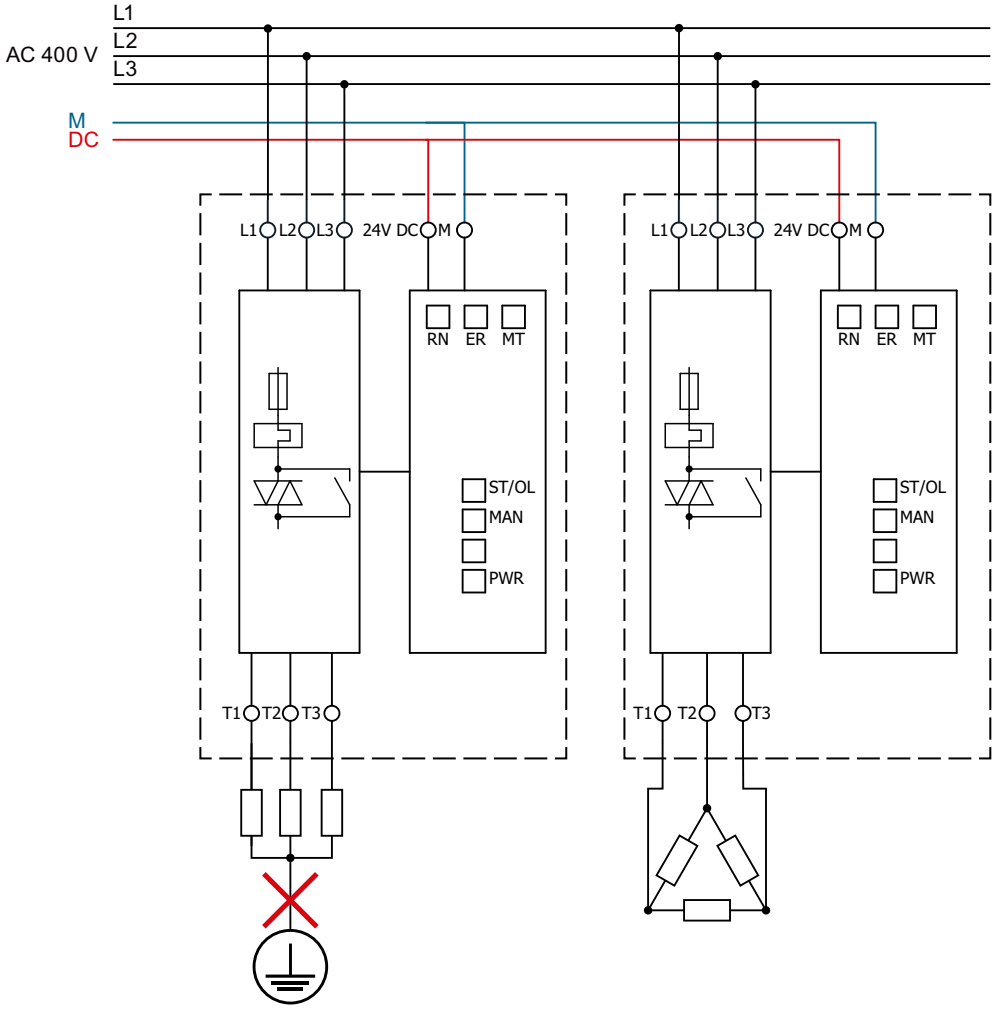
B.1.5 Resistive load

Star connection
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

Delta connection:
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

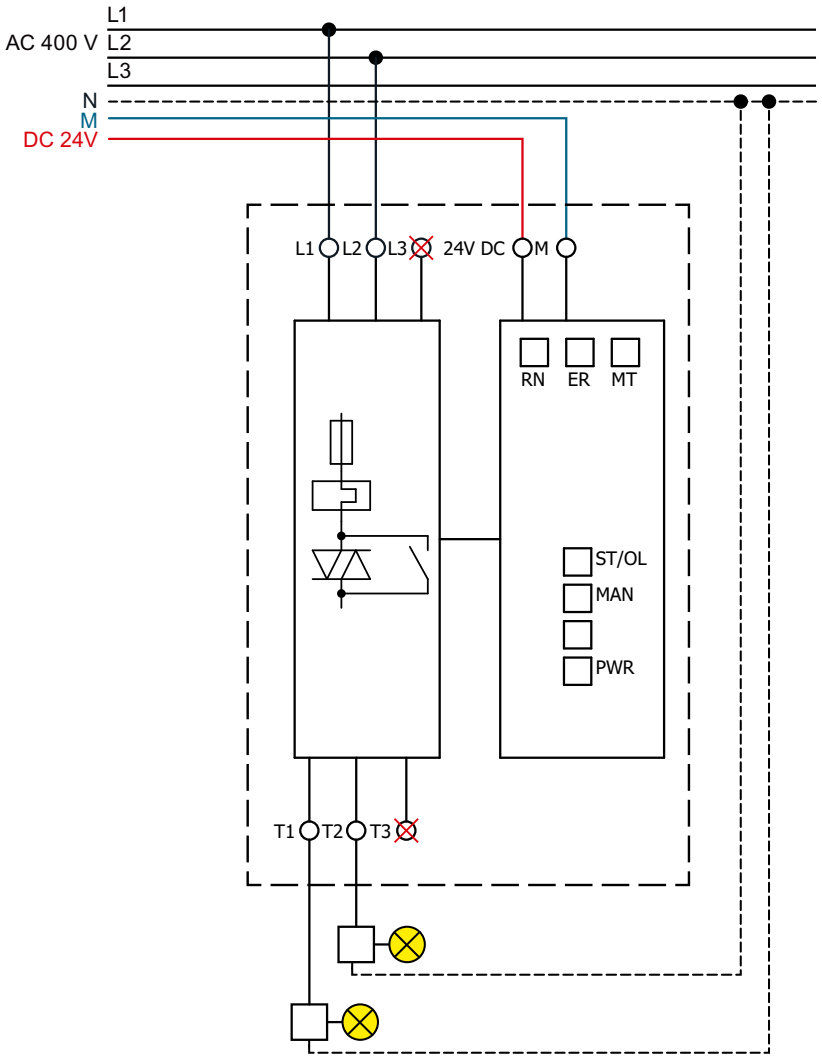


Do not connect PE or N to the neutral point.
In the multi-pole representation, the N and PE conductors are not shown separately.

B.1.6 Gas discharge lamps

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0



In the multi-pole representation, the PE conductor is not shown separately.

NOTE

Motor model und response to overload of the gas discharge lamp

Observe the set motor model and the overload response of the gas discharge lamp for the parameterization of the motor starter.

B.2 Connection examples for fail-safe motor starters

B.2.1 General information

Shutdown options
The safe tripping of the ET 200SP motor starter can take place in various ways, e.g.

- With a 3SK safety relay
- With a fail-safe ET 200SP F-DQ digital output module
- With a fail-safe ET 200SP F-PM E power module

Documentation and sample projects
You will find an entry Safe shutdown of ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109748128) in the Industry Online Support. This entry describes methods of switching off one or more ET 200SP F motor starters in a safety-oriented manner.

The attached documentation "Power module F PM-E" contains a decision-making matrix, which illustrates the various switch-off variants.

Shutdown principle ET 200SP F motor starter		Application example with SK safety relay	Application example with fail-safe digital output F-DQ	Application example with fail-safe power module F-PM-E
Hardware variety	Suitable for group shutdown	Yes	Yes	Yes
	Suitable for single shutdown	Yes	Yes	No
Use in cyclically requested safety functions (e.g. protective door, light curtain)		Yes	Yes	No
Use in acyclically requested safety functions (e.g. emergency stop)		Yes	Yes	Yes
Motor starter can still be addressed by CPU after fail-safe shutdown		Yes	Yes	No
Suitable for immediate recovery		Yes	Yes	No (recovery time ≥ 2.2 s)
External wiring effort		Yes	Yes	No
Standard and safety engineering		Separate	Integrated into a device	Integrated into a device

Further information
See"SIRIUS Safety Integrated" Application Manual (https://support.industry.siemens.com/cs/ww/en/view/83150405).

B.2.2 Safety-related shutdown

Single shutdown

With the BaseUnits BU30-MS5 to BU30-MS6, a single shutdown can be implemented with the aid of the F-DI. Single shutdown in SIL3 Cat. 4 PL e is possible here with fail-safe control modules with pp-switching or pm-switching.

For the single use of the BU30-MS7 and BU30-MS10, a fail-safe control module with pp-switching is basically to be used.

			1)	2)	3)	4)	5)	6)	7)	8)	9)
BU30-MS1	BU with 24 V and 500 V infeed	3RK1908-0AP00-0AP0	x	-	x	x	-	x	-	-	-
BU30-MS2	BU with 500 V infeed	3RK1908-0AP00-0CP0	-	x	x	x	-	x	-	-	-
BU30-MS3	BU with 24 V infeed	3RK1908-0AP00-0BP0	x	-	x	-	x	x	-	-	-
BU30-MS4	BU without infeed	3RK1908-0AP00-0DP0	-	x	x	-	x	x	-	-	-
BU30-MS5	BU F-DI (without forwarding) with 500 V infeed	3RK1908-0AP00-0EP0	-	x	x	x	-	x	x	-	-
BU30-MS6	BU F-DI (without forwarding) without infeed	3RK1908-0AP00-0FP0	-	x	x	-	x	x	x	-	-
BU30-MS7	BU F-DI infeed with 500 V infeed	3RK1908-0AP00-0GP0	-	x	x	x	-	x	x	-	x
BU30-MS8	BU F-DI forwarding with 500 V infeed	3RK1908-0AP00-0HP0	-	x	x	x	-	x	-	x	x
BU30-MS9	BU F-DI forwarding without infeed	3RK1908-0AP00-0JP0	-	x	x	-	x	x	-	x	x
BU30-MS10	BU F-DI infeed without 500 V infeed	3RK1908-0AP00-0KP0	-	x	x	-	x	x	x	-	x

1) 24 V infeed
2) 24 V import from left module
3) 24 V forwarding
4) 500 V infeed
5) 500 V import from left
6) 500 V forwarding
7) F-DI infeed
8) F-DI import from left
9) F-DI forwarding

Group shutdown

With the BaseUnits BU30-MS7 to BU30-MS10, a group shutdown can be implemented with the aid of the F-DI.

The group shutdown in SIL3 Cat 4 PL e is only possible with fail-safe control modules with pp-switching. A group shutdown is also possible by a fail-safe shutdown of the supply voltage with all motor starter BaseUnits.

⚠ WARNING

Safety-related shutdown using the F-DI

Depending on the I/O used, the shutdown takes place via one or two output channels (terminals):

- PM-switching: The shutdown takes place via two output channels.
- PP-switching: The shutdown takes place via one output channel.

Shutdown via one output channel (PP switching) achieves SILCL 3 according to EN 62061, PL e/Cat. 4 according to EN ISO 13849-1 if steps are taken to ensure that the cables are installed in such a way that they are protected against a cross-circuit/line-to-line fault.

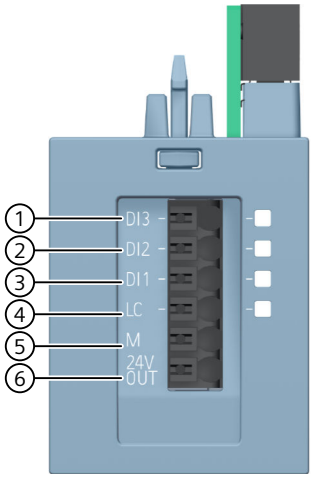
For the BU-30-MS7 to BU-30-MS10 F-DI forwarding BaseUnits, only PP switching is possible.

For the single F-DI BaseUnits BU-30-MS5 and BU-30-MS6, PM and PP switching are possible.

B.2.3 Connecting the 3DI/LC module for the motor starter

Procedure

The figure below shows the connections of the 3DI/LC module:



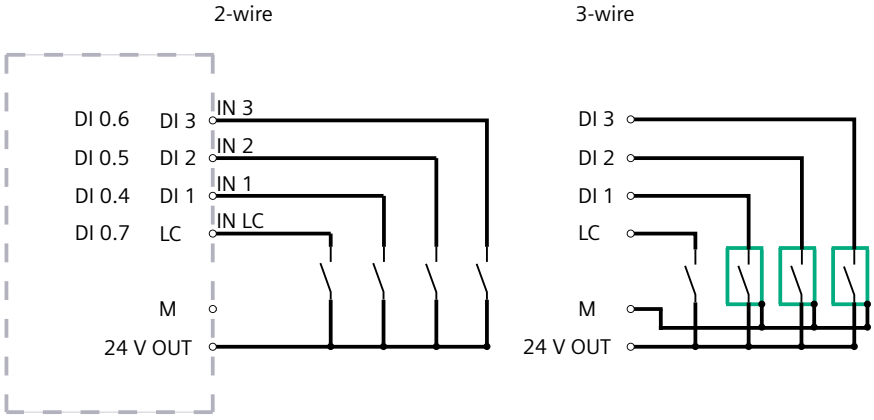
① Digital input 3
② Digital input 2
③ Digital input 1
④ Local control (manual local)
⑤ Ground
⑥ 24 V DC/ 100 mA output

NOTE

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6).
Connect only cables of maximum 30 m to the 3DI/LC module.
The supply (5 and 6) is protected against short circuits.

Terminal sketch of the 3DI/LC module

The following diagram shows a terminal sketch of the 3DI/LC module:



DI 1.4 to DI 1.7: Bit in PII

Figure 1-446 Connection example of inputs

⚠ WARNING

The digital inputs (1 to 4) are not isolated. The reference potential is M (5), and therefore SELV/PELV. Only supply the inputs with the 24 V DC output (6).
Do not connect any temperature sensors for winding control of motors if they do not have protective separation. Otherwise, in the event of a fault, a dangerous voltage may be transmitted to the sensor cables and thus to the SELV/PELV circuits. If these cables are then touched, it can lead to death, serious injury and enormous material damage.

SIEMENS

SIMATIC

S7-1500/ET 200MP Automation system

System Manual

11/2025
A5E03461182-AN

Introduction 1
Safety information 2
New properties/functions 3
Industrial cybersecurity 4
System overview 5
Application planning 6
Installation 7
Wiring 8
Configuring 9
Basics of program execution 10
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S7-1500/ET 200MP Automation system

System Manual

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Introduction

1

Purpose of the documentation

This documentation provides important information on configuring, installing, wiring and commissioning the S7-1500 automation system/ET 200MP distributed I/O system.

Basic knowledge required

General knowledge in the field of automation engineering is required to understand this documentation.

Validity of the documentation

This documentation applies to all products of the SIMATIC S7-1500 and SIMATIC ET 200MP product families.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

ID link for the digital nameplate



The ID link is a globally unique identifier according to IEC 61406-1, which you will find in the future as a QR code on your product.

The figure shows an example of an ID link for the digital output module DQ 16x24VDC/0.5A BA.

You can recognize the ID link by the frame with a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates and other helpful information about your product.

Special information

NOTE

Important note for maintaining the operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of systems from a safety perspective.

You need to subscribe to the corresponding notifications to ensure that you always remain up-to-date and are able to make any necessary changes to your plant regarding operational safety should the need arise.

Log into Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

NOTE

Increased safety measures

Anywhere that errors can cause injury or property damage, special standards must be applied to the safety of the entire plant. Special, plant-specific rules exist for this purpose, which must also be taken into account by the owner when setting up the controller.

For electronic controllers with safety responsibility, the measures that must be taken to prevent or control errors are based on the risk posed by the plant. For this, the owner must ensure implementation of additional measures for the plant, for example, use of safety-related controllers such as the S7-1500 F fail-safe automation system.

NOTE
When using F-CPUs in safety mode and fail-safe modules, note the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

1.1 SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**
  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).
- **Product support**
  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**
  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**
  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**
  For answers and solutions concerning automation technology.
- **mySiePortal**
  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

1.2 S7-1500/ET 200MP documentation guide

1.2.1 Information classes S7-1500/ET 200MP

1.2.1.1 S7-1500/ET 200MP documentation guide



The documentation for the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require. Changes and supplements to the manuals are documented in a Product Information.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

Basic information



The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- S7-1500/ET 200MP System Manual
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules
- Equipment Manuals Power Supply Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC S7-1500 and ET 200MPsystems.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manual Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the S7-1500 and ET 200MP systems on the Internet (https://support.industry.siemens.com/cs/ww/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/86140384)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet
(https://support.industry.siemens.com/cs/ww/en/view/86630375).

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:



Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:



Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)



YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety information

2

2.1 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

2.2 Safety-related symbols

2.2.1 Devices without explosion protection

The following table contains an explanation of the symbols located in your SIMATIC device, its packaging or the accompanying documentation.

Symbol	Meaning
	General warning sign **Caution/Notice** You must read the product documentation. The product documentation contains information about the potential risks and enable you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by electrically skilled person. IEC 60417 No. 6182
 CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
 EMC	Note that the device must be constructed and connected in accordance with EMC regulations.
 230V MODULES	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2

Symbol	Meaning
	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-DB Symbol 5180
	Be aware that the device is only approved for the industrial field and only for indoor use.
	Note that an enclosure is required for installing the device. Enclosures are considered: • Standing control cabinet • Serial control cabinet • Terminal boxes • Wall enclosure

2.2.2 Devices with explosion protection

The following table contains an explanation of the symbols located in your SIMATIC device, its packaging or the accompanying documentation.

Symbol	Meaning
	The assigned safety symbols apply to devices **with Ex approval**. You must read the product documentation. The product documentation contains information about the potential risks and enable you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by electrically skilled person. IEC 60417 No. 6182
	Observe the mechanical rating of the device.
	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
	Note that the device must be constructed and connected in accordance with EMC regulations.
	When the device is under voltage, note that it may not be installed or removed, or plugged or pulled.
	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2

Symbol	Meaning
 24V MODULES	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-DB Symbol 5180
 INDOOR USE ONLY INDUSTRIAL USE ONLY	Be aware that the device is only approved for the industrial field and only for indoor use.
 ZONE 2 INSIDE CABINET IP54	For Zone 2 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP54.
 ZONE 22 INSIDE CABINET IP6x	For Zone 22 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP6x.

2.3 Intended use

The system is used to control machines and plants.

Intended use also includes observance of this documentation, in particular the safety instructions and conditions of use. See Technical specifications (Page 382) section.

2.4 Changes to the device and spare parts

Modifications to the device can impair the safety and function of the device:

- Do not make any changes or modifications to the device.
- Do not remove or paste over safety instructions on the device.
- Do not tape over, cover or install ventilation slots.
- Only use original spare parts and accessories.
- Only use the software provided by Siemens.

2.5 Knowledge and personnel qualification

All persons working with this device require the following knowledge:

- Contents of this document as well as contents of the enclosed documents.
- Handling the device (after instruction)
- Relevant standards and regulations
- Accident prevention regulations

The following activities are reserved for specially qualified personnel:

Working on electrical parts
Work on electrical parts may only be performed by the following persons:

- Qualified electricians
- Persons trained in electrical engineering under the direction and supervision of qualified personnel.

Commissioning and configuration
Commissioning and configuration requires general knowledge in the field of automation technology.

2.6 Personal protective equipment

The personal protective equipment depends on the activity and is determined by the operator.

To avoid material damage during packing, unpacking and installation activities we recommend:

- ESD wrist strap
- ESD shoes

2.7 Open Source Software

This product, solution or service ("Product") contains third-party software components. These are either open source software licensed under a license recognized by the Open Source Initiative (https://opensource.com/) or a license defined by Siemens as comparable ("OSS") and/or commercial software or freeware. With respect to the OSS components, the applicable OSS license conditions prevail over any other terms and conditions covering the Product. The OSS portions of this Product are provided royalty-free and can be used at no charge.

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2.8 Safe working

2.8.1 Working on electrical parts

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualification (Page 20)).
- Always observe the country-specific safety rules.
- Notify all those who will be affected by the procedure.
- Follow the 5 safety rules according to DIN EN 50110-1 (VDE 0105-1):

1. Disconnect
2. Secure to prevent reconnection
3. Verify safe isolation from the supply (all poles)
4. Ground and short-circuit
5. Erect barriers around or cover adjacent live parts

The 5 safety rules must be applied in the above order prior to starting work on an electrical system. After completing the work, proceed in the reverse order.

It is assumed that every electrician is familiar with the 5 rules.

2.9 Residual risks

Despite all the technical and procedural risk reductions that have been carried out, not all dangers can be avoided.

The following sections describe these residual risks and measures to avoid them.

2.9.1 Live parts

Electrocution on contact with live parts leads to life-threatening injuries (death).

Operation

- Do not open the device.
- Never use damaged devices.
- Pull the plug and not the cable.

Installation and connection

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualification (Page 20)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 22))
- Fuse the connection cables according to the current-carrying capacity of the cable used, taking into account the applicable standards.
- Install the device in a control cabinet. The enclosures, cabinets or electrical equipment rooms must guarantee protection against electric shock and spread of fire.
- Ground the device in compliance with the applicable regulations.
- For the 24 V DC supply (SELV/PELV), only use power supply units that provide safe electrical extra-low voltage in accordance with IEC 61131-2 or IEC 61010-2-201.

Maintenance

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualification (Page 20)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 22))

2.9.2 External power supply to modules

Even if the main supply to the plant is disconnected, externally supplied modules can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.

For special SIMATICmodules, e.g. relay modules, you can connect or switch voltages larger than 24 V DC, e.g. 230 V AC. In some applications, these modules are supplied with voltages from outside the system (external power supply). In the event of an external power supply, a dangerous voltage may still be present on these modules even if the system is disconnected.

Maintenance

Ensure the following points before starting work:

- The plant is completely disconnected from the power supply.
- All externally supplied plant units are disconnected from the power supply

2.9.3 Voltage dangerous to touch due to permissible electric potential difference

Due to the permissible electric potential difference, a dangerous voltage may be present at the inputs of modules. An electric shock on contact with live parts can lead to death or serious injury.

Special SIMATIC modules, such as analog input modules, have isolated channels. In this case, there is no connection between the potential of the sensor and the potential of the module. If a dangerous voltage within the permissible electric potential difference occurs at the sensor, this voltage may also be present at the measurement channel of the module.

You can find the permissible electric potential differences in the technical specifications section of the modules' Equipment Manuals.

Maintenance

Ensure the following points before starting work:

- The plant is completely disconnected from the power supply.
- All externally supplied plant units are disconnected from the power supply

2.9.4 Conductive pollution

Electrocution during transmission of electrical energy via conductive contamination to the body leads to life-threatening injuries (death).

- Install the device in a control cabinet.
- Keep the control cabinet free of conductive contamination.

2.9.5 Overheating

Smoke development and fire due to overheating of the device and lines lead to burns and life-threatening injuries (death).

To avoid overheating:

- Ensure the correct installation position.
- Ensure sufficient air supply (for example, do not mask or cover ventilation slots, maintain mounting clearances).
- Only use undamaged cables.

Installation and connection

- Follow the instructions for the mounting position.
- Adhere to the specified ventilation clearances.
- Fuse the connecting cables according to the cable cross-section.

Maintenance

- Check plug-in connections and cables regularly for damage.

2.9.6 Uncontrolled movements

Uncontrolled movements of driven machine or system parts during commissioning, operation, maintenance and repair.

- Follow the safety instructions described in the function manuals.

2.9.7 Unsafe operating states

Unsafe operating states may result in personal injury of unknown extent.
The following factors can be triggers:

- Manipulation of the software, e.g. viruses, trojans or worms.

Manipulation of the software, e.g. viruses, trojans or worms.

- Adhere to the protective measures against tampering with the software (see section Industrial cybersecurity (Page 40)).
- Perform available updates in a timely manner.
- Protect files stored on removable media from malware with appropriate protective measures, e.g. virus scanner.
- Set up access protection for the CPU.

2.10 Behavior in case of emergency

- Force EMERGENCY OFF.

When the safe operating state has been restored:

- Unlock the EMERGENCY OFF mechanism.
- The person responsible for the system ensures that the system starts up in a controlled and defined manner.

2.11 Material damage

2.11.1 Transport and storage

- Only pack, store, transport and ship electronic components, modules or devices in the original product packaging or in other suitable materials, e.g. conductive foam rubber or aluminum foil.
- Observe the limits during transport and storage. See Technical specifications (Page 382) section.

2.11.2 Installation and connection

- We recommend touching components, modules and devices only if they are grounded by one of the following measures:
  - With an ESD wrist strap.
  - With ESD shoes or ESD grounding strips in ESD areas with conductive flooring.
- Place electronic components, modules and devices only on conductive surfaces (e.g. tables with ESD coating, conducting ESD plastic foam, ESD packing bags, ESD transport containers).
- Ensure that there is sufficient overvoltage protection.
- Do not install/remove the following elements when the power is on:
  - Front connectors
  - I/O modules
  - CPU

New properties/functions

3

What's new in the S7-1500, ET 200MP System Manual, Edition 11/2025 compared to Edition 11/2024?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Backup and restore configuration of the CPU from the central user	As of FW version V4.1 of a CPU, a central user can also back up and restore the configuration. Read about the rules you need to follow when backing up and restoring.	Section Backing up and restoring the CPU configuration (Page 326)
	Integrated safety		
	Temporary account lock for local user accounts	As of STEP 7 V21, you can set up a temporary account lock for local user accounts for CPUs as of FW version V4.1. The temporary account lock provides protection against brute force attacks.	Section Temporary account lock in case of brute force attacks (Page 269)
	SIMATIC S7 data	This appendix in the S7-1500/ET 200MP System Manual provides you with an overview of the data that the SIMATIC S7-1500 automation system generates and makes available to you.	Appendix SIMATIC data (Page 420)
	Communication of the CPU		
	New function for OPC UA	Enables cross-vendor communication.	Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
	Activating IP forwarding through data record transfer	For CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU via data record transfer.	
	Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support the SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If the IO controller and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP. Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.	PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) Function Manual
	Technology functions of the CPU		
	General functions	Distribution of the processing of motion jobs across multiple cores Improved performance	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
	Axis functions (S7-1500T only)	Specification of the motion setpoints of a superimposing axis in addition to the basic motion of the axis Extended scope of functions	Axis functions (https://support.industry.siemens.

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Axis functions (S7-1500T only)	Cam can be used as a time-based position profile Extended scope of functions	com/cs/us/en/view/109817884) Function Manual
	Synchronous operation functions (S7-1500T only)	Range scaling on a cam before or during active camming Extended scope of functions	Synchronous operation functions (https://support.industry.siemens.com/cs/us/en/view/109817888) Function Manual
		Cross-PLC synchronous operation with communication via isochronous I-device Extended scope of functions	
	Kinematics functions (S7-1500T only)	New predefined kinematics type "6-axis articulated arm with offset wrist" available Extended scope of functions	Kinematics functions (https://support.industry.siemens.com/cs/us/en/view/109817886) Function Manual
		As of firmware version V4.1, the following CPUs support the motion control package "S7-1500T Motion Control Kinplus" V10.0: • CPU 1516T/TF-3 PN • CPU 1517T/TF-3 PN	
	Interpreter functions (S7-1500T only)	Value of a tag can be changed at a breakpoint in debug program mode Extended scope of functions	Interpreter functions (https://support.industry.siemens.com/cs/us/en/view/109817891) Function Manual
	Trace functionality of the CPU		
	Creating a long-term trace configuration from a long-term trace measurement	Extended scope of functions	Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
	Recording, display and analysis of events in the TIA Portal	Diagnostics of Motion Control jobs Extended scope of functions	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
	PID control		
	New version V2.0 of PID_Temp controller	Use for cooling-only applications	PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036) Function Manual
		Temporary shutdown of the heating	
		Manual stopping of the integral-action component	
		Active limiting of the integral-action component and change of output value limits in automatic mode	
		Improved anti-windup behavior in the cascade	

What's new in the S7-1500, ET 200MP System Manual, Edition 11/2024 since the previous version 11/2023?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Extension of the CPU portfolio	The following CPUs have been added to the CPU portfolio: • 1517(F)-3 PN • 1518(F)-3 PN • 1516T(F)-3 PN • 1517T(F)-3 PN • 1518T(F)-3 PN The CPUs mentioned above have 2 ports at the PROFINET interface X2 and the same PROFINET functionalities as at the PROFINET interface X1. In addition, these CPUs provide higher performance and make more data work memory available.	As of section System overview (Page 74)
	Performance boost through configurable environmental conditions	In the case of the following CPUs, you can specify the ambient conditions at the operating location in the hardware configuration and thus optimize the program processing of the CPU: • 1518(F)-3 PN • 1518T(F)-3 PN	Cycle and response times (https://support.industry.siemens.com/cs/us/en/view/59193558) Function Manual
	Integrated safety		
	Central user management	System-wide, central management of users and user groups outside TIA Portal via UMC server. User management for comprehensive automation solutions with multiple projects, users, and user groups can work in all projects in which they are activated and the appropriate rights have been assigned to them. During operation, users can be added to or removed from a group or their passwords can be changed – all without the CPU configuration having to be changed or loaded.	Section Central user management (Page 271)
	Retentive memory area for syslog messages	S7-1500 CPUs store Syslog messages retentively as of FW Version V4.0. This means that events that require a restart of the CPU also remain in the syslog storage.	Section Industrial cybersecurity (Page 40)
	Programming the CPU		
	SIMATIC Controller Profiling	You start or stop the profiling of an S7-1500 CPU as of firmware version V4.0 using the new "Profiling" instruction. When starting the profiling, specify the configuration with which the profiling data is to be recorded.	STEP 7 online help

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Programming the CPU	For S7-1500 CPUs as of firmware version V4.0, the nesting depth has been extended for the following elements: • PLC data types • Tags of the STRUCT data type • Tags of the ARRAY of STRUCT / ARRAY of UDT data type Previously, the maximum nesting depth was eight elements. You can now nest up to 26 elements inside each other. An ARRAY of STRUCT/UDT requires three hierarchy levels in each case. If you use these data types, the maximum nesting depth is reduced accordingly.	STEP 7 online help
	Communication of the CPU		
	New function for OPC UA	Enables cross-vendor communication.	Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
	Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If IO controllers and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP. Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.	PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) Function Manual
	Web server of the CPU		
	System web pages	Introduction of the system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) Function Manual
	New Web API methods	The Web API has been expanded to include the following functions: • Reading out basic information of the CPU • Reading out API session information • Reading out technology objects and their values • Configuring the HTTP response header • Further options for configuring web applications The extended scope of functions of the Web API offers additional access options. The configuration of the HTTP header also extends access to the web server via HMI Unified Panels.	
	Technology functions of the CPU		
	Axis functions	Defining the motion transition Extended scope of functions	Axis functions (https://support.industry.

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Axis functions	Stopping the basic motion Extended scope of functions	siemens.com/cs/us/en/view/109817884) Function Manual
	Synchronous operation functions (T-CPU only)	New cyclic cam types with larger definition ranges Extended scope of functions	Synchronous operation functions (https://support.industry.siemens.com/cs/us/en/view/109817888) Function Manual
		Directly set a following axis synchronously at a specified leading value position in camming. New synchronization mode of the following axis in camming: • Direct synchronous setting at the specified leading value position Extended scope of functions	
		New synchronization modes of the following axis in gearing: • Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position • Subsequent synchronization using leading value distance with calculated synchronous position Extended scope of functions	
		Reversal tolerance of the leading value adjustable in gearing and camming. Synchronization and desynchronization are not aborted with a fluctuating leading value.	
		Cross-PLC synchronous operation with communication via PN/PN coupler Extended scope of functions	
		Cross-PLC synchronous operation across multiple projects Use of externally supplied projects possible.	
	Kinematics functions (T-CPU only)	Extension of the kinematics control panel Improved commissioning	Kinematics functions (https://support.industry.siemens.com/cs/us/en/view/109817886) Function Manual
		Display of effective dynamic limits Extension of the kinematics control panel	
	Interpreter functions (T-CPU only)	"Debug" program mode The execution of the Interpreter program can be tested.	Interpreter functions (https://support.industry.siemens.com/cs/us/en/view/109817891) Function Manual
	Trace functionality of the CPU		
	Named value data types in Traces	"Named values" are values that are assigned a unique name. In TIA Portal, you declare named values within "named value data types". They contain a set of values to which a unique set of names is assigned.	Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual

What's new?		What are the customer benefits?	Where can I find the information?
New contents		Named values are easily referenced throughout the program and increase the readability and maintainability of the program. This makes it easy to monitor/analyze the named value data types in the trace.	Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
	Recording as binary file for long-term trace and long-term project trace	Recording as binary file instead of a CSV file and saving in a DAT file. This makes it possible to monitor/analyze long-term traces and long-term project traces directly in TIA Portal.	
	Acquiring events from technology objects in the Trace recording	Detecting events in the Trace recording, which occur at a Motion Control technology object as of V9.0 during recording. Monitoring/analyzing of the correct sequence and parameterization of Motion Control jobs in complex applications.	
	Cross-project Trace	Recording of values from multiple projects with a PN/PN coupler. Monitoring/analyzing of signals and events from multiple projects.	

What's new in the S7-1500, ET 200MP System Manual, Edition 11/2023 since the previous version 01/2023?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	"Industrial cybersecurity" section	Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities. The section contains the following information: • Basic information on the subject of industrial cybersecurity • Measures to protect individual components and the entire system against manipulation and unwanted access.	Section Industrial cybersecurity (Page 40)
	Syslog messages	As of TIA Portal version V19 and FW version V3.1, you can forward the syslog messages of an S7-1500 CPU to a syslog server.	
	CPU 1511(F)-1 PN	Expansion of the code work memory: 300 KB (standard CPU), 450 KB (F-CPU).	Section System overview (Page 74)
	Compact CPUs	Expansion of the work memory: • Code work memory: 300 KB (CPU 1511C-1 PN), 400 KB (CPU 1512C-1 PN) • Data work memory: 1.5 MB (CPU 1511C-1 PN), 2 MB (CPU 1512C-1 PN)	

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Local user management	As of TIA Portal version V19 and FW version V3.1, S7-1500 CPUs have improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). As of the above-mentioned version, you manage all project users with their rights (for example, access rights) for all CPUs in the project. Management is performed in the editor for users and roles in the TIA Portal.	Section Local user management (Page 259)
	"Random" instruction	The "Random" instruction is supported as of FW version V3.1: You can use this instruction to generate a 32-bit random number.	STEP 7 online help
	SIMATIC Controller Profiling	With SIMATIC Controller Profiling you can analyze and evaluate the runtime behavior of your user program on an S7-1500 CPU as of FW Version V3.1. All the relevant information can be displayed graphically and evaluated in a web browser.	Application example SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/us/en/view/109750245)
	Appendix "Use over 2,000 m above sea level and extended temperature range"	The previously permissible ambient temperature range has been extended for many modules. The permissible installation heights have been extended to installation heights of up to 5000 m, depending on the module.	Appendix Use over 2 000 m above sea level and extended temperature range (Page 410)

What's new in the S7-1500, ET 200MP System Manual, Edition 01/2023 since the previous version 11/2022?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	General safety instructions	This section contains a compilation of general safety instructions for the SIMATIC S7-1500/ET 200MP automation system.	Section General safety instructions

What's new in the S7-1500, ET 200MP System Manual, Edition 11/2022 since the previous version 05/2021?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	S7-1500 Motion Control KinPlus	The "S7-1500T Motion Control KinPlus" software enables control of kinematics with 5 or 6 interpolating axes.	S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manuals
	Technology and standard CPUs	Expansion of the work memory	Section Technical specifications of CPUs (Page 100)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Increase in the number of simultaneously active jobs for asynchronous instructions (OUC and S7 communication)	The CPU can process a larger number of asynchronous instructions in parallel with the cyclic user program.	Section Asynchronous instructions (Page 246)
	Management of web server certificates during CPU runtime	You can load or update web server certificates not only in STOP mode but also in RUN mode.	Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) Function Manual
	New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	

What's new in the S7-1500, ET 200MP System Manual, Edition 05/2021 since the previous version 11/2019?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Active backplane bus	The active backplane bus is used in applications with high availability requirements. Applications in which even short plant downtimes would result in significant economic damage. The active backplane bus provides you with the following advantages: • Reaction-free pulling and plugging of I/O modules during operation • Reserve capacity (= gaps in system configuration) for later use	Section Components (Page 91) Active backplane bus (https://support.industry.siemens.com/cs/de/de/view/109778694/en) Equipment Manual
	CPU 1518(F)-4 PN/DP MFP	A Linux-based operating system (SIMATIC Industrial OS) is pre-installed on the CPUs 1518(F)-4 PN/DP MFP (multifunctional platform) to allow you to use Linux-based apps and software, for example.	Starting from section System overview (Page 74)
	CPU 1518(F)-4 PN/DP	Expansion of work memory and motion control resources: • Code work memory: 6 MB (standard CPU), 9 MB (F-CPU) • Data work memory: 60 MB • Motion control resources: 15360 This expansion allows you to implement larger and more extensive applications with the CPUs.	Starting from section System overview (Page 74)
	CPU 1518T-4 PN/DP	Extension of the CPU portfolio with the CPU 1518T-4 PN/DP: CPU 1518T-4 PN/DP offers a very large program and data memory for demanding usage in applications that contain central I/O in addition to distributed automation structures. CPU 1518T-4 PN/DP features high-performance, extended motion control functions, for example: • Synchronous operation functions • Kinematics functions	Starting from section System overview (Page 74)

What's new?		What are the customer benefits?	Where can I find the information?
New contents		Important technical specifications: • Code work memory: 9 MB • Data work memory: 60 MB • Motion control resources: 15360 • Extended motion control resources: 512	
	CPU 1518TF-4 PN/DP	Extension of the CPU portfolio with the CPU 1518TF-4 PN/DP: CPU 1518TF-4 PN/DP offers a very large program and data memory for demanding usage in applications that contain central I/O in addition to distributed automation structures. The CPU can also be used for safety functions according to IEC 61508 up to SIL-3 and ISO 13849 up to PLe for safety applications. CPU 1518TF-4 PN/DP features high-performance, extended motion control functions, for example: • Synchronous operation functions • Kinematics functions Important technical specifications: • Code work memory: 9 MB • Data work memory: 60 MB • Motion control resources: 15360 • Extended motion control resources: 512	Starting from section System overview (Page 74)
	New motion control technology functions for the following tasks: • Desynchronization of gearing or camming • Following value shift in gearing or camming • Simulation of the kinematic motions • Copying the calculated cam elements	Extended areas of application	Motion Control (Page 133) section
Changed contents	With the introduction of DHCP (Dynamic Host Configuration Protocol), NTP servers can also be obtained via DHCP. This changes the configuration, in order to define where the NTP server obtains its configuration from: • via the hardware configuration of the CPU • via DHCP • via the block T_CONFIG	More assignment options from NTP servers to the CPU.	Section Time synchronization (Page 330)

What's new in the S7-1500, ET 200MP System Manual, Edition 11/2019 since the previous version 12/2017?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	DIN rail adapter	You can install the SIMATIC S7-1500/ET 200MP automation system on a standard 35 mm DIN rail using the DIN rail adapter.	Sec. Installing the DIN rail adapter (Page 177)
	Communication module IO-Link Master	With the IO-Link master, you can do the following during operation: • Changing parameters for the production and processing of product variants and batches down to sensor/actuator level • Specify remote diagnostics or detailed diagnostics up to the sensor/actuator	Section Communication module IO-Link Master (Page 131)
	Communications processor CP 1545-1	Communication processors connect the SIMATIC S7-1500 automation system securely with networks. With the integrated security functions, communication processors protect the S7-1500 automation system and lower-level networks from unauthorized access. Communication processors use encryption to protect data transfer against manipulation and espionage.	Section CM communication modules / CP communications processors (Page 129)
	Technology module TM NPU	With the TM NPU technology module, you can: • Process large amounts of data via neural networks • Perform visual quality check • Control robot systems via screen • Using pick-and-place applications	Section Technology Module TM NPU (Page 145)
	Basic analog input module	The new, simple and inexpensive analog input module provides data for temperature measurement with RTD via 8 channels.	Section Analog input modules (Page 122)

What's new in the S7-1500, ET 200MP System Manual, Edition 12/2017 since the previous version 09/2016?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Technology CPUs	• Extension of the technology CPU portfolio by the CPUs 1516T(F)-3 PN/DP • All technology CPUs feature the new technology object TO_Kinematics. With the TO_Kinematics, you can implement complex Motion Control applications for controlling 2D, 3D and 4D kinematics.	Starting from section System overview (Page 74)
	CPU1518(F)-4 PN/DP MFP	• Extension of the CPU portfolio by the CPUs 1518(F)-4 PN/DP MFP (multifunctional platform) • The CPU can execute STEP 7 blocks of the "usual" user program as well as blocks and applications programmed with C/C++.	Starting from section System overview (Page 74)

What's new?		What are the customer benefits?	Where can I find the information?
New contents		• The multifunctional platform offers you the option of running C/C++ code synchronously in the CPU cycle (via the CPU function library). In addition, the multifunctional platform can run C/C++ applications as separate applications in parallel to CPU runtime. • With C/C++ applications, you can implement parallel processes for the STEP 7 user program, for example, for preprocessing or sending data via Industrial Ethernet. A CPU can perform several tasks at the same time, the complexity of functions is reduced and the time required for implementation is reduced. • You can re-use existing technological know-how in C/C++ code synchronously and asynchronously to the STEP 7 user program.	
	Password provider	As an alternative to manual password entry, you can link a password provider to STEP 7. A password provider offers you the following advantages: • More convenient handling of passwords. STEP 7 automatically imports the password for the blocks. This saves you time • Optimum block protection as the users do not know the password themselves	Section Know-how protection (Page 284)
	GetSMCinfo instruction	With the help of the GetSMCinfo instruction you can respond to information provided by the memory card in the user program and if required, replace the memory card as a precautionary measure. This process makes sense if you write to the card often in your application, for example if you use data logs.	STEP 7 online help
	Testing with breakpoints	When testing with breakpoints, you execute a program from one breakpoint to another. Testing with breakpoints provides you with the following advantages: • Testing SCL and STL program code with the help of breakpoints • Localization of logic errors step by step • Simple and quick analysis of complex programs prior to actual commissioning • Recording of current values within individual executed loops • Use of breakpoints for program validation also possible in SCL/STL networks within LAD/FBD blocks	Section Test functions (Page 374)
Changed contents	PS 60W 24/48/60VDC HF system power supply	The PS 60W 24/48/60VDC HF enables extended retentivity of the CPU's data work memory. In the event of failure of the supply voltage, the PS 60W 24/48/60VDC HF supplies sufficient power for the CPU to back up the entire data work memory (without retentive data) to the SIMATIC Memory Card.	Section Use of system power supplies (Page 160)

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Time synchronization	For all applications that require the exact time, you update the CPU time using the NTP method. This also automatically sets the CPU time beyond subnet limits.	Section Time synchronization (Page 330)
	Reading out the identification and maintenance data using the Get_IM_Data instruction	With the Get_IM_Data instruction you can read out the identification and maintenance data of the modules without much programming work. With the Get_IM_Data instruction you can access identification and maintenance data (I&M) of a module in the user program. I&M data is information saved in a module. This allows you to • Check the system configurations • React to hardware changes • React to hardware faults in the user program. Finding and elimination of hardware errors is easier.	Section Reading out and entering I&M data (Page 334)

What's new in the S7-1500, ET 200MP System Manual, Edition 09/2016 since the previous version 12/2014?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Compact CPUs	You can use compact CPUs for smaller to medium-sized applications. The compact CPUs have integrated analog and digital on-board I/O as well as integrated technology functions.	Starting from section System overview (Page 74)
	Technology CPUs	You can use technology CPUs for demanding applications. Technology CPUs are equipped with expanded motion control functions.	Starting from section System overview (Page 74)
	Fail-safe modules	With fail-safe modules, you replace the conventional safety engineering technical setup. For example, this involves replacement of switching devices for EMERGENCY OFF, protective door monitoring and two-hand operation.	Starting from section System overview (Page 74)
	Formatting, erasing or converting a SIMATIC Memory Card via the display	Your SIMATIC Memory Card is formatted, erased or converted to a program card directly via the display without having to use STEP 7. You save time.	Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101) Function Manual
Changed contents	Asynchronous instructions	You are given an overview of the resource consumption of asynchronous instructions. This ensures adequate resources in the CPU.	Section Asynchronous instructions (Page 246)

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Configuration control	Configuration control provides you with the following advantages: • Different configuration levels of a standard machine can be handled in a single project. • No changes to the hardware configuration or user program are needed. • Centralized/distributed configuration of a system is flexibly variable • Easy handling during maintenance, versioning and upgrades. • Hardware savings: You only use the I/O modules that you currently need. • Potential savings when building, commissioning and creating documentation for standard machines.	Section Configuration control (Page 291)
	Wiring rules for the power supply elements	You are given information on proper connection of the power supply elements.	Section Wiring rules (Page 203)
	Connecting the CPU/interface module to the load current supply	You are given information on proper connection of the CPU/interface module to the load current supply.	Section. Connecting the CPU/interface module to the load current supply (Page 210)
	Firmware update via accessible devices	You are given information on fast firmware updates via accessible devices in the network.	Section Firmware update (Page 359)

Industrial cybersecurity

4

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

In the first part of this section you will find basic information on the subject of industrial cybersecurity. Subsequent sections describe recommended measures for protecting the entire system and the individual components from manipulation and unwanted access.

NOTE

Security-relevant changes to software or devices are documented in the section New properties/functions (Page 27).

4.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

4.2 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction (Page 11) section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. Enter the name or article number of the product in the product search.
5. Select the "Other types" option from the filter menu for "Type," and choose "Download" and "Product note".
6. For the document you want to be informed about, select "Add to my favorites" using the 3 dots on the right.

   For example, if you would like to be informed about all firmware versions of the CPUs, select the entry "Firmware update S7-1500 CPUs incl. displays and ET 200 CPUs (ET 200SP, ET 200pro)".
7. In the following dialog, enter the name of the favorite, select the storage location, and select the "Notify me" option. Then click the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

4.3 Basic information on industrial cybersecurity

4.3.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (for example, due to the destruction of data or denial of service (DoS))

4.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices that do not have their own security functions

- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

4.4 Integrated security concept and security strategies

4.4.1 Comprehensive security concept "Defense in Depth"

With Defense in Depth, Siemens provides a multi-layer security concept that offers industrial plants comprehensive and far-reaching protection in accordance with the recommendations of the IEC 62443 international standard.

Productivity and know-how are protected on 3 levels:

Plant security
Plant security uses various methods to safeguard critical components from physical access by people. This starts with classic building access and extends to securing sensitive areas using access control (for example, code card, iris scan, fingerprint or access code).

Network security
Automation networks must be protected against unauthorized access. This is achieved through security measures on the product, but also those in the product-related environment.

System integrity
Targeted measures must be taken to protect existing know-how or to prevent unauthorized access to automation processes. The measures protect against unauthorized configuration changes, and highlight attempts at manipulation.

You can find more information on the topics of Defense in Depth, plant security, network security, and system integrity on the SIEMENS Industrial cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) Web page.

You can also visit the download center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) to obtain more information on the topic of industrial cybersecurity. The "Operational Guidelines", for example, provide recommendations on basic security measures for secure machine and plant operation in an industrial environment.

4.4.2 Security management

The ISO 27001 and IEC 62443 standards call for a comprehensive approach in information technology (IT) and operational technology (OT) to protect against cyber attacks.

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

- Defining cybersecurity and IT security as an important criterion in the procurement and selection of machines and software applications
- Use of suitable measures to protect production resources, data, and communication from manipulation and theft
- Providing all necessary resources and training to employees to fully support these goals

For this purpose, suitable measures must be selected after a risk assessment and a cost-benefit analysis in order to protect material and intellectual property and prevent damage from occurring. These measures should be integrated into corporate processes and procedures, evaluated regularly, and firmly anchored in the corporate culture. In addition to protecting intellectual property, the protection of personal data must be ensured at all organizational units and levels.

Siemens will provide you with information and support. Subscribe to the Security feeds (https://www.siemens.com/cert) for information on vulnerabilities. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home) and create filters to be notified when important information is published. The procedure is described in the section Notification of security updates (Page 41). Consider using Siemens Cybersecurity Services.

Responsibility in the digital supply chain

Cybersecurity should play a critical role in the evaluation and procurement process. The entire life cycle of a product should be considered to ensure protection against current and future risks. These include, for example, security updates throughout the product life cycle, including guidelines for secure disposal of the product.

Siemens plans and announces the provision of security updates, as well as total discontinuation of products, as part of product support.

Employee awareness

Regular training in cybersecurity and continuous testing of training success are essential so that cybersecurity measures are internalized in processes and work instructions. This involves general training in the use of software and IT hardware for company communication and as work equipment, for example:

- Secure handling of USB devices
- Encrypted communication
- Use of VPN
- Rules for passwords and use of access
- Setting up two-factor authentication
- Educating employees about the dangers posed by malware, phishing, social engineering and other factors

Furthermore, if applicable, production equipment and software training should always include the topic of cybersecurity.

Maintaining the security concept through updates

Keeping software up-to-date is essential, for example, to benefit from the following measures:

- Implementation of new security strategies, protocols and techniques
- Closing of security vulnerabilities
- Elimination of security vulnerabilities

To this end, it is necessary to keep a constant eye on the further development of protective measures and, if necessary, the expansion of requirements.

Recommendations:

- Set up notifications for (security) updates
- Subscribe to information on vulnerabilities
- Monitor and implement the further development of the technology, especially in the area of cybersecurity

Always keep technology and knowledge up to date.

Consideration of the risks posed by cyber attacks in the Threat and Risk Assessment (TRA)

Make an inventory of all software, hardware, and infrastructure devices, in order to identify risks to the location or organization. Incident response procedures must be incorporated into all IT and manufacturing processes. The choice of risk mitigation measures should be based on a cost-benefit analysis and classification of risks. This is followed by the introduction of cybersecurity rules and procedures and the training of personnel.

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

Cybersecurity must be part of the corporate culture and process landscape and must be internalized and lived by all employees.

Continuously monitoring the security situation

You have the following options to monitor the cybersecurity situation continuously:

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and resolve security vulnerabilities in a targeted manner.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network

- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: for example, network segmentation, firewalls, VPN, DMZ (demilitarized zones)

4.5 Operational application environment and security assumptions

4.5.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

Operational reliability and intended use

Read the "Special information" in the Introduction (Page 11) section.

Area of application

Observe the section Areas of application SIMATIC S7-1500 and ET 200MP (Page 77).

4.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Threat and Risk Assessments (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection
In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security
You can ensure physical corporate security by the following measures, among others:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security
You can ensure the physical production security by, among others, the following measures:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsafe on systems.

4.6 Security properties of the devices

The security properties of the individual devices are listed in the Equipment Manuals.

4.7 Secure operation of the system

This section describes measures recommended by Siemens to protect your system from manipulation and unauthorized access.

4.7.1 Hardening measures

System hardening, also simply referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which a restrictive user and rights management system is implemented.

4.7.2 Secure configuration

Secure configuration involves control over all software components, along with their interfaces, ports, and services.

Activated services and ports pose a risk, for example of unauthorized access to the network and to programs.

To minimize the risk, activate solely the required services at all the automation components. Take all activated services (especially Web servers, FTP, remote maintenance etc.) into account in the security concept. Consider the default states of ports and services in your security concept.

You can find an overview of all ports and services used in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.7.3 Access control

In addition to physical protection, also establish logical safeguards to control access to your system:

- Use a restrictive user and rights management system, for example, for accessing the CPUs and TIA Portal.
- Refer to the information about password management in the section Protection (Page 256) and in the STEP 7 online help (TIA Portal).

4.7.4 Handling of sensitive data

Data protection information

Siemens Aktiengesellschaft observes the applicable data protection laws, including the General Data Protection Regulation (GDPR), in particular the rules of data minimization and data-protection-friendly default settings (privacy by design, privacy by default).

This means for the products in this system:

Products with user management save user names and passwords to manage access rights. User names are also saved in logging alarms. These logging alarms are provided with a time stamp and stored in the internal cache of the CPU. They can be forwarded to a central syslog server. You can find more information in the section Syslog messages (Page 61).

In addition, the products do not store any personal data.

If you establish a reference to an identifiable person by linking these data with other data (such as shift schedules), or if you store personal data on the same medium (such as a hard disk), you must yourself ensure that the data protection regulations are observed.

Information on the secure removal of data from the CPU, interface module and SIMATIC Memory Card is provided in the section Secure decommissioning (Page 50).

Storage of security-relevant data

When storing your security-relevant data on your PC, independently ensure secure data storage.

Also observe the section Sensitive data (Page 58).

4.7.5 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

- Always keep your plant/products up to date to benefit from troubleshooting and to minimize potential risks.
- Use email notifications to be automatically informed about firmware updates.

You can find more information in the following:

- The section Firmware update (Page 359)
- The section Notification of security updates (Page 41)

4.7.6 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. A vulnerability can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes Security Vulnerabilities in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following website of the Siemens Aktiengesellschaft: Siemens ProductCERT and Siemens CERT (https://new.siemens.com/global/en/products/services/cert.html?s=SIMATIC#SecurityPublications)

"Search Security Advisories" is the default entry in the "SIMATIC" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please let us know immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

4.7.7 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

4.7.8 Security checks

Security checks for data, files, and archives serve to ensure data integrity at the storage location and during file transmission, protecting against manipulation and transmission errors. This is often achieved using digital checksums that are provided alongside the data. Tools (such as SHA-256 or SHA-512) for calculating and verifying these checksums are provided in many systems and named according to their respective calculation methods.

File Integrity Guidelines describe the prescribed procedure for integrity checks.

Integrity protection is a protection function for engineering data and firmware files.

Communication integrity means protecting communication against unauthorized manipulations to ensure high system availability. A central element in this regard is, for example, the use of digital checksums when accessing controllers. (Source: Industrial Cybersecurity website (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html))

4.7.9 Secure decommissioning

In the following section, you will find information on how to properly decommission individual components of your automation system. Decommissioning is necessary when the component has reached the end of its service life.

Decommissioning includes environmentally sound disposal and secure removal of all digital data of electronic components with storage medium.

4.7.9.1 Securely removing data

Before disposing of components of your automation system, you should securely delete all data from the storage media of these components. How to securely delete data from the devices so that it cannot be recovered is described below.

NOTICE
Data misuse resulting from non-secure deletion of data Incomplete or non-secure deletion of data from data memories can result in data misuse by third parties. For this reason, ensure secure deletion of data from all storage media used before disposing of the product.

Secure erasure of data from the CPU and SIMATIC Memory Card

To delete all data from the data memories of the CPU, reset the CPU to factory settings. The function deletes all information that was saved internally on the module.

For secure deletion of the data, follow these steps in the order given:

1. Format the SIMATIC Memory Card.

   The formatting deletes all contents from the SIMATIC Memory Card.

   Formatting with STEP 7:

   – Establish an online connection.
   – Open the online and diagnostics view of the CPU (either from the project context or via "Accessible devices").
   – In the dialog window, select "Functions > Format memory card" and then click the "Format" button.

   Formatting using the display of a CPU:

   – In the display of the CPU, select the menu "Settings" > "Card functions" > "Format card" and confirm with OK.

2. Restore the factory settings of the CPU.
   We recommend resetting the CPU in STEP 7. When you reset a CPU to factory settings, select the options shown in the figure before the reset.

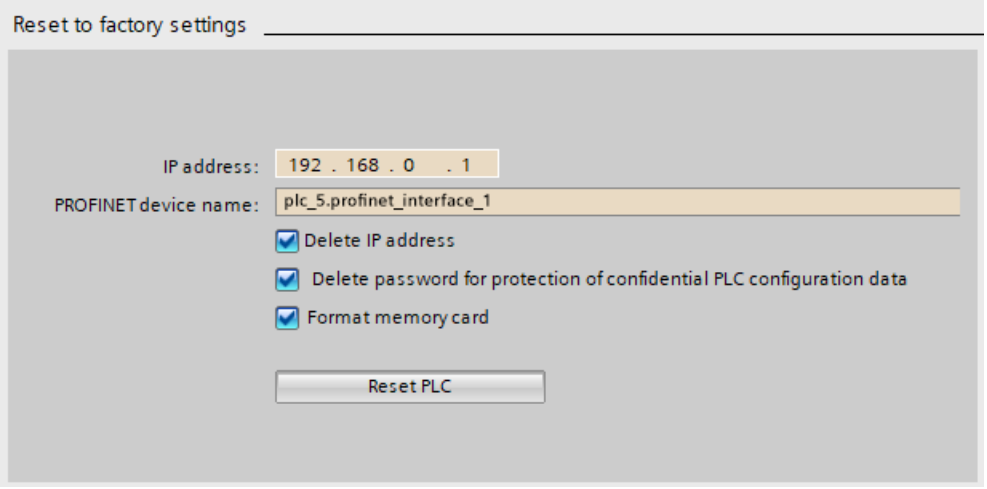


Figure 1-447 Resetting the CPU to factory settings

NOTE
If you reset the CPU using STEP 7 and you have selected the "Format memory card" option, you can skip step 1 of the described sequence of steps.

Result: All data that was still contained in the data memories of the modules and the SIMATIC Memory Card has been deleted. You can now dispose of the components.

For more information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 365).

NOTE
If you no longer plan to use the SIMATIC Memory Card after formatting it, destroy it before disposing of it.
A secure destruction method is to shred the card to such a degree that it cannot be reconstructed. For this, you can also use a waste disposal service that specializes in data storage medium destruction.

Secure erasure of data from the interface module

With the following tools, you can securely erase the data from the interface module:

- STEP 7 < V19
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

Follow these steps in the order given:

1. Establish an online connection.
2. Open the Online and Diagnostics view of the IM (either from the project context or via "Accessible devices").
3. In the dialog box "Functions > Reset to factory settings", select the option "Delete I&M data" and then the "Reset" button.

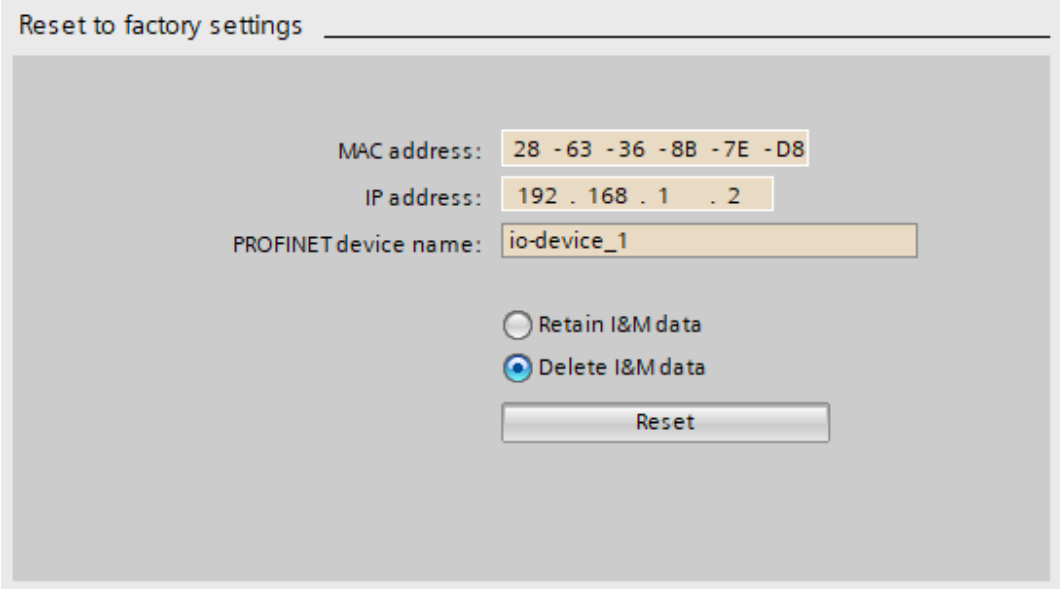


Figure 1-448 Resetting an interface module to factory settings

Result: All the data that was still in the data memories of the interface module was deleted. You can now dispose of the components.

For more information on resetting the interface module to factory settings, refer to the section Resetting an interface module to factory settings (Page 370).

NOTE

STEP 7 ≥ V19

Only the communication parameters will be securely deleted on "Reset to factory settings" with the "Delete I&M data" option enabled when you use STEP 7 ≥ V19.

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

If you want to securely remove all data, use one of the tools listed above for this purpose.

4.7.9.2 Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

NOTE

Recycler Guides

Disassembly of electronic devices may only be carried out by specialists trained in the recycling of electronic products.

The Siemens Recycler Guides provide step-by-step disassembly instructions and material composition information of the products. This information helps recyclers direct specific materials to specialized recyclers and thus maximize the recovery of resources.

You can find the Recycler Guides in the SiePortal (https://sieportal.siemens.com/en-ww/home) in the "Support" area by using the search term "Recycler Guide".

4.8 Secure operation of the engineering software

For more information on secure operation of the engineering software, refer to the TIA Portal online help.

4.9 Secure operation of CPUs

This section describes measures recommended by Siemens to protect your device from manipulation and unauthorized access.

4.9.1 Secure configuration

Information about ports, services, and default states can be found in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and the Equipment Manual.

4.9.2 User management and access control

4.9.2.1 Administration of user accounts

Creating and managing user accounts with appropriate usage rights is an important measure, as every active user represents a potential security risk.

Take the following security measures:

- Train your personnel in understanding their rights and password assignment
- Regularly check the user accounts

You can find information on creating and managing user accounts in the Protection (Page 256) section under "User management" and in the online help for STEP 7 (TIA Portal).

4.9.2.2 Assigning secure passwords

Using non-secure passwords can easily lead to data misuse. Non-secure passwords can be easily guessed or decrypted.

- Therefore, always change the default passwords during commissioning and use different passwords for different users, functions and devices.
- When changing the password, do not use passwords (or parts of passwords) that were used in the past.
- Also, change passwords for functions you don't personally use to prevent misuse of such unused functions.
- Always keep your passwords confidential and ensure that only authorized individuals have access to the respective passwords.
- Go over the required minimum password length and use a mixture of lower- and upper-case letters, numbers and characters.

The STEP 7 online help (TIA Portal) provides information on creating secure passwords.

Overview of all components and functions with password protection

Components and functions with password protection	Comment
SIMATIC S7 app	See section SIMATIC S7 app (Page 154)
Syslog (with certificate protection)	See section Syslog messages (Page 61)
CPU	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
OPC UA	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section OPC UA communication
SNMP Community-String (similar to a password)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section SNMP
Secure communication (with certificate protection)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
Web server	See the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560)

4.9.2.3 Password management

- You can find comprehensive recommendations for creating secure passwords in the Industrial security Configuration Manual (https://support.industry.siemens.com/cs/us/en/view/108862708).
- Establish guidelines for assigning passwords and intervals for password changes.
- Settings for checking password policies when passwords are assigned or changed can be configured in the TIA Portal. For more information, please refer to the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

- Modify and reset the password for protecting confidential configuration data.
  You can find information on the following topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925):
  - Description of how to change the password
  - Description of how to delete or reset the password
  - Description of how to assign the password via a SIMATIC Memory Card
- Access to a password-protected CPU can be configured through the display, if the CPU has a display; see section Using the display to set additional password protection (Page 283).
- For user management and access control, use the Local/central user management (Page 259).
- Using a password provider: In STEP 7, you can set up a password provider; see section Know-how protection (Page 284).
- In addition, you can use commercially available password management programs.

Setting password protection without engineering system

You can change your password for a user account in the user management via the web server of the CPU:

- API method Api.ChangePassword: Changing a password in runtime

You can find more information about the available methods of the web server's Web API in the Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) Function Manual.

4.9.2.4 Setting protection levels

For detailed information about setting up protection levels for the CPU and assigning user authorizations, refer to the section Configuring access protection for the CPU (Page 280) and the STEP 7 online help (TIA Portal).

4.9.2.5 Certificate management

You can create, assign and manage certificates with TIA Portal for the following functions of the CPUs:

- Secure Open User Communication
- OPC UA communication
- Secure PG/HMI communication
- Web server

You can find all relevant information about "Certificate management" in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.9.3 Protection functions

Integrated protection functions of the CPU protect against unauthorized access.

You can find an overview of the protective functions supported by your CPU in the respective Equipment Manual.

A description of the protection functions and their activation can be found in the section Protection (Page 256).

4.9.4 Signed firmware update for CPUs

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect Internet source

Principle of the signed firmware updates for CPUs

Firmware updates for CPUs contain a digital signature.

The digitally signed firmware update files are available for download on the Siemens Support Web page (https://support.industry.siemens.com/cs/de/en/view/109478459).

The CPU verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the CPU can detect a manipulated or corrupted firmware update file and reject it.

Note that the CPU performs the verification only after the complete firmware download has taken place.

The procedure for carrying out firmware updates for CPUs is described in the section Firmware update (Page 359).

Diagnostics alarms and remedy

The success/failure of the signed firmware update is reported:

- In the diagnostics buffer of the CPU
- On the display of the CPU if the CPU has a display
- In the Syslog storage of the CPU

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file used by you originates from a secure source and was downloaded unchanged. As a check calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support Web page.
3. Repeat the firmware update.

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109483101).

4.9.5 Secure Boot for CPUs

Secure Boot

Secure Boot verifies, before the boot process, whether firmware has been falsified, for example through manipulation or accidental falsification.
Secure Boot ensures the authenticity and integrity of the firmware executed by the device.

Principle of "Secure Boot" for CPUs

CPUs as of article number 6ES751x-xxx03-0AB0 and as of 6ES751x-xxx10-0AB0 verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before their startup.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to the signed firmware update for CPUs (Page 56), Secure Boot prevents a manipulation of the firmware by a physical intervention into the CPU.

Secure Boot is integrated in the CPU and cannot be deactivated for security reasons.

4.9.6 Web server

The CPUs have an integrated web server.

It comes with built-in security features:

- Activation for specific interfaces
- Access via the secure transmission protocol "HTTPS" using the CA-signed or self-signed web server certificate
- Authentication via local or central user management
- Changing the password of local users during runtime via Web API

The functions are described in detail in the Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) Function Manual.

4.9.7 Secure communication/OPC UA

Additional protection is provided by the protection functions of the secure communication and OPC UA protocols.

Information about the protocols Secure Communication and OPC UA can be found in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.9.8 Sensitive data

Security-relevant and sensitive data can be protected through appropriate measures such as passwords and protection functions.
For certain data, protection is already essential and implemented within the system (e.g. certificate management in the TIA Portal).

Sensitive data	Comment	Where can I find more information?
Confidential configuration data (private keys, passwords/access data)	Protection by using a strong password	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Protection of confidential configuration data
User management data	-	Protection (Page 256) section STEP 7 online help
Configuration of CPUs and interface modules	Protection through PROFINET Security Class 1	Function manual PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Blocks (data blocks, logic blocks)	Know-how protection, copy protection, write protection	Protection (Page 256) section
Data deemed sensitive by the operator	Backups, other configuration data, analysis data	Backing up and restoring the CPU configuration (Page 326) section

4.9.9 Backups and data backups

Regular data backups after successful installation should be part of a successful security concept. Whether for restoring a project if required, if the changes made do not yield the desired results, or for saving an installation in an emergency.

Backup of a STEP 7 project:

- Project backup via the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300)
- Project backup via TIA Portal, see FAQ What options are there in STEP 7 (TIA Portal) for backing up projects and what is the significance of the backup files of the projects? (https://support.industry.siemens.com/cs/us/en/view/92561565)

You can find more information in the section Backing up and restoring the CPU configuration (Page 326).

4.9.10 Additional protective measures for network security

To secure a CPU via further measures, the following options are available:

- Use of the CP 1543-1 or CP 1545-1 with security functions

  The use of an Ethernet CP provides you with additional access protection through a firewall and possibilities to establish secure VPN connections. See also operating instructions SIMATIC NET: S7-1500 - Industrial Ethernet CP 1543-1 (https://support.industry.siemens.com/cs/us/en/view/67700710) and S7-1500 - Industrial Ethernet SIMATIC CP 1545-1 (https://support.industry.siemens.com/cs/us/en/view/109771664).

- Various measures increase protection against unauthorized access to functions and data of the CPU from external sources and via the network. For information on the protection functions, refer to the Overview of protective functions (Page 256) section, under Further measures for protection of the CPU.
- You can find information on network security and network components for protection against unauthorized access in the Network security section of the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.9.11 Remote access to CPU

4.9.11.1 Using a Web server

When using Web servers, traditional firewalls are no longer sufficient to protect modern networks.

Information about potential risks when using Web servers can be found in the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560).

4.9.11.2 Remote access via Internet

Communication via SINEMA Remote Connect (SINEMA RC)

The "SINEMA Remote Connect" (SINEMA RC) application is available for remote maintenance purposes. SINEMA RC uses OpenVPN to encrypt the data. The center of communication is the SINEMA RC server, which is used for communication between the devices and manages the configuration of the communication system.

You can use the CP 1543-1 communication processor for remote maintenance via SINEMA RC.

More information on communication via SINEMA RC can be found in the Operating instructions S7-1500 - Industrial Ethernet SIMATIC CP 1543-1 (https://support.industry.siemens.com/cs/de/de/view/109986722/en) and on the Internet.

4.9.11.3 Remote access via TIA Portal

Communication via TIA Portal Cloud Connector

The TIA Portal Cloud Connector enables you to access the local PG/PC interface and the SIMATIC hardware connected to it from a TIA Portal Engineering in a cloud environment.

Use the "TIA Portal Cloud Connector" via a VPN solution (for example, SINEMA RC).

More information on communication via TIA Portal Cloud Connector in the STEP 7 (TIA Portal) online help. You can find details on working with the TIA Portal Cloud Connector in this application example (https://support.industry.siemens.com/cs/de/de/view/109747305/en).

4.9.12 Recording Security events

Syslog storage

Syslog stands for "System Logging Protocol," a standard for transmitting log messages triggered by security events. Predefined events in a network device are collected as security events in the device (syslog client) and stored as syslog messages in the local cache.

A syslog server collects and categorizes syslog messages, which can then be analyzed and filtered and displayed in various ways. Additionally, notifications for critical events can be configured.

The following security events, for example, are collected in the CPU diagnostic buffer:

- Going online with the correct or incorrect password
- Manipulated communication data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (via an instruction or, if applicable, the CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

The above-listed security events are also stored as syslog messages in the local cache of a CPU as of firmware version V3.1. You can find an overview of all syslog messages in the following Entry (https://support.industry.siemens.com/cs/ww/en/view/109823696).
The content of a syslog message is based on IEC 62443-3-3.

You can find more information in the section Syslog messages (Page 61).

Connection to a SIEM system

A SIEM system (Security Information and Event Management) analyzes security events in real time and can be installed, for example, on the syslog server.

4.9.13 Syslog messages

Using syslog messages

International standards and national regulations for the IT security of automation components require, for example, the ability to log safety-related events.
Syslog (System Logging) is an IETF standard protocol (RFC 5424) for the transfer of recorded events and meets this requirement. A CPU records the following events, for example:

- Security events
- Firmware updates
- Changes to the user program
- Changes to the configuration
- Changes to the operating mode

The collecting of security-relevant events cannot be deactivated. Each CPU as of FW version saves V3.1 syslog messages in a local cache. By querying this cache, you can view the syslog messages and identify potential security risks.

For CPUs as of FW version V4.0, the local cache is located in the retentive memory area. As a result, syslog messages are retained after a POWER OFF/POWER ON transition or when the CPU is switched off. As a result, events that require one or more CPU restarts are also retained in syslog storage, such as restoring the CPU configuration.

The cache of a CPU is organized as a ring buffer. If the storage limit of the cache is reached and additional security events occur, the oldest messages in the cache are overwritten.

You have the option of transferring the events collected by the CPU to a syslog server in the network.

NOTE

Deleting the retentive syslog storage

If you want to expand or store a CPU as of FW version V4.0, the syslog messages are retained in the syslog storage of the CPU. To prevent unwanted transmission of saved syslog messages, return the CPU to factory settings (reset to factory settings) before removing or storing.

After a successful reset, the syslog storage only contains one boot up entry, which provides information about the reset to factory settings.

Forwarding to a syslog server

From STEP 7 V19 and a CPU as of FW version V3.1, it is possible to transfer syslog messages to a server, for example, SINEC INS. The syslog messages are transferred to the syslog server via the syslog protocol. The syslog server saves all syslog messages from its connected devices. Messages of system and network events are stored centrally in a storage location in the syslog server. At the syslog server interface, you can view the collected syslog messages and thereby determine the source of potential security risks or problems.

If you want S7-1500 CPUs to transfer their syslog messages to a syslog server, configure either a TLS or UDP connection. Syslog messages are sent to the syslog server via port 514 (UDP) or port 6514 (TLS over TCP) by default.

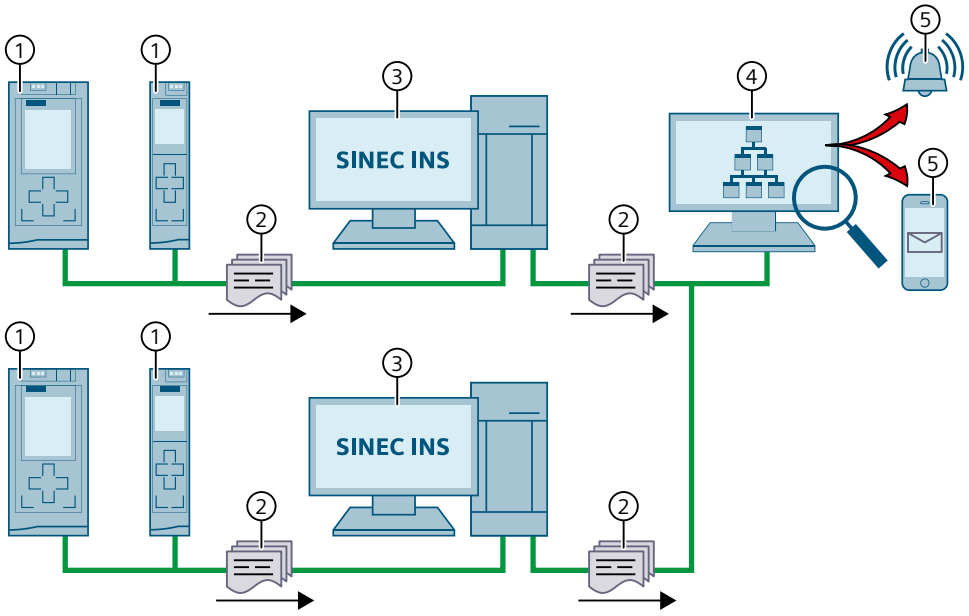
Use solely a TLS connection in productive operation. TLS ensures that all syslog messages from the CPU are securely transferred to the syslog server.

You can also use a UDP connection for commissioning and testing scenarios. A UDP connection is not secured. A UDP connection also does not guarantee transfer of all syslog messages to the configured syslog server.

Processing in a Security Information and Event Management system (SIEM system)

In order to be able to accept and process the incoming syslog messages, a SIEM system must "understand" the syslog protocol according to RFC 5424.

The SIEM system breaks down the incoming syslog messages into individual elements. These elements are assigned to their own event within the SIEM system. Within this event, it is analyzed whether there are connections between the individual syslog messages. In this way, the SIEM system detects possible attack vectors and, if necessary, informs the user, for example, in the event of multiple attacks at several points in the system.



① CPUs
② Syslog messages
③ Syslog server, for example, SINEC INS
④ SIEM system
⑤ Notify user

Figure 1-449 Forwarding and processing of syslog messages

More information

More information on network management with SINEC INS is available in the "SIMATIC NET: Network management SINEC INS V1.0 SP2" (https://support.industry.siemens.com/cs/us/en/view/109781023) manual.

You can find information on the structure of syslog messages in the Structure of the Syslog messages (Page 65) section.

4.9.13.1 Transfer the syslog messages to a syslog server

A CPU can send syslog messages to a syslog server via a TLS or UDP connection.

Recommendation: Use solely a TLS connection for the productive operation. You can also use a UDP connection for commissioning or testing scenarios.

Transmitting syslog messages via a TLS connection

A TLS connection ensures that all syslog messages from a CPU are securely transmitted to the syslog server. If the TLS connection is interrupted, the syslog messages are cached in the CPU cache. The CPU only sends the cached syslog messages when the TLS connection to the syslog server is established again.

Each syslog message is transferred to a syslog server only once. If you address another syslog server in the settings for the syslog server, syslog messages that have already been transferred are not transferred to a newly configured syslog server.

Since the cache of a CPU is organized as a ring buffer, the oldest messages are overwritten as soon as the memory limit is reached and further security events occur. Overwriting syslog messages that have not yet been transferred to a syslog server is reported as a security event (overflow event) in syslog storage. If syslog messages are overwritten over a long period of time, the overflow event is repeated regularly. As soon as the first message is sent back to the syslog server, another security event is generated. This security event confirms that syslog messages are being transferred back to the syslog server.

Message in the diagnostics buffer of the CPU

If a syslog server is configured in the CPU properties, the CPU also records overwriting of non-transmitted syslog messages in the diagnostics buffer.

As soon as a non-transmitted syslog message is overwritten, the CPU reports maintenance demanded as an incoming event in the diagnostics buffer. In addition, the MAINT LED of the CPU also signals incoming maintenance demanded.

As soon as the syslog messages are sent back to the syslog server, the CPU reports maintenance demanded as an outgoing event in the diagnostics buffer. If the CPU does not report any further maintenance demanded, the MAINT LED also turns off again.

Information on the status and error display of the CPU can be found in the respective device manuals.

Requirements

If you want to transfer the syslog messages of a CPU to a syslog server, the following requirements must be met:

- STEP 7 as of version V19
- CPU as of FW version V3.1
- A project has been created in STEP 7
- The device or network view of STEP 7 is open

Procedure

To configure the CPU to transfer syslog messages to a syslog server, following these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Syslog server".
3. In the "Connection to syslog server" area, select the "Enable transfer of syslog messages to a syslog server" option. The selection options below become editable.
4. Select one of the following options from the "Transport protocol" drop-down list:
   - "Transport Layer Security (TLS) - server and client authentication": Encrypted data transfer, syslog server and client (CPU) must authenticate themselves.
   - "Transport Layer Security (TLS) - only server authentication": Encrypted data transfer, only the syslog server needs to authenticate itself.
   - "UDP": Unencrypted data transfer, syslog server and client (CPU) do not need to authenticate themselves.

   In the next sections you can read how to select the certificates for authentication (logon) depending on the settings specified.
5. In the "Addresses of the syslog servers" column, enter a valid server address.
6. In the "Port" column, enter a valid port number.
   By default, STEP 7 uses the following port numbers:
   - Standard TCP port for TLS: 6514
   - Standard UDP port: 514

Result: You have configured the transfer of syslog messages to a syslog server.

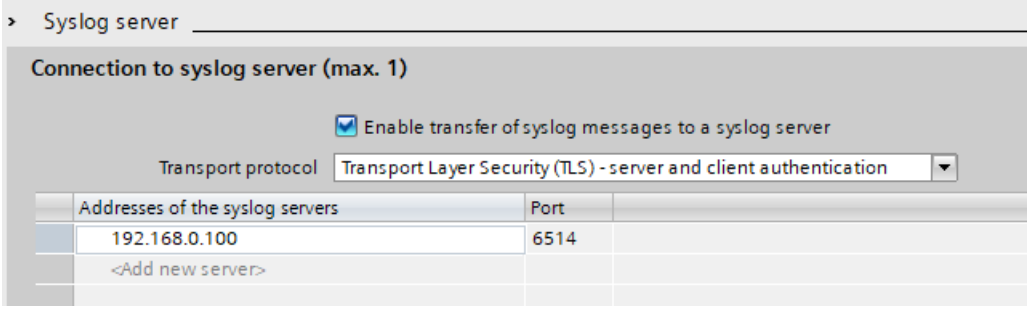


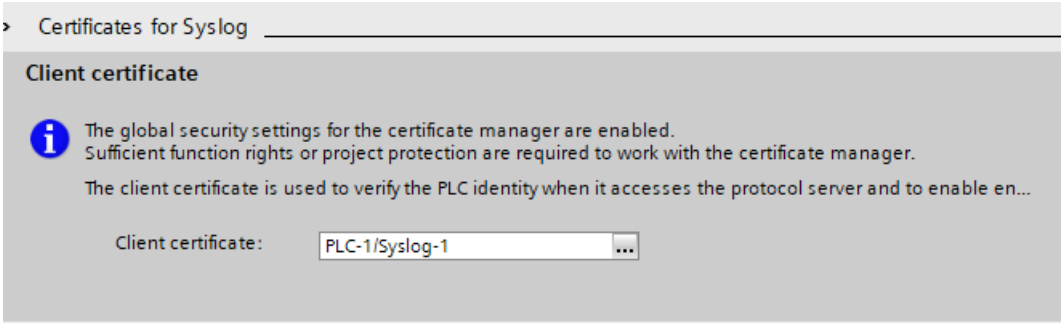
Figure 1-450 Transfer of syslog messages to a syslog server configured

Selecting the client certificate

STEP 7 provides the required client certificate for a CPU for the TLS transport protocol. If the certificate is managed within the CPU, you can either choose an existing certificate or create a new certificate. To do so, follow these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Certificates for Syslog".

3. Select the appropriate certificate in the "Client certificate" field.



Selecting the server authentication

After selecting the TLS transport protocol, the configured syslog server must authenticate itself. This ensures that the CPU only connects to a trusted server. If you want to waive server authentication, activate the automatic acceptance of server certificates during runtime. To configure these settings, follow these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Certificates for Syslog".
3. In the "Trusted servers" area, specify whether the connected syslog server is to be authenticated. In this case, it is necessary to complete the following information:
   - Add trusted server: Add a valid server certificate in the "Common name of subject" column.
   - Automatically accept certificates during runtime: Activate the "Automatically accept server certificates during runtime" option. Editing in the table is then not possible.

NOTE

No authentication with automatically accepted server certificates

If you enable the "Automatically accept server certificates during runtime" option, a server does not need to authenticate itself. This means that the CPU can also connect to unknown servers that could represent a security risk.

Only select this option during commissioning or in a protected environment.

4.9.13.2 Structure of the Syslog messages

A CPU collects syslog messages in a local cache. These syslog messages are structured according to the syslog protocol (RFC 5424) and consist of the following elements:

- HEADER
- STRUCTURED-DATA
- MSG (Message)

The following sections describe the structure and parameters of the individual elements.

Structure of the HEADER element

The header contains all the data required for further processing of the syslog message. A space separates the individual parts of the header (exception: No space between PRI and VERSION). A CPU transmits the following header in syslog messages, for example:

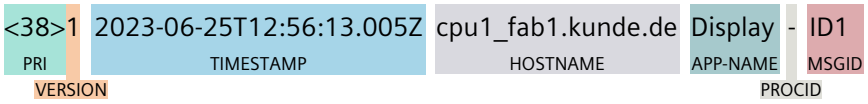


Figure 1-451 Example: HEADER of the syslog message of a CPU

The following table describes the parameters in the prescribed order.

Parameter	Description
PRI	PRI encodes the priority of the syslog message, divided into Severity (severity of the message) and Facility (origin of the message). The PRI value is formed as follows: • PRI = Facility x 8 + Severity Possible values: • Severity – 0 = Emergency: system is unusable – 1 = Alert: action must be taken immediately – 2 = Critical: critical conditions – 3 = Error: error conditions – 4 = Warning: warning conditions – 5 = Notice: normal but significant condition – 6 = Informational: informational messages – 7 = Debug: debug-level messages • Facility – 1 = User-level messages – 2 = Mail system – 3 = System daemons – 4 = Security/authorization messages – 5 = Messages generated internally by syslog – 6 = Line printer subsystem – 7 = Network news subsystem – 8 = UUCP subsystem – 9 = Clock daemon – 10 = Security/authorization messages – 11 = FTP daemon – 12 = NTP subsystem – 13 = Log audit – 14 = Log alert A CPU does not use all of the listed severity/facility values.
VERSION	Version number of the syslog specification.
TIMESTAMP	The device sends the time stamp in the format "2023-06-25T12:56:13.005Z" as UTC time without time zone and correction for daylight-saving/standard time.
HOSTNAME	Contains the name or the IP address (PROFINET interface X1) of the device or system from which the syslog message has been sent. IPv4 address according to RFC1035: Bytes in decimal representation: XXX.XXX.XXX.XXX IPv6 address according to RFC4291 Section 2.2 "-" is output if information is missing.
APP-NAME	Contains the component (device part or application) from which the message has been generated. "-" is output if information is missing.
PROCID	The process ID serves to clearly identify the individual processes, for example during analysis and troubleshooting. "-" is output if information is missing.
MSGID	ID to identify the message. "-" is output if information is missing.

Structure of the STRUCTURED-DATA element

STRUCTURED-DATA provides information in an interpretable and decomposable data format. The following applications are possible, for example:

- More information about the syslog message
- Application specific information

STRUCTURED-DATA can contain one or more elements (SD-ELEMENT). Each SD element must be enclosed in square brackets. If STRUCTURED-DATA consists of multiple SD elements, the individual SD elements are separated by a space.

Each SD-ELEMENT consists of its name (SD-ID) and one or more name-value pairs (SD-PARAM). Each name-value pair consists of a parameter name (PARAM-NAME) and the associated value (PARAM-VALUE). A space separates the individual components (SD-ID and SD-PARAM) within an SD element.

A CPU transmits the following SD ELEMENT in a syslog message, for example:

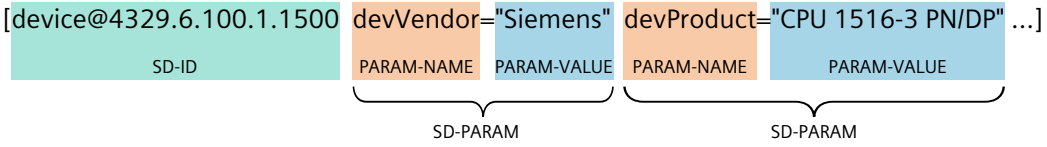


Figure 1-452 Example: SD ELEMENT of the syslog message of a CPU

Structure of the MSG element

In the MSG (MESSAGE) element, a CPU transmits the simplified name of the event in English. The following table shows what the content of a message of the MESSAGE element can look like.

MESSAGE	Description
SE_LOCAL_SUCCESSFUL_LOGON	The local logon has been successful (e.g. on the operator display of the CPU).

More information

You can read more information about the structure and transmission of syslog messages in the following RFCs (Request for Comments):

- The syslog protocol (RFC 5424) (https://tools.ietf.org/html/rfc5424)
- Transferring syslog messages via Transport Layer Security (RFC 5425) (https://tools.ietf.org/html/rfc5425)
- Transferring syslog messages via UDP (RFC 5426) (https://tools.ietf.org/html/rfc5426)

4.10 Secure operation of interface modules

Device-specific security information and instructions for interface modules can be found in the respective Equipment Manual.

4.10.1 Data integrity for interface modules

Data integrity refers to the completeness and correctness (integrity) of data, which is an essential prerequisite for the proper functioning of systems.

Measures for data privacy, data consistency, and data security ensure that data used within devices cannot be damaged, altered (manipulated), or deleted during processing or transmission, and at the very least, any changes to the data are detected.

Data integrity for interface modules

To detect intentional or accidental changes to data within an interface module and its associated modules, the possibility of dynamic integrity checking is introduced for PROFINET interface modules.

The ability to detect integrity breaches enhances the resilience of the distributed I/O system.

Data integrity within a distributed I/O system is entirely covered within the interface module and does not pertain to other components of the automation system.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

A CRC (Cyclic Redundancy Check) is always the same for specific, unchanged memory content. When the memory content changes, the interface module (IM) calculates a different checksum for this content by reading and comparing the I&M4 data. By comparing with the initial CRC, you can determine whether the data in the memory has been modified or not:

- CRC stayed the same: No change in the data within this memory area of the interface module IM
- CRC changed: The data within this memory area of the IM was modified

Only you, as the user, know whether changes to the data of an interface module were intentional or not. If changes were not intentional, you can detect that the data of the interface module has been compromised through changed CRCs and respond accordingly.

I&M data

PROFINET devices provide Identification and Maintenance data (I&M data), which is a set of predefined data structures containing the internal module status. With this data, a module can be identified, its serial number can be determined, etc.

The CRC checksums are mapped in the maintenance data **I&M4** of the interface module.

NOTE

Requirements for calculating the CRCs

The CRCs via the memory contents of the interface module are calculated only when you request to read the I&M4 data.

The CRCs cover not only the interface module itself but can also take into consideration combined checksums from associated modules (refer to the section on the structure of the data record for I&M data). Process data is not included in the calculation of CRCs.

Example:

- You put your distributed I/O system into operation and read the CRC CHK_OVERALL with the value "0x55AAA678" ("16#55AAA678") from the interface module via the I&M4 data.
- As long as no changes have been made to the data of the interface module or the associated modules, each subsequent read will give the value "0x55AAA678" or "16#55AAA678".
- Once you read a different CRC CHK_OVERALL, for example, "0xCC9876FF", you will realize that there must have been changes to the data of the interface module or the associated modules.

The quality of the statement regarding the data integrity of the distributed I/O system improves with each module associated with the interface module that supports I&M4 data. Refer to the Equipment Manual of the respective module to find out if and from which firmware version the module supports I&M4 data.

The structure of the I&M data 0 to 4 is described in the section Record structure for I&M data (Page 336).

Spare parts scenario

The spare parts scenario is ensured. This means that you can replace interface modules with the same article number. For the "new" interface module, the static data such as the serial number and MAC addresses will change. Note that this is why the replacement is reflected in the changed identification data CHK_STATIC_LOCAL and consequently also in CHK_OVERALL.

More information on the spare parts scenario and compatibility can be found in the Equipment Manual of the interface module.

4.10.2 Signed firmware update for interface modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect Internet source

Information on whether your interface module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of the signed firmware update for interface modules

Firmware updates for interface modules may include a digital signature. The digitally signed firmware update files are available for download on the Siemens Support Web page.

The interface module verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the interface module can detect a manipulated or corrupted firmware update file and reject it.

Note that the interface module performs the verification only after the complete firmware download has taken place.

Subsequently, a notification is sent to the firmware update tool regarding the success or failure of the signature verification.

You still have all the options for firmware updates, as described in the Firmware update (Page 359) section, when performing signed firmware updates for modules. If the firmware update was not successful, the module will continue to run with the previous firmware.

Diagnostics alarms and remedy

When performing a firmware update for a module with an established connection between the IM and CPU, the following options for notifications are available in the CPU's diagnostic buffer:

- Successful integrity check of the firmware for the module
- Rejection of non-secure firmware for the module

You can find more information in the section on diagnostics alarms in the equipment manual for the respective module.

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file used by you originates from a secure source and was downloaded unchanged. As a check calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support website.
3. Repeat the firmware update.

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/de/de/view/109483101/en).

4.10.3 Secure Boot for interface modules

Secure Boot

Secure Boot verifies, before the boot process, whether firmware has been falsified, for example through manipulation or accidental falsification.
Secure Boot ensures the authenticity and integrity of the firmware executed by the device.

Information on whether your interface module supports Secure Boot is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of "Secure Boot" for interface modules

Interface modules verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before being executed.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to signed firmware updates for interface modules, Secure Boot also prevents manipulation of the firmware through physical intervention in the interface module.

Secure Boot is integrated into the interface module and cannot be deactivated for security reasons.

NOTE

Longer startup duration of the interface module
The signature verification of Secure Boot significantly extends the startup time of the interface module. You can find time specifications in the Equipment Manual of the interface module, in the Technical specifications section.

LED display on the interface module

If the Secure Boot verification results in an invalid signature, the LEDs RUN, ERROR, and MAINT on the interface module will flash. In this case, you need to replace the interface module.

4.11 Secure operation of I/O modules

Device-specific security information and instructions for I/O modules can be found in the respective Equipment Manual.

4.11.1 Data integrity for I/O modules

Data integrity for I/O modules

In order to detect intentional or accidental changes to the data of an interface module and the assigned modules, the dynamic integrity check for I/O modules is introduced. Information on whether your I/O module supports the data integrity check is available in the Technical specifications section of the corresponding Equipment Manual.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as serial numbers, parameter settings, calibration data and I&M data of I/O modules. The interface module stores the checksums in the I&M4 data area.

You can find more information on the principle of data integrity and I&M4 data in the section Data integrity for interface modules (Page 68).

Spare parts scenario

The spare parts scenario is still ensured. This means that you can replace I/O modules with the same article number. For the "new" I/O module, the static data such as the serial number will change. Note that the replacement is therefore reflected in the following modified I&M4 data of the interface module:

- CHK_STATIC_SUBS
- CHK_OVERALL_SUBS
- CHK_OVERALL

You can find the structure of I&M data in the section Record structure for I&M data (Page 336).

4.11.2 Signed firmware update for I/O modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect Internet source

Signed firmware update for I/O modules

Firmware updates for I/O modules can contain a digital signature. Information on whether your I/O module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

The digitally signed firmware update files are available for download on the Siemens Support Web page.

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 70) applies.

4.12 Secure operation of power supply modules

Device-specific security information and instructions for the power supply modules can be found in the respective Equipment Manual.

4.12.1 Signed firmware update for system power supplies (PS)

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect Internet source

Signed firmware update for system power supplies (PS)

Firmware updates for system power supplies (PS) can contain a digital signature. Information on whether your power supply module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

The digitally signed firmware update files are available for download on the Siemens Support Web page.

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 70) applies.

System overview

5

5.1 Overview of the SIMATIC S7-1500 automation system

5.1.1 The SIMATIC automation systems

You need optimum solutions for every application in order to automate your machines and plants economically and flexibly.

The SIMATIC controller portfolio includes a variety of systems:

- The SIMATIC S7-1200 Basic Controller is the intelligent choice for compact automation solutions with integrated communication and technology functions.
- If plant complexity and system performance are priorities, the SIMATIC S7-1500 automation system is the right choice for you. The SIMATIC S7-1500 controller builds on the more simple functionality of the SIMATIC S7-1200 Basic Controller and fulfills the highest demands on performance, flexibility and networking capability.
- The SIMATIC ET 200SP Distributed Controller combines the advantages of the S7-1500 and the very compact design of the ET 200SP with high channel density. By using distributed intelligence, you save costs and space in the control cabinet.
- For use outside the cabinet, the CPU 1513pro-2 PN and CPU 1516pro-2 PN offer you SIMATIC S7-1500 functionality in the design of the ET 200pro in the degree of protection IP65/IP67.
- If you require PC-based automation, use the SIMATIC S7-1500 software controller. The PC-based controller is autonomous from the operating system during operation.
- If you want to increase the availability of your system, use the redundant system S7-1500R/H. In the system, two CPUs (primary and backup CPU) process the user program in parallel and permanently synchronize all relevant data. In the event of failure of the primary CPU, the backup CPU takes over control of the process at the point of interruption.

The SIMATIC controllers are integrated into the Totally Integrated Automation Portal and offer consistent data management and a uniform operating concept. With its integrated functions, engineering in the TIA Portal ensures consistent functionality.

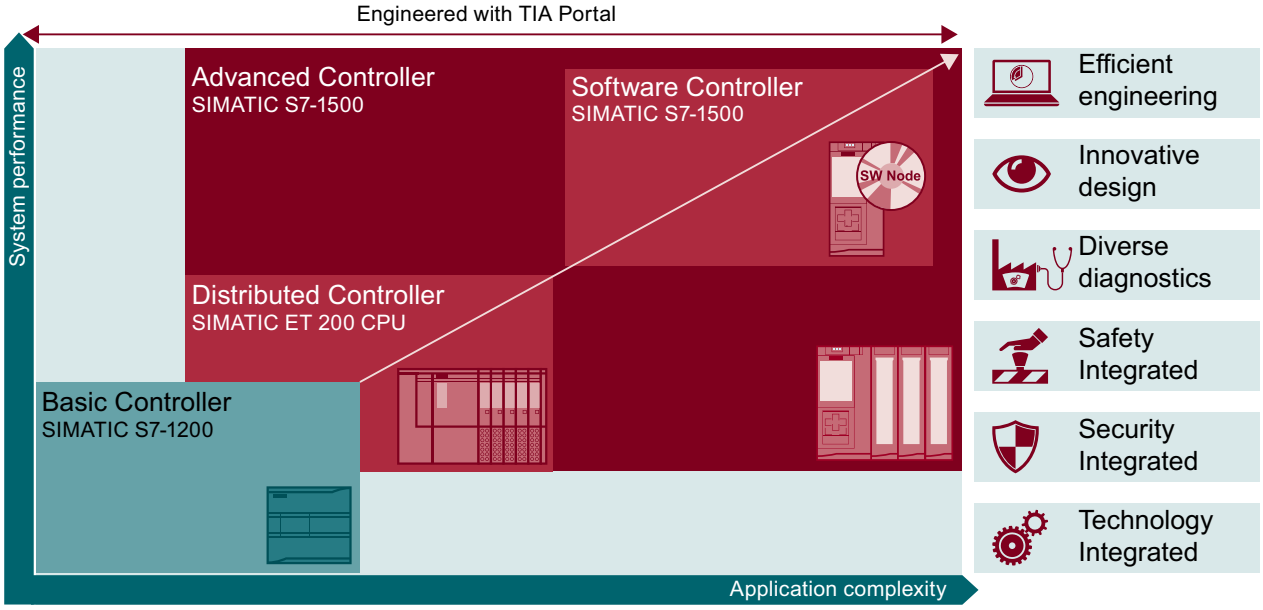


Figure 1-453 Overview of SIMATIC automation systems

The SIMATIC S7-1500 automation system supports all conventional communication standards.

All the SIMATIC S7-1500 CPUs offer integrated motion control functions. Technology CPUs are available for extended motion control functions.

The SIMATIC S7-1500 CPUs are also available as fail-safe controllers.

Diagnostic functions across all components simplify troubleshooting. Changes to the parameter assignment can be implemented quickly and easily with the integrated display.

Integrated security functions help against:

- Manipulation
- Theft of know-how

Integrated security functions offer additional security mechanisms for the configuration of secured networks.

5.1.2 Comparison of SIMATIC automation systems

The tables below compare the main technical specifications of the SIMATIC systems.

	Basic Controller	**Controller**	
	SIMATIC S7-1200	**SIMATIC ET 200SP CPU**	**SIMATIC ET 200SP Open Controller CPU 1515SP PC2**
Data work memory, max.	150 KB	3.5 MB	5 MB
Code work memory, max.	150 KB	900 KB	1 MB
Load memory/mass storage, max.	32 GB (via SIMATIC Memory Card)	32 GB (via SIMATIC Memory Card)	320 MB
I/O address area, max.	1024/1024 bytes	32/32 KB	32/32 KB

	Basic Controller	**Controller**	
	SIMATIC S7-1200	**SIMATIC ET 200SP CPU**	**SIMATIC ET 200SP Open Controller CPU 1515SP PC2**
Integrated interfaces, max.	1 x PROFINET IO (2-port switch)	1 x PROFINET IO (2-/3-port switch, support of BusAdapters) 1 x PROFINET IO	1 x PROFINET IO (2-port switch)
Controller with integrated inputs and outputs	X	---	---
Configuration control	---	X	X
Web server	X	X	X
Isochronous mode	---	Distributed	Distributed
Integrated display	---	---	As Windows application
Technology integrated	Motion Control PID Control	Motion Control PID Control	Motion Control PID Control
Extended motion control functions	---	In T-CPUs	In T-CPUs
Security integrated	X	X	X
Integrated system diagnostics	X	X	X
Integrated safety functionality	In F-CPUs	In F-CPUs	In F-CPUs
Degree of protection	IP20	IP20	IP20

	Distributed Controller	**Advanced Controller**			
	SIMATIC ET 200pro	**SIMATIC S7-1500**		**Software Controller SIMATIC S7-1500**	**SIMATIC S7-1500R/H**
Data work memory, max.	7.5 MB	150 MB		20 MB	150 MB
Code work memory, max.	2 MB	18 MB		5 MB	18 MB
Load memory/mass storage, max.	32 GB (via memory card)	32 GB (via memory card)		320 MB	32 GB
I/O address area, max.	32/32 KB	32/32 KB		32/32 KB	32/32 KB
Integrated interfaces, max.	1 x PROFINET IO (3-port switch) 1 x PROFINET IO	1 x PROFINET IO (2-port switch) 1 x PROFINET IO 1 x PROFINET 1 x PROFIBUS	2 x PROFINET IO (2-port switch) 1 x PROFINET	Support the hardware interfaces	2 x PROFINET IO (2-port switch) 1 x PROFINET 2 x H-Sync interface (only H/HF-CPUs)
Controller with integrated inputs and outputs	---	C-CPU		---	---
Configuration control	X	X		X	---
Web server	X	X		X	X (only Web API)

	Distributed Controller	Advanced Controller		
	SIMATIC ET 200pro	**SIMATIC S7-1500**	**Software Controller SIMATIC S7-1500**	**SIMATIC S7-1500R/H**
Isochronous mode	Distributed	Centralized and distributed	Distributed (support using CP 1625)	---
Integrated display	---	X	As Windows application	X
Technology integrated	Motion Control PID Control	Motion Control PID Control C-CPUs: High-speed counters, PWM, PTO, frequency output	Motion Control PID Control	PID Control
Extended motion control functions	---	In T-CPUs	In T-CPUs	
Security integrated	X	X	X	X
Integrated system diagnostics	X	X	X	X
Integrated safety functionality	In F-CPUs	In F-CPUs	In F-CPUs	In F-CPUs
Degree of protection	IP65/67	IP20	Depending on hardware	IP20
Redundancy connections (synchronization link)	---	---	---	PROFINET ring (R-CPUs) Fiber-optic cable (H-CPUs)
System redundancy	---	---	---	X

5.1.3 Areas of application SIMATIC S7-1500 and ET 200MP

Area of application SIMATIC S7-1500

The SIMATIC S7-1500 automation system offers you the required flexibility and performance for a wide range of controller applications in machine and plant engineering. The scalable configuration makes it possible for you to adapt your PLC onsite to the local conditions.

As well as the standard motion control and technology functions available in the S7-1500, SIMATIC S7-1500 technology CPUs offer you additional features such as enhanced synchronous operation and kinematics functions.

The SIMATIC S7-1500 automation system conforms with IP20 degree of protection and is intended for use in a dry environment and installation in a control cabinet.

SIMATIC S7-1500R/H CPUs (redundant or fault-tolerant CPUs) offer you the option to increase the availability of your system. In order to be able to switch from the primary CPU to the backup CPU in case of need, the user program is processed synchronously on two CPUs.

Area of application Distributed I/O system ET 200MP

SIMATIC ET 200MP is a modular, scalable and universally usable distributed I/O system. SIMATIC ET 200MP offers the same system benefits as the SIMATIC S7-1500. A central controller accesses the I/O modules of the ET 200MP as central I/O modules via PROFINET or PROFIBUS.

SIMATIC ET 200MP convinces with its high performance:

- For shortest response times
- For large configuration limits
- For fastest applications

This is also accompanied by the high-speed backplane bus, special input/output modules and the consistent use of PROFINET mechanisms.

Area of application F-system SIMATIC Safety with S7-1500 and ET 200MP

By using fail-safe SIMATIC S7-1500 CPUs and modules, you can implement applications for safety engineering. This enables you to achieve almost seamless integration of machine safety into the SIMATIC S7-1500 and ET 200MP. You use one system at the same time for both your standard and fail-safe automation. This provides you with economic benefits, reliability as well as potential savings on hardware, engineering tasks and storage costs.

5.1.4 Plant components and automation levels

The Advanced Controllers SIMATIC S7-1500 are used for complete production automation and in applications for medium-sized and high-end machines. The combination of the individual SIMATIC components offers powerful and flexible automation solutions that cover all ranges of control applications:

- The process signals are connected to the central controller via fieldbus
- All modules are located directly in the automation system or in the distributed I/O system
- F-CPUs with integrated safety functionality ensure fail-safe processes
- SIMATIC S7-1500 is intended for installation in the control cabinet with IP20 degree of protection

The SIMATIC S7-1500 is integrated across all communication standards consistently in the various automation levels.

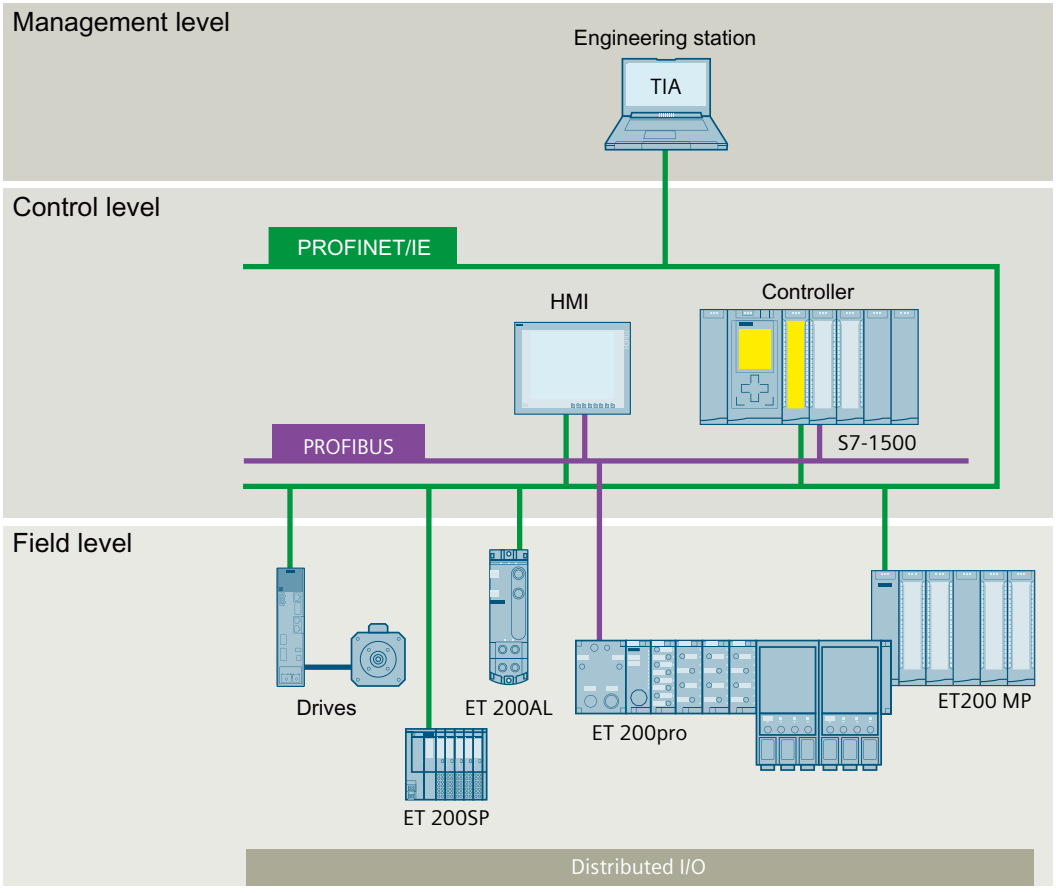


Figure 1-454 Basic structure: SIMATIC S7-1500 at management, control and field level

You can also find an overview of the SIMATIC S7-1500 automation system on the Internet (https://www.siemens.com/global/en/products/automation/systems/industrial/plc/simatic-s7-1500.html).

5.1.5 Scalability

In order to suit the requirements of your plant planning, the SIMATIC S7-1500 controllers can be scaled in their processing speed and configuration limits. They also offer networking facilities via different communications standards.

Safety Integrated, Motion Control, and other technology functions can be used for all plant sizes.

Different example applications with different SIMATIC S7-1500 CPUs are shown in the following:

SIMATIC S7-1500 with integrated I/O

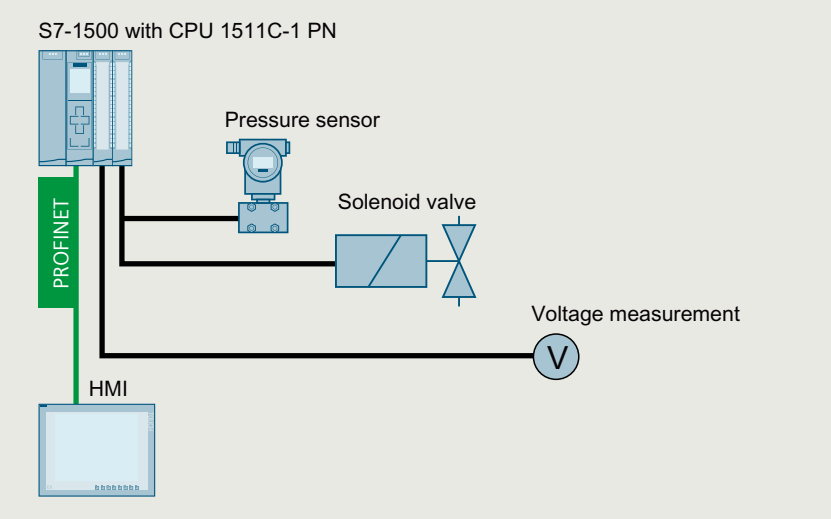


Figure 1-455 Example: Plant configuration with SIMATIC S7-1500 with integrated I/O

SIMATIC S7-1500 with I/O, ET 200MP and HMI device

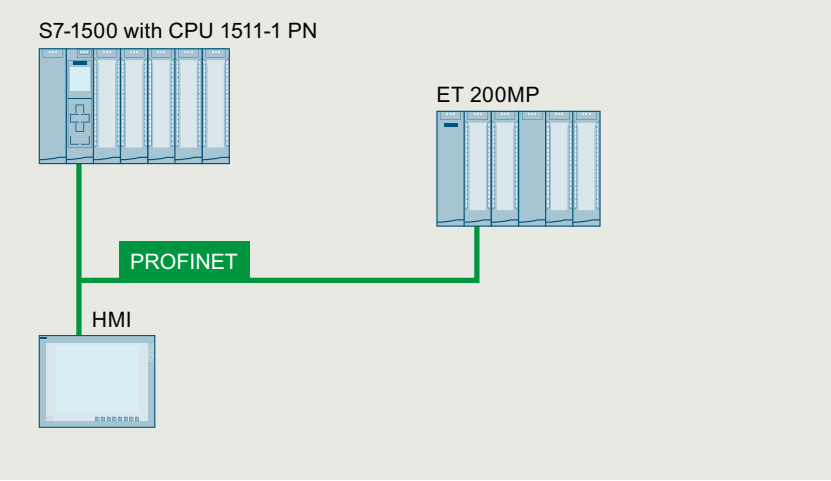


Figure 1-456 Example: Plant configuration with SIMATIC S7-1500 with I/O, ET 200MP and HMI device

SIMATIC S7-1500 with Motion Control, distributed I/O and IO-Link devices

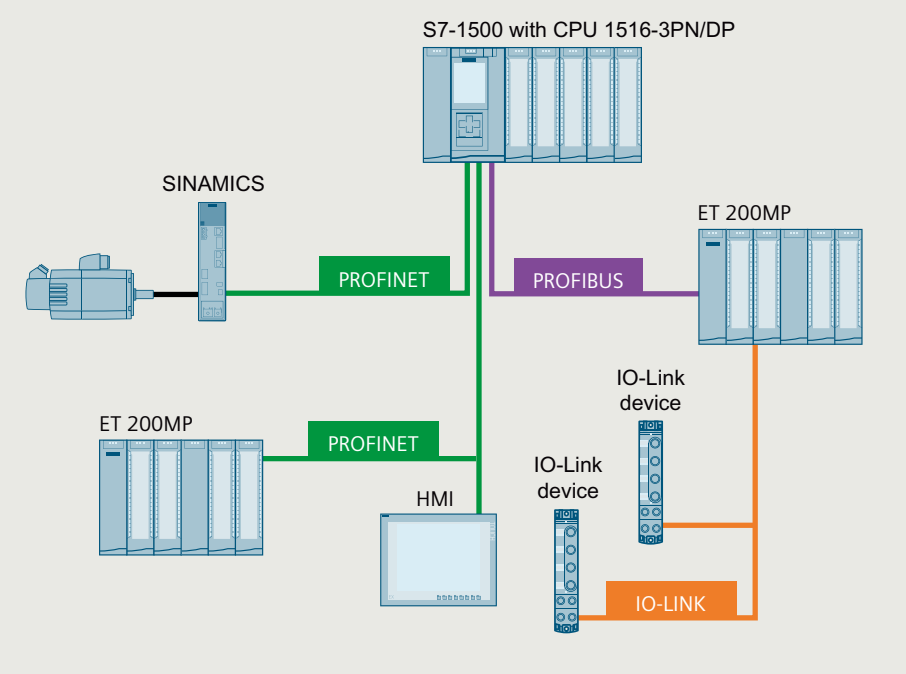


Figure 1-457 Example: Plant configuration with SIMATIC S7-1500, Motion Control, distributed I/O and IO-Link devices

SIMATIC S7-1500 with safety und WLAN integration

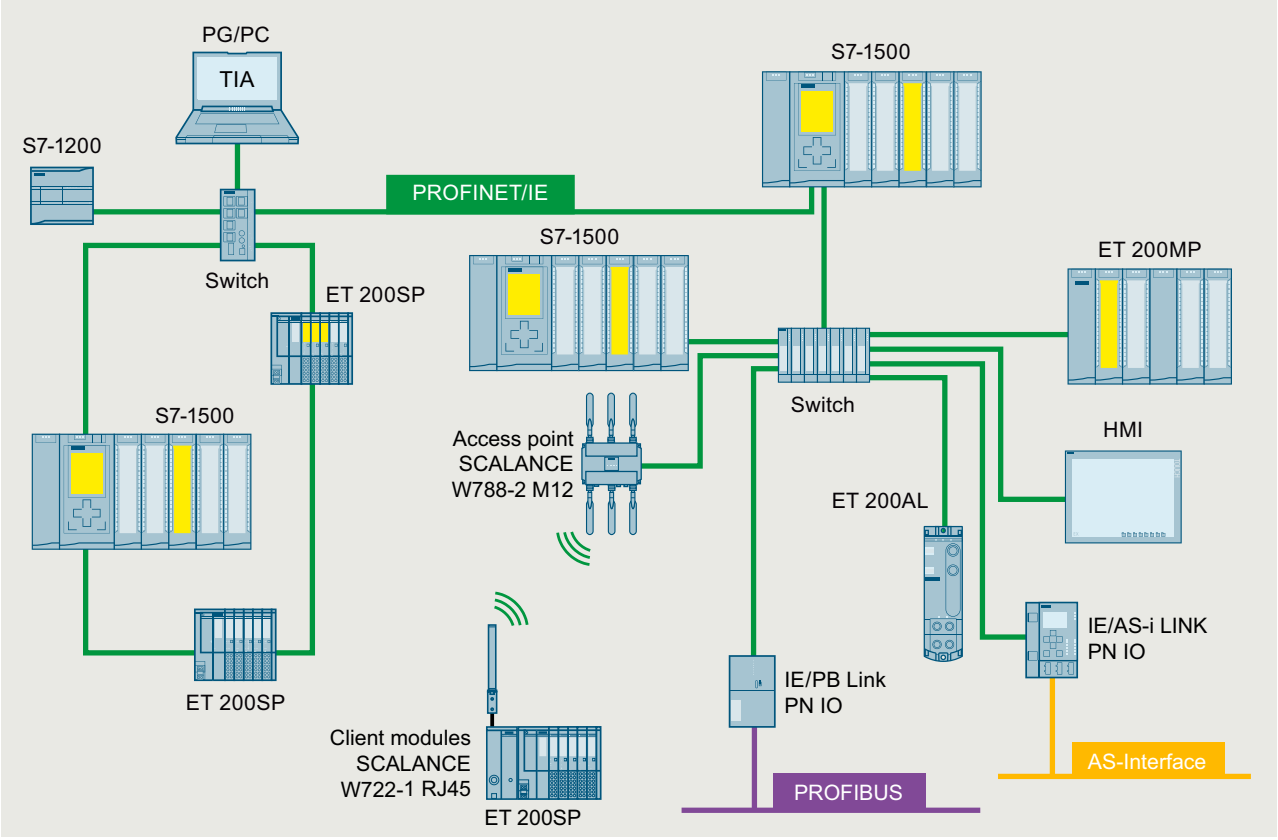


Figure 1-458 Example: Plant configuration with SIMATIC S7-1500 and Safety on PROFINET

SIMATIC S7-1500 with redundant IO modules

You can use the "LRedlo" instructions to connect and monitor IO modules redundantly to a SIMATIC S7-1500. You can find an application example with a user program at the following link (https://support.industry.siemens.com/cs/ww/de/view/109767576/en) .

5.1.6 Overview of features

Automation system SIMATIC S7-1500

Through the integration of numerous new performance features, the S7-1500 automation system offers you excellent operability and the highest performance.

Important properties and functions

Easy to use

- Uniform front connectors
- Pre-wiring position enables easy connecting and reconnecting
- Integrated shield for high signal measurement quality

High performance

- Fast signal processing for faster reaction times and high productivity
- Fast backplane bus for high baud rate and efficient transmission protocol
- Location-independent information acquisition thanks to integrated web server
- High number of connections and PROFINET ports
- Variety of networking options in systems (IO controller, I-device, shared device)

Wide range of diagnostics

- Integrated system diagnostics for uniform display concept without additional programming effort
- User-defined interrupts
- Evaluate system errors using system blocks

Innovative design

- Onboard display for diagnostics and first commissioning
- High degree of variability through scalability up to 30 I/O modules per rack
- Innovative labeling system maximizes organization in very limited spaces
- Compact CPUs with integrated analog and digital on-board I/O and integrated technology functions



Communication standards

- PROFINET IO
- PROFIBUS DP
- Point-to-point (RS232, RS485)

Efficient engineering

- STEP 7 language innovations while maintaining proven functions
- Support of different programming languages (STL, LAD, FBD, SCL, CFC, GRAPH)
- Consistency check by STEP 7 instead of in the CPU

Safety Integrated

- Easy integration of fail-safe CPUs (F-CPUs) and fail-safe modules (F-modules)
- One F-CPU for fail-safe and non-fail-safe applications
- Setting of all F parameters via software

Security Integrated

- Protection level concept for greater access protection
- Know-how protection against unauthorized access and modifications
- Copy protection on the SIMATIC Memory Card against copying of user programs

Technology Integrated

- Motion control functionality supports the connection of PROFIdrive-capable drives
- Technology CPUs with advanced motion control functions
- Easy programming of motion sequences with PLCopen motion control blocks
- Temperature controller
- PID control for continuous and discrete closed-loop control processes with autotuning for easy commissioning and optimal control performance
- Seamless integration into TIA Portal for synchronous configuration and uniform operating concept
- TRACE support for effective commissioning, diagnostics and fast optimization of drives and closed-loop controls

Figure 1-459 SIMATIC S7-1500 automation system - Properties and functions

Distributed I/O system ET 200MP

The ET 200MP distributed I/O system is a scalable and flexible system for connecting the process signals to a CPU via a fieldbus.

The modules have a very high channel density and a low variety of parts. This simplifies ordering, logistics and spare parts handling significantly.

Important properties and functions

Innovative design

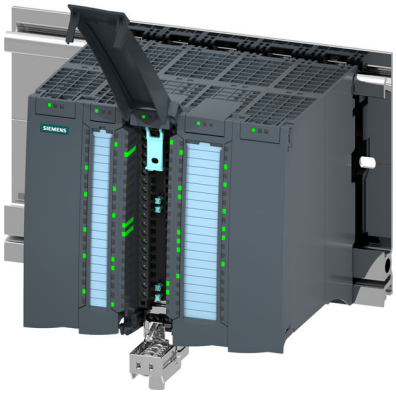
- High channel density (e.g. 32 channels on 25 mm wide I/O module)
- High degree of variability through scalability up to 30 I/O modules per station
- Innovative labeling system maximizes organization in very limited spaces

Safety Integrated

- Easy integration of fail-safe modules (F-modules)
- Setting of all F parameters via software

Easy to use

- With I/O modules of the S7-1500 automation system
- Screw-type or push-in terminal connections
- Configuration adjustment for future configuration levels through integrated configuration control
- Uniform front connectors
- Pre-wiring position enables easy connecting and reconnecting



Interface modules

- IO device with PROFINET IO interface (2 ports)
- DP device with PROFIBUS DP interface

High performance

- Isochronous PROFINET IO with send clocks as fast as 250 µs

Powerful technology

- Technology modules for counting, position detection, and time-based IO functionality

Communication standards

- PROFINET IO
- PROFIBUS DP
- Point-to-point (RS232, RS485)

Figure 1-460 SIMATIC ET 200MP distributed I/O system - Properties and functions

5.2 Configuration

5.2.1 Configuration of the SIMATIC S7-1500 Automation System

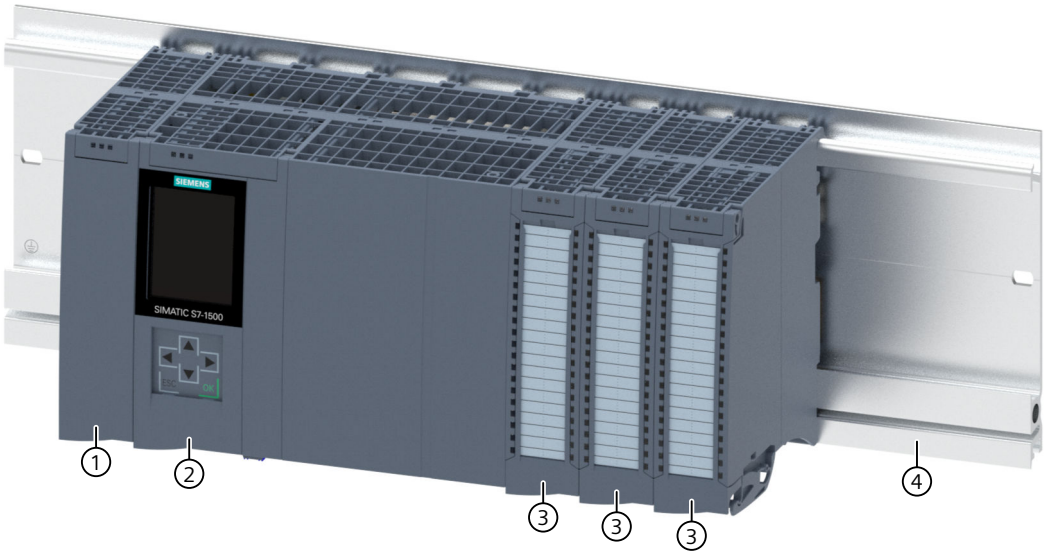
Configuration

The SIMATIC S7-1500 automation system is made up of the following components:

- CPU (standard, fail-safe, compact or technology CPU)
- Digital and analog I/O modules
- Communications modules (PROFINET/Ethernet, PROFIBUS, point-to-point)
- Technology modules (counting, position detection, time-based IO)
- Load current supply
- System power supply (optional)

You install the S7-1500 automation system on a mounting rail. You can install up to 32 modules (CPU, system power supply and 30 I/O modules) on the mounting rail. You connect the modules to each other with U connectors.

Configuration example



① System power supply
② CPU
③ I/O modules
④ Mounting rail with integrated DIN rail profile

Figure 1-461 Example configuration of an S7-1500 automation system

5.2.2 Configuration of the distributed I/O system SIMATIC ET 200MP

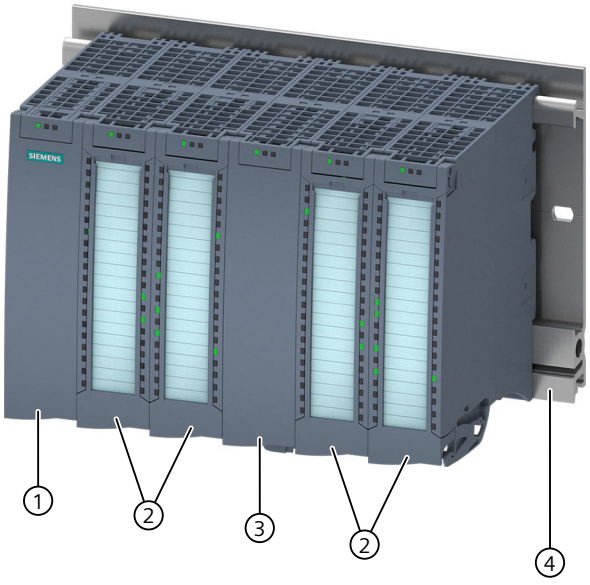
Configuration

The SIMATIC ET 200MP distributed I/O system is made up of the following components:

- Interface module (PROFINET or PROFIBUS)
- Digital and analog I/O modules
- Communications modules (point-to-point)
- Technology modules (counting, position detection, time-based IO)
- System power supply (optional)

The ET 200MP distributed I/O system is installed on a mounting rail like the S7-1500 automation system.
The I/O modules of the SIMATIC ET 200MP distributed I/O system can be used in a decentralized configuration (with an ET 200MP interface module) or in a centralized configuration (with an S7-1500 CPU).

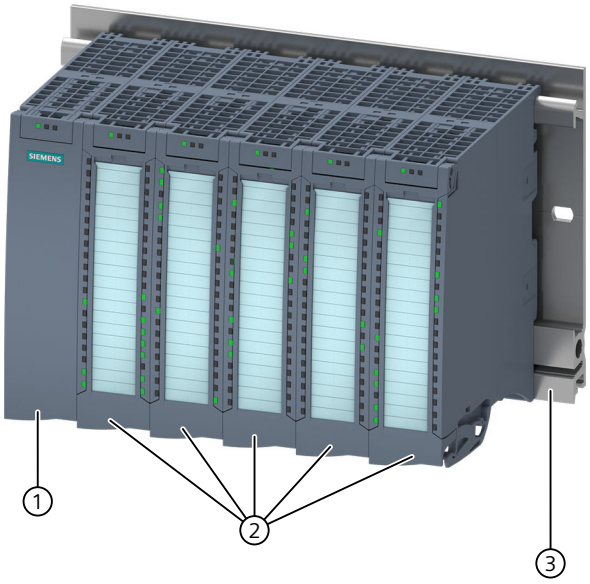
Example of a configuration with the IM 155-5 PN ST interface module



① Interface module
② I/O modules
③ System power supply
④ Mounting rail with integrated DIN rail profile

Figure 1-462 Example of a configuration of the ET 200MP with IM 155-5 PN ST

Example of a configuration with the IM 155-5 DP ST interface module



① Interface module
② I/O modules
③ Mounting rail with integrated DIN rail profile

Figure 1-463 Example of a configuration of the ET 200MP with IM 155-5 DP ST

5.2.3 Configuration of a fail-safe system with SIMATIC S7-1500

Fail-safe automation systems

Fail-safe automation systems (F-systems) are used in systems with higher safety requirements. F-systems control processes and ensure that they are in a safe state immediately after shutdown. In other words, F-systems control processes in which an immediate shutdown does not endanger persons or the environment.

Safety Integrated

Safety Integrated is the integrated safety concept for automation and drive technology from Siemens.

Proven technologies and systems from automation technology, such as SIMATIC S7-1500 in this case, are used for safety systems. Safety Integrated includes the complete safety sequence, ranging from sensor, actuator and fail-safe modules right through to the controller, including safety-related communication via standard fieldbuses. Drives and controllers handle safety tasks in addition to their actual functions.

SIMATIC Safety F-system with S7-1500 and ET 200MP

The figure below contains an example of an F-system SIMATIC Safety with S7-1500, ET 200MP, and PROFINET IO.

You can combine fail-safe I/O modules and non-fail-safe I/O modules in a can be combined in a S7-1500/ET 200MPconfiguration.

The fail-safe IO controller (F-CPU) exchanges:

- Safety-related data with fail-safe modules.
- Non-safety-related data with non-fail-safe modules.

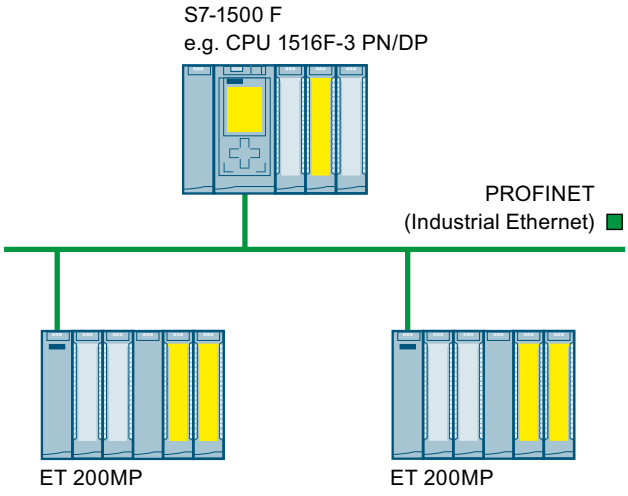


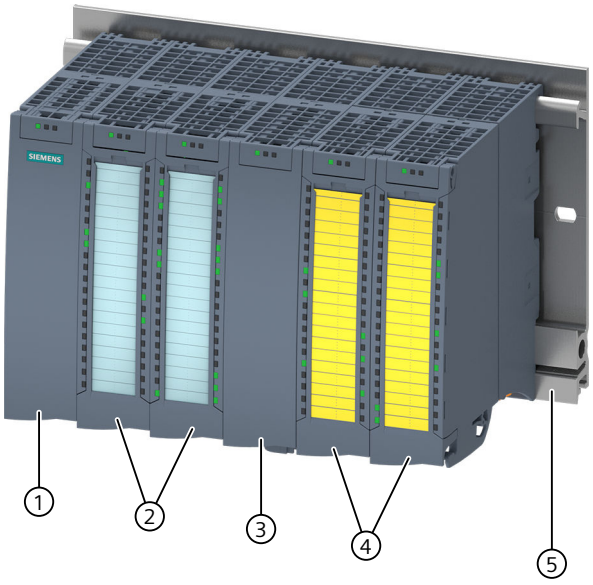
Figure 1-464 Fail-safe automation system SIMATIC Safety (example)

Fail-safe I/O modules S7-1500/ET 200MP

The following fail-safe I/O modules are available for S7-1500/ET 200MP:

- Fail-safe digital input modules detect the signal states of safety-related sensors and send the relevant safety frames to the F-CPU.
- Fail-safe digital output modules control actuators for safety-oriented tasks.

Configuration example of the ET 200MP with fail-safe I/O modules



① Interface module
② I/O modules
③ Power supply (optional)
④ Fail-safe I/O modules
⑤ Mounting rail with integrated DIN rail profile

Figure 1-465 Configuration example of the ET 200MP with fail-safe I/O modules

Hardware and software requirements

You use the S7-1500/ET 200MP fail-safe I/O modules:

- In S7-1500 with S7-1500 F-CPUs as of firmware version V1.7
- Distributed in ET 200MP with S7-1500 F-CPUs as of firmware version V1.5 and all F-CPUs that can be selected in the hardware catalog of the TIA Portal

Fail-safe I/O modules in ET 200MP require the following interface modules:

- IM 155-5 PN BA, as of firmware version V4.3
- IM 155-5 PN ST, as of firmware version V3.0.0
- IM 155-5 PN HF, as of firmware version V3.0.0
- IM 155-5 DP ST, as of firmware version V3.0.0

To configure and program fail-safe I/O modules S7-1500/ET 200MP , you need:

- STEP 7, V13 SP1 or higher
- Option package STEP 7 Safety Advanced as of V13 SP1 + HSP0086

Use in safety mode only

You can only use the S7-1500/ET 200MP fail-safe I/O modules in safety mode. They cannot be used in non-fail-safe mode, i.e. standard mode.

Achievable safety classes

Fail-safe I/O modules are equipped with integrated safety functions for safety mode.

You can achieve the safety classes of the table below:

- By corresponding parameter assignment of the safety functions in STEP 7
- With a specific combination of fail-safe and non-fail-safe I/O modules as well as
- With a special arrangement and wiring of the sensors and actuators

Table 1-804 Safety classes that can be achieved with S7-1500/ET 200MP in safety mode

Safety class in safety mode		
According to IEC 61508:2010	**According to ISO 13849-1:2015**	
SIL3	Category 3	(PL) Performance Level d
SIL3	Category 4	(PL) Performance Level e

More information

An overview of the technical specifications of the fail-safe I/O modules can be found in section Fail-safe digital modules (Page 121).

The applications and wiring for the particular safety class are described in the manuals of the fail-safe I/O modules.

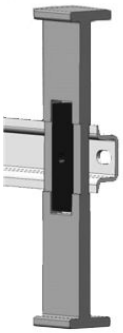
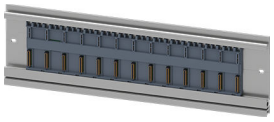
5.3 Components

Components of the S7-1500 automation system/ET 200MP distributed I/O system

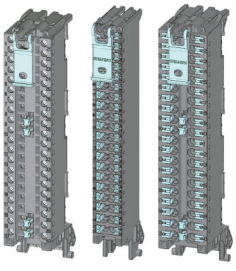
Table 1-805 Components S7-1500/ET 200MP

Component	Function	Diagram
Mounting rail	The mounting rail is the module rack of the SIMATIC S7-1500/ET 200MP automation system. You can use the entire length of the mounting rail (rimless assembly). The mounting rails can be ordered as Accessories/spare parts (Page 406) accessories.	

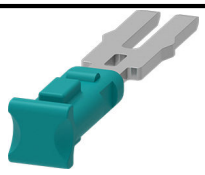
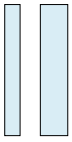
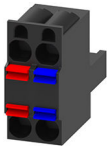
* Additionally the PS 60W 24/48/60V DC HF keeps the complete work memory of the CPU retentive.

Component	Function	Diagram
DIN rail adapter	The SIMATIC S7-1500/ET 200MP automation system is installed on a standard 35 mm DIN rail using the DIN-rail adapter. The DIN-rail adapter can be ordered as an accessory/spare part (Page 406).	
Active backplane bus	Properties of the active backplane bus: • Reaction-free pulling and plugging of I/O modules during operation • Reserve capacity for later use The active backplane bus can be used with the following interface modules: • IM 155-5 PN HF (6ES7155-5AA00-0AC0 as of firmware version V4.4) • IM 155-5 MF HF (6ES7155-5MU00-0CN0 as of firmware version V5.0) You can find more information on the active backplane bus (for example, installing, configuring, technical specifications) in the Active backplane bus (https://support.industry.siemens.com/cs/de/de/view/109778694/en) Equipment Manual. The active backplane bus can be ordered as an accessory/spare part (Page 406).	
PE connection element for mounting rail	The set of screws is threaded into the mounting rail's T-profile groove, and is required for grounding the mounting rail. The set of screws is contained in the scope of delivery of the mounting rails in the standard lengths (160 to 830 mm) and can be ordered as Accessories/spare parts (Page 406).	
CPU (standard, fail-safe, compact or technology CPU)	The CPU runs the user program. The integrated system power supply of the CPU supplies the modules used via the backplane bus. Additional features and functions of the CPU: • Communication via Ethernet • Communication via PROFIBUS/PROFINET • HMI communication • Integrated web server • OPC UA server • OPC UA client • Integrated technology (for example, motion control functions, trace functionality) • Integrated system diagnostics • Integrated protection functions (access, know-how and copy protection) • Safety mode (when using fail-safe CPUs)	 

* Additionally the PS 60W 24/48/60V DC HF keeps the complete work memory of the CPU retentive.

Component	Function	Diagram
Interface module for PROFINET IO	The interface module: • Is used as an IO device on PROFINET IO. • Links the ET 200MP distributed I/O system with the IO controller. • Exchanges data with the I/O modules via the backplane bus. • Can be used with the BusAdapters of the ET 200SP (only IM 155-5 MF HF).	
Interface module for PROFIBUS DP	The interface module: • Is used as a DP Device on PROFIBUS DP. • Links the ET 200MP distributed I/O system with the DP master. • Exchanges data with the I/O modules via the backplane bus.	
I/O module/ fail-safe I/O module	The I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are divided into the following module types: • Digital input (DI, F-DI) • Digital output (DQ, F-DQ) • Digital input/digital output (DI/DQ) • Analog input (AI) • Analog output (AQ) • Analog input/analog output (AI/AQ) • Technology module (TM) • Communication module (CM) • Communication processor (CP) A U connector is included in the scope of delivery for each I/O module. For fail-safe I/O modules, an additional electronic coding element for saving the PROFIsafe address is included in the scope of delivery and can be ordered as spare part Accessories/spare parts (Page 406).	
U connector	The individual modules are connected to one another with the U connector. The U connector provides the mechanical and electrical connection between the modules. The U connector is included in the scope of delivery of all modules (exceptions: CPU, interface module) and can be ordered as Accessories/spare parts (Page 406).	
Front connectors	The front connectors are used to wire the I/O modules. The front connectors for technology and analog modules must be supplemented with a shielding bracket, power supply element, and shield connection clamp. The components are included in the scope of delivery of the technology modules, analog modules and compact CPUs (for onboard I/O) and can be ordered as Accessories/spare parts (Page 406) accessories. There are front connectors with screw terminals and push-in terminals for 35 mm modules, and with push-in terminals for 25 mm modules. The front connectors for 25 mm modules are included in the scope of delivery of the I/O modules and compact CPUs (for onboard I/O). Four potential bridges and one cable tie are included in the scope of delivery of the front connectors for 35 mm modules. The front connectors for 25 mm modules have no potential bridges due to the compact module design.	

* Additionally the PS 60W 24/48/60V DC HF keeps the complete work memory of the CPU retentive.

Component	Function	Diagram
Potential bridges for front connector	You jumper two terminals with potential bridges. The potential bridges are included in the scope of delivery of the front connector and can be ordered as Accessories/spare parts (Page 406). The front connectors for 25 mm modules have no potential bridges. Therefore, you should also observe the information in the product manual for the respective digital or analog module.	
Shielding bracket	The shielding bracket is an insertable bracket for modules with EMC-critical signals (for example, analog modules, technology modules), and, together with the shield connection clamp, permits the low impedance application of shielding with minimal installation times. The shielding bracket is included in the scope of delivery of the analog modules, technology modules, and compact CPUs (for onboard I/O) and can be ordered as Accessories/spare parts (Page 406).	
Shield clamp	The shield connection clamps are used to attach cable shielding to the shielding bracket. The shield connection clamp is included in the scope of delivery of the analog modules, technology modules, and compact CPUs (for onboard I/O) and can be ordered as Accessories/spare parts (Page 406).	
Power supply element	The power supply element is inserted in the front cable connector, and serves to supply power to modules with EMC-critical signals (analog modules, technology modules). The power supply element (connection technology: screw terminal) is included in the scope of delivery of the analog and technology modules and can be ordered as Accessories/spare parts (Page 406).	
Labeling strips for the exterior of the front cover of the I/O modules	The labeling strips are used to label the modules for specific plants. You can label the labeling strips using a machine. The labeling strips are available in different colors: • Al gray: Non-fail-safe modules • Yellow: Fail-safe modules The labeling strips are included in the scope of delivery of the I/O modules and compact CPUs (for onboard I/O). Additional labeling strips can be ordered as Accessories/spare parts (Page 406).	
4-pole connection plug for supply voltage of the CPU/interface module	The supply voltage is supplied by means of the 4-pole connection plug.	
Display module	The display module is a plug-in display module.	
Display	The display is the front cover with integrated display module and operator controls for local diagnostics, display and operation.	

Component	Function	Diagram
System power supply (PS)	The system power supply is a diagnostics-capable power supply module, that can be connected with the backplane bus using a U connector. A system power supply is required when the power fed from the CPU/interface module into the backplane bus is not sufficient to supply the connected modules with power. System power supplies are available in various models: • PS 25 W 24 V DC • PS 60 W 24/48/60 V DC • PS 60W 24/48/60V DC HF* • PS 60 W 120/230 V AC/DC A power cable connector with coding element and U-connector is included in the scope of delivery for the system power supply and can be ordered as spare part.	
Load current supply (PM)	The load current supply (PM) supplies the system power (PS), central modules (CPU), interface module and input and output circuits of the I/O modules with 24 V DC. If you are using load current supplies, we recommend the devices from the SIMATIC series. These devices can be mounted on the mounting rail. Load current supplies are available in various models: • PM 70 W 120/230 V AC • PM 190 W 120/230 V AC As an alternative to the SIMATIC load power supplies (PM), you can also use SITOP smart power supplies. Use of a SITOP smart power supply is recommended in these cases, among others: • Higher power requirement • Redundancy • Uninterruptible power supply For more information on the SITOP modules, refer to an FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/96998532).	

* Additionally the PS 60W 24/48/60V DC HF keeps the complete work memory of the CPU retentive.

Reference

You can find more information on the different function classes (for example, basic, standard) of the interface and I/O modules in an FAQ on the Internet (https://support.industry.siemens.com/cs/de/de/view/109476914/en).

5.4 CPUs



Figure 1-466 Controller

SIMATIC S7-1500 controllers are characterized by maximum performance capability thanks to a high-performance backplane bus, very short terminal-to-terminal response time and extremely fast signal processing.

The controller (CPU) executes the user program. The integrated system power supply of the controller provides power to the modules used through the backplane bus.

A fail-safe version is available for each SIMATIC S7-1500 controller (except compact CPUs and the redundant CPU 1513R-1 PN and CPU 1515R-2 PN). To use the safety functions in the TIA Portal, you need the "STEP 7 Safety Advanced" option package.

During commissioning of the plant you can, for example, change the IP address of the CPU directly via the display, thus saving time and costs. In the event of a service call, the plant downtimes are minimized by quick access to diagnostics alarms.

For effective commissioning and fast optimization of drives and controls, the SIMATIC S7-1500 supports extensive trace functions for all CPU tags.

A SIMATIC S7-1500 controller also offers additional functions:

- Communication via Ethernet/PROFINET
- Communication via PROFIBUS
- HMI communication
- Communication via OPC UA
- Web server, technology functions, system diagnostics, protection functions integrated
- When using an F-CPU: Safety mode
- When using a S7-1500 R/H CPU: Redundancy
- When using a T-CPU: Extended motion control functions

5.4.1 What can you do with the CPU?

SIMATIC S7-1500 provides you with a variety of CPUs that can be integrated. You can expand each CPU with I/O, communications and technology modules.

Example: The performance of a CPU 1511-1 PN with 1.5 MB data work memory is sufficient for your application. If you require additional communication interfaces, you can extend the CPU with communication modules for Industrial Ethernet, PROFINET and PROFIBUS. Modules for serial communication are also available.

The following overview supports you in selecting the CPU and shows the respective maximum size of the data work memory:

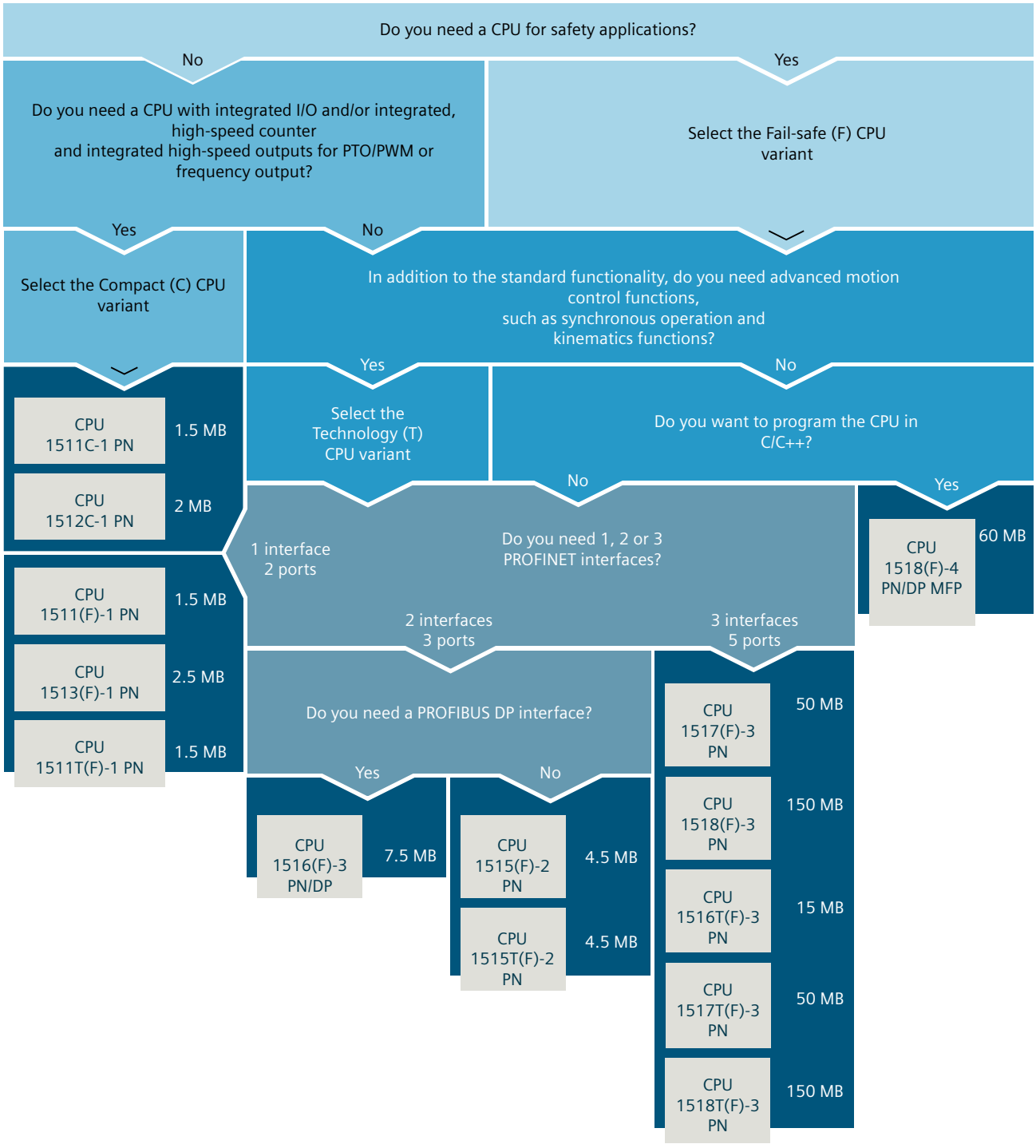


Figure 1-467 Selection guide for CPUs

5.4.2 Technical specifications of CPUs

Table 1-806 Standard CPUs and F-CPUs

CPU	1511-1 PN 1511F-1 PN 1511T-1 PN 1511TF-1 PN	1513-1 PN 1513F-1 PN	1515-2 PN 1515F-2 PN 1515T-2 PN 1515TF-2 PN	1516-3 PN/DP 1516F-3 PN/DP	1517-3 PN 1517F-3 PN	1518-3 PN 1518F-3 PN 1518T-3 PN 1518TF-3 PN
				1516T-3 PN 1516TF-3 PN	1517T-3 PN 1517TF-3 PN	1518-4 PN/DP M-FP 1518F-4 PN/DP MFP
Article number						
Standard CPU:	6ES7511-1AL03--0AB0 (https://mall.industry.siemens.com/mall/de/de/-Catalog/Product/6ES7511-1AL03-0AB0)	6ES7513-1AM03-0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7513-1AM03-0AB0)	6ES7515-2AN03--0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7515-2AN03-0AB0)	6ES7516-3AP03--0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7516-3AP03-0AB0)	6ES7517-3AQ10--0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7517-3AQ10-0AB0)	6ES7518-3AT10--0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7518-3AT10-0AB0)
F-CPU	6ES7511-1FL03--0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7511-1FL03-0AB0)	6ES7513-1FM03-0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7513-1FM03-0AB0)	6ES7515-2FN03--0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7515-2FN03-0AB0)	6ES7516-3FP03--0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7516-3FP03-0AB0)	6ES7517-3FQ10-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7517-3FQ10-0AB0)	6ES7518-3FT10-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7518-3FT10-0AB0)
T-CPU	6ES7511-1TL03--0AB0 (https://mall.industry.siemens.com/mall/en/en/-Catalog/Product/6ES7511-1TL03-0AB0)	---	6ES7515-2TN03--0AB0 (https://mall.industry.siemens.com/mall/en/en/Catalog/Product/6ES7515-2TN03-0AB0)	6ES7516-3TP10--0AB0 (https://mall.industry.siemens.com/mall/en/us/-Catalog/Product/6ES7516-3TP10-0AB0)	6ES7517-3TQ10-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7517-3TQ10-0AB0)	6ES7518-3TT10-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7518-3TT10-0AB0)
TF-CPU	6ES7511-1UL03--0AB0 (https://mall.industry.siemens.com/mall/en/de/-Catalog/Product/6ES7511-1UL03-0AB0)	---	6ES7515-2UN03--0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7515-2UN03-0AB0)	6ES7516-3UP10--0AB0 (https://mall.industry.siemens.com/mall/en/us/-Catalog/Product/6ES7516-3UP10-0AB0)	6ES7517-3UQ10--0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7517-3UQ10-0AB0)	6ES7518-3UT10--0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7518-3UT10-0AB0)
CPU 1518 MFP	---	---	---	---	---	6ES7518-4AX00--1AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7518-4AX00-1AB0)

CPU	1511-1 PN 1511F-1 PN 1511T-1 PN 1511TF-1 PN	1513-1 PN 1513F-1 PN	1515-2 PN 1515F-2 PN 1515T-2 PN 1515TF-2 PN	1516-3 PN/DP 1516F-3 PN/DP	1517-3 PN 1517F-3 PN	1518-3 PN 1518F-3 PN 1518T-3 PN 1518TF-3 PN
				1516T-3 PN 1516TF-3 PN	1517T-3 PN 1517TF-3 PN	1518-4 PN/DP M-FP 1518F-4 PN/DP MFP
CPU 1518F MFP	---	---	---	---	---	6ES7518-4FX00--1AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7518-4AX00-1AB0)
Equipment Manual						
Standard CPU:	↓ (https://support.industry.siemens.com/cs/ww/en/view/109752841)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109752842)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109767406)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109767407)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963203)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963204)
T-CPU	↓ (https://support.industry.siemens.com/cs/ww/en/view/109739188)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/109739189)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963205)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963206)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963207)
CPU 1518 MFP	---	---	---	---	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/109749061)
F-CPU	↓ (https://support.industry.siemens.com/cs/de/en/view/109478599)					
Supply voltage, permissible range of all the CPUs 19.2 V DC ... 28.8 V DC						
Code work memory						
Standard CPU:	300 KB	600 KB	1 MB	2 MB	4 MB	12 MB
T-CPU	450 KB	---	1.5 MB	3 MB	6 MB	18 MB
F-CPU	450 KB	900 KB	1.5 MB	3 MB	6 MB	18 MB
TF-CPU	450 KB	---	1.5 MB	3 MB	6 MB	18 MB
MFP-CPU	---					6 MB
FMFP-CPU	---					9 MB
Data work memory	1.5 MB	2.5 MB	4.5 MB	7.5 MB	50 MB	150 MB
				25 MB		60 MB
Processing times						
Bit operations	6 ns	6 ns	6 ns	6 ns	0.6 ns	0.3 ns
				1.2 ns		1 ns
Word operations	7 ns	7 ns	7 ns	7 ns	1.3 ns	0.8 ns
				2.6 ns		2 ns
Integrated interfaces						
PROFINET I-O	1	1	2	2	2	2
PROFINET	---	---	---	---	1	1

CPU	1511-1 PN 1511F-1 PN 1511T-1 PN 1511TF-1 PN	1513-1 PN 1513F-1 PN	1515-2 PN 1515F-2 PN 1515T-2 PN 1515TF-2 PN	1516-3 PN/DP 1516F-3 PN/DP	1517-3 PN 1517F-3 PN	1518-3 PN 1518F-3 PN 1518T-3 PN 1518TF-3 PN
				1516T-3 PN 1516TF-3 PN	1517T-3 PN 1517TF-3 PN	1518-4 PN/DP M-FP 1518F-4 PN/DP MFP
PROFINET	---	---	---	1	1	1
Number of PROFINET ports	2	2	3	3	5	5
				5		4
PROFIBUS DP	---	---	---	1	---	---
				---		1
Technology						
Motion control resources*	1120	1120	2400	2400	20480	30720
				12800		15380
Typical number of positioning axes (at 4 ms servo/IPO cycle)	5	5	7	110	70 T(F)-CPU: 140	1518(F): 140 1518T(F): 280
				11		140
Extended motion control resources (T-CPUs only)	90	---	120	540	720	1560
						512
Max. number of positioning axes	14	14	30	30	128	128
Additional functions						
Isochronous mode	Centralized and distributed	Centralized and distributed	Centralized and distributed	Centralized and distributed	Centralized and distributed	Centralized and distributed
Web server	X	X	X	X	X	X

* See Motion Control (Page 133) section

Table 1-807 Compact CPUs

Controller	1511C-1 PN	1512C-1 PN
Article number	6ES7511-1CL03-0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES751-1-1CL03-0AB0)	6ES7512-1CM03-0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES751-2-1CM03-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109963074)	↓ (https://support.industry.siemens.com/cs/de/en/view/109963073)
Supply voltage, permissible range	19.2 V DC to 28.8 V DC	19.2 V DC to 28.8 V DC
Code work memory	300 KB	400 KB
Data work memory	1.5 MB	2 MB
Processing time for bit operations	6 ns	6 ns

Controller	1511C-1 PN	1512C-1 PN
Processing time for Word operations	7 ns	7 ns
PROFINET interfaces	1	1
Number of PROFINET ports	2	2
Integrated analog inputs/outputs	5 inputs/2 outputs	5 inputs/2 outputs
Integrated digital inputs/outputs	16 inputs/16 outputs	32 inputs/32 outputs
Technology		
Motion control resources*	1120	1120
Typical number of positioning axes (at 4 ms servo/IPO cycle)	5	5
Max. number of positioning axes	10	10
Isochronous mode	Distributed	Distributed
High-speed counters	6 (max. 100 kHz)	6 (max. 100 kHz)
Frequency meter	6 (max. 100 kHz)	6 (max. 100 kHz)
Period duration measurement	6 channels	6 channels
Pulse generators (pulse width modulation, Pulse Train Output, frequency output)	4	4
Web server	X	X

* See Motion Control (Page 133) section

Code work memory: Volatile memory that contains runtime-relevant parts of the program code.

Data work memory: Volatile memory that contains the runtime-relevant parts of the data blocks and technology objects.

5.4.3 Web server

The SIMATIC S7-1500 CPUs have an integrated web server.

You can display the CPU status without additional software installation via a web browser and control it to a limited extent. Graphically visualized process variables and user-defined websites facilitate information acquisition and diagnostics of plant states.



Figure 1-468 Home page web server

Example: Web server simplifies maintenance of treatment plants

Automation task:

Implementation of a user interface for fault management of a treatment plant.

Feature:

Treatment plants operate fully automatically, they are not manned. The operator optionally receives an SMS if a fault occurs. For diagnostics, the operator directly accesses the corresponding web sites.

Solution:

Creation of user sites for the web server of a SIMATIC S7-1500 CPU. The customer can make changes to the web sites himself, e.g. the mobile number for the SMS messages, settings in the CPU or the message texts.

Benefits

The web server provides you with the following advantages:

- Access via web browsers to a SIMATIC S7-1500 with plant-relevant operating data
- Display of service and diagnostics information over large distances
- Access restrictions for unauthorized users

Additional information

A detailed description of handling the web server can be found in the Function Manual "SIMATIC S7-1500 web server" SIMATIC S7-1500 Web server (https://support.industry.siemens.com/cs/de/en/view/59193560).

5.4.4 Safety

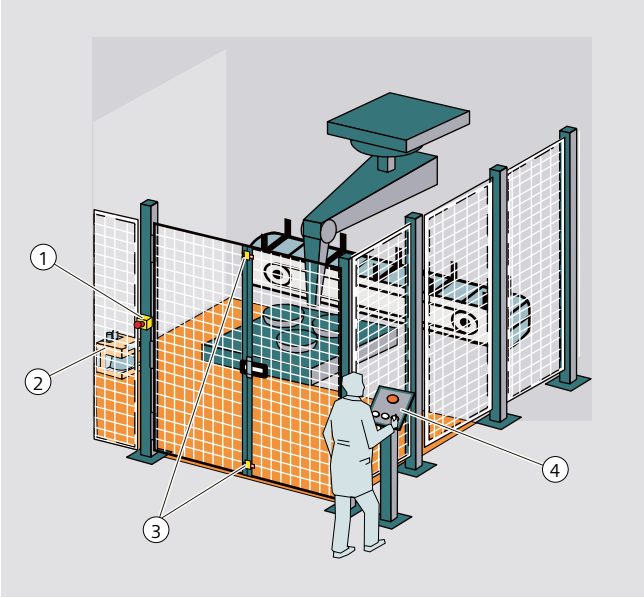
For fail-safe operation of your plant, program the F-CPUs of the SIMATIC S7-1500. Use the "STEP 7 Safety Advanced" option package of the TIA Portal for this purpose. In combination with the TIA Portal, the F-CPUs offer optimal integration of fail-safe systems into your engineering environment; one controller, one communication system, and one engineering platform for standard and fail-safe automation:

- Integration of safety technology
- Instructions approved by German Technical Inspectorate for frequently required safety applications
- Integration of safety-related functions up to SIL 3 according to IEC 61508 or PL e and Category 4 according to ISO 13849-1 or EN ISO 13849-1
- Uniform engineering for standard and safety automation
- Simple documentation of safety-related changes via the F-change history in STEP 7 Safety
- Support in the acceptance of the safety program and no renewed acceptance of the safety program after changes in the standard program

Example: Production cell with access protection

Automation task:

A laser scanner monitors access to a production area. The maintenance area is secured by a protective door. Entering the production area or opening the protective door, just like an emergency stop, results in the shutdown or stopping of the production cell.



① Emergency stop
② Laser scanner
③ Protective door
④ Control panel with start and acknowledgment key

Figure 1-469 Production cell with access protection

Feature:

Start-up of the system is only possible with unlocked emergency stop, closed protective door and free protection area of the laser scanner. After activating the emergency stop, opening the protective door or addressing the protection area, a user acknowledgement is required to restart production operations again. Access protection to the F-CPU and the safety program is essential for productive operation.

Solution:

Use of a SIMATIC S7-1500 F-CPU with fail-safe modules in the distributed I/O system ET 200SP on the PROFINET IO.

The F modules ET 200SP take over the connections for emergency stop, monitoring of the protective door, monitoring of the access area, the motor and the user acknowledgment. Perform the relevant programming in STEP 7. The safety program runs in the CPU.

Benefits

SIMATIC Safety Integrated provides you with the following advantages:

- Engineering with SIMATIC STEP 7 Safety Advanced in the TIA Portal, same engineering and operating concept for standard and fail-safe automation task
- Use of instructions approved by the German Technical Inspectorate from the system library Safety in the safety program, e.g. for protective door, emergency stop, monitored feedback loop circuit and user acknowledgment, saves time and reduces the error rate
- Simple connections of PROFIsafe devices via PROFINET and PROFIBUS
- Additional password protection for F-CPU and safety program is set up for IT security.
- Integration in integrated system diagnostics

Additional information

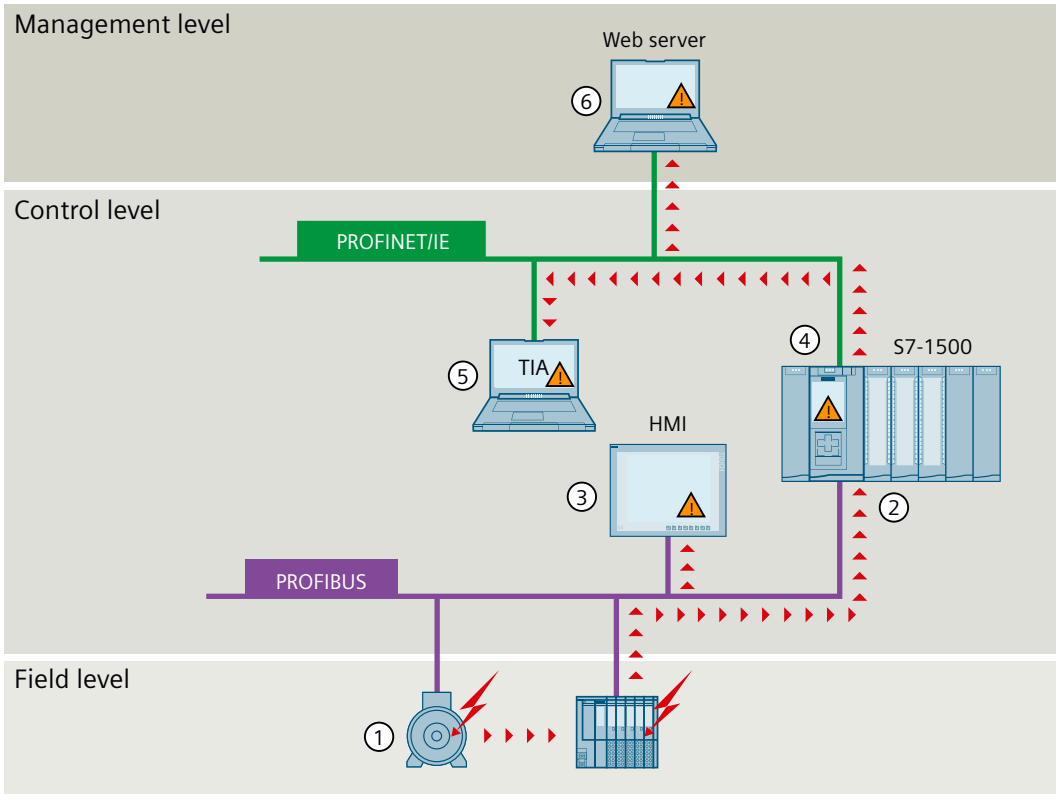
A detailed description of the topic "Safety Integrated" is available in the programming and operating manual SIMATIC Safety - Configuring and Programming SIMATIC Safety - Configuration and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

5.4.5 Diagnostics

Integrated diagnostics across all levels of the automation is incorporated in the SIMATIC S7-1500 automation system. All SIMATIC products have integrated diagnostic functions which you can use to analyze and localize faults and errors efficiently. This reduces the commissioning periods required and minimizes standstill times in production.

A uniform display concept ensures that error messages in the STEP 7, on the HMI, the Web server and in the display of the CPU are visualized identically as plain text information.

You can optionally configure machine and plant diagnostics. This means that the logic of these process diagnostic messages or monitoring depends directly on the state of the plant and is defined by you.



① Monitoring functions are integrated in the hardware as standard.
② Diagnostics is implemented system-wide across bus limits.
③ Output of the cause of the error in plain text, archiving and logging of alarms
④ Automatic localization of the error source
⑤ Configurability of alarms
⑥ Plant-wide, uniform display of system status

Figure 1-470 *Display of diagnostic information*

Faults in the plant are immediately detected and reported on the display devices, even in STOP mode. As a result, system diagnostics is always consistent with the actual state of the plant.

Advantages and customer benefits

Integrated system diagnostics offers the following advantages:

- Diagnostics is always consistent with the actual state of the plant. The system diagnostics also works in the STOP mode of the CPU.
- The uniform display concept enables efficient error analysis.
- The immediate identification of the error source in the event of an error speeds up commissioning and minimizes production downtimes.
- By configuring diagnostics events, you tailor the diagnostics to the requirements of your automation task.

5.4.6 Trace

for effective commissioning and optimization of drives and closed-loop controls, the SIMATIC S7-1500 CPUs feature integrated trace functionality. The trace function records the CPU tags, depending on the settable trigger conditions. Tags are, for example, drive parameters or system and user tags of a CPU. You can display and evaluate the saved recordings with STEP 7.

By visualizing the entire process with real-time trace, you identify, for example, sporadic events in the system during commissioning and service.

The event recording adds the recording of status changes to Motion Control jobs as well as coming and going program and technology alarms to the signal recording with the trace.

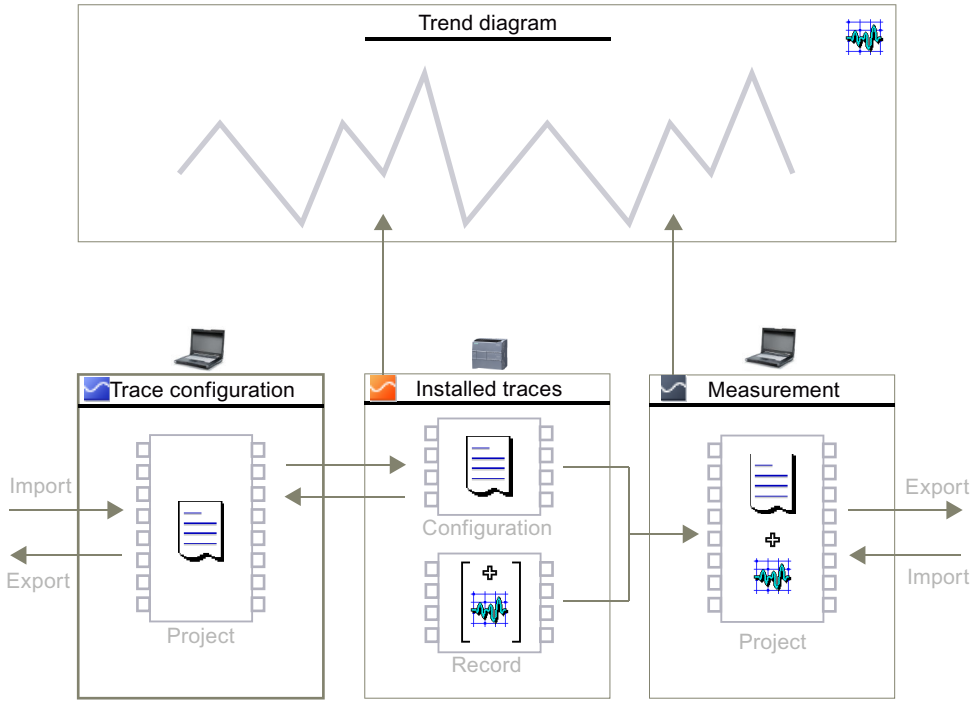


Figure 1-471 Schematic overview

Example: Trace optimizes the commissioning of packaging machines

Automation task:

At what speed does a plant reach its maximum productivity? How do you quickly determine the optimum settings?

The packaging machine ensures quick and reliable packaging of ECG electrodes on a rotary table which is loaded and unloaded by a conveyor belt.

Feature:

After filling is the correct time for further transport of the packaged electrodes. Light barriers trace the position of the electrodes for this.

Solution:

The Trace function of a SIMATIC S7-1500 CPU visualizes the exact sequence of selected signals over a short period of time. It supports the start-up engineer in finding the exact light barrier positions and the optimum speed for belts and the rotary table.

The trace recordings are supplied to the customer as part of the plant project. In the event of a fault, the customer recognizes whether changes to the basic settings have caused the fault.

In addition, the trace recordings are stored as a "measurement" on the SIMATIC memory card, up to 999 trace recordings are available for evaluation.

Advantages and customer benefits

The Trace function provides you with the following advantages:

- Cost-effective and easy evaluation as the signals are available in the CPU
- Monitoring of highly dynamic processes
- Up to 8 independent trace jobs simultaneously
- Recordings of individual cycles for up to 64 different tags in a .csv file over a longer period (e.g. hours, days) → Long-term trace.
- recording in separate CPU memory area for easy localization of sporadic errors
- Various trigger options
- Various zoom and cursor measuring functions
- Recording of status changes to motion control jobs
- Recording of incoming and outgoing program and technology alarms
- Saving trace recordings on the SIMATIC memory card
- export of measurements, e.g. for user-specific processing

Project trace

A project trace includes trace configurations of multiple devices and records the signals across devices.

Synchronization takes place via a global trigger that can be triggered by any device. After receiving the global trigger, the devices with valid project trace configuration start the recording.

More information

You can find a detailed description of the "Trace" function in the Function Manual SIMATIC/SINAMICS Using the trace and logic analyzer function SIMATIC/SINAMICS Trace and logic analyzer function (https://support.industry.siemens.com/cs/ww/en/view/64897128).

5.5 Interface modules for SIMATIC S7-1500 I/O devices

An interface module connects the SIMATIC S7-1500 I/O devices as ET 200MP distributed I/O system via PROFINET or PROFIBUS with the controller. The interface module exchanges the data between the higher-level controller and the I/O modules.

Interface modules

Short designation	**IM 155-5 MF HF**	**IM 155-5 PN HF IM 155-5 PN ST**	**IM 155-5 PN BA**	**IM 155-5 DP ST**
Article number				
High Feature (HF)	6ES7155-5MU00-0CN0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7155-5MU00-0CN0)	6ES7155-5AA00-0AC0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7155-5AA00-0AC0)	---	---
Standard (ST)	---	6ES7155-5AA01-0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7155-5AA01-0AB0)	---	6ES7155-5BA00-0AB0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7155-5BA00-0AB0)
Basic (BA)	---	---	6ES7155-5AA00-0AA0 (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7155-5AA00-0AA0)	---
Equipment Manual				
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/us/en/view/109826205)	↓ (https://support.industry.siemens.com/cs/ww/en/view/89261636)	---	---
Standard (ST)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193106)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/78324181)
Basic (BA)	---	---	↓ (https://support.industry.siemens.com/cs/ww/de/view/109745036)	---
Supply voltage	24 V DC	24 V DC	24 V DC	24 V DC
Number of IO modules	30	30	12	12

Short designation	IM 155-5 MF HF	IM 155-5 PN HF IM 155-5 PN ST	IM 155-5 PN BA	IM 155-5 DP ST
Interfaces	1 x PROFINET IO; integrated 2-port switch, 2 ports via BusAdapter	1 x PROFINET IO; integrated 2-port switch	1 x PROFINET IO; integrated 2-port switch	1 x PROFIBUS
Min. slave interval	---	---	---	100 µs
Isochronous real-time communication (IRT)	X	X	---	---
Isochronous mode	V5.2.1 or higher (shortest cycle 250 µs)	X (shortest cycle 250 µs)	---	---
Prioritized startup	---	X	---	---
Device replacement without programming device	X (LLDP; addressing via a tool, for example, STEP 7)	X (LLDP; address assignment by a tool, for example, STEP 7)	X (LLDP; address assignment by a tool, for example, STEP 7)	---
Shared device	4 IO controllers	High Feature: 4 IO controllers Default: 2 IO controllers	2 IO controllers	---
Identification and maintenance data	I&M 0 to 3	I&M 0 to 3	I&M 0 to 3	I&M 0 to 3
Media redundancy (MRP)	X	X	X	---
Media redundancy with planned duplication (MRPD)	X	High Feature: X Default:	---	---
System redundancy on S7-400H	with GSD file	High Feature: With GSD file and STEP 7 V5.5 SP3 or higher Default:	---	---
System redundancy in S7-1500R/H	X	High Feature: X Default:	---	---
GSD file for ET 200MP	PROFINET (https://support.industry.siemens.com/cs/ww/en/view/68-189683)	PROFINET (https://support.industry.siemens.com/cs/ww/en/view/68-189683)	PROFINET (https://support.industry.siemens.com/cs/ww/en/view/68-189683)	PROFIBUS (https://support.industry.siemens.com/cs/ww/en/view/80-206700)

5.6 Input and output modules

The I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions.



Digital and analog modules provide the inputs/outputs that are required for the respective task.

The input/output modules are divided into function classes.

Function classes of input/output modules

The table below shows selected properties and technical specifications of different function classes of input/output modules.

Function class		
High Speed (HS)	Special modules for extremely fast applications Shortest input delays Shortest conversion times Isochronous mode	
High Feature (HF)	Flexible use Even for complex applications Parameters for each channel Diagnostics for each channel Add-on functions	With analog modules • Highest accuracy (< 0.1%) • High common mode voltage (e. g. 60 V DC / 30 V AC), with single-channel electrical isolation if required
Standard (ST)	Medium price range Parameter per load group / module Diagnostics per load group / module	With analog modules • Universal modules • Accuracy ≥ 0.3% • Common-mode voltage approx. 10 V to 20 V
Basic (BA)	Inexpensive, simple modules No parameters No diagnostics	

5.6.1 Which I/O devices are the correct ones?

SIMATIC S7-1500 offers a wide range of I/O modules. Depending on the complexity of your plant and the technical and functional requirements, you perform your planning flexibly and in a modular manner with SIMATIC components.

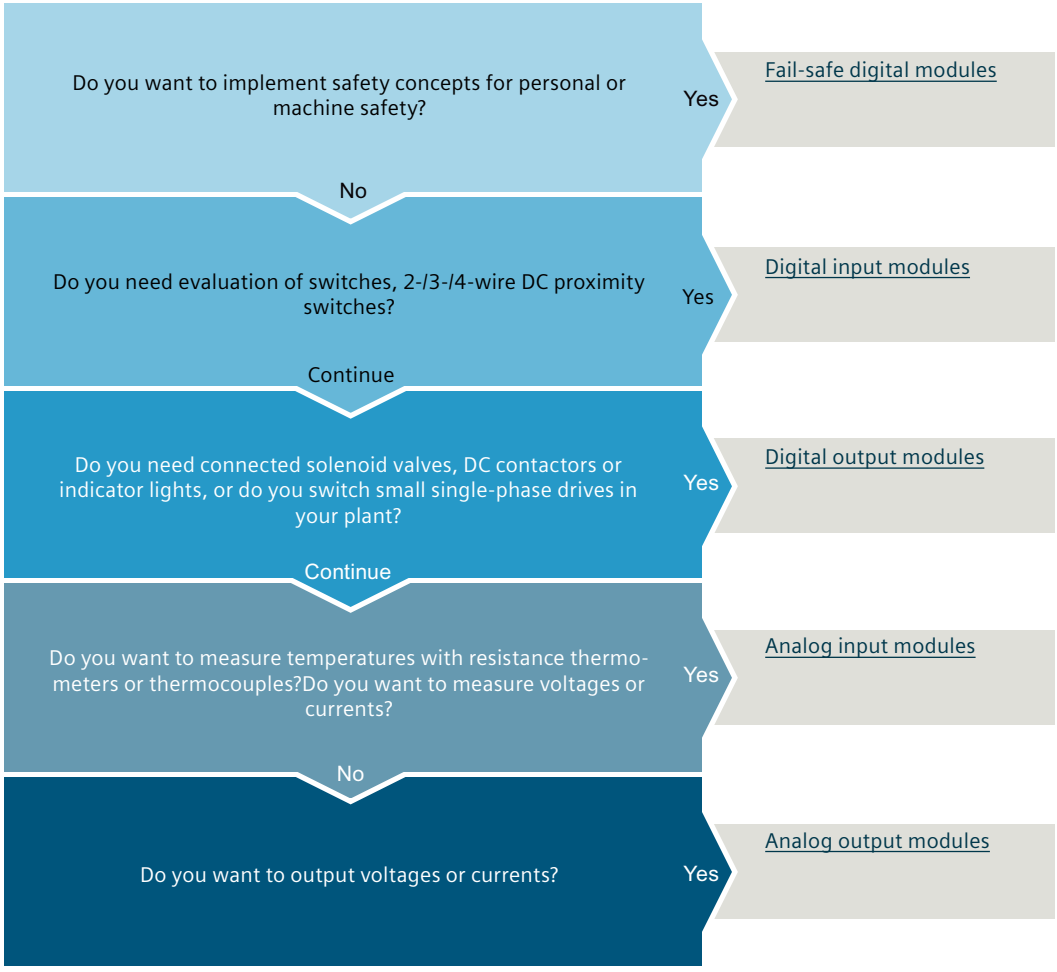


Figure 1-472 Selection guide for input/output modules

5.6.2 Digital input modules

Digital input modules

Short designation	DI 16x24VDC HF DI 16x24VDC BA	DI 32x24VDC HF DI 32x24VDC BA	DI 16x24VDC SRC BA	DI 16x24...125VUC HF
Article number				
High Feature (HF)	6ES7521-1BH00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1BH00-0AB0)	6ES7521-1BL00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1BL00-0AB0)	---	6ES7521-7EH00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-7EH00-0AB0)

Short designation	DI 16x24VDC HF DI 16x24VDC BA	DI 32x24VDC HF DI 32x24VDC BA	DI 16x24VDC SRC BA	DI 16x24...125VUC HF
Basic (BA)	6ES7521-1BH10-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1BH10-0AA0)	6ES7521-1BL10-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1BL10-0AA0)	6ES7521-1BH50-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1BH50-0AA0)	---
Equipment Manual				
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193001)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59192896)	---	↓ (https://support.industry.siemens.com/cs/ww/zh/view/109480460)
Basic (BA)	↓ (https://support.industry.siemens.com/cs/ww/en/view/83501190)	↓ (https://support.industry.siemens.com/cs/ww/en/view/83499481)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59191844)	---
Width				
High Feature (HF)	35 mm	35 mm	---	35 mm
Basic (BA)	25 mm	25 mm	35 mm	---
Number of inputs	16	32	16	16
Electrical isolation between channels	---	X	---	X
Number of potential groups	1	2	1	1
Rated input voltage	24 V DC	24 V DC	24 V DC	24 V UC to 125 V UC
Diagnostic interrupt	Only with HF	Only with HF	---	X
Hardware interrupt	Only with HF	Only with HF	---	X
Isochronous mode	Only with HF	Only with HF	---	---
Input delay				
High Feature (HF)	0.05 ms to 20 ms (configurable)		---	0.05 ms to 20 ms (configurable with DC) 20 ms (fixed at AC)
Basic (BA)	Typ. 3 ms (fixed)	Typ. 3 ms (fixed)	Typ. 3 ms (fixed)	---
Integrated counting function (Two channels can optionally be used as counter with 3 kHz)	Only with HF: • Counting up to 3 kHz • V2.2.1 or higher: Counting up to 6 kHz	Only with HF: • Counting up to 1 kHz • V2.2.1 or higher: Counting up to 6 kHz	---	V1.1.0 or higher: Counting up to 6 kHz (only DC)

Digital input modules

Short designation	DI 16x230VAC BA	DI 16xNAMUR HF	DI 16x24VDC HS
Article number			
High Feature (HF)	---	6ES7521-7TH00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-7TH00-0AB0)	---

Short designation	DI 16x230VAC BA	DI 16xNAMUR HF	DI 16x24VDC HS
Basic (BA)	6ES7521-1FH00-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-1FH00-0AA0)	---	---
High Speed (HS)	---	---	6ES7521-7BH00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7521-7BH00-0AB0)
Equipment Manual			
High Feature (HF)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/109798382)	---
Basic (BA)	↓ (https://support.industry.siemens.com/cs/de/en/view/59193398)	---	---
High Speed (HS)	---	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/109806801)
Width	35 mm	35 mm	35 mm
Number of inputs	16	16	16
Electrical isolation between channels	X	---	---
Number of potential groups	4	2	2
Rated input voltage	120/230 V AC	8.2 V DC	24 V DC
Diagnostic interrupt	---	X	X
Hardware interrupt	---	X	X
Isochronous mode	---	X	X
Oversampling	---	---	X
Input delay			
High Feature (HF)	---	0.05 ms to 20 ms (configurable)	---
Basic (BA)	Typ. 25 ms (fixed)	---	---
High Speed (HS)	---	---	0.05 ms to 20 ms (configurable)
Integrated counting function (Two channels can optionally be used as counter with 3 kHz)	---	Counting up to 20 kHz	Counting up to 20 kHz

Digital input/output module

Short designation	DI 16x24VDC / DQ 16x24V/0.5A BA
Article number	
High Feature (HF)	---

Short designation	DI 16x24VDC / DQ 16x24V/0.5A BA
Basic (BA)	6ES7523-1BL00-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7523-1BL00--0AA0)
Equipment Manual	
High Feature (HF)	---
Basic (BA)	↓ (https://support.industry.siemens.com/cs/ww/en/view/83501523)
Width	
High Feature (HF)	---
Basic (BA)	25 mm
Number of inputs	16
Electrical isolation between channels	---
Number of potential groups	DI: 1 / DQ: 2
Rated input voltage	24 V DC
Diagnostic interrupt	---
Hardware interrupt	---
Isochronous mode	---
Input delay	
High Feature (HF)	---
Basic (BA)	Typ. 3 ms (fixed)
Integrated counting function (Two channels can optionally be used as counter with 3 kHz)	---

Advantages

The digital input modules provide you with the following advantages:

- High channel density with low variety of parts, therefore less effort for ordering, logistics and storage of spare parts
- Modules in 25 mm size without parameter assignment and diagnostics, therefore simple commissioning
- Front connector in screw-type connection system or in push-in system for 25 mm and 35 mm modules
- Same mechanical design, same handling and same accessories for all modules
- Same pin assignment for wiring, which means that circuit diagrams and wiring plans can be universally used
- Any combination of narrow and wide modules
- Can be used centrally in SIMATIC S7-1500 and in the ET 200MP distributed I/O system

- Cost-effective implementation of simple counting tasks with two counter inputs each of the following modules:
  - DI 16x24V DC HF
  - DI 32x24V DC HF
  - DI 16xNAMUR HF
  - DI 16xUC HF
  - DI 16x24VDC HS

5.6.3 Digital output modules

Digital output modules and digital input/output module (DC)

Short designation	DQ 8x24VDC/2A HF	DQ 32x24VDC/0.5A HF DQ 32x24VDC/ 0.5A BA	DQ 16x24VDC/0.5A HF DQ 16x24VDC/ 0.5A BA	DI 16x24VDC / DQ16x24V/0.5A BA
Article number				
High Feature (HF)	6ES7522-1BF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-1BF00-0AB0)	6ES7522-1BL01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-1BL01-0AB0)	6ES7522-1BH01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-1BH01-0AB0)	---
Basic (BA)	---	6ES7522-1BL10-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-1BL10-0AA0)	6ES7522-1BH10-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-1BH10-0AA0)	6ES7523-1BL00-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7523-1BL00-0AA0)
Equipment Manual				
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193089)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109480716)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109480717)	---
Basic (BA)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/83500404)	↓ (https://support.industry.siemens.com/cs/ww/en/view/83500415)	↓ (https://support.industry.siemens.com/cs/ww/de/view/83501523)
Width				
High Feature (HF)	35 mm	35 mm	35 mm	---
Basic (BA)	---	25 mm	25 mm	25 mm
Number of outputs	8	32	16	16
Type	Transistor	Transistor	Transistor	Transistor
Electrical isolation between channels	X	Only with BA	Only with BA	X
Number of potential groups	2	4; only with BA	2; only with BA	DQ: 2 / DI: 1
Rated output voltage	24 V DC	24 V DC	24 V DC	24 V DC
Rated output current	2 A	0.5 A	0.5 A	0.5 A
Diagnostic interrupt	X	Only with HF	Only with HF	---
Hardware interrupt	---	---	---	---

Short designation	DQ 8x24VDC/2A HF	DQ 32x24VDC/0.5A HF DQ 32x24VDC/ 0.5A BA	DQ 16x24VDC/0.5A HF DQ 16x24VDC/ 0.5A BA	DI 16x24VDC / DQ16x24V/0.5A BA
Isochronous mode	---	Only with HF	Only with HF	---
Pulse width modulation (PWM)	X	---	---	---
Switching cycle counter	X	---	Only with HF	---

Short designation	DQ 8x24VDC/5A HS
Article number	6ES7522-5BF00-0AB0 (https://mall.industry.siemens.com/mall/en/ww/Catalog/Product?mlfb=6ES7522--5BF00-0AB0&SiepCountryCode=ww)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/en/en/view/109978899)
Width	35 mm
Number of outputs	8
Type	Transistor
Electrical isolation between channels	X
Number of potential groups	2
Rated output voltage	24 V DC
Rated output current	5 A
Diagnostic interrupt	X
Hardware interrupt	---
Isochronous mode	X
Oversampling	X
Pulse width modulation (PWM)	X
Switching cycle counter	X

Digital output modules (UC, AC)

Short designation	DQ 16x24 ...48VUC/ 125VDC/0.5A ST	DQ 8x230VAC/5A ST relay	DQ 16x230VAC/2A ST relay	DQ 8x230VAC/2A ST Triac	DQ 16x230VAC/1A ST Triac
Article number	6ES7522-5EH00-0-AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-5EH00-0AB0)	6ES7522-5HF00-0-AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-5HF00-0AB0)	6ES7522-5HH00-0-AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-5HH00-0AB0)	6ES7522-5FF00-0A-B0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-5FF00-0AB0)	6ES7522-5FH00-0-AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7522-5FH00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109480462)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59192915)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109475445)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193088)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109475446)
Width	35 mm	35 mm	35 mm	35 mm	35 mm
Number of outputs	16	8	16	8	16
Type	Transistor	Relay	Relay	Triac	Triac

Short designation	DQ 16x24 ...48VUC/ 125VDC/0.5A ST	DQ 8x230VAC/5A ST relay	DQ 16x230VAC/2A ST relay	DQ 8x230VAC/2A ST Triac	DQ 16x230VAC/1A ST Triac
Electrical isolation between channels	X	X	X	X	X
Number of potential groups	1	16	8	8	8
Relay coil supply voltage	---	24 V DC	24 V DC	---	---
Rated output voltage	24 V DC to 125 V DC / 24 V AC to 48 V AC	24 V DC to 120 V DC / 24 V AC to 230 V AC	24 V DC to 120 V DC / 24 V AC to 230 V AC	230 V AC	230 V AC
Rated output current	0.5 A	5 A	2 A	2 A	1 A
Diagnostic interrupt	---	X	X	---	---
Hardware interrupt	---	---	---	---	---

Advantages

The digital output modules provide you with the following advantages:

- High channel density with low variety of parts, therefore less effort for ordering, logistics and storage of spare parts
- Modules in 25 mm size without parameter assignment and diagnostics, therefore simple commissioning
- Front connector in screw-type connection system or in push-in system for 25 mm and 35 mm modules
- Same mechanical design, same handling and same accessories for all modules
- Switching cycle counter for planning maintenance cycles
- Same pin assignment for wiring, which means that circuit diagrams and wiring plans can be universally used
- Any combination of narrow and wide modules
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system
- High feature module DQ 8x24VDC/2A HF: You can use pulse width modulation (PWM) to easily generate periodic pulses with a constant rated voltage and a variable pulse duration.

  Typical use:

  – Control of proportional valves and way valves (for example, energy savings by reducing the holding current)
  – Heating control, for example via an external additional power unit
- High-current module DQ 8 HS:
  – 5 A per channel
  – 8 A per channel group

5.6.4 Fail-safe digital modules

Fail-safe digital modules

Fail-safe digital modules are available for implementing safety concepts in the area of equipment and personnel safety (for example, for emergency stop devices in the operation of processing machines).

The fail-safe modules ensure safe processing of field information (sensors: e.g., EMERGENCY OFF buttons, light barriers; actuators, e.g. motor control). You are provided with all the hardware and software components required for safe processing, according to the required safety class. The following table shows the available fail-safe modules.

Short designation	F-DI 16x 24VDC PROFIsafe	F-DQ 8x24VDC/2A PPM
Article number	6ES7526-1BH00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-26-1BH00-0AB0)	6ES7526-2BF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-26-2BF00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109482426)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109482427)
Width	35 mm	35 mm
Number of inputs	16	---
Number of outputs	---	8
Type output	---	Transistor
Electrical isolation between channels	---	---
Rated input voltage	24 V DC	---
Rated output voltage	---	24 V DC
Rated output current	---	2 A
Maximum achievable safety class in safety mode	PLe/SIL 3	PLe/SIL 3
Low demand mode: PFD according to SIL3	< 5.00E-05	< 6.00E-05
High demand/continuous mode: PFH according to SIL3	< 1.00E-09 1/h	< 2.00E-09 1/h
Diagnostic interrupt	X	X
Hardware interrupt	---	---
Input delay	0.4 ms to 20 ms (configurable by channel)	---

Benefits

The fail-safe input and output modules S7-1500 provide you with the following advantages:

- High-channel, fail-safe inputs and outputs
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system
- processing of standard and safety programs
- Uniform engineering for standard and safety automation in the TIA Portal
- Integration of safety-related functions up to SIL 3 according to IEC 61508:2010 or PL e and category 4 according to ISO 13849-1:2015 or according to EN ISO 13849-1:2015

5.6.5 Analog input modules

Analog input modules and analog input/output module

Short designation	AI 8xU/I HF AI 8xU/I HS	AI 8xU/R/RTD/TC HF AI 8xU/I/RTD/TC ST	AI 4xU/I/RTD/TC ST AI 8xU/I/R/RTD BA	AI 4xU/I/RTD/TC / AQ 2xU/I ST
Article number				
High Feature (HF)	6ES7531-7NF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7NF00-0AB0)	6ES7531-7PF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7PF00-0AB0)	---	---
High Speed (HS)	6ES7531-7NF10-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7NF10-0AB0)	---	---	---
Standard (ST)	---	6ES7531-7KF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7KF00-0AB0)	6ES7531-7QD00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7QD00-0AB0)	6ES7534- 7QE00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7534-7QE00-0AB0)
Basic (BA)	---	---	6ES7531-7QF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7531-7QF00-0AB0)	---
Equipment Manual				
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109483587)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109483586)	---	---
High Speed (HS)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193206)	---	---	---
Standard (ST)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193205)	↓ (https://support.industry.siemens.com/cs/ww/en/view/91688401)	↓ (https://support.industry.siemens.com/cs/ww/en/view/91688109)
Basic (BA)	---	---	↓ (https://support.industry.siemens.com/cs/de/en/view/109763142)	---
Width	35 mm	35 mm	25 mm	25 mm
Number of inputs	8	8	4	4
Resolution	16 bits including sign	16 bits including sign	16 bits including sign	16 bits including sign

Short designation	AI 8xU/I HF AI 8xU/I HS	AI 8xU/R/RTD/TC HF AI 8xU/I/RTD/TC ST	AI 4xU/I/RTD/TC ST AI 8xU/I/R/RTD BA	AI 4xU/I/RTD/TC / AQ 2xU/I ST
Measurement type	Voltage, current	Voltage, current, resistance, thermal resistor, thermocouple	Voltage, current, resistance, resistance thermometer, thermocouple	Voltage, current, resistance, thermal resistor, thermocouple
Electrical isolation between channels	Only with HF	Only with HF	---	---
Number of potential groups	1	1	---	---
Rated supply voltage	24 V DC	24 V DC	24 V DC	24 V DC
Permissible potential difference between inputs (UCM)	HF: 60 V DC / 30 V AC HS: 10 V DC	HF: 60 V DC / 30 V AC ST: 10 V DC	20 V DC	20 V DC
Diagnostic interrupt	X	X	X	X
Hardware interrupt	X Two high limits and two low limits in each case	X Two high limits and two low limits in each case	X Two high limits and two low limits in each case	X Two high limits and two low limits in each case
Isochronous mode	Only HS	---	---	---
Conversion time (per channel)	HF: Fast mode: 4/18/22/102 ms; Standard mode: 9/52/62/302 ms HS: 62.5 µs, per module, regardless of number of activated channels	HF: Fast mode: 4/18/22/102 ms; Standard mode: 9/52/62/302 ms ST: 9/23/27/107 ms	9/23/27/107 ms	9/23/27/107 ms
Calibration in RUN mode	Only with HF	Only with HF	X	X
Oversampling	Only with HS	---	---	---
Measuring range adaptation	Only with HF	---	---	---
Scale measured values	Only with HF	---	---	---
Scale temperatures	---	Only with HF	---	---

Short designation	AI 8xHART HF	AI 24xCVM HF
Article number		
High Feature (HF)	6ES7531-7TF00-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES753-1-7TF00-0AB0)	6ES7531-7LK00-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES753-1-7LK00-0AB0)
Equipment Manual		
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/us/en/view/109821074)	↓ (https://support.industry.siemens.com/cs/us/en/view/109963246)
Width	35 mm	25 mm
Number of inputs	8	24
Resolution	16 bits including sign	16 bits including sign
Measurement type	Current	Voltage
Electrical isolation between channels	X	---
Number of potential groups	1	1
Rated supply voltage	24 V DC	24 V DC

Short designation	AI 8xHART HF	AI 24xCVM HF
Permissible potential difference between inputs (UCM)	60 V DC / 30 V AC	---
Diagnostic interrupt	X	X
Hardware interrupt	X Two high limits and two low limits in each case	X Two high limits and two low limits in each case
Isochronous mode	---	---
Conversion time (per channel)	Fast mode: 7/21/25/106 ms; Standard mode: 12/55/65/307 ms	8/22/25/105 ms
Calibration in RUN mode	X	X
Oversampling	---	---
Measuring range adaptation	---	---
Scale measured values	---	---
Scale temperatures	---	---

Advantages

Analog input modules detect process signals, for example, pressure or temperature and pass the process signals on in digitalized form (16 bit format) to the CPU. You use the analog input modules to measure current (2-wire and 4-wire transducer), voltages, resistances (resistance thermometer) and temperatures (thermoelements). The measurement types depend on the module used.

The analog input modules provide you with the following advantages:

- Front connector in screw-type connection system or in push-in system for 25 mm and 35 mm modules
- Same mechanical design, same handling and same accessories for all modules
- Components required for shielding are included in the scope of delivery and allow simple and quick installation without the use of tools
- Same pin assignment for wiring, which means that circuit diagrams and wiring plans can be universally used
- Any combination of narrow and wide modules
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system

Overview of functions

In the following you will find a brief overview of special functions of the modules. You can find a detailed description of the functions in the equipment manual of the module.

Measuring range adjustment of the analog input module AI 8xU/I HF

The function adjusts the measuring range to the sensor. You can increase the resolution for a configurable part of the measuring range in S7 format. The measured signal is resolved precisely to more decimal places around a specific operating point.

Scaling of the measured values of the analog input module AI 8xU/I HF

With measured value scaling, you display the user data of the module in REAL format (32-bit floating point) instead of S7 format. You can thus directly assign a technological variable to the analog value of the module. The conversion is made directly in the module, which saves power and cycle time in the CPU.

You can combine the measured value scaling with the measuring range adjustment. In this case, the measuring range is adjusted first and then the representation of the measured value is scaled.

Calibration in runtime

The following analog modules offer you the calibration function at runtime:

- AI 4xU/I/RTD/TC ST
- AI 8xU/I/RTD BA
- AI 8xU/I/RTD/TC ST
- AI 8xU/I HS
- AI 8xU/I HF
- AI 8xHART HF
- AI 8xU/R/RTD/TC HF
- AI 16xU BA
- AI 16xI BA
- AI 24xCVM HF
- AI 4xU/I/RTD/TC / AQ 2xU/I ST

The calibration compensates for influences on the measuring result by cables and/or temperature. A calibration checks the process values output by the analog input module, determines the deviation from the actual values and compensates for measuring errors.

Typical use:

- For plants in which sensors detect relatively small voltages or currents
- For applications which require regular calibration for all components in a measuring circuit.

Oversampling of the AI 8xU/I HS analog input module

Oversampling divides a PROFINET bus cycle into equidistant bus sub-cycles. This requires isochronous mode.

Oversampling acquires data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles. Use for quality-monitoring measurements, for example when recording pressure trends during the blowing process of PET bottle production.

5.6.6 Analog output modules

Analog output modules and analog input/output module

Short designation	AQ 8xU/I HS	AQ 4xU/I HF AQ 4xU/I ST	AQ 2xU/I ST	AI 4xU/I/RTD/TC / AQ 2xU/I ST
Article number				
High Feature (HF)	---	6ES7532-5ND00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7532-5ND00-0AB0)	---	---
High Speed (HS)	6ES7532-5HF00-0AB0 (https://mall.industry.siemens.com/mall/de/WW/Catalog/Product/6ES7532-5HF00-0AB0)	---	---	---
Standard (ST)	---	6ES7532-5HD00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7532-5HD00-0AB0)	6ES7532-5NB00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7532-5NB00-0AB0)	6ES7534-7QE00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7534-7QE00--0AB0)
Equipment Manual				
High Feature (HF)	---	↓ (https://support.industry.siemens.com/cs/ww/en/view/109483585)	---	---
High Speed (HS)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193551)	---	---	---
Standard (ST)	---	↓ (https://support.industry.siemens.com/cs/ww/de/view/59191850)	↓ (https://support.industry.siemens.com/cs/ww/en/view/91688388)	↓ (https://support.industry.siemens.com/cs/ww/en/view/91688109)
Width	35 mm	35 mm	25 mm	25 mm
Number of outputs	8	4	2	2
Resolution	16 bits including sign	16 bits including sign	16 bits including sign	16 bits including sign
Output type	Voltage/current	Voltage/current	Voltage/current	Voltage/current
Electrical isolation between channels	---	Only with HF	---	---
Number of potential groups	---	1	---	---
Rated supply voltage	24 V DC	24 V DC	24 V DC	24 V DC
Diagnostic interrupt	X	X	X	X
Isochronous mode	X	Only with HF	---	---

Short designation	AQ 8xU/I HS	AQ 4xU/I HF AQ 4xU/I ST	AQ 2xU/I ST	AI 4xU/I/RTD/TC / AQ 2xU/I ST
Conversion time (per channel)	50 µs, regardless of number of activated channels	HF: 125 µs, regardless of number of activated channels ST: 0.5 ms	0.5 ms	0.5 ms
Calibration in RUN mode	X	Only with ST	X	X
Oversampling	X	---	---	---

Short designation	AQ 8xHART HF
Article number	
High Feature (HF)	6ES7532-8TF00-0AB0 (https://mall.industry.siemens.com/mall/en/us/Catalog/Product/6ES7532-8TF00-0AB0)
Equipment Manual	
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/us/en/view/109954408)
Width	35 mm
Number of outputs	8
Resolution	16 bits including sign
Output type	Current
Electrical isolation between channels	---
Number of potential groups	---
Rated supply voltage	24 V DC
Diagnostic interrupt	X
Isochronous mode	---
Conversion time (per channel)	---
Calibration in RUN mode	X
Oversampling	---

Advantages

Analog output modules convert a 16-bit digital value into current or voltage and output it at the process. With the analog output modules you control, for example, proportional valves or small servo drives.

The analog output modules provide you with the following advantages:

- Front connector in screw-type connection system or in push-in system for 25 mm and 35 mm modules
- Same mechanical design, same handling and same accessories for all modules
- Components required for shielding are included in the scope of delivery and allow simple and quick installation without the use of tools
- Same pin assignment for wiring, which means that circuit diagrams and wiring plans can be universally used
- Any combination of narrow and wide modules
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system

Overview of functions

In the following you will find a brief overview of special functions of the modules. A detailed description of the functions is available in the device manual of the module.

Calibration in runtime

The following analog modules offer you the calibration function at runtime:

- AQ 2xU/I ST
- AQ 4xU/I ST
- AQ 4xU/I HF
- AQ 8xU/I HS
- AQ 8xHART HF
- AI 4xU/I/RTD/TC / AQ 2xU/I ST

The calibration compensates for influences on the measuring result by cables and/or temperature. A calibration checks the process values output by the analog output module, determines the deviation from the actual values and compensates for output errors.

Typical use:

- For plants in which sensors process relatively small voltages or currents.
- For applications which require regular calibration for all components in a measuring circuit.

Oversampling of the AQ 8xU/I HS analog output module

Oversampling divides a PROFINET bus cycle into equidistant bus sub-cycles. This requires isochronous mode.

Oversampling acquires data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles. Used, for example, for controlling a feed valve, the output data is controlled exactly at the current position of the machine.

5.7 Communication

5.7.1 Interfaces for communications

Interfaces for communication via PROFINET and PROFIBUS DP (as of CPU 1516) are already integrated in the CPUs. Additional communication modules enhance the communication capabilities of the SIMATIC S7-1500 with additional functions or interfaces, e.g. 8xIO-Link. The following communications options are available for your automation task:

Communication options	PN/IE	DP	Serial
PG communication for commissioning, testing, diagnostics	X	X	---
HMI communication for operator control and monitoring	X	X	---
Open User Communication	X	---	---
Secure Open User Communication	X	---	---
Data exchange via OPC UA as server	X	---	---
Data exchange via OPC UA as client	X	---	---
Direct data exchange between IO controllers	X	---	---

Communication options	PN/IE	DP	Serial
Communication via Modbus TCP	X	---	---
Communication via UDP Multicast	X	---	---
Sending process alarms via e-mail	X	---	---
File management and file access via FTP (File Transfer Protocol); CP may be the FTP client and FTP server	X	---	---
S7 communication	X	X	---
Serial point-to-point or multi-point connection Data exchange via point-to-point with Freeport, 3964 (R), USS or Modbus protocol	---	---	X
Web server Data exchange via HTTP(S), for example for diagnostics	X	---	---
SNMP (Simple Network Management Protocol)	X	---	---
Time synchronization	X	X	---

5.7.2 CM communication modules / CP communications processors

For special requirements of your plant, use communications processors (CPs) for security functions to secure Industrial Ethernet networks.

If your system requires additional interfaces, communication modules (CM) expand your S7-1500 CPU with other interfaces of an interface type such as PROFINET, PROFIBUS or point-to-point connection. The CMs for point-to-point connection allow, for example, Freeport or Modbus communication via their RS232, RS422 and RS485 interfaces.

Communication modules for PROFINET and Industrial Ethernet

Short designation	CM 1542-1	CP 1543-1	CP 1545-1
Article number	6GK7542-1AX10-0XE0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6GK7542-1AX10-0XE0)	6GK7543-1AX10-0XE0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6GK7543-1AX10-0XE0)	6GK7545-1GX10-0XE0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6GK7545-1GX10-0XE0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109986489)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109986722)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109986488)
Bus system	PROFINET	Industrial Ethernet	Industrial Ethernet
Interface	RJ45	RJ45	RJ45
Data transmission rate	10/100 Mbps	10/100/1000 Mbps	10/100/1000 Mbps
Functionality and protocols	TCP/IP, ISO-on-TCP, UDP, Modbus TCP, S7 communication, IP broadcast/multicast, SNMPV1	TCP/IP, ISO, UDP, Modbus TCP, S7 communication, IP Broadcast/Multicast, Security, Secure Open User Communication, SMTPS, diagnostics SNMPV1/V3, DHCP, FTP client/server, email, IPV4/IPV6	TCP/IP, ISO, UDP, Modbus TCP, S7 communication, IP Broadcast/Multicast, Security, Secure Open User Communication, SMTPS, diagnostics SNMPV1/V3, DHCP, FTP client/server, email, IPV4/IPV6
Diagnostic interrupt	X	X	X

Short designation	CM 1542-1	CP 1543-1	CP 1545-1
Hardware interrupt	X	---	---
Isochronous mode	---	---	---
Link to cloud systems via MQTT	---	---	X
OPC UA PubSub via UDP	---	---	---

Communication modules for PROFIBUS

Short designation	CM 1542-5	CP 1542-5
Article number	6GK7542-5DX10-0XE0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6GK7-542-5DX10-0XE0)	6GK7542-5FX10-0XE0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6GK7-542-5FX10-0XE0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109978312)	↓ (https://support.industry.siemens.com/cs/ww/en/view/76894900)
Bus system	PROFIBUS	PROFIBUS
Interface	RS485	RS485
Data transmission rate	9600 bps to 12 Mbps	9600 bps to 12 Mbps
Functionality and protocols	DPV1 master/slave, S7 communication PG/OP communication Open User Communication	DPV1 master/slave, S7 communication PG/OP communication FDL
Diagnostic interrupt	X	X
Hardware interrupt	X	X
Isochronous mode	---	---

Communication modules for point-to-point connection

Short designation	CM PtP RS232 HF CM PtP RS232 BA	CM PtP RS422/485 HF CM PtP RS422/485 BA
Article number		
High Feature (HF)	6ES7541-1AD00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-41-1AD00-0AB0)	6ES7541-1AB00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-41-1AB00-0AB0)
Basic (BA)	6ES7540-1AD00-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-40-1AD00-0AA0)	6ES7540-1AB00-0AA0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-40-1AB00-0AA0)
Equipment Manual		
High Feature (HF)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59057160)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59061372)
Basic (BA)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59057152)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59057390)
Interface	RS232	RS422/485

Short designation	CM PtP RS232 HF CM PtP RS232 BA	CM PtP RS422/485 HF CM PtP RS422/485 BA
Data transmission rate		
High Feature (HF)	300 to 115 200 bps	300 to 115 200 bps
Basic (BA)	300 to 19 200 bps	300 to 19 200 bps
Frame length, max.		
High Feature (HF)	4 KB	4 KB
Basic (BA)	1 KB	1 KB
Diagnostic interrupt	X	X
Hardware interrupt	---	---
Isochronous mode	---	---
Protocols		
High Feature (HF)	Freeport, 3964 (R), Modbus RTU master, Modbus RTU device	Freeport, 3964 (R), Modbus RTU master, Modbus RTU device
Basic (BA)	Freeport, 3964 (R)	Freeport, 3964 (R)

Benefits

The communication modules point-to-point connection S7-1500 provide you with the following advantages:

- Connection of legacy and external systems possible
- Connection of data readers or special sensors
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system
- Variety of physical interfaces, e.g. RS232 and RS422 or RS485
- Predefined protocols, e.g. 3964(R), Modbus RTU or USS
- Application-specific protocols based on Freeport (ASCII)
- Uniform programming interface for all modules
- Diagnostic interrupt for simple fault rectification

5.7.3 Communication module IO-Link Master

Communication module IO-Link Master

An 8-port IO-link master module CM 8xIO-link is available for the S7-1500 automation system/ET 200MP distributed I/O system.

IO-Link is a point-to-point connection between a master and a device. Both conventional and intelligent sensors/actuators can be used as devices at the IO link via unshielded standard cables using proven 3-wire technology.

You can use the 8-port IO link master as follows:

- Central, directly behind a S7-1500 CPU (a total of 30 I/O modules, plug-in type)
- Distributed with ET 200MP to PROFINET and PROFIBUS

With the IO link, you can easily change the parameters for the production and processing of different product variants and batches up to sensor/actuator level during CPU runtime. A

considerably more detailed diagnostics up to sensor or actuator or a remote diagnostics is possible.

Table 1-808 Communication module IO-Link Master

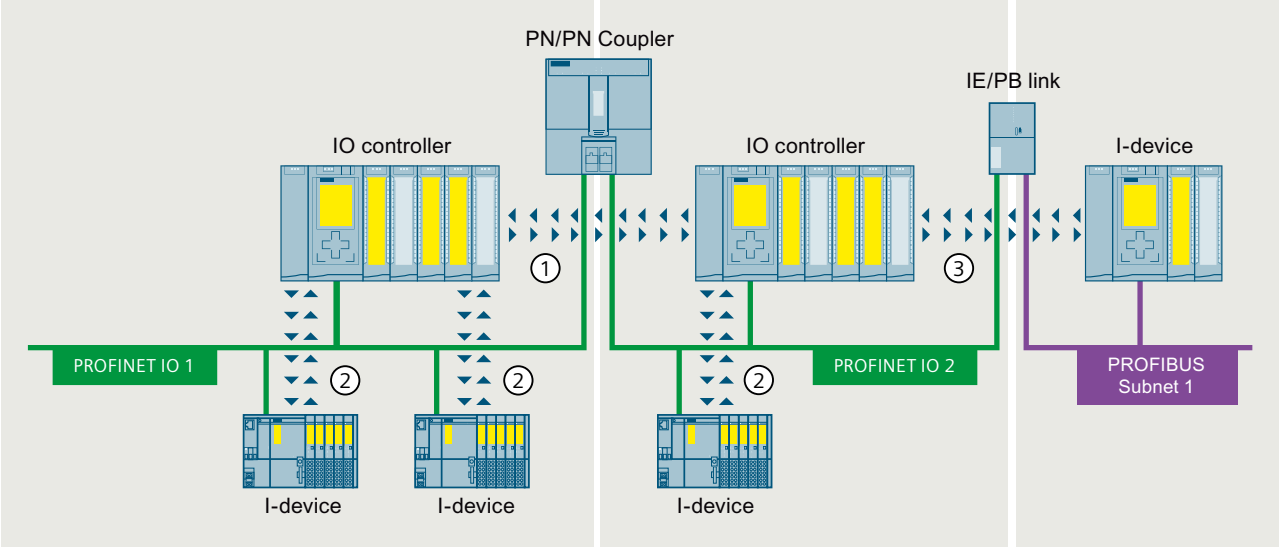
Short designation	**CM 8x IO-Link**
Article number	6ES7547-1JF00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7547-1JF00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109763143)
Bus system	IO-Link
Interface	8 ports
Data transmission rate	COM1 (4.8 kbaud), COM2 (38.4 kbaud), COM3 (230.4 kbaud)
Functionality and protocols	IO-Link Protocol 1.0 IO-Link Protocol 1.1
Diagnostic interrupt	X
Hardware interrupt	---
Isochronous mode	---

Benefits:

- Simplified and reduced wiring, engineering and commissioning
- Time savings
- Higher availability due to pre-assembled cable
- Avoidance of plant downtimes through preventive maintenance
- High diagnostics capability
- Configurable diagnostics can be set for each channel

5.7.4 Safety-related communication via fail-safe modules

The figure below provides an overview of the possibilities of safety-related communication via PROFINET IO in SIMATIC Safety fail-safe systems with S7-1500 F-CPUs.



1. Safety-related IO controller - IO controller communication
2. Safety-related IO controller - I-device communication
3. Safety-related IO controller-I-device communication (via IE/PB link to PROFIBUS)

Figure 1-473 Example of safety-related communication

5.8 Technology functions

5.8.1 Motion control

You use the integrated Motion Control functionality of SIMATIC S7-1500 for positioning and moving axes. Depending on the CPU, the SIMATIC S7-1500 automation system supports different configuration limits for motion control technology objects.

With Motion Control instructions according to PLCopen, you control PROFIdrive-capable drives and drives with analog setpoint interface.

Drives with a stepper motor interface are connected using telegram 3 and with the help of PTO (Pulse Train Output) pulse generators. Use the following modules to control the stepper motors:

- TM PTO 2x24V / TM PTO 4
- SIMATIC MICRO-Drive F-TM StepDrive

SIMATIC S7-1500T CPUs

The Technology CPUs extend the Motion Control functions available in all SIMATIC S7-1500 controllers for demanding solutions to include gearing and camming and kinematics.

The S7-1500 T-CPUs are also suitable for safety applications, so that you only need one CPU for standard, safety and comprehensive Motion Control automation tasks.

Motion control technology objects

The table below shows the technology objects that are supported by the SIMATIC S7-1500 and S7-1500T. * They occupy Motion Control resources or Extended Motion Control resources in the CPU.

Technology objects	SIMATIC S7-1500	SIMATIC S7-1500T	Resource requirements per technology object
Speed-controlled axis	X	X	40
Positioning axis	X	X	80
Synchronous axis	X	X	160
External encoder	X	X	80
Measuring input	X	X	40
Output cam	X	X	20
Cam track	X	X	160
Cam of type "TO_Cam"	---	X	2*
Cam of type "TO_Cam_10k"	---	X	20*
Cam of the type "TO_Cam_600Seg"	---	X	2*
Cam of the type "TO_Cam_6kSeg"	---	X	20*
Kinematics	---	X	30*
Interpreter	---	X	60*
Interpreter program	---	X	0
Interpreter mapping	---	X	0
Leading axis proxy	---	X	3*

* They occupy Extended Motion Control resources in the CPU.

Motion control technology functions

The table below shows the technology functions offered by both SIMATIC S7-1500 and S7-1500T and the extended Motion Control functions of the technology CPUs.

Technology functions	SIMATIC S7-1500	SIMATIC S7-1500T
Enable, disable technology objects	X	X
Acknowledge alarms, restart technology object	X	X
Reference technology objects, set reference point	X	X
Pause axis	X	X
Position axis absolutely	X	X
Position axis relatively	X	X
Move axis at set velocity/speed	X	X
Move axis via a time-based position profile	---	X

Technology functions	SIMATIC S7-1500	SIMATIC S7-1500T
Move axis in jog mode	X	X
Positioning axis overlapping	X	X
Pause superimposed motions on the axis	X	X
Set alternative encoder as operationally active encoder	---	X
Hold and disable axis	X	X
Controlling bits of control word 1 and 2	X	X
Write parameter	X	X
Save absolute encoder adjustment for device replacement	X	X
Start one-time measuring	X	X
Start cyclic measuring	X	X
Abort active measuring	X	X
Activate/deactivate output cam	X	X
Activate/deactivate cam track	X	X
Start gearing	X	X
Start gearing with specified synchronous positions	---	X
Start velocity synchronous operation	---	X
Absolute shift of master value on the following axis	---	X
Relative shift of master value on the following axis	---	X
Relative shift of following value on the following axis	---	X
Absolute shift of following value on the following axis	---	X
Start camming	---	X
Simulate synchronous operation	---	X
Desynchronize gearing	---	x
Desynchronize camming	---	x
Specify additive master value	---	X
Interpolate cam	---	X
Read master value of a cam	---	X
Read out slave value of a cam	---	X
Cyclically read out following value of a cam	---	X
Copy calculated cam elements	---	X
Specify motion setpoints	---	X
Specify superimposed motion setpoints	---	X
Activate and deactivate force/torque limiting / fixed stop detection	X	X
Specify additive torque	X	X
Specify upper and lower torque limits	X	X
Interrupt motion control of kinematics	---	X
Continue motion control of kinematics	---	X
Stop motion of kinematics	---	X
Position kinematics with linear motion	---	X
Position kinematics relatively with linear motion	---	X
Position kinematics with circular motion	---	X
Position kinematics relatively with circular motion	---	X
Move kinematics with synchronous "point-to-point" motion, absolute	---	X
Move kinematics with synchronous "point-to-point" motion, relative	---	X

Technology functions	SIMATIC S7-1500	SIMATIC S7-1500T
Start conveyor tracking	---	X
Set kinematics to simulation mode	---	X
Define workspace zone	---	X
Define kinematics zone	---	X
Activate workspace zone	---	X
Deactivate workspace zone	---	X
Activate kinematics zone	---	X
Deactivate kinematics zone	---	X
Re-define tool	---	X
Change active tool	---	X
Redefine object coordinates system	---	X
Transform axis coordinates into cartesian coordinates	---	X
Transforming Cartesian coordinates into axis coordinates	---	X
Load/unload the Interpreter program	---	X
Start execution of the Interpreter program	---	X
Stop execution of the Interpreter program	---	X

Motion Control configuration example

The SINAMICS Startdrive engineering tool is available in the TIA Portal for easy commissioning and optimization of SINAMICS drives. SINAMICS Startdrive enables efficient commissioning by means of the integrated axis control panel and extensive diagnostic functions.

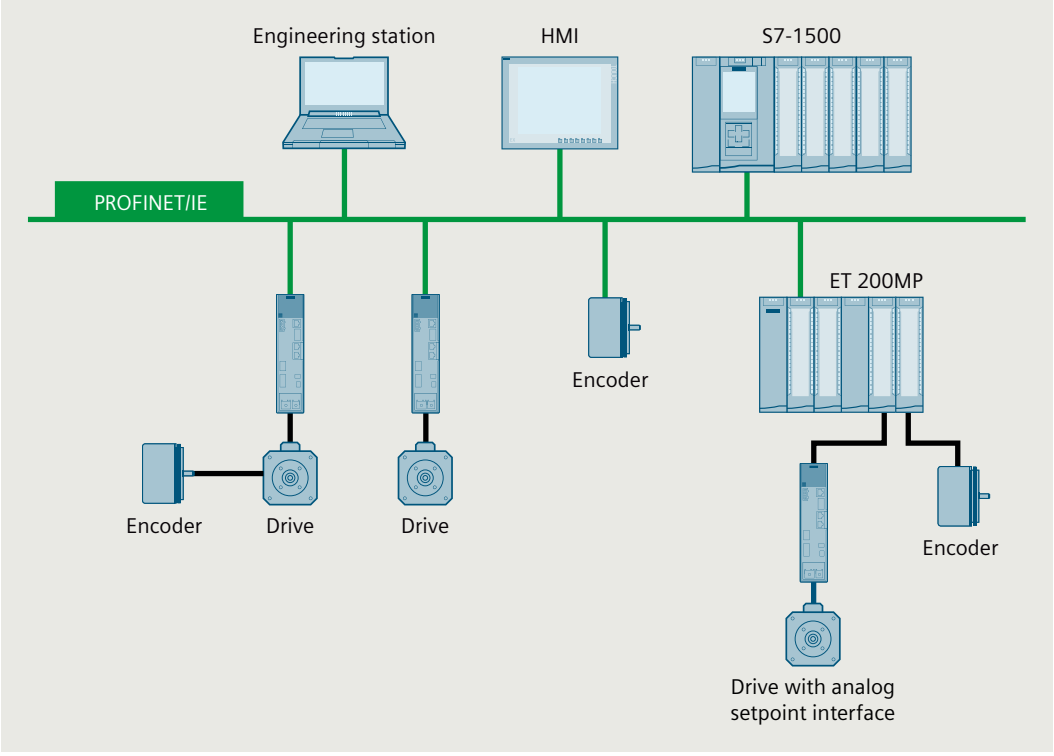


Figure 1-474 Example of a Motion Control configuration

Example: Quick and flexible packaging of luxury goods thanks to the CPU SIMATIC S7-1500T

Automation task:

Development of a modular, automatic packaging machine with a speed of up to 50 packages per minute.

Feature:

The packaging machine enables the outer packaging of individual products as well as containers at medium to high speeds (more than 40 products per minute). The possibility of quick changeover to new products is a condition. Scalability and cost efficiency is paramount in the automation solution.

Solution:

A SIMATIC S7-1500 TIME-CPU controls several axes in parallel with its technology functions gearing and camming.

The SINAMICS V90 drive communicates with the CPU via PROFINET IO with IRT. You assign parameters to the technology functions via technology objects with STEP 7.

Advantages

Motion Control with SIMATIC S7-1500T CPUs provide you with the following advantages:

- Rugged and stable motion control platform with easy extensibility to include additional axes
- Automatic alignment of the technological variables between controller and drive by means of technology objects; reduced engineering, commissioning and service times
- Simple setup and commissioning of the technology functions in the TIA Portal, no specialist knowledge required
- Inclusion in the integrated system diagnostics and trace function, thus reducing maintenance times and downtimes
- Numerous options for using synchronized axes in gearing with specification of the synchronous position, in camming and in velocity synchronous operation
- Configuration limits can be expanded through cross-PLC synchronous operation
- Graphical and tabular configuration and optimization and diagnostics of cams with integrated cam editor saves time and reduces the error rate
- Adaptation and calculation of the cam disks in the user program during operation, e.g. for quick product changeover
- Control of kinematics for handling tasks such as pick-and-place, assembly and palletizing

S7-1500 Motion Control KinPlus

The "S7-1500T Motion Control KinPlus" software extends the S7-1500T kinematics functions. The "S7-1500T Motion Control KinPlus" software enables control of kinematics with 5 or 6 interpolating axes.

More information

More information can be found in the function manuals S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109751049)

5.8.2 PID Control

PID controllers are integrated as standard in all S7-1500 CPUs. PID controllers measure the actual value of a physical variable, for example, temperature or pressure, and compare the actual value with the setpoint. Based on the resulting system deviation, the controller calculates a manipulated variable that causes the actual value to reach the setpoint as quickly and stably as possible.

You can choose from three different PID technology objects:

PID technology object	Description
PID_Compact	The PID_Compact technology object provides a PID controller with integrated tuning for actuators with proportional action behavior. Different operating modes are possible with PID_Compact, such as: • Pretuning • Fine tuning • Automatic mode • Manual mode
PID_3Step	The PID_3Step technology object provides a PID controller with tuning for valves or actuators with integrating behavior. You can configure the following controllers: • Three-point stepping controller with position feedback • Three-point stepping controller without position feedback • Valve controller with analog output value
PID_Temp	The PID_Temp technology object provides a continuous PID controller with integrated tuning. PID_Temp is specially designed for closed-loop temperature control and is suitable for heating, cooling or heating/cooling applications. Two outputs are available, one for heating and one for cooling. You can also use PID_Temp for other control tasks. PID_Temp can be cascaded. You can use PID_Temp in manual or automatic mode.

Example: PID Control optimizes the drying process

Automation task: Development of a temperature control for drying panes of glass in the production of mirrors**.**

Feature: The drying process is a critical phase in silvering mirrors. It is decisive for optimum product quality. During the silvering process, the glass panes are treated with chemical solutions and then dried in a pre-heated oven. Temperature control plays a key role in the drying process.

Solution: A PID controller controls the temperature in the drying oven. The filament of each infrared lamp in the oven is controlled separately and remotely. Control was previously only possible manually.

Benefits

The integrated controller PID Control of the SIMATIC S7-1500 CPUs offer you the following advantages:

- High-quality end product due to optimum control performance
- High flexibility in the drying oven
- Time savings thanks to automatic control parameter optimization for optimum control performance and simple commissioning

More information

A detailed description of PID Control in SIMATIC S7-1500 can be found in the Function Manual "SIMATIC S7-1200, S7-1500 PID Control" SIMATIC S7-1200, S7-1500 PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036).

5.8.3 Technology functions of the compact CPUs

Technology functions are integrated into the SIMATIC S7-1500 compact CPUs.

Function	Value	Description
Six high-speed counters	Up to 100 kHz	For pulse and incremental encoders
Frequency measurement	0.04 Hz - 400 kHz	
Period duration measurement	2.5 µs - 25 s	
Velocity measurement		Dependent on measurement interval and signal evaluation Unit can be defined by user
Pulse width modulation (PWM output)	Max. 4 (up to 100 kHz)	Output of a signal with defined period duration and variable on-load factor at DQ
Pulse Train Output (PTO output)	Max. 4 (up to 100 kHz)	Output of position information, e. g. for activation of stepper motor drives or simulation of an incremental encoder
Frequency output	Up to 100 kHz	Precise assignment of a frequency value with high frequencies

Benefits

Compared with the other SIMATIC S7-1500 CPUs, the compact CPUs offer added value in a small space:

- The CPU with display and inputs/outputs in one enclosure
- Compact size with high performance
- Important technology functions such as counting, measuring and positioning are integrated
- Cost effective compared to modular systems with CPU and modules
- Space saving design
- Can be expanded by SIMATIC S7-1500 input and output modules

5.8.4 Technology modules for counting, measuring and position detection

For technological tasks, powerful technology modules are available that perform these tasks largely autonomously and reduce the load on the CPU. Use the technology objects "Counting and measuring" or "Motion Control" for easy configuration and operation of the operating modes.

The table below shows the available technology modules for counting, measuring and position detection.

Short designation	**TM Count 2x24V**	**TM PosInput 2**
Article number	6ES7550-1AA01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-50-1AA01-0AB0)	6ES7551-1AB01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES75-51-1AB01-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109783960)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109813005)
Connectable encoders	Incremental encoder for signals, 24 V asymmetrical, Pulse encoders with/without direction signal, Pulse encoders up/down	Incremental encoders for signals according to RS422 (5 V differential signal) or 5 V asymmetrical, Pulse encoders with/without direction signal, Pulse encoders up/down, Absolute encoders (SSI)
Max. count frequency	200 kHz 800 kHz with four-fold pulse	1 MHz 4 MHz with four-fold pulse
Integrated DI	3 DIs per counter channel for • Start • Stop • Capture • Synchronization	2 DIs per counter channel for • Start • Stop • Capture • Synchronization
Integrated DQ	2 DQs for comparators and limit values	2 DQs for comparators and limit values
Counting functions	• 32 bits up/down • Adjustable counting range • Comparator • Incremental position detection for motion control	• 32 bits up/down • Adjustable counting range • Comparator • Incremental and absolute position detection for motion control
Measuring functions	Frequency Period duration Velocity	Frequency Period duration Velocity
Diagnostic interrupt	X	X
Hardware interrupt	X	X
Isochronous mode	X	X

Benefits

Technology modules for counting, measuring and position detection offer you the following advantages:

- Fast and timely detection of events with fine resolution for high productivity and product quality
- Hardware-level signal processing for rapid counting, measurement and position detection for a variety of transducers
- Simple setup and commissioning of the technology functions in STEP 7
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system
- Quick response thanks to different hardware interrupts

5.8.5 Technology module for time-based IO

Time-based IO modules enable you to achieve maximum precision and speed - regardless of the performance of the controller and the fieldbus. The time-based IO modules output signals with a precisely defined response time. The I/O signals are processed on a time basis.

The table below shows the most important features of the technology modules for time-based IO. In conjunction with the "Cam" and "Cam track" technology objects, the TM Timer DIDQ modules ensure highly accurate cam output. In conjunction with the "Measuring input" technology object, the TM Timer DIDQ module ensure highly accurate detection of passing products.

Short designation	**TM Timer DIDQ 24x24V**
Article number	6ES7552-1AA01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7552-1AA01-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109974309)
Connectable encoders	24 V incremental encoder with signals A and B 24 V pulse encoder with a signal
Max. count frequency	200 kHz with fourfold evaluation
Integrated DI	8 DI with the following functions: • Up to 2 time stamps per cycle (resolution 1 µs) • 32x oversampling • Counting function up to 50 kHz • Incremental encoder acquisition with 2 phase-shifted tracks • Configurable input filter to suppress interference
Integrated DQ	16 DQs with the following functions: • Up to 2 time stamps per cycle (resolution 1 µs) • 32x oversampling • Pulse-width modulated output • Configurable substitute values per DQ
Diagnostic interrupt	X
Hardware interrupt	---
Isochronous mode	X (required for the time stamp and oversampling functions)

Benefits

The technology modules for time-based IO offers you the following advantages:

- Meets stringent requirements for precision and speed, independent of the CPU and fieldbus
- Signals are read in and output precisely, to within 1 microsecond
- Exact definition of response times, independent of the application cycle
- Typical use: cam control, length measurement, time measurement, as a probe, for dosing fluid quantities

5.8.6 Technology module TM PTO 4

You can use the TM PTO 4 technology module to connect up to four stepper motor axes to an S7-1500 system. The module is connected to the technology objects "speed axis", "positioning axis" or "synchronous axis" via a conversion of the PROFIdrive telegram 3 and forms the interface to the drive. The number of steps output is returned as position actual value.

The table below shows the main features of the technology module TM PTO 4.

Short designation	**TM PTO 4**
Article number	6ES7553-1AA01-0AB0 (https://mall.industry.siemens.com/mall/en/ww/Catalog/Product?mlfb=6ES7553-1AA01-0AB0&SiepCountryCode=de)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109974308)
Number of axes	4
Available signals per axis	2x RS422 2x DQ (24 V DC) 2x DI (24 V DC) 1x DIQ (24 V DC)
Parameterizable functions	PTO (Pulse Train Output) signal interface: • 24 V asymmetric • RS 422 symmetrical • TTL (5 V) asymmetrical PTO (Pulse Train Output) signal type: • Pulse and direction • Count up/down • Incremental encoder Digital inputs/outputs: • Drive enable • Reference switch • Measuring input • Drive ready
Diagnostic interrupt	X
Hardware interrupt	---
Isochronous mode	X

Advantages

- Direct control of the axes via pulse signals.
- High-frequency pulse signals for precise positioning and fast motion of the connected axes.
- Precise and dynamic axis control through isochronous processing.

5.8.7 Technology module TM FAST

The TM FAST technology module provides you the opportunity to control particularly fast processes with short response times in the micro- and nanosecond range. You can define the hardware functionality of the module through application-specific programming. Supplementary software components and related information can be found in the following Internet entry (https://support.industry.siemens.com/cs/ww/en/view/109817062).

The table below shows the main features of the technology module TM FAST.

Short designation	TM FAST
Article number	6ES7554-1AA00-0AB0 (https://mall.industry.siemens.com/mall/en/ww/Catalog/Product?mlfb=6ES7554--1AA00-0AB0&SiepCountryCode=de)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109816087)
Available signals	8x RS485 (can also be used as 5 V asymmetrical) 8x DI (24 V DC) 8x DQ (24 V DC) 4x DIQ (24 V DC)
Diagnostic interrupt	X
Hardware interrupt	---
Isochronous mode	X

Advantages

Application-specific programming of the FPGA (Field-Programmable Gate Array) in the module, e.g. for the following applications:

- Individual communication protocols
- Individual cam functions
- Controlling laser mirrors
- Precise evaluation of incremental encoders with very high frequencies
- Precise measurement of pulse durations in the micro- and nanosecond range
- Short response times in the micro- and nanosecond range

5.8.8 Technology module for weighing technology

The technology modules SIWAREX WP521 and SIWAREX WP522 are used for the acquisition and processing of signals from weighing or force transducers. You can connect one scale (WP521) or two separate scales (WP522) respectively to the modules. The SIWAREX modules offer high accuracy.

The table below shows the main features of the technology modules for weighing technology.

Short designation	**TM electronic weighing system SIWAREX WP 521 ST**	**TM electronic weighing system SIWAREX WP 522 ST**
Article number	7MH4980-1AA01 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/7MH4-980-1AA01)	7MH4980-2AA01 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/7MH4-980-2AA01)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109742780)	
Weighing channel	1 channel	2 channels
Interfaces	RS 485 with Modbus RTU or for connecting the remote display (per channel) Ethernet interface with SIWATOOL protocol and Modbus TCP/IP (1 for both channels)	
Integrated digital inputs	DI 3x24VDC	
Integrated digital outputs	DQ 4x24VDC	
Load cell connection	DMS load cells in 6- or 4-wire technology (per channel), 1 to 4 mV/V	
Functions	• Adjust the scale with weights or automatically • 3 limits • Tare • Set to zero • Trace • Commission with SIWATOOL (service tool for PC)	
Diagnostic interrupt	---	
Hardware interrupt	X (configurable)	

Benefits

The weighing modules SIWAREX for SIMATIC S7-1500 offer you the following advantages:

- Seamless integration of simple weighing applications such as platform and hopper scales in SIMATIC S7-1500
- Use for level monitoring, e.g. silos and bunkers
- Can be used centrally in SIMATIC S7-1500 and in ET 200MP distributed I/O system
- SIWAREX WP521 ST for the setup of one scale
- SIWAREX WP522 ST for the setup of two separate scales, with the same space requirements as WP521 ST
- Free sample application on the Internet for the quick implementation of customer or industry-specific solutions

5.8.9 Technology Module TM NPU

Technology Module TM NPU

Applications based on artificial intelligence can be implemented using the TM NPU technology module. The technology module TM NPU is used in the S7-1500 automation system / ET 200MP distributed I/O system.

The integrated AI processor (AI - Artificial Intelligence) enables the processing of large amounts of data from connected sensors, as well as data from the user program of the CPU. Connect the sensor technology via the integrated USB interface of the TM NPU, e.g.: Cameras or microphones. For TM NPU with V1.0.0, use the USB camera from Intel, type RealSense D435.

The supplied data is processed at high speed in the TM NPU over neural networks. The TM NPU transmits the processing result via the backplane bus to the CP. The CPU then evaluates the data in the user program.

Typical areas of application:

- Visual quality check in production plants
- Pick-and-place applications
- Image-guided robotic systems

Table 1-809 Technology Module TM NPU

Short designation	**TM NPU**
Article number	6ES7556-1AA00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7556-1AA00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/109765877)
Interfaces	Ethernet (1 port) USB 3.1 (1 Port) SD card slot
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	No
Diagnostic functions	Yes
Product function	
Artificial intelligence / Processing of neural networks	Yes

Benefits:

- Design of flexible and precise production processes
- Reduction of time required for configuration, programming and commissioning

5.8.10 Technology module TM MFP

Technology module TM MFP

The TM MFP (technology module multifunctional platform) is a module for IT applications that are not included in the control tasks of the CPU. The technology module processes, for example, the data of connected cameras or robot systems and the data from the user program of the CPU.

The Linux-based operating system SIMATIC Industrial OS (IndOS) has been pre-installed on the TM MFP. The Graphics Processing Unit (GPU) of the built-in processor is able to run and accelerate AI routines. This enables fast and efficient processing of large amounts of data and optimization of processes.

The technology module supports Docker software (not pre-installed by default) for loading software and algorithms, for example, into the TM MFP in the form of bins.

Typical areas of application:

- Edge computing for SIMATIC controllers
- Data processing of connected sensors, e.g. cameras
- Execution and acceleration of AI routines

Table 1-810 Technology module TM MFP

Short designation	**TM MFP**
Article number	6ES7558-1AA00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7558-1AA00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/us/en/view/109820481)
Interfaces	2x Ethernet (1 port each) 2x USB 3.0 DisplayPort
Interrupts/diagnostics/status information	
Status display	No
Interrupts	No
Diagnostic functions	No
Product function	
Execution of IT applications	Yes

Advantages

- Supports applications in high-level languages, e.g. C, C++ or Python
- Fast and efficient processing of large amounts of data

5.9 Power supply

The power supply of an automation system to be dimensioned according to plant size. The SIMATIC S7-1500 CPUs are supplied via a load power supply or a system power supply. A system power supply that supplies the backplane bus is integrated in the CPUs. Depending on the system configuration, you can expand the integrated system power supply with up to two additional system power supply modules. If your plant has high power requirements, e.g. I/O load groups, you can connect additional load power supplies.

The table below shows the main differences between the two power supplies for the SIMATIC S7-1500 automation system:

Power supply	Description
Load current supply (PM)	Supplies 24 V DC to the S7-1500 system components such as CPU, system power supply (PS), input/output circuits of the I/O modules and any sensors and actuators. You can install the load power supply directly to the left of the CPU (without connection to the backplane bus). If you supply the voltage for the backplane bus via a system power supply, then the supply of the CPU or the interface module with DC 24 V is optional.
System power supply (PS)	Supplies only internally required system voltage. Supplies parts of the module electronics and the LEDs. Additionally the PS 60W 24/48/60V DC HF keeps the complete work memory of the CPU retentive.

Configuration example of a system with load power supply and system power supply

The following figure shows a system configuration with load power supply and additional system power supply.

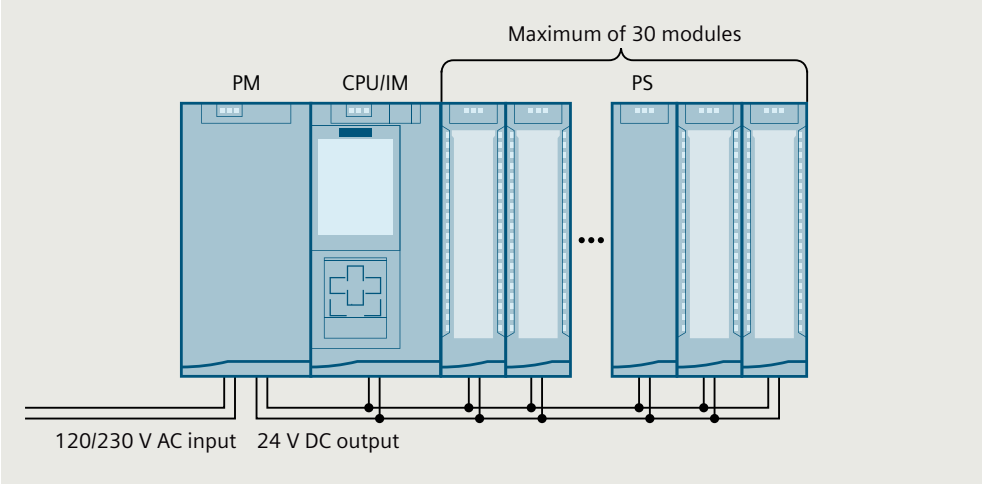


Figure 1-475 Overall configuration of power supply

In order to ensure the supply of the modules from the backplane bus, the incoming power is compared with the required power in the TIA Portal engineering system or in the TIA Selection Tool.

As early as in the planning stages, make sure that the power fed into the backplane bus is always greater than or equivalent to the power drawn.

System power supply modules

System power supplies supply the internal electronics of the S7-1500 modules with power via the backplane bus. The table below shows the available system power supply modules:

Short designation	PS 25 W 24 V DC	PS 60 W 24/48/60 V DC	PS 60 W 24/48/60 V DC HF	PS 60 W 120/230 V AC/DC
Article number	6ES7505-0KA01-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7505-0KA00-0AB0)	6ES7505-0RA00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7505-0RA00-0AB0)	6ES7505-0RB00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7505-0RB00-0AB0)	6ES7507-0RA00-0AB0 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6ES7507-0RA00-0AB0)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193552)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59192919)	↓ (https://support.industry.siemens.com/cs/ww/en/view/109746400)	↓ (https://support.industry.siemens.com/cs/ww/en/view/59193004)
Rated input voltage	24 V DC	24 VDC, 48 VDC, 60 VDC	24 VDC, 48 VDC, 60 VDC	120 V AC, 230 V AC 120 V DC, 230 V DC
Output power	25 W	60 W	60 W	60 W
Electrical isolation from the backplane bus	X	X	X	X
Diagnostic interrupt	X	X	X	X
Energy buffering for data backup in the CPU	---	---	Up to 20 MB retentive	---

Load power supply modules

The load power supply modules with automatic range selection of the input voltage are optimally adapted in design and functionality to the SIMATIC S7-1500 controller. The table below shows the available load power supply modules:

Short designation	PM 70 W 120/230 V AC	PM 190 W 120/230 V AC
Article number	6EP1332-4BA00 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6EP1332-4BA00)	6EP1333-4BA00 (https://mall.industry.siemens.com/mall/en/WW/Catalog/Product/6EP1333-4BA00)
Equipment Manual	↓ (https://support.industry.siemens.com/cs/ww/en/view/68036174)	↓ (https://support.industry.siemens.com/cs/ww/en/view/68022506)
Rated input voltage	120/230 V AC, with automatic switchover	120/230 V AC with automatic switchover
Output voltage	24 V DC	24 V DC
Rated output current	3 A	8 A
Power consumption	84 W	213 W

Using a SITOP power supply as an alternative to a load power supply

Alternatively, an external 24 V power supply from the SITOP range (https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10008864) (SITOP smart or SITOP modular) can be used:

- For higher output currents and 1-phase or 3-phase infeed
- With redundant installation (https://support.industry.siemens.com/cs/ww/de/view/109768676/en) of the 24 V power supply as protection against failure of a power supply unit
- With buffering of the 24 V power supply (e.g. with DC UPS) as protection against power failure
- With selective monitoring of 24 V loads as protection against overload or short-circuit

5.10 Connection elements and system cabling

Front connector and shield contact

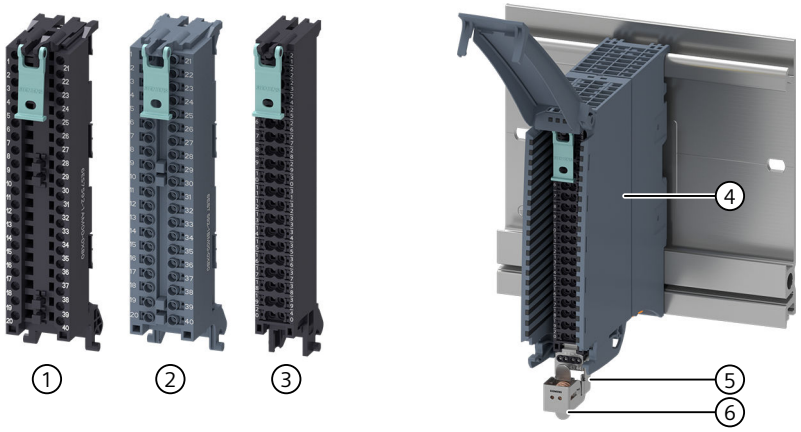
The front connectors are used to wire the I/O modules. For modules with EMC-critical signals, such as analog modules and technology modules, the front connectors also need a shield contact.

The front connectors are available for 35 mm modules optionally with screw terminals and push-in terminals and for 25 mm modules with push-in terminals. The front connectors for 25 mm modules are included in the scope of delivery of the I/O modules.

24 V DC is supplied, for example, via a plug-in infeed element for analog modules.

The shield contact consists of shield bracket and shield terminal. Together with the shield terminal, the shield bracket allows the low-impedance, module-level connection of cable shields with minimum installation times. The shielding takes place without tools.

The components (infeed element, shielding bracket and shield clamp) are included in the scope of delivery of the modules.



1. Front connector 35 mm with screw terminals
2. Front connector 35 mm with push-in terminals
3. Front connector 25 mm with push-in terminals
4. Front connector
5. Shield bracket
6. Shield clamp

Figure 1-476 Versions of the front connector with and without shield

U connector

The individual modules are connected to one another with the U connector. The U connector establishes the mechanical and electrical connection between the modules. The U connectors are included in the scope of delivery of the I/O modules.

System cabling SIMATIC TOP connect



Figure 1-477 Example: System cabling with SIMATIC TOP connect

For 35 mm modules, the system cabling SIMATIC TOP connect with prefabricated connection elements is available in two versions:

- Fully modular connection consisting of front connector module, connection cables and connection modules for connecting sensors and actuators from the field
- Flexible connection, consisting of front connector with single cores for wiring within the cabinet

You can find more information in the SIMATIC TOP connect for S7-1500 and ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/95924607) manual.

5.11 Software

5.11.1 TIA Portal

The SIMATIC controllers are integrated into the Totally Integrated Automation Portal. Engineering with TIA Portal offers:

- Configuration and programming
- Shared data management
- A uniform operating concept for control, visualization and drives

The TIA Portal simplifies the integrated engineering in all configuration phases of a plant.

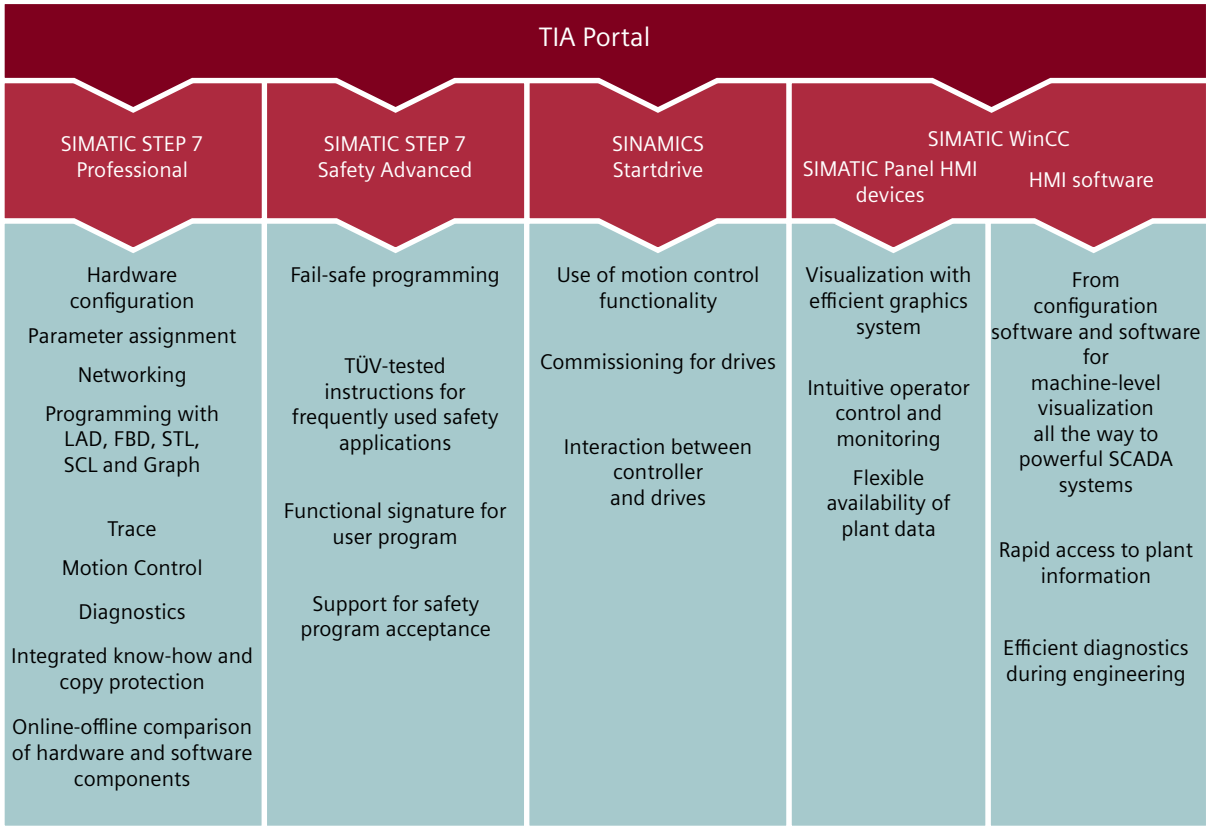


Figure 1-478 TIA Portal overview

5.11.2 TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/tia/tia-selection-tool.html).

5.11.3 SIMATIC Automation Tool

You use the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of the TIA Portal. The SIMATIC Automation Tool provides you with a multitude of functions:

- Network browsing and creation of a table showing the accessible devices in the network.
- Flashing of device LEDs or HMI display to locate a device
- Downloading of addresses (IP, subnet, gateway) to a device
- Downloading the PROFINET name (station name) to a device
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your PG/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- Performing a CPU memory reset
- Resetting devices to factory settings
- Downloading a firmware update to a device
- Documentation and backup of the configuration in
  - Standard .csv text file
  - Encrypted and password-protected .sat file
- Advanced functions:
  - Up to 10 concurrent connections
  - Scheduler for scheduling device operations at a time and frequency of your choosing
  - Ability to insert multiple devices in a single operation
  - Support for devices behind a NAT router
  - Archiving of SAT projects and related file data
  - Card browser for working with files and folders on SIMATIC Memory Cards in your CPUs

These functions can be executed as bulk operation, that is, simultaneously on various S7 stations and other devices.

The SIMATIC Automation Tool additionally has a Software Development Kit (SDK) version. With the SIMATIC Automation Tool SDK (Software Development Kit), you can create applications based on the SIMATIC Automation Tool API (Application Programming Interface). To deal with a large number of device automation tasks efficiently, these user-specific applications can be distributed to third parties including the API software. You do not need any license keys to use the user-specific applications.

5.11.4 SINETPLAN

SINETPLAN (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html), the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. Thus, you prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through import and simulation of existing STEP7 projects
- Efficiency through securing existing investment in the long term and optimal exploitation of resources

5.11.5 PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

SIEMENS PRONETA (https://support.industry.siemens.com/cs/ww/en/view/67460624) is available for free on the Internet.

5.11.6 SIMATIC S7 app

With the SIMATIC S7 app (https://www.siemens.com/global/en/products/software/mobile-apps/simatic2go.html), you can establish a secure connection via WLAN to SIMATIC S7-1500 and ET 200SP with, for example, the following functions:

- Detect up to 50 networked CPUs via HTTPS and establish a connection
- Change CPU operating mode (RUN/STOP)
- Read out CPU diagnostics information and send via e-mail
- Monitor and modify variables and tags
- High security through encrypted communication and encrypted profile data; password to start app and establish the connection

Application planning

6

6.1 Hardware configuration

Introduction

The S7-1500 automation system/ET 200MP distributed I/O system consists of a single-row configuration in which all modules are installed on one mounting rail. The modules are connected by means of U connectors, and thus form a self-assembling backplane bus.

You can configure the S7-1500 automation system/ET 200MP distributed I/O system with fail-safe and non-fail-safe modules.

6.1.1 Hardware configuration of the S7-1500 automation system

Maximum configuration

- The integrated system power supply of the CPU supplies 10 W or 12 W (depending on CPU type) to the backplane bus. The power budget calculation determines the exact number of modules (without optional PS) that can be operated with the CPU. The operating principle is described in section Power balance calculation (Page 167).
- A maximum of three system power supplies (PS) is possible. one system power supply (PS) can be inserted to the left of the CPU and two system power supplies (PS) can be inserted to the right of the CPU.
- If you use a system power supply (PS) left next to the CPU, a maximum configuration of 32 modules is possible. The modules occupy slots 0 to 31. If further system power supplies (PS) are required to the right of the CPU, they also occupy a slot.

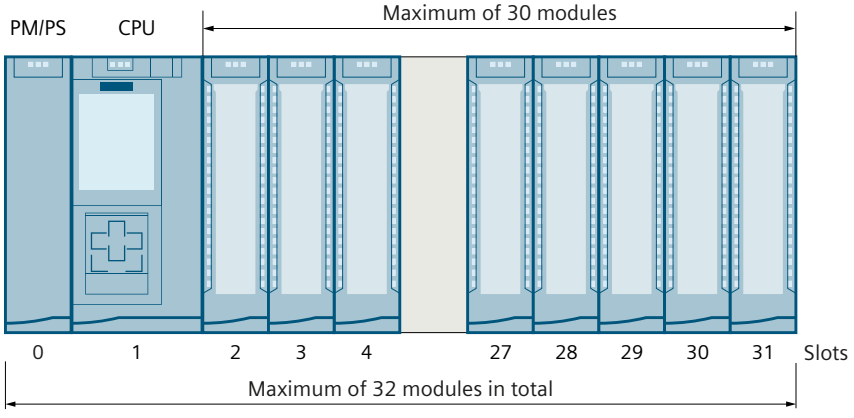


Figure 1-479 S7-1500 maximum configuration

Applicable modules

The following table shows which modules may be used in the various slots:

Table 1-811 Assignment of slot numbers

Module type		Permissible slots	Maximum number of modules
Load current supply (PM)*		0**	Unlimited / only 1 PM can be configured in STEP 7
System power supply (PS)		0; 2 - 31	3
PS 60W 24/48/60VDC HF system power supply		0	1***
CPU		1	1
Analog and digital I/O modules		2 - 31	30
Communication modules			
• Point-to-point		2 - 31	30
• PROFINET/Ethernet, PROFIBUS			
	When using a CPU 1511-1(F) PN, CPU 1511C-1 PN, CPU 1511T(F)-1 PN	2 - 31	4
	When using a CPU 1512C-1 PN	2 - 31	6
	When using a CPU 1513(F)-1 PN	2 - 31	6
	When using a CPU 1515(F)-2 PN, CPU 1515T(F)-2 PN	2 - 31	6
	When using a CPU 1516(F)-3 PN/DP, CPU 1516T(F)-3 PN/DP, CPU 1516T(F)-3 PN	2 - 31	8
	When using a CPU 1517(F)-3 PN/DP, CPU 1517(F)-3 PN, CPU 1517T(F)-3 PN/DP, CPU 1517T(F)-3 PN	2 - 31	8
	When using a CPU 1518(F)-4 PN/DP, CPU 1518T(F)-4 PN/DP, CPU 1518(F)-4 PN/DP MFP, CPU 1518(F)-3 PN, CPU 1518T(F)-3 PN	2 - 31	8
Technology modules		2 - 31	30

* No connection to the backplane bus.

** When slot 0 is occupied by a load current supply (PM) in STEP 7, this slot can no longer be used for a system power supply (PS) in STEP 7. You do not have to configure a load current supply (PM) in STEP 7.

When you occupy slot "0" with the system power supply (PS), you can plug in a load current supply (PM) in the TIA Portal to the left of the PS in slot 100.

***The PS 60W 24/48/60VDC HF must only be inserted to the left of the CPU. Use a different system power supply (PS) for other power segments in the configuration to the right of the CPU.

6.1.2 Hardware configuration of the ET 200MP distributed I/O system with PROFINET interface module

Maximum configuration

- The integrated system power supply of the interface module feeds 14 W into the backplane bus. The power budget calculation determines the exact number of I/O modules that can be operated with the interface module (without optional PS). The operating principle is described in section Power balance calculation (Page 167).
- You use the integrated power supply for the IM 155-5 PN BA interface module. No 'additional system power supplies (PS) must be used. You can insert a maximum of 12 modules to the right of an interface module.

- The interface modules IM 155-5 MF HF and IM 155-5 PN HF also support the configuration with an active backplane bus. You can find information on the active backplane bus (e.g. installing, configuring, technical specifications) in the Active backplane bus (https://support.industry.siemens.com/cs/us/en/view/109778694) Equipment Manual.
- The following applies to the interface modules IM 155-5 PN ST and IM 155-5 PN HF: A maximum of three system power supplies (PS) is possible. You can insert one system power supply (PS) to the left of the interface module and two system power supplies (PS) to the right of the interface module.
  If you insert a system power supply (PS) to the left of the interface module, this yields a possible maximum configuration of a total of 32 modules (up to 30 modules to the right of the interface module). If further system power supplies (PS) are required to the right of the interface module, they also occupy a slot.

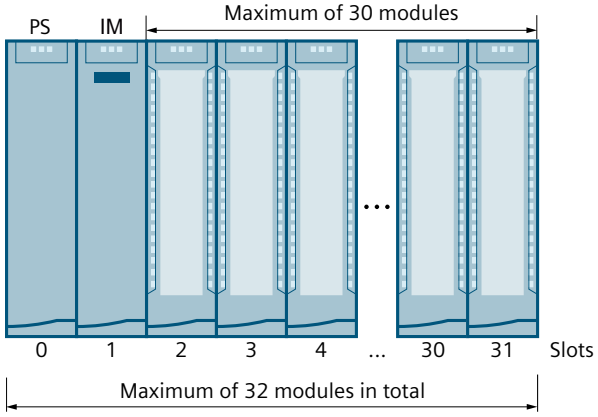


Figure 1-480 Maximum configuration ET 200MP with IM 155-5 PN ST or IM 155-5 PN HF

Applicable modules

The following table shows which modules may be used in the various slots:

Table 1-812 Assignment of slot numbers

Module type	Permissible slots IM 155-5 PN BA	Permissible slots IM 155-5 PN ST, IM 155-5 PN HF	Maximum number of modules
Load current supply (PM)*	-	0**	Unlimited / only 1 PM can be configured in STEP 7
System power supply (PS)	-	0; 2 - 31	3
PS 60W 24/48/60VDC HF system power supply	-	0	1***
Interface module	1	1	1
Analog and digital I/O modules	2 - 13	2 - 31	12 or 30
Communication modules			
• Point-to-point	2 - 13	2 - 31	12 or 30
Technology modules	2 - 13	2 - 31	12 or 30

* No connection to the backplane bus.

** When slot 0 is occupied by a load current supply (PM) in STEP 7, this slot can no longer be used for a system power supply (PS) in STEP 7. You do not have to configure a load current supply (PM) in STEP 7.

***The PS 60W 24/48/60VDC HF must only be inserted to the left of the interface module. Use a different system power supply (PS) for other power segments in the configuration to the right of the interface module.

6.1.3 Hardware configuration of the ET 200MP distributed I/O system with PROFIBUS interface module

Maximum configuration

The integrated system power supply of the interface module feeds 14 W into the backplane bus. You can insert a maximum of 12 modules to the right of an interface module. The power budget calculation determines the exact number of I/O modules that can be operated with the interface module. The operating principle is described in section Power balance calculation (Page 167).

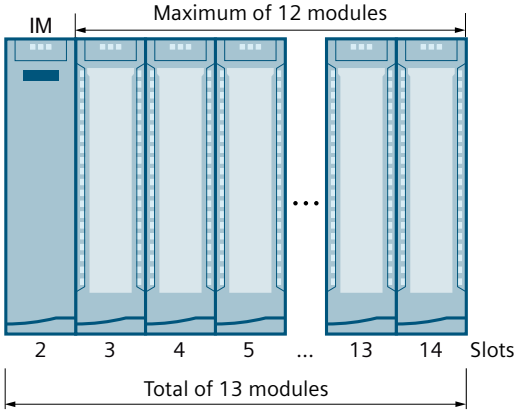


Figure 1-481 Maximum configuration ET 200MP with IM 155-5 DP

Applicable modules

The following table shows which modules may be used in the various slots:

Table 1-813 Assignment of slot numbers

Module type	Permissible slots	Maximum number of modules
Interface module	2	1
Analog and digital I/O modules	3 - 14	12
Communications modules		
Point-to-point	3 - 14	12
Technology modules	3 - 14	12

6.2 System and load power supply

Types of power supplies

The S7-1500 automation system/ET 200MP distributed I/O system distinguishes between two types of power supply:

- System power supply (PS)
- Load current supply (PM)

System power supply (PS)

The system power supply has a connection to the backplane bus (U connector) and supplies solely the internally required system voltage. This system voltage supplies parts of the module electronics and the LEDs. A system power supply can also supply CPUs or interface modules if these are not connected to a 24 VDC load current supply.

Load current supply (PM)

The load current supply feeds the input/output circuits of the modules, as well as the sensors and actuators of the plant, if installed. If you supply the voltage for the backplane bus via a system power supply, then the supply of the CPU/interface module with 24 V DC is optional.

Special characteristic of the load current supply

Load current supplies are mounted on the "S7-1500 mounting rail" and do not have a connection to the backplane bus.

Total configuration with power supplies

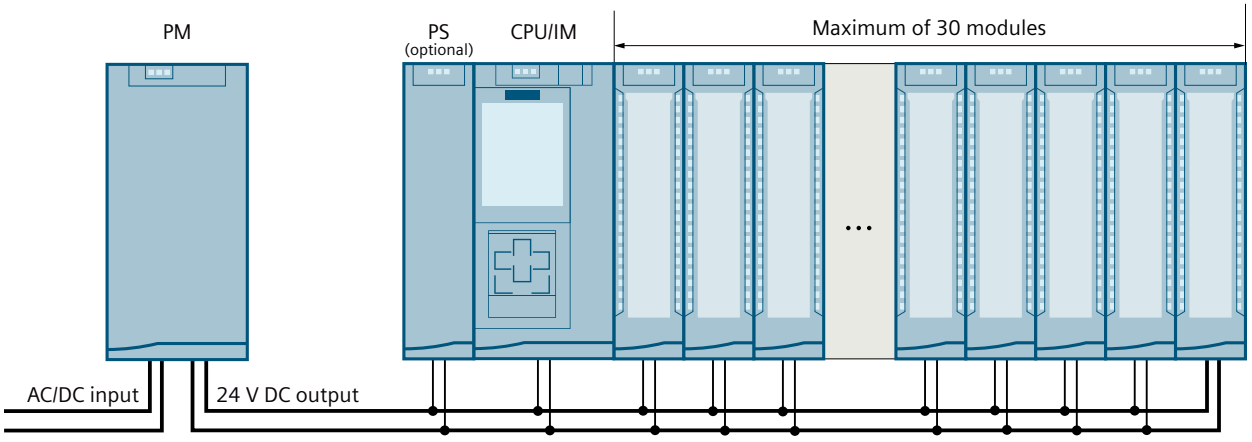


Figure 1-482 Total configuration with load current supply (PM) and system power supply (PS)

Optionally, you can insert up to two system power supplies (PS) in the slots to the right of the CPU/interface module.

The number of load current supplies is unlimited.

Observe the installation rules and specified installation distances in the manuals of the load current supplies.

System power supplies

- PS 25W 24VDC: Supply voltage with 24 V DC and infeed power to the backplane bus of 25 W
- PS 60W 24/48/60VDC: Supply voltage with 24/48/60 V DC and infeed power to the backplane bus of 60 W

- PS 60W 24/48/60VDC HF:
  - Supply voltage with 24/48/60 V DC and infeed power to the backplane bus of 60 W
  - Extended retentive memory for CPUs as of FW V2.1.0 (see section Special requirements when using a system power supply PS 60W 24/48/60VDC HF (Page 164)).
- PS 60W 120/230V AC/DC: Supply voltage with 120/230 V AC and infeed power to the backplane bus of 60 W

Load current supplies

The load current supplies listed below have been technically adapted especially to the S7-1500 automation system/ET 200MP distributed I/O system. Use of the listed load current supplies is not imperative because you can use a SITOP module, for example, as an alternative.

- PM 70W 120/230VAC: Supply voltage with 120/230 V AC
- PM 190W 120/230VAC: Supply voltage with 120/230 V AC

Also note the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/96998532) in connection with load current supply units.

6.2.1 Use of system power supplies

Introduction

You can use system power supplies with the CPUs and the interface modules IM 155-5 PN ST and IM 155-5 PN HF.

If the power fed from the CPU/interface module into the backplane bus is not sufficient to supply all connected modules with power, system power supplies (PS) are required.

Whether or not you need a system power supply depends on the power consumption of the modules used. The power supplied by the CPU/interface module and the system power supplies must be greater than the power required by the I/O modules.

During configuration, STEP 7 compares the supplied power and the power required by the modules. If the required power is too high, you receive a corresponding message from STEP 7.

In addition, the system power supply PS 60W 24/48/60V DC HF buffers the power in the event of power failures and therefore enables the retentivity of the data of a CPU – without a battery and therefore maintenance-free.

Slots for system power supplies

The following slots may be used for system power supplies:

- A system power supply in slot 0 to the left of the CPU/interface module
- Up to 2 system power supplies in the slots to the right of the CPU/interface module (power segments) A power segment consists of a power supply module and the modules supplied by it.

NOTE

The system power supply PS 60W 24/48/60V DC HF can only be inserted in slot 0.

Power segment

The following applies for the CPUs and interface modules M 155-5 PN ST and IM 155-5 PN HF: If you are using system power supplies to the right of the CPU/interface module, divide the configuration into power segments.

Configuration variant with power segments

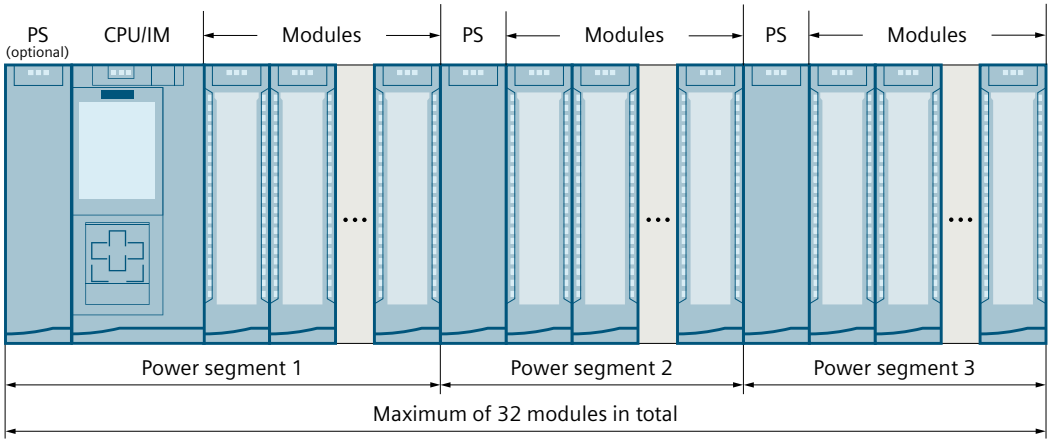


Figure 1-483 Configuration variants with 3 power segments

NOTE

When you configure with STEP 7, STEP 7 automatically checks configuration for consistency and tells you from which module you must open a new power segment.

Overload in the power segment

If an overload occurs in a power segment, the red SF LED flashes on the system power supply (PS). All I/O modules to the right of the PS in the power segment will be switched off.

Remedy:

1. Correct the configuration in the power segment of the overloaded PS.
2. Switch the supply voltage power off and on again via the on-off switch on the PS.
3. Switch the CPU from STOP to RUN mode.

Reference

Information about the required power is available in the section Power balance calculation (Page 167).

Additional information on the performance values (power feed, power consumption) of the CPU, interface module, system power supply, and I/O modules can be found in the manuals (https://support.automation.siemens.com/WW/view/en/57251228) of the respective modules.

6.2.2 Special considerations for the use of a system power supply in the first power segment

Infeed options

There are three options for the infeed of the required system voltage in the backplane bus:

- Infeed via CPU/interface module
- Infeed via CPU/interface module and system power supply
- Infeed only via system power supply in slot 0

Infeed via CPU/interface module

Infeed via the CPU/interface module generally suffices for small and medium hardware configurations. The power consumption of the connected modules must not exceed the power supplied by the CPU/interface module.

In this configuration variant, supply the CPU/interface module with 24 V DC from a load current supply.

Procedure

To set up the supply by means of the CPU/interface module, follow these steps:

1. Open the "Properties" tab of the CPU/interface module in STEP 7 and select the "System power supply" in the navigation.
2. Select the option "Connection to supply voltage L+".

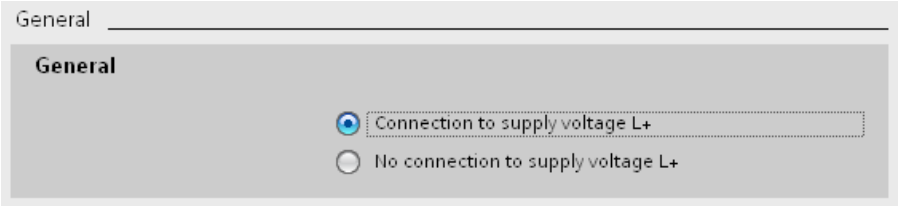


Figure 1-484 Supply voltage via CPU/interface module only

Infeed via CPU/interface module and system power supply

For larger hardware configurations, infeed into the backplane bus by the CPU/interface module alone no longer suffices. If the modules consume more power in total than the power supplied by the CPU/interface module, you must insert an additional system power supply.

Supply the system power supply with the permissible supply voltage and the CPU/interface module with 24 V DC.

Both the system power supply and the CPU/interface module feed current into the backplane bus. The supplied power is summed.

Power addition: "Infeed power of the system power supply" + "Infeed power of the CPU/interface module"

Procedure

To set up the supply by means of the CPU/interface module and system power supply, follow these steps:

1. Open the "Properties" tab of the CPU/interface module in STEP 7 and select the "System power supply" in the navigation.
2. Select the option "Connection to supply voltage L+".

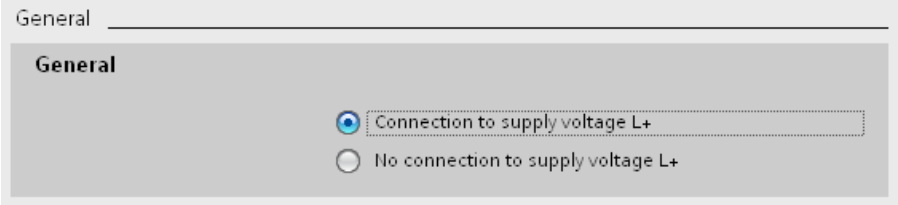


Figure 1-485 Supply voltage via the CPU/interface module and system power supply

Infeed via system power supply only

As a further possibility you can supply the required power to the backplane bus using only a system power supply (in slot 0). In this case, the CPU/interface module is not supplied with 24 V DC, and draws its supply from the backplane bus. The system power supply must be inserted to the left of the CPU/interface module for this.

In general, you can use system power supplies with AC or DC infeed for the configuration.

If no supply voltage with 24 V DC is present (and e.g. only CMs/CPs are inserted next to the CPU), you can use a system power supply with 230 V AC because the CMs/CPs are supplied via the backplane bus.

Procedure

To set up infeed only via the system power supply, follow these steps:

1. Open the "Properties" tab of the CPU/interface module in STEP 7 and select the "System power supply" in the navigation.
2. Select the option "No connection to supply voltage L+".

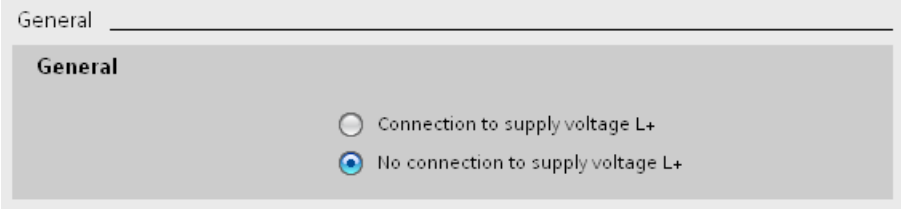


Figure 1-486 No infeed into the backplane bus by means of the CPU/interface module

6.2.3 Special requirements when using the power supply PS 60W 24/48/60VDC HF

S7-1500 - Extended retentive memory for CPUs as of FW V2.1.0

When you use the PS 60W 24/48/60VDC HF system power supply, the entire data area can be used as retentive memory for CPUs as of firmware version V2.1.0 and higher.

The PS 60W 24/48/60VDC HF supplies enough energy in case of a POWER OFF that the CPU can save the entire data area retentively.

Requirements

- STEP 7 V14 SP1 or higher
- PS 60W 24/48/60VDC HF system power supply
- CPU with firmware version as of V2.1.0, see table below

Applicable CPUs

The size of the retentive memory depends on the size of the work memory for data of the CPU used. The table below shows the applicable CPUs with the required hardware function versions.

CPU with firmware version V2.1.0 or higher	Hardware function version	Article number	Max. retentive memory
CPU 1511-1 PN	FS01 or higher	6ES7511-1AK01-0AB0 6ES7511-1AK02-0AB0	1 MB
		6ES7511-1AL03-0AB0	1.5 MB
CPU 1511F-1 PN	FS01 or higher	6ES7511-1FK01-0AB0 6ES7511-1FK02-0AB0	1 MB
		6ES7511-1FL03-0AB0	1.5 MB
CPU 1511T-1 PN	FS01 or higher	6ES7511-1TK01-0AB0	1 MB
		6ES7511-1TL03-0AB0	1.5 MB
CPU 1511TF-1 PN	FS01 or higher	6ES7511-1UK01-0AB0	1 MB
		6ES7511-1UL03-0AB0	1.5 MB
CPU 1511C-1 PN	FS01 or higher	6ES7511-1CK00-0AB0 6ES7511-1CK01-0AB0	1 MB
		6ES7511-1CL03-0AB0	1.5 MB

CPU with firmware version V2.1.0 or higher	Hardware function version	Article number	Max. retentive memory
CPU 1512C-1 PN	FS01 or higher	6ES7512-1CK00-0AB0 6ES7512-1CK01-0AB0	1 MB
		6ES7512-1CM03-0AB0	2 MB
CPU 1513-1 PN	FS01 or higher	6ES7513-1AL01-0AB0 6ES7513-1AL02-0AB0	1.5 MB
		6ES7513-1AM03-0AB0	2.5 MB
CPU 1513F-1 PN	FS01 or higher	6ES7513-1FL01-0AB0 6ES7513-1FL02-0AB0	1.5 MB
		6ES7513-1FM03-0AB0	2.5 MB
CPU 1515-2 PN	FS01 or higher	6ES7515-2AM01-0AB0 6ES7515-2AM02-0AB0	3 MB
		6ES7515-2AN03-0AB0	4.5 MB
CPU 1515F-2 PN	FS01 or higher	6ES7515-2FM01-0AB0 6ES7515-2FM02-0AB0	3 MB
		6ES7515-2FN03-0AB0	4.5 MB
CPU 1515T-2 PN	FS01 or higher	6ES7515-2TM01-0AB0	3 MB
		6ES7515-2TN03-0AB0	4.5 MB
CPU 1515TF-2 PN	FS01 or higher	6ES7515-2UM01-0AB0	3 MB
		6ES7515-2UN03-0AB0	4.5 MB
CPU 1516-3 PN/DP	FS01 or higher	6ES7516-3AN01-0AB0 6ES7516-3AN02-0AB0	5 MB
		6ES7516-3AP03-0AB0	7.5 MB
CPU 1516F-3 PN/DP	FS01 or higher	6ES7516-3FN01-0AB0 6ES7516-3FN02-0AB0	5 MB
		6ES7516-3AP03-0AB0	7.5 MB
CPU 1516T-3 PN	FS01 or higher	6ES7516-3TP10-0AB0	15 MB
CPU 1516T-3 PN/DP	FS01 or higher	6ES7516-3TN00-0AB0	5 MB
CPU 1516TF-3 PN	FS01 or higher	6ES7516-3UP10-0AB0	15 MB
CPU 1516TF-3 PN/DP	FS01 or higher	6ES7516-3UN00-0AB0	5 MB
CPU 1517-3 PN	FS01 or higher	6ES7517-3AQ10-0AB0	50 MB
CPU 1517-3 PN/DP	FS03 or higher	6ES7517-3AP00-0AB0	8 MB
CPU 1517F-3 PN	FS01 or higher	6ES7517-3FQ10-0AB0	50 MB
CPU 1517F-3 PN/DP	FS03 or higher FS01 or higher	6ES7517-3FP00-0AB0 6ES7517-3FP01-0AB0	8 MB
CPU 1517T-3 PN	FS01 or higher	6ES7517-3TQ10-0AB0	50 MB
CPU 1517T-3 PN/DP	FS01 or higher	6ES7517-3TP00-0AB0	8 MB
CPU 1517TF-3 PN	FS01 or higher	6ES7517-3UQ10-0AB0	50 MB
CPU 1517TF-3 PN/DP	FS01 or higher	6ES7517-3UP00-0AB0	8 MB
CPU 1518-3 PN	FS01 or higher	6ES7518-3AT10-0AB0	100 MB
CPU 1518F-3 PN	FS01 or higher	6ES7518-3FT10-0AB0	100 MB
CPU 1518T-3 PN	FS01 or higher	6ES7518-3TT10-0AB0	100 MB
CPU 1518TF-3 PN	FS01 or higher	6ES7 518-3UT10-0AB0	100 MB
CPU 1518-4 PN/DP	FS03 or higher	6ES7518-4AP00-0AB0	20 MB
CPU 1518F-4 PN/DP	FS03 or higher	6ES7518-4FP00-0AB0	20 MB
CPU 1518T-4 PN/DP	FS01 or higher	6ES7518-4TP00-0AB0	20 MB

CPU with firmware version V2.1.0 or higher	Hardware function version	Article number	Max. retentive memory
CPU 1518TF-4 PN/DP	FS01 or higher	6ES7518-4UP00-0AB0	20 MB
CPU 1518-4 PN/DP MFP	FS01 or higher	6ES7518-4AX00-1AB0	20 MB
CPU 1518F-4 PN/DP MFP	FS01 or higher	6ES7518-4FX00-1AB0	20 MB

Connection, structure and configuration of an S7-1500 with PS 60W 24/48/60VDC HF

- You must insert the system power supply PS 60W 24/48/60VDC HF in slot 0.



Figure 1-487 Slot PS 60W 24/48/60VDC HF

- If you are using the PS 60W 24/48/60VDC HF, the 24 V supply of the CPU is not taken into account in the power budget calculation.

NOTE
You may only connect the 24 V DC supply voltage directly to the system power supply and not to the CPU.

You must set the "System power supply" parameter to the option "No connection to supply voltage L+" during configuration of the CPU. STEP 7 checks the setting when compiling the configuration.

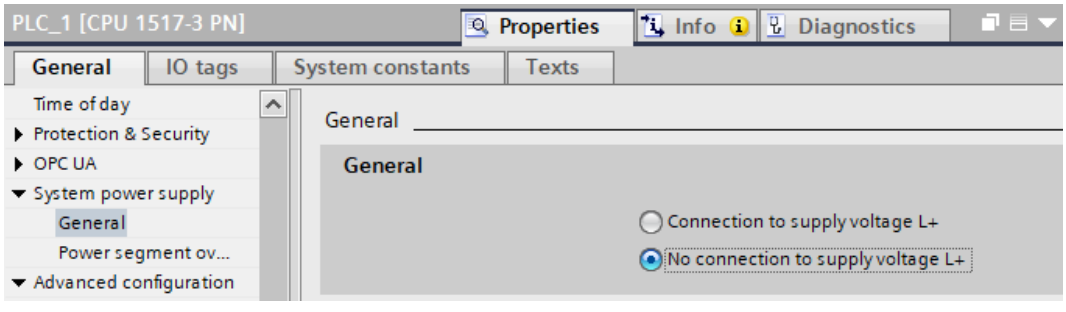


Figure 1-488 Connecting PS 60W 24/48/60VDC HF

- The parameter "Startup > Comparison preset to actual module" must be set to the value "Startup CPU only if compatible" during configuration of the PS 60W 24/48/60VDC HF. Reason: The retentivity of the entire CPU work memory (data) is only guaranteed when the PS 60W 24/48/60VDC HF is inserted.

  When you insert the PS 60W 24/48/60VDC HF, STEP 7 automatically sets the parameter.

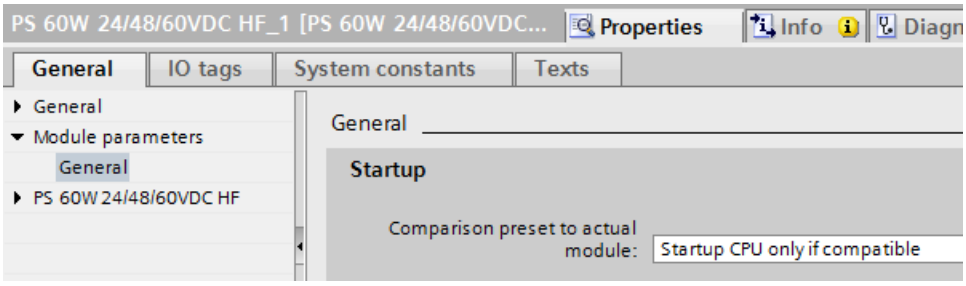


Figure 1-489 Startup of PS 60W 24/48/60VDC HF

NOTE

Other power segments in the configuration

The PS 60W 24/48/60VDC HF must only be inserted to the left of the CPU / interface module. Use a different system power supply (PS) for other power segments in the configuration to the right of the CPU / interface module.

Missing diagnostics for the PS 60W 24/48/60VDC HF

In case of POWER OFF, saving the extended retentive data is most important. The CPU as of FW V2.1.0 and higher does **no longer** output the following diagnostics of the PS 60W 24/48/60VDC HF:

- Supply voltage fault
- Switch position Off

6.3 Power balance calculation

Principle of power balance calculation

In order to ensure the supply of the modules from the backplane bus, the power balance calculation compares the infed power with the required power for the modules. The supplied power of all system power supplies including the CPU/interface module must be greater than or equal to the power taken from the modules.

In order to operate the configuration with its used modules, the power balance must be positive for each power segment in use.

This means that the power fed into the power segment is greater than the power consumed by the modules.

Take care even during planning, that the power fed into the backplane bus is always greater than or equal to the power drawn. The TIA Selection Tool (https://new.siemens.com/global/en/products/automation/topic-areas/tia/tia-selection-tool.html) aids you during planning.

The power fed into the backplane bus by the CPU/interface module and system power supply is listed in the technical specifications of the CPU/interface module in the corresponding manuals.

The power consumed from the backplane bus by an I/O module or the CPU/interface module can be found in the technical specifications in the corresponding manuals.

The power balance calculation is performed:

- When configuring with STEP 7
- During operation by the CPU

Power balance calculation when configuring with STEP 7

STEP 7 checks compliance with the power balance during the configuration.

Proceed as follows to evaluate the power balance calculation:

1. Perform the configuration of the S7-1500/ET 200MP with all the required modules.
2. In the network view, select the CPU/interface module or the system power supply.
3. Open the "Properties" tab in the inspector window.
4. Select the "System power supply" entry in the area navigation.
5. Check the "Power segment overview" table, so see whether the power balance is positive. If the power balance is negative, STEP 7 marks the underpowered modules in red.

Power segment overview

	Module	Slot	Power consumption
	PS 25W 24VDC_1	0	25.00W
	PLC_1	1	12.00W
	DI 32x24VDC HF_1	2	-1.10W
	DQ 8x230VAC/5A ST_1	3	-0.80W
	AI 8xU/I/RTD/TC ST_1	4	-0.70W
	AQ 4xU/I ST_1	5	-0.60W
		Summary	33.80W

Figure 1-490 Example of a power balance calculation with STEP 7

Power balance calculation check for overload by the CPU/interface module

The CPU / the interface module monitors compliance with a positive power balance:

- At every POWER ON
- At every change of the installed hardware

Causes for overload

An overload can still occur despite a positive power balance during planning. The cause for overload can be a hardware configuration that does not correspond to the configuration in STEP 7, for example:

- More I/O modules inserted in the actual configuration than in the STEP 7 project.
- A supply voltage L+ (24 V DC) that is necessary for operation is not connected when system voltage infeed via the CPU/interface module is specified during parameter assignment (see section Special considerations for the use of a system power supply in the first power segment (Page 162)).
- A system power supply that is necessary for operation is not inserted.
- A system power supply that is necessary for operation is not switched on (power connection plug or on/off switch).
- A system power supply that is necessary for operation has no U connector inserted.

Response of the CPU to negative power balance or failure of system power supplies

As soon as the CPU detects a negative power balance/overload, the following actions are executed:

- The CPU stores the retentive data.
- The CPU enters the event in the diagnostics buffer.
- The CPU carries out a restart and repeats this until the cause of the negative power balance is resolved.

Response of the interface module to negative power balance or failure of system power supplies

As a result of the overload, the interface module switches off all power segments. The I/O controller or DP master can no longer access the I/O modules. The interface module provides diagnostic information and periodically checks the connection to the backplane bus and re-establishes the connection.

Exception: In the case of a voltage drop or a hardware fault in power segment 2 or 3, the corresponding system power supply module switches off its power segment (and possibly the following segments), and generates a diagnostic alarm, if possible.

More information on the behavior of the system power supply (PS) in the event of a fault can be found in the manuals for the system power supplies.

6.4 Use of load power supplies

Introduction

The load current supply (PM) supplies the system power (PS), central modules (CPU), interface module and input and output circuits of the I/O modules with DC 24 V.

Load current supplies can be mounted on the mounting rail but do not have a connection to the backplane bus.

Observe the installation rules and specified installation distances in the manuals of the load current supplies.

Use of multiple load current supplies

Several load current supplies (PM) can be used as follows for higher output currents:

Every load current supply feeds independent 24 V DC load lines.

Alternatively you can use an external 24 V power supply, e.g. from the SITOP line.

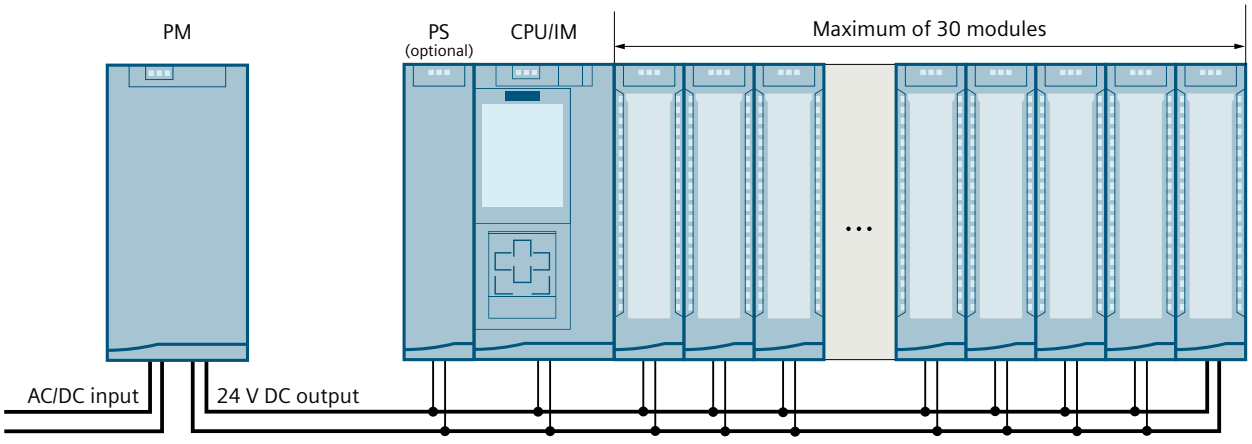


Figure 1-491 Supply of the modules from 24 V DC load current suppl

NOTE

Alternative 24 V supply of the modules from the control cabinet

If safe electrical separation (SELV/PELV according to IEC 61131-2 and IEC 61010-2-201) is guaranteed, you can alternatively supply the modules with 24 V DC from the control cabinet.

Reference

More information on load current supplies can be found on the Internet (https://mall.industry.siemens.com) in the online catalog and in the online ordering system.

Installation 7

7.1 Basics

Introduction

All modules of the S7-1500 automation system/ET 200MP distributed I/O system are open equipment. This means that you may only install this system in housings, cabinets or electrical operating rooms that are located indoors. The housings, cabinets and electrical operating rooms must guarantee protection against electric shock and spread of fire. The requirements for mechanical strength must also be met. The housings, cabinets, and electrical operating rooms must not be accessible without a key or tool. Personnel with access must have been trained or authorized.

Installation position

The S7-1500 automation system / ET 200MP distributed I/O system is designed for the following mounting positions:

- Horizontal mounting position for ambient temperatures up to 60 °C
- Vertical mounting position (CPU is down) for ambient temperatures up to 40 °C

More information can be found in chapter Mechanical and climatic ambient conditions (Page 395).

Mounting rail

You can mount the following components on the mounting rails alongside the S7-1500/ET 200MP modules:

- Modules from the S7-1200 and ET 200SP range
- Terminals
- Circuit breakers
- Small contactors
- Similar components

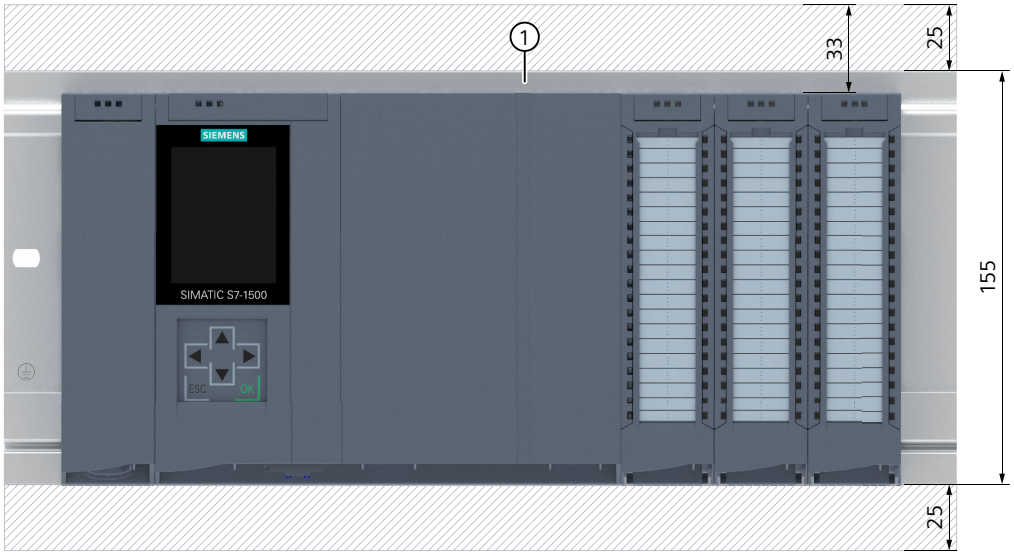
These components can influence the installation dimensions for the cable duct.

Modules can be mounted right to the outer edge of the mounting rail.

The mounting rails are available in various lengths. You order the mounting rails using the online catalog or the online ordering system. You can find the available lengths and article numbers in the section Accessories/spare parts (Page 406).

Minimum clearances

The modules can be mounted to the outer edge of the mounting rail. Maintain the following minimum clearances at the top and bottom when installing or removing the S7-1500 automation system / ET 200MP distributed I/O system:



① Upper edge of the mounting rail

Figure 1-492 Minimum clearances in the control cabinet

Installation rules

- The installation starts on the left with a CPU/interface module or a system power supply/load current supply.
- You connect the modules to each other with U connectors.
- Note that no U connector protrudes from the first and last module.

NOTE

Only remove and insert modules when the power to the system is switched off.

⚠ WARNING

Protection from conductive contamination

Protect the devices against conductive contamination. At the same time, note the ambient conditions.

Protection from conductive contamination can, for example, be achieved by installing the devices in a control cabinet with the appropriate degree of protection.

7.2 Installing the mounting rail

Lengths and drill holes

The mounting rails are delivered in six lengths:

- 160 mm
- 245 mm
- 482.6 mm (19 inches)
- 530 mm
- 830 mm
- 2 000 mm

You can find the article numbers in the appendix Accessories/spare parts (Page 406).

The mounting rails (from 160 to 830 mm) come with two drill holes for fixing screws. A set of screws for grounding the mounting rail is provided.

The 2 000 mm mounting rail is designed for assemblies with special lengths and does not have holes for fixing screws. No set of screws for grounding is enclosed with the mounting rail (can be ordered as Accessories/spare parts (Page 406)).

The specifications of the maximum offsets between two drill holes can be found in the table, "Dimensions for the drill holes".

Tools required

- Commercially available hacksaw
- Drill ∅ 6.5 mm
- Screwdriver
- Size 10 adjustable screw-wrench or socket wrench for grounding cable connection
- Adjustable screw-wrench, matching the selected fixing screws
- Stripping tool and crimp tool for the grounding cable

Required accessories

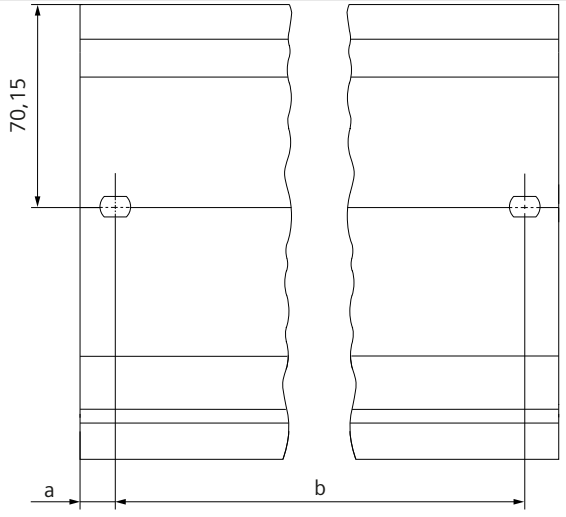
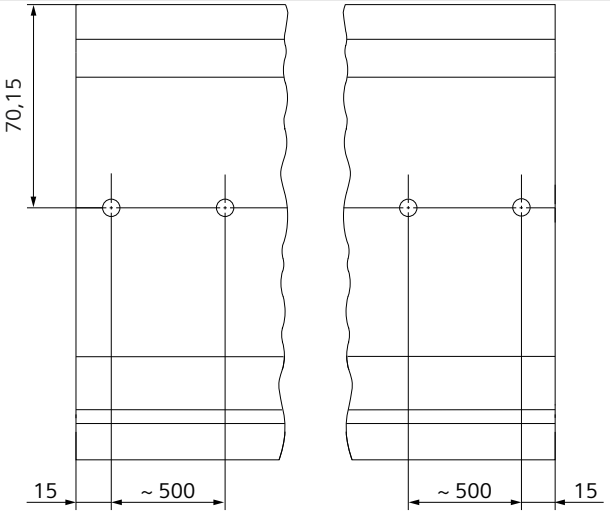
Use the following screw types for fastening the mounting rails:

Table 1-814 Required accessories

For ...	you can use ...	Explanation
• Outer fixing screws • Additional fixing screws (for mounting rails > 482.6 mm)	M6 socket cap screw	Choose a suitable screw length for your assembly. You also need washers for cylinder head screws with an internal diameter of 6.4 mm and an external diameter of 11 mm.
	M6 hex screw	

Dimensions for the drill holes

Table 1-815 Dimensions for the drill holes

"Standard" mounting rails	"Longer" mounting rails
	

Length of the mounting rail	Distance a	Distance b
160 mm	10 mm	140 mm
245 mm	10 mm	225 mm
482.6 mm	8.3 mm	466 mm
530 mm	15 mm	500 mm
830 mm	15 mm	800 mm

Additional fixing screws (for mounting rails > 530 mm)

For mounting rails longer than 530 mm, we recommend using additional fixing screws at intervals of >482 mm on the identification groove.

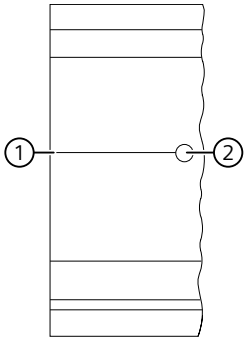
Preparing the 2 000 mm mounting rail for installation

To prepare the 2 000 mm mounting rail for installation, proceed as follows:

1. Cut the 2 000 mm mounting rail to the required length.
2. Mark the holes. The necessary dimensions can be found in the table "Dimensions for the drill holes":
   - Two drill holes at the beginning and end of the mounting rail
   - Additional drill holes at equal intervals of 500 mm maximum, along the identification groove
3. Drill the marked holes according to the selected type of fastening.
4. Ensure that there are no burrs or shavings on the mounting rail.

NOTE

To ensure secure installation of the modules, make sure you position the drill holes centered on the identification groove and only use screws of the maximum size.



① Identification groove for additional drill holes
② Additional drill hole

Figure 1-493 Preparing the 2 000 mm mounting rail for installation

Installing the mounting rail

Place the mounting rail such that sufficient space remains for installation of and heat dissipation from the modules. Note the figure Minimum clearances in the control cabinet.

Screw the rail onto the mounting surface.

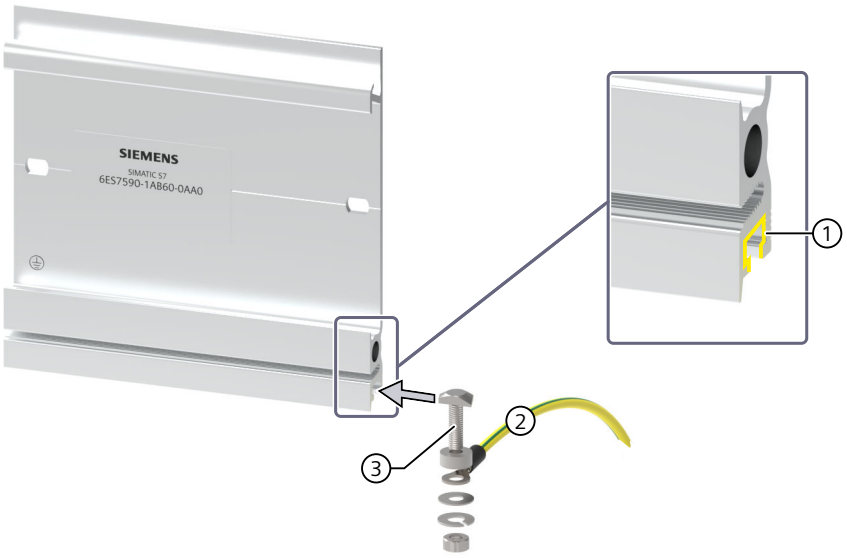
Attaching the protective conductor

The S7-1500 automation system/ ET 200MP distributed I/O system has to be connected to the protective conductor system of the electrical system to ensure electrical safety.

Proceed as follows to connect the protective conductor:

1. Strip the ground conductor with a minimum diameter of 10 mm^2. Attach a ring cable lug for M6 bolts with the crimping pliers.
2. Slide the enclosed bolt into the T profile groove.
3. Insert the spacer, ring terminal with the grounding connector, flat washer, and lock washer onto the bolt (in that order). Thread on the hexagon nut. Fasten the components in place with the nut (tightening torque 4 Nm).

4. Connect the opposite end of the grounding cable to the central grounding point/protective conductor busbar (PE).



① T-profile groove
② Protective conductor (PE)
③ PE connection element for mounting rail

Figure 1-494 Attaching the protective conductor (protective earth)

NOTE

Alternative grounding of the mounting rail

Grounding with the grounding screw is not required if the following requirements are met: The mounting rails must be permanently connected to the protective circuit using an equivalent fitting that complies with the applicable standards, for example by permanent attachment to a grounded control cabinet wall.

Note

You can find more information on the exact dimensions of the mounting rails in the appendix Dimension drawings of the mounting rails (Page 399).

7.3 Installing the standard rail adapter

Introduction

The DIN rail adapter allows you to mount the SIMATIC S7-1500/ET 200MP automation system on the standard 35 mm mounting rails.

You order the DIN rail adapter as separate accessories.

NOTE

Note the following reduced technical specifications regarding mechanical load when you install the S7-1500/ET 200MP modules on the 35 mm DIN rail using the DIN rail adapter:

Vibration test acc. to IEC 60068-2-6 (sinusoidal)

- 5 Hz ≤ f ≤ 8.4 Hz, constant amplitude **3.5 mm**
- 8.4 Hz ≤ f ≤ 150 Hz, constant acceleration **1 g**

Duration of vibration: 10 frequency sweeps per axis in each of three perpendicular axes

Shock, tested according to IEC 60068-2-27

- Type of shock: Half-sine
- Shock intensity: **150 m/s**^{2} peak value, **11 ms** duration
- Direction of shock: **3** shocks each in (+/-) direction, along each of the 3 mutually perpendicular axes

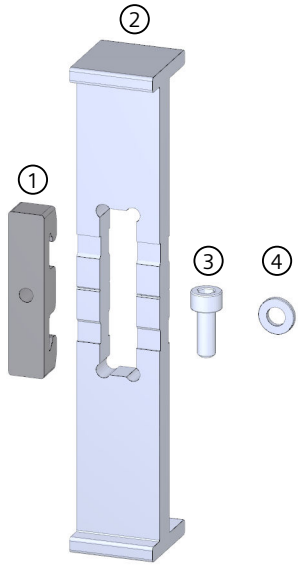
Article number

6ES7590-6AA00-0AA0

The scope of delivery consists of ten adapters, ten hexagon socket-head screws and ten washers.

View

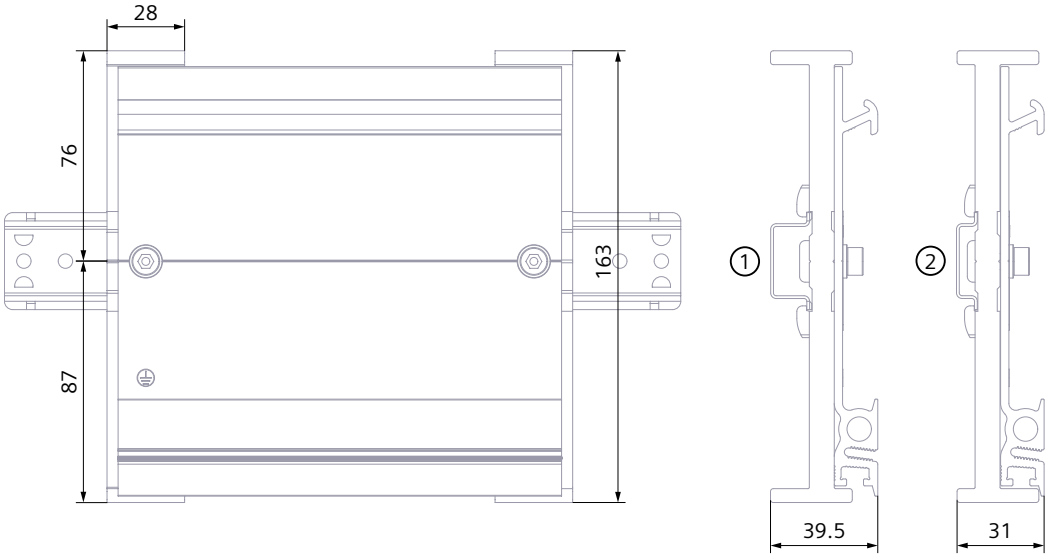
The DIN rail adapter consists of a clamp, an adapter frame and a hexagon socket-head screw with washer.



① Clamp
② Adapter frame
③ Hexagon socket-head screw
④ Washer

Figure 1-495 Parts of the DIN rail adapter

Dimensional drawing



① Position of the adapter frame during mounting to the standard DIN rail 35 mm x 7.5 mm
② Position of the adapter frame during mounting to the standard DIN rail 35 mm x 15 mm

Figure 1-496 Dimensional drawing

Tools required

Wrench matching the hexagon socket head cap screw M6 according to EN ISO 4762 (DIN 912).

Properties

- The DIN rail adapter makes it possible to mount the S7-1500/ET 200MP mounting rail on standard 35 mm DIN rails.
- The DIN rail adapter allows the use of prefabricated control cabinet and terminal box systems.
- The total length of the S7-1500/ET 200MP mounting rail can be used again completely as before.
- To ensure optimal stability, the clearance between the two DIN rail adapters must be no more than 250 mm or less.

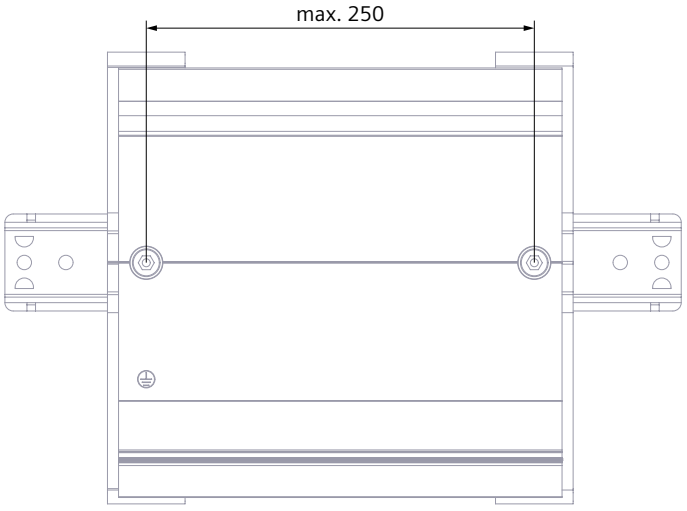


Figure 1-497 Distance between two DIN rail adapters

NOTE

Note that, depending on the mounting rail width, the mounting rail adapter can protrude up to 4 mm on each side due to the drill holes.
You can find an overview of the protrusion dimensions for the various DIN rails in the table below.

Table 1-816 Additional lateral space required

Mounting rail	Article number	Additional space required with adapter
• 160.0 mm (with drill holes)	6ES7590-1AB60-0AA0	4 mm
• 245.0 mm (with drill holes)	6ES7590-1AC40-0AA0	4 mm
• 482.6 mm (with drill holes)	6ES7590-1AE80-0AA0	8 mm
• 530.0 mm	6ES7590-1AF30-0AA0	0 mm
• 830.0 mm (with drill holes)	6ES7590-1AJ30-0AA0	0 mm

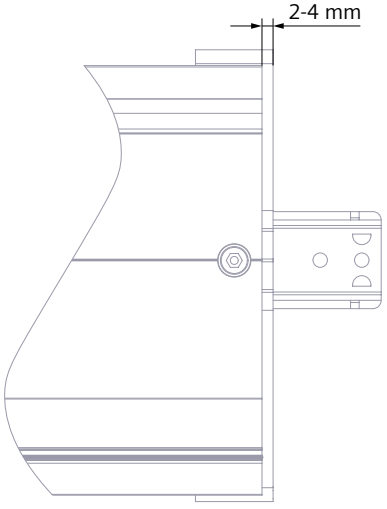


Figure 1-498 DIN rail adapter protrusion

Procedure

Mounting on the standard DIN rail 35 mm x 7.5 mm
To install DIN rail adapter on the standard DIN rail 35 mm x 7.5 mm, follow these steps:

1. Set the clamp onto the standard DIN rail.
2. The **shorter** transverse edge of the adapter frame points towards the cabinet or box wall (2).
3. Place the S7-1500/ET 200MP mounting rail on the adapter frame so that the groove in the S7-1500/ET 200MP mounting rail matches the groove in the adapter frame.
   Place the S7-1500/ET 200MP mounting rail with the adapter frame on the clamp (4).
4. Use screws to fasten the S7-1500/ET 200MP mounting rail to the DIN rail adapter and the standard mounting rail (tightening torque 5 Nm to 6 Nm).

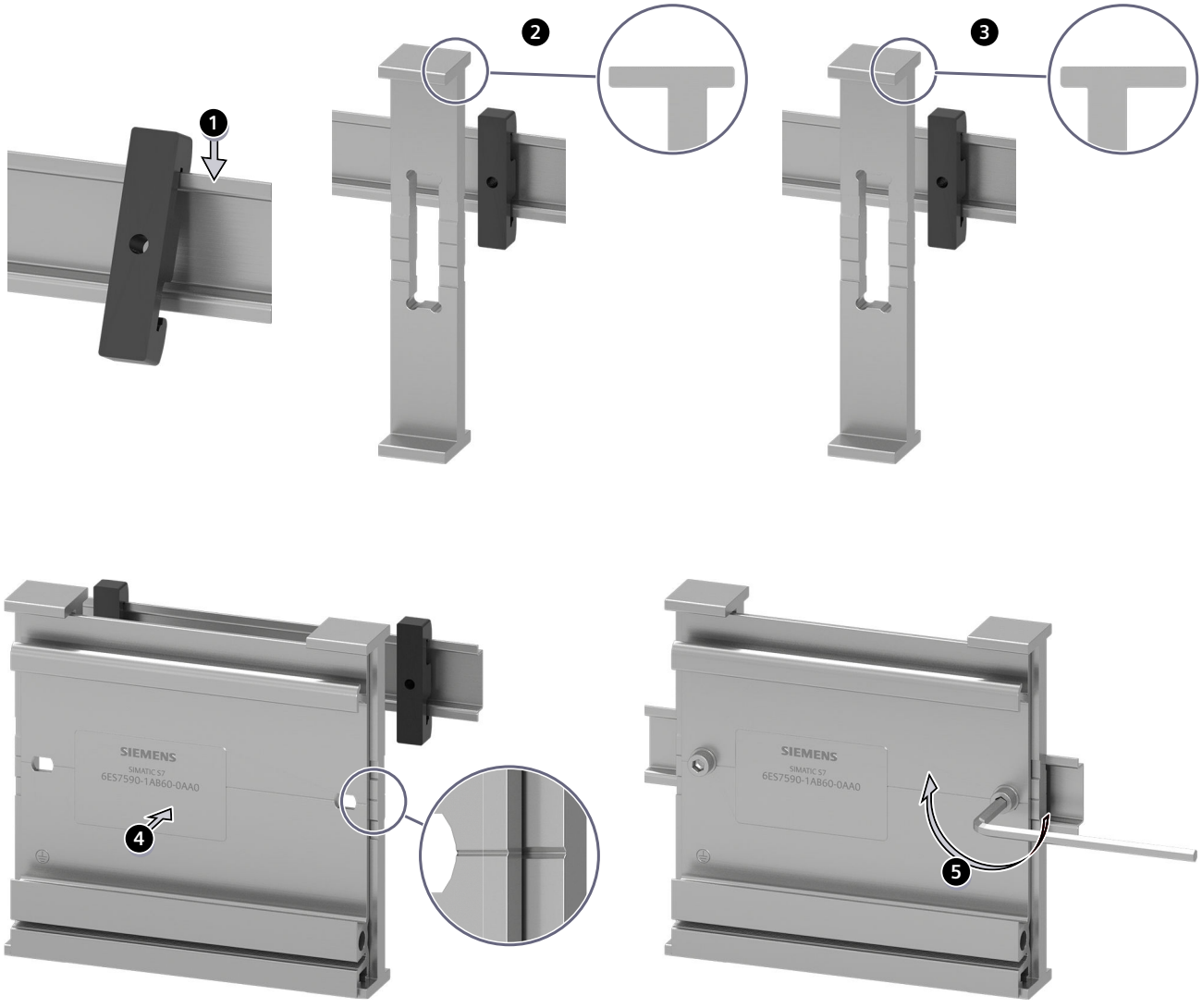


Figure 1-499 Mounting sequence of the DIN rail adapter to the DIN rail 35 mm x 7.5 mm or 35 mm x 15 mm

Mounting to the standard DIN rail 35 mm x 15 mm
To install DIN rail adapter on the standard DIN rail 35 mm x 15 mm, follow these steps:

1. Set the clamp onto the standard DIN rail.
2. The **longer** transverse edge of the adapter frame points toward the cabinet or box wall (3).
3. Place the S7-1500/ET 200MP mounting rail on the adapter frame so that the groove in the S7-1500/ET 200MP mounting rail fits into the groove in the adapter frame.
   Place the S7-1500/ET 200MP mounting rail with the adapter frame onto the clamp (4).
4. Use screws to fasten the S7-1500/ET 200MP mounting rail to the standard rail adapter and the standard mounting rail (tightening torque 5 Nm to 6 Nm).

7.4 Installing a system power supply

Introduction

The system power supply has a connection to the backplane bus and supplies the connected modules with the internal supply voltage.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Installing a system power supply

To install the system power supply, follow these steps:

1. Insert the U-connector into the back of the system power supply.
2. Hang the system power supply on the mounting rail.
3. Swivel the system power supply to the rear.

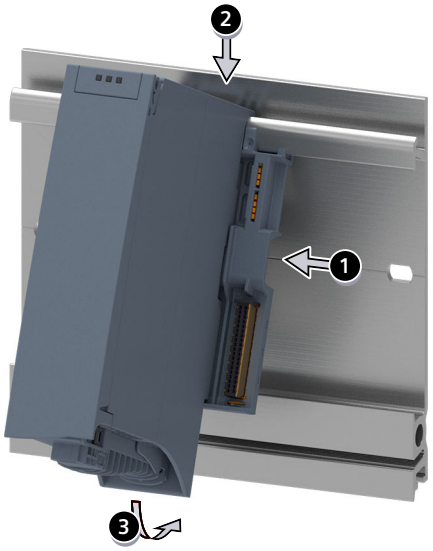


Figure 1-500 Installing a system power supply

4. Open the front cover.
5. Disconnect the power cable connector from the system power supply.
6. Screw the system power supply tight (tightening torque 1.5 Nm).
7. Insert the already wired-up power cable connector into the system power supply.

Information about wiring of the power cable connector is available in the section Connecting system power supply and load current supply (Page 209).

Uninstalling a system power supply

The system power supply is wired up.

To uninstall the system power supply, follow these steps:

1. Open the front cover.
2. Shut down the system power supply.
3. Switch off the supplied supply voltage.
4. Disconnect the power cable connector, and remove the connector from the system power supply.
5. Unscrew the fixing screw.
6. Swivel the system power supply out of the mounting rail.

Reference

Additional information can be found in the manuals for the system power supplies.

7.5 Installing a load current supply

Introduction

Load current supplies do not have a connection to the backplane bus of the S7-1500 automation systems/ET 200MP distributed I/O system and also do not occupy a slot on the backplane bus. The load current supply (PM) supplies the system power (PS), CPU, interface module and input and output circuits of the I/O modules with DC 24 V.

Requirements

The mounting rail is installed.

Tools required

Screwdriver with 4.5 mm blade

Installing a load current supply

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/78027451)

To install a load current supply, follow these steps:

1. Hook the load current supply on the mounting rail.
2. Swivel the load current supply to the rear.



Figure 1-501 Installing a load current supply

3. Open the front cover.
4. Disconnect the power cable connector from the load current supply.
5. Screw the load power supply tight (tightening torque 1.5 Nm).
6. Insert the already wired-up power cable connector into the load current supply.

For a description on how to wire the power cable connector, refer to the section Connecting system power supply and load current supply (Page 209).

NOTE
Load current supplies can only be mounted on the left or right side outside the S7-1500 automation system/ET 200MP distributed I/O system. If you mount a load current supply on the right of the configured setup, the heat development of the load current supply may make a gap to the configured setup necessary. For additional information, refer to the relevant manuals. The number of load current supplies that can be used is unlimited.

Uninstalling the load current supply

The load current supply is wired up.

To uninstall a load current supply, follow these steps:

1. Open the front cover.
2. Shut down the load current supply.
3. Turn off the feed supply voltage.
4. Disconnect the power cable connector, and remove the connector from the load current supply.
5. Unscrew the fixing screw.
6. Swivel the load current supply out of the mounting rail.

Reference

Additional information can be found in the manuals for the load current supplies.

7.6 Installing the CPU

Introduction

The CPU executes the user program and supplies the electronics of the modules with power via the backplane bus.

Requirements

The mounting rail is installed.

In a system power supply located on the left next to the CPU, a U connector is inserted on the back right.

NOTE

Protective film

Please note that the CPU is supplied with a removable protective film on the display. You can remove the protective film as required.

Tools required

Screwdriver with 4.5 mm blade

Installing the CPU

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/78027451)

To install a CPU, follow these steps:

1. Insert a U-connector into the back right on the CPU.
2. Install the CPU to the mounting rail. Also push the CPU to the left system power supply if necessary.
3. Ensure that the U-connector is inserted at the system power supply. Swivel the CPU in to the rear.

4. Screw the CPU tight (tightening torque 1.5 Nm).



Figure 1-502 Installing the CPU

Uninstalling the CPU

The CPU is wired, and is followed by additional modules.

To uninstall a CPU, follow these steps:

1. Open the front cover.
2. Switch the CPU into STOP mode.
3. Turn off the feed supply voltage.
4. Pull off the connector for the supply voltage.
5. Loosen the bus connectors for PROFIBUS/PROFINET with the screwdriver.
6. Disconnect the bus connector from the CPU.
7. Undo the CPU fixing screws.
8. Pivot the CPU out of the mounting rail.

Device damage caused by electrical fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that can be damaged by electrostatic fields or electrostatic discharge.

NOTICE
Device damage caused by electrical fields or electrostatic discharge Electrical fields or electrostatic discharge can cause function failures that result from damaged individual components, integrated circuits, modules or devices. • Pack, store, transport and send electronic components, modules or devices only in the original product packaging or in other suitable materials, e.g. conducting foam rubber or aluminum foil. • Only touch components, modules and devices when you have grounded yourself with one of the following measures: – Wear an ESD wrist strap – Wear ESD shoes or ESD grounding strips in ESD areas with a conducting floor • Place electronic components, modules and devices only on conducting surfaces (table with ESD coating, conducting ESD plastic foam, ESD packing bag, ESD transport container).

7.7 Installing the interface module

Introduction

The interface module connects the ET 200MP with the PROFINET IO/PROFIBUS DP.

The interface module exchanges data between the higher-level controller and the I/O modules.

Requirements

The mounting rail is installed.

For a system power supply located to the left of the interface module, a U connector is inserted on the back left.

Tools required

Screwdriver with 4.5 mm blade

Installing the interface module

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/67462859)

To install an interface module, proceed as follows:

1. Mount the U-connector on the back right-hand side of the interface module.
2. Hook the interface module on the rail.

3. Pivot the interface module towards the back.
4. Tighten the interface module (tightening torque 1.5 Nm).

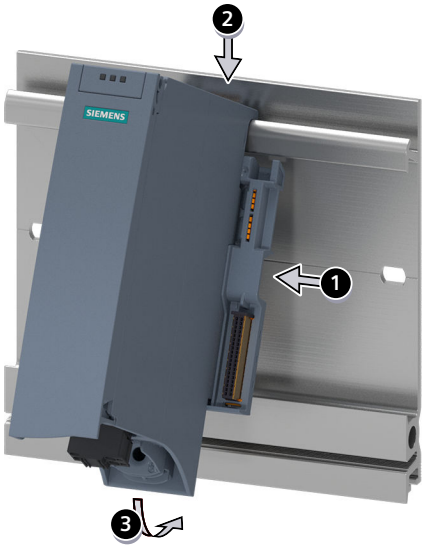


Figure 1-503 Installing the interface module

Uninstalling the interface module

The interface module is wired and is followed by additional modules.

To uninstall the interface module, follow these steps:

1. Switch off the supply voltage for the interface module.
2. Open the front cover.
3. Loosen the bus connector and the connector for the supply voltage with the screwdriver.
4. Remove the plug from the interface module.
5. Loosen the fixing screw of the interface module.
6. Pivot the interface module out of the mounting rail.

7.8 Installing I/O modules

Introduction

The I/O modules are then mounted to the right of the CPU/interface module. I/O modules form the interface between the controller and the process. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions.

Requirements

The mounting rail is installed.

The CPU/interface module is installed.

In the module/CPU/interface module located to the left of the I/O module, a U-connector is inserted on the back right.

Tools required

Screwdriver with 4.5 mm blade

Installing I/O modules

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/78027451)

Proceed as follows to install an I/O module:

1. Insert a U connector into the back right on the I/O module.
   Exception: the last I/O module in the assembly
2. Install the I/O module on the mounting rail. Push the I/O module up to the left module.
3. Pivot the I/O module towards the back.
4. Tighten the I/O module (tightening torque 1.5 Nm).

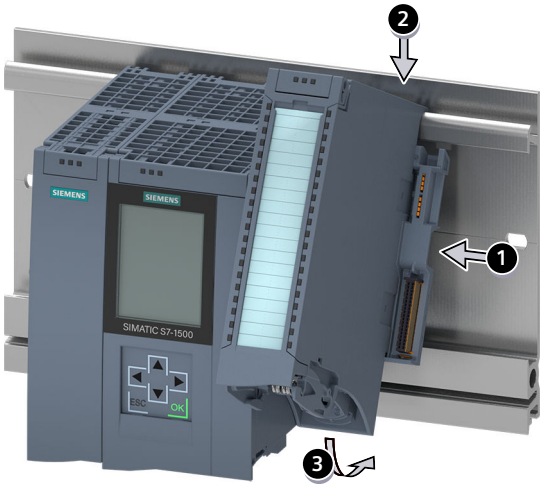


Figure 1-504 Installing I/O module

Uninstalling I/O modules

The I/O module is wired.

Proceed as follows to dismantle an I/O module:

1. Turn off all feed supply voltages.
2. Open the front cover.
3. For communications modules: Loosen and remove the connector from the module.
4. At I/O modules: Pull the front connector out of the I/O module using the unlocking strap. Swivel the front connector downward. Remove the front connector from the guide grooves.

5. Loosen the fixing screw of the I/O module.
6. Pivot the I/O module out of the mounting rail.

Wiring

8

8.1 Rules and regulations for operation

Introduction

The S7-1500 automation system / ET 200MP distributed I/O system is a component of plants or systems. Special rules and regulations must be adhered to in line with the area of application.

This section provides an overview of the most important rules that must be observed for the integration of the S7-1500 automation system/ ET 200MP distributed I/O system in a plant or system. Please follow these rules when connecting the S7-1500 automation system/ ET 200MP distributed I/O system.

Specific application

Observe the safety and accident prevention regulations that are applicable to specific applications (for example Machinery Directive).

EMERGENCY-STOP devices

EMERGENCY OFF equipment to IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts after a voltage dip or power failure.
- Bus communication is reestablished following a fault.

If a hazardous operating state occurs, force an EMERGENCY STOP.

After the EMERGENCY-STOP device has been unlocked, the S7-1500 automation system / ET 200MP distributed I/O system must not started uncontrolled or undefined.

External fuses/switches

Install the external fuses/switches in the proximity of the S7-1500 automation system/ET 200MP distributed I/O system.

Line voltage

The points to note for line voltage are set out below.

- For fixed plants or systems without multipole circuit breaker, a mains disconnection device (multipole) must be available in the building installation.
- For load current supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the S7-1500 automation system/ET 200MP distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

You can find additional information in the section Information on insulation tests, protection class, degree of protection and rated voltage (Page 397).

24 V DC supply

The following describes what you must pay attention to in terms of the 24 V DC supply:

- Power supply units for the 24 V DC supply (SELV/PELV) must supply a safe extra-low voltage according to IEC 61131-2 or IEC 61010-2-201.
- To protect the S7-1500 automation system/ET 200MP distributed I/O system from lightning and overvoltages, use overvoltage arresters.

  Suitable components for the lightning and overvoltage protection are specified in the Defining interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.

Requirements for power supplies in the event of voltage interruption

NOTE

To ensure adherence to IEC 61131-2, only use power packs/power supply units (e.g. 230/400 V AC → 24 V DC) with a mains buffering time of at least 10 ms. Observe the relevant requirements in your application (e.g. product standard for "burners" 30 ms according to EN 298 or 20 ms according to NAMUR recommendation NE 21) with respect to possible voltage interruptions. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).

Of course, these requirements also apply to power packs/power supply units not constructed using S7-1500 or ET 200SP/S7-300-/S7-400 technology.

Protection against electrical shock

As protection against electric shock you must connect the mounting rail and if necessary, all other existing protective conductor connections of the S7-1500 automation system / ET 200MP distributed I/O system conductively with the protective conductor.

You may only use conductors in the colors yellow-green for connections to protective conductor connections.

Protection against external electrical influences

To protect against electrical effects or faults, observe the following rules:

- The system for discharging electromagnetic interference must be connected to a protective conductor with a sufficient cross-section for all plants with an S7-1500 automation system / ET 200MP distributed I/O system.
- You must ensure that all supply, signal and bus cables are correctly routed and installed.
- For signal and bus lines, a cable break, wire break or a cross circuit must not lead to undefined states in the plant or system.

Reference

Additional information can be found in the function manual, Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566).

8.2 Additional rules and regulations for operation of the S7-1500/ET 200MP with fail-safe modules

8.2.1 Safety extra-low voltage (SELV, PELV) for failsafe modules

Key statement

⚠ WARNING

The failsafe modules must be operated with safety extra-low voltage (SELV, PELV).
You can find more information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.
The fail-safe modules operate at a rated voltage of 24 V DC. The tolerance range is 19.2 V DC to 28.8 V DC.
The fail-safe motor starters operate with the 24 V DC rated voltage. The tolerance range is 20.4 V DC to 28.8 V DC.
Within the overvoltage range from 32 V DC to 36 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 36 V DC, the F-modules are permanently de-energized.
Use a power supply unit that does not exceed U_m = 36 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g., use of a surge protection device.
All system components that can supply electrical energy in any form whatsoever must fulfill this condition.
Each additional circuit (24 V DC) used in the system must have a safety extra low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.
Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module must not exceed a fault voltage U_m in the event of a fault.

⚠ WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.
An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which could cause the fault voltage U_m to be exceeded.

8.2.2 Requirements of sensors and actuators for fail-safe modules

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

⚠ WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have a service life of 20 years as defined in IEC 61508:2010 without considerable loss of safety.
The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".
To achieve the respective safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PLd, it is sufficient that a sensor has a single-channel connection. However, to achieve SIL3/Cat. 3/PLd with a single-channel connected sensor, the sensor itself must be SIL3/Cat. 3/PLd-capable. Otherwise, this safety level can only be achieved through two-channel connection of sensors.

To achieve Cat.4, sensors must be connected by two channels.

⚠ WARNING

In the case of fail-safe input modules, a "0" value is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.
Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the respective actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Duration requirements for sensor signals

⚠ WARNING

Observe the following requirements for sensor signals:

- In order to ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- In order for pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Safe detection of inputs through F-modules

The minimum duration of sensor signals for fail-safe modules with inputs is dependent:

- On the parameters assigned for input delay
- On the parameters of the short-circuit test of sensor supplies.
- On the configured discrepancy behavior with 1oo2 (2v2) evaluation.

The duration of the signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in section "Response times" of the respective F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, briefly switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

High-speed actuators may briefly drop out or be activated during this test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

If the actuators switch voltages greater than 24 V DC (e.g. 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (acc. to standard IEC 60664-1).
This is generally the case with relays and contactors and you must pay particular attention to this with semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

8.2.3 Capacitive crosstalk of digital input/output signals

Readback errors may occur on the F-DQ modules if the fail-safe digital output signals and fail-safe digital input signals are routed through a single cable.

Cause: Capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers due to the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. The module detects a cross circuit/short circuit and performs a safety-related shutdown.

Solution:

- Separate cables for fail-safe DI modules and fail-safe DQ modules / non-fail-safe DQ modules
- Coupling relay or diodes in the outputs
- Disable the short-circuit test of the sensor supply if safety class requirements allow it.

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

Solution:

- Spatially disconnect the inductive loads or shield against the magnetic field.
- Configure the "Max. readback time dark test" to 50 ms or higher.

8.3 Operation on grounded infeed

Introduction

Information is provided below on the overall configuration of an S7-1500 automation system/ET 200MP distributed I/O system on a grounded infeed (TN-S system). The specific subjects discussed are:

- Shut-off devices, short circuit and overload protection in accordance with
  - IEC 60364, corresponds to DIN VDE 0100
  - IEC 60204, corresponds to DIN VDE 0113
- Load current supplies and load circuits

Grounded infeed

In the case of grounding incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical isolation (SELV in accordance with IEC 61131-2 or IEC 61010-2-201)

System power/load current supplies with 24 V DC output voltage feature safe electrical separation and a voltage limit (extra-low voltage). Load power supplies/system power supplies with a 24 V DC output voltage are not connected to the protective conductor.
In accordance with IEC 61131-2 / IEC 61010-2-201, this protection is referred to as SELV (Safety Extra Low Voltage).

Either the wiring of SELV circuits must be safely isolated from the wiring of other circuits that are not SELV, or the insulation of all wires must be dimensioned for the higher voltage.

Protective extra-low voltage (PELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load current supplies with grounded 24 V DC output voltage require a safe connection to the protective conductor and a voltage limit (extra-low voltage).

In accordance with IEC 61131-2 / IEC 61010-2-201, this protection is referred to as PELV (Protective Extra Low Voltage).

Either the wiring of PELV circuits must be safely isolated from the wiring of other circuits that are not PELV, or the insulation of all wires must be dimensioned for the higher voltage.

Reference potential of the controller

The reference potential of the S7-1500 automation system/ ET 200MP distributed I/O system is connected with the mounting rail through a high-resistance RC combination in the CPU/interface module. In this way, high-frequency interference currents are conducted and electrostatic charges are avoided. Despite the grounded mounting rail, the reference potential of the S7-1500 automation system / ET 200MP distributed I/O system has to be considered as ungrounded due to the high-resistance connection.

If you want to configure the S7-1500 automation system/ET 200MP distributed I/O system with grounded reference potential, connect the M connection of the CPU/interface module galvanically with the protective conductor.

You can find a simplified representation of the potential relationships in section Electrical configuration (Page 201).

Short-circuit and overload protection

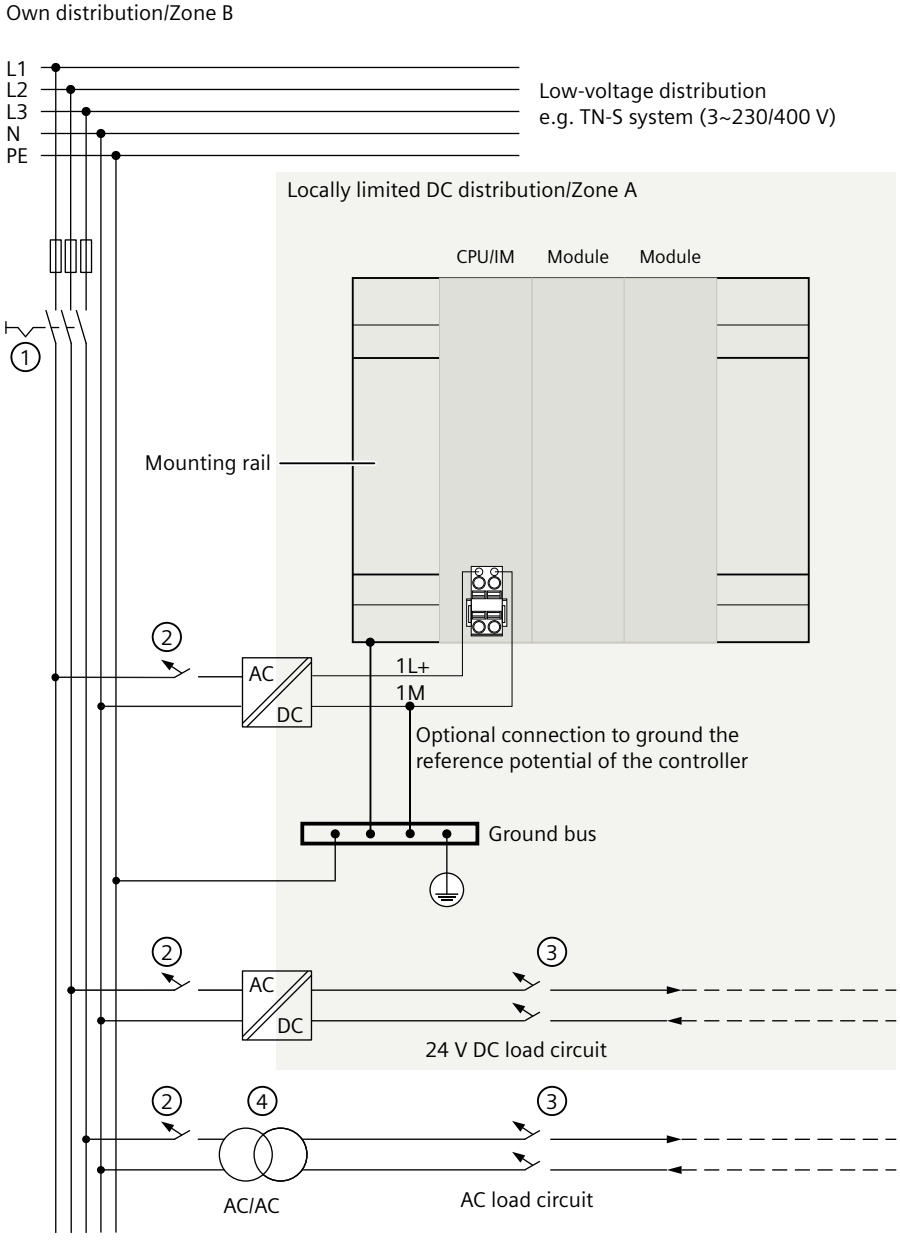
Various measures as protection against short-circuits and overloads are required for setting up a full installation. The nature of the components and the degree to which the required measures are binding depends on the IEC (DIN VDE) regulation applicable to your plant configuration. The table refers to the following figure and compares the IEC (DIN VDE) regulations.

Table 1-817 Components and required measures

	Reference to following figure	**IEC 60364 (DIN VDE 0100)**	**IEC 60204 (DIN VDE 0113)**
Shut-off device for control system, sensors, and actuators	①	Main switch	Disconnector
Short-circuit and overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	• With grounded secondary circuit: fuse **unipolar** • Otherwise: fuse **all poles**
Load power supply for AC load circuits with more than five items of electromagnetic equipment	④	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

S7-1500/ET 200MP in the overall configuration

The figure below shows the overall configuration of the S7-1500/ET 200MP (load current supply and grounding concept) with infeed from a TN-S system.



① Main switch
② Short-circuit and overload protection on the primary side
③ Short-circuit and overload protection on the secondary side
④ Optional for galvanic isolation

Figure 1-505 Operating the S7-1500/ET 200MP with grounded reference potential

NOTE

In general, you must connect all modules with DC supply of the automation system S7-1500/distributed I/O system ET 200MP to their own distribution (or batteries) by means of an upstream local power supply unit. If you connect the modules with DC supply directly to their own distribution, you need to provide additional protective measures against overvoltages.

8.4 Electrical configuration

Galvanic isolation

With the S7-1500 automation system/ET 200MP distributed I/O system, there is galvanic isolation between:

- The primary side of the system power supply (PS) and all other circuit components
- The (PROFIBUS/PROFINET) communication interfaces of the CPU/interface module and all other circuit components
- The load circuits/process electronics and all other circuit parts of the S7-1500/ET 200MP components

High-frequency interference currents are conducted and electrostatic charges are avoided through integrated RC combinations or integrated capacitors.

S7-1500 potential relationships

The following figure shows a simplified representation of the potential relationships of the S7-1500 automation system.

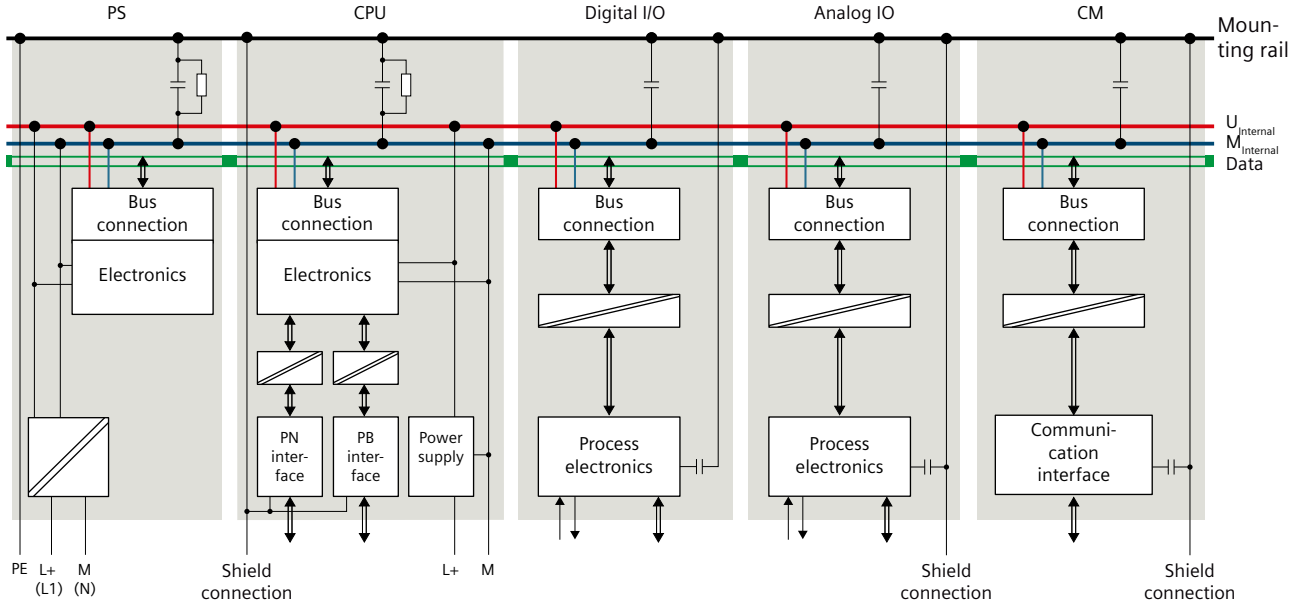


Figure 1-506 Potential relationships for S7-1500 using CPU 1516-3 PN/DP as an example

Potential relationships ET 200MP on PROFINET IO

The following figure shows a simplified representation of the potential relationships of the ET 200MP distributed I/O system on PROFINET IO.

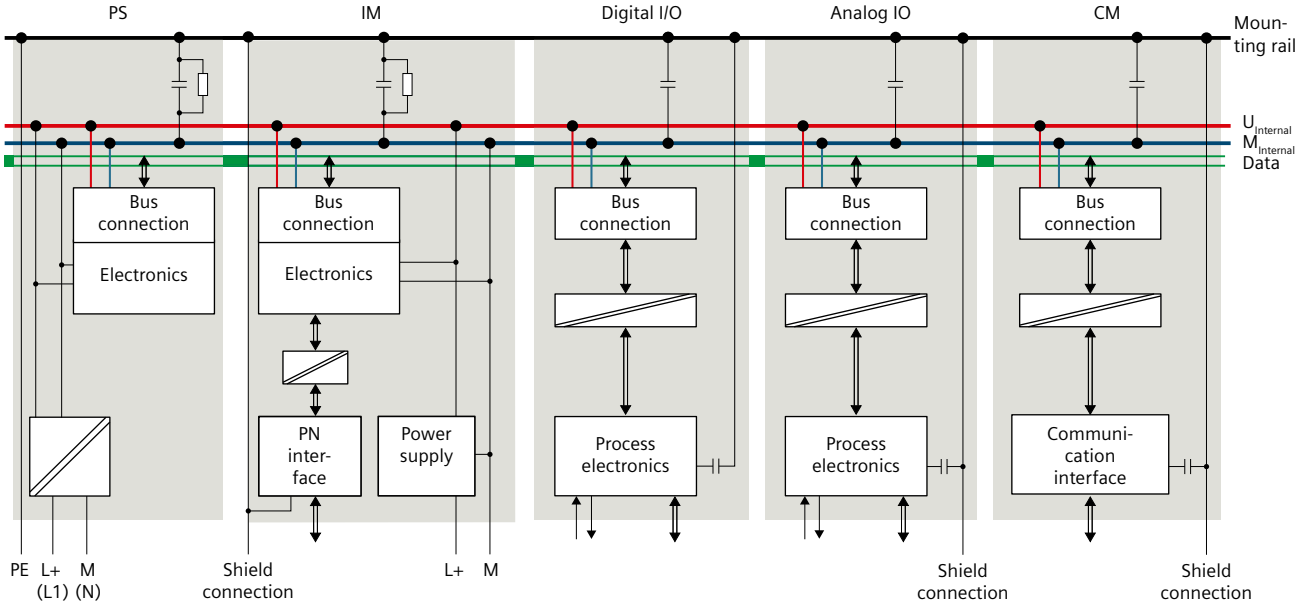


Figure 1-507 Potential relationships for ET 200MP using an IM 155-5 PN HF interface module as an example

Potential relationships ET 200MP on PROFIBUS DP

The following figure shows a simplified representation of the potential relationships of the ET 200MP distributed I/O system on PROFIBUS DP.

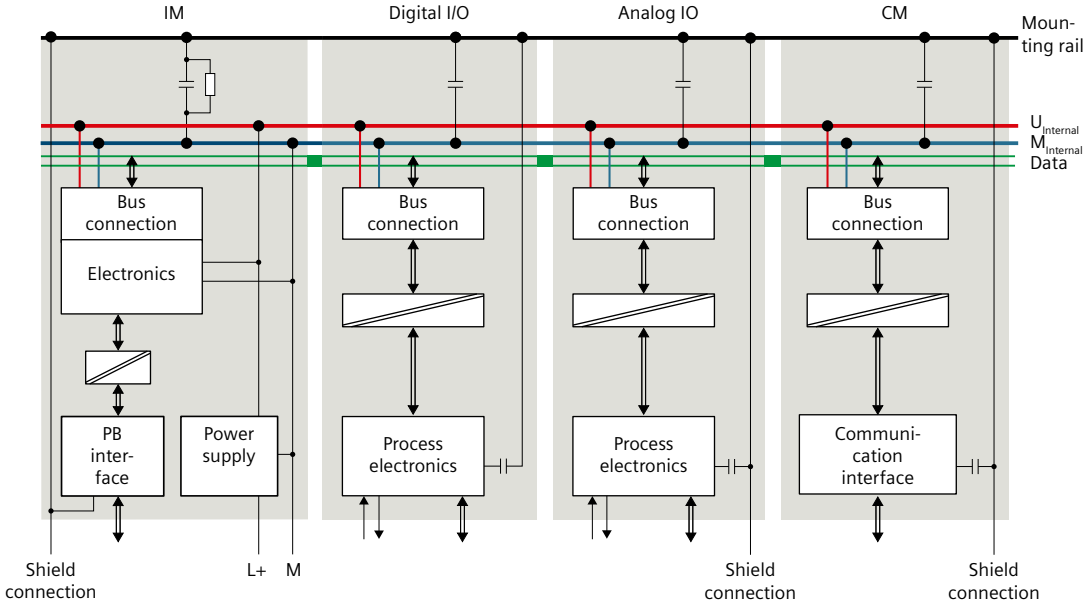


Figure 1-508 Potential relationships for ET 200MP using an IM 155-5 DP ST interface module as an example

8.5 Wiring rules

Introduction

Use suitable cables for connecting the S7-1500 automation system/ET 200MP distributed I/O system. Also select the cable insulation corresponding to the applied voltage. The following tables present the wiring rules for the CPU, interface module, system power supply, load current supply, front connector and power supply elements.

CAUTION

Use copper cables on connectors with terminal connections.
Use only copper cables (Cu) for all signal and supply lines that are connected to the device via terminals, for example, 24 V DC power supply cable to the 24 V DC power supply connections.

CPU, interface module, system power supply and load current supply

Table 1-818 Wiring rules for CPU, interface module, system power supply and load current supply

Wiring rules for ...		CPU/interface module	System power and load current supply
Permitted cable cross-sections of solid cables (Cu)		-	-
		-	-
Permitted cable cross-sections of flexible cables (Cu)	Without wire end sleeve	0.25 to 2.5 mm^2	0.5 to 2.5 mm^2
		AWG*: 24 to 14	AWG*: 20 to 14
	With end sleeve	0.25 to 1.5 mm^2	0.5 to 1.5 mm^2
		AWG*: 24 to 16	AWG*: 20 to 16
Number of wires per connection		1	1
Stripped length of the wires		10 to 11 mm	7 to 8 mm
End sleeves according to DIN 46228	without plastic sleeve	Design A, 10 mm long	Design A, 7 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E, 10 mm long	Design A, 7 mm long
Sheath diameter		-	8.5 mm
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection system		Push-in terminal	Screw terminal
Tightening torque		-	from 0.5 Nm to 0.6 Nm

* American Wire Gauge

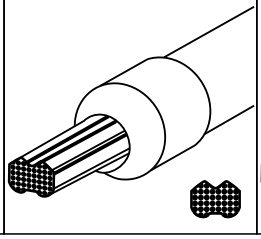
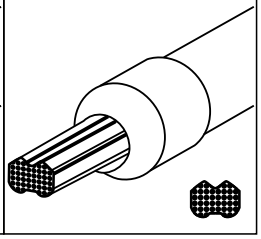
Front connectors

Table 1-819 Wiring rules for front connector

Wiring rules for ...		40-pin front connector (screw terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 25 mm module)
Permitted cable cross-sections of solid cables (Cu)		up to 0.25 mm^2	up to 0.25 mm^2	up to 0.25 mm^2
		AWG*: up to 24	AWG*: up to 24	AWG*: up to 24
Permitted cable cross-sections of flexible cables (Cu)	Without wire end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2 (max. 40 x 0.75 mm^2)
		AWG*: 24 to 16	AWG*: 24 to 16	AWG*: 24 to 16 (max. 40 x 0.75 mm^2)
	With end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2 (max. 32 x 0.75 mm^2; 8 x 1.5 mm^2)
		AWG*: 24 to 16	AWG*: 24 to 16	AWG*: 24 to 16 (max. 32 x AWG 19; 8 x AWG 16)
Number of wires per connection		1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve

* American Wire Gauge

** End sleeve

Wiring rules for ...		40-pin front connector (screw terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 35 mm module)	40-pin front connector (push-in terminal, for 25 mm module)
Stripped length of the wires		8 mm up to max. 0.75 mm^2(corresponding to length of end sleeve**: 8 mm) 10 to 12 mm for all cross-sections (corresponding to length of end sleeve**: 10 mm, 12 mm)	8 to 11 mm (corresponding to length of end sleeve**: 8 mm, 10 mm)	8 to 11 mm (corresponding to length of end sleeve**: 8 mm, 10 mm)
End sleeves according to DIN 46228	without plastic sleeve	Design A: 8 mm long up to max. 0.75 mm^2, 10 mm and 12 mm long for all cross-sections	Design A: 8 mm and10 mm long	Design A: 8 mm and10 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E 8 mm long up to max. 0.75 mm^2, 10 mm and 12 mm long for all cross-sections	Design E 8 mm and10 mm long	Design E 8 mm and10 mm long
Sheath diameter		-	-	-
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection system		Screw terminal	Push-in terminal	Push-in terminal
Tightening torque (screw terminal)		From 0.4 Nm to 0.7 Nm	-	-
Max. actuating force for complete opening of the push-in terminal		-	40 N	40 N
Recommended crimp shape for end sleeve		-	Corresponding to crimping tool PZ 6/5 	Corresponding to crimping tool PZ 6/5 

* American Wire Gauge

** End sleeve

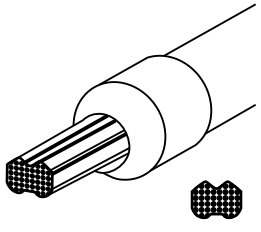
NOTE

40-pin front connector (screw terminal, for 35 mm modules), article number 6ES7592-1AM00-0XB0

In case of a total current of more than 8 A, apply the supply voltage 24 V DC (terminals 19 and 39) and the ground (terminals 20 and 40) twice.

Power supply elements

Table 1-820 Wiring rules for power supply elements (component of shield set)

Wiring rules for ...		Power supply element (screw terminal, for 35 mm module)	Power supply element (push-in terminal, for 25 mm module)
Permitted cable cross-sections of solid cables (Cu)		-	-
		-	-
Permitted cable cross-sections of flexible cables (Cu)	Without wire end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2
		AWG*: 24 to 16	AWG*: 24 to 16
	With end sleeve	0.25 to 1.5 mm^2	0.25 to 1.5 mm^2
		AWG*: 24 to 16	AWG*: 24 to 16
Number of wires per connection		1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve	1 or combination of 2 wires up to 1.5 mm^2 (total) in the same end sleeve
Stripped length of the wires		8 mm up to max. 0.75 mm^2(corresponding to length of end sleeve**: 8 mm) 10 to 12 mm for all cross-sections (corresponding to length of end sleeve**: 10 mm, 12 mm)	8 to 11 mm (corresponding to length of end sleeve**: 8 mm, 10 mm)
End sleeves according to DIN 46228	without plastic sleeve	Design A: 8 mm long up to max. 0.75 mm^2, 10 mm and 12 mm long for all cross-sections	Design A: 8 mm and10 mm long
	with plastic sleeve 0.25 to 1.5 mm^2	Design E 8 mm long up to max. 0.75 mm^2, 10 mm and 12 mm long for all cross-sections	Design E 8 mm and10 mm long
Sheath diameter		-	-
Tool		3 to 3.5 mm screwdriver, conic design	3 to 3.5 mm screwdriver, conic design
Connection system		Screw terminal	Push-in terminal
Tightening torque (screw terminal)		From 0.4 Nm to 0.7 Nm	-
Max. actuating force for complete opening of the push-in terminal		-	40 N
Recommended crimp shape for end sleeve		-	Corresponding to crimping tool PZ 6/5 

* American Wire Gauge

** End sleeve

Permissible cable temperature

NOTE

Permissible cable temperature

When choosing a cable, remember that the cable temperature in operation can be up to 30 °C higher than the ambient temperature of the S7-1500/ET 00MP system.

Example: If you use the system in a switchgear cabinet at an ambient temperature of 30 °C, you must use a connecting conductor with a temperature range of at least 60 °C.

With terminals that carry a current load of ≥ 8 A during operation, you must expect a cable temperature of up to 65 °C above the ambient temperature.

You can determine the required cable temperature more precisely for each application. To do so, measure the cable temperature in the system at a load corresponding to the maximum possible power and ambient temperature values.

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

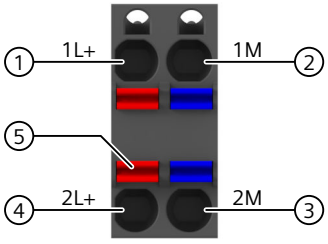
8.6 Connecting the supply voltage

Introduction

The supply voltage of the CPU/interface module is supplied by means of a 4-pole connection plug, which is located on the front or below on the CPU / interface module.

Connection for supply voltage (X80)

The connections of the 4-pole connector have the following meaning:



① +24 V DC of the supply voltage (current limited to 10 A)
② Ground of the supply voltage (current limited to 10 A)
③ Ground of the supply voltage for loop-through
④ +24 V DC of the supply voltage for loop-through
⑤ Spring opener (one spring opener per terminal)

Figure 1-509 Connection for supply voltage

The cable connector offers you the option of looping the supply voltage uninterrupted, even when it is unplugged.

For the maximum wire cross-sections, observe the information in the tables of the Wiring rules (Page 203).

Requirements

- Only wire the cable connector when the supply voltage is turned off.
- Observe the Wiring rules (Page 203).

Tools required

3 to 3.5 mm screwdriver

Tool-free connection of cables: multi-wire (stranded), with end sleeve or ultrasonic compressed

To connect a wire without tools, follow these steps:

1. Strip 8 to 11 mm of the wires.
2. Seal or crimp the wire with end sleeves.
3. Insert the wire into the push-in terminal as far as it will go.
4. Push the wired connector into the socket of the CPU/interface module.

Connection of wires: multi-wire (stranded), without end sleeve, unprocessed

To connect a wire without end sleeve, follow these steps:

1. Strip 8 to 11 mm of the wires.
2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.
3. Pull the screwdriver out of the spring release.
4. Push the wired connector into the socket of the CPU/interface module.

Loosening a wire

Push with the screwdriver as far as it will go into the spring release. Remove the wire from the push-in terminal.

Uninstalling the connection plug

To uninstall the connection plug, you need a screwdriver. With the screwdriver, pry the connection plug out of the CPU/interface module.

8.7 Connecting system power supply and load current supply

Introduction

In the delivery condition of the system power supplies/load current supplies, power connectors are inserted. The modules and the associated power connectors are coded. There are two parts to the coding element. One coding element is located in the module, and the other in the power connector. The system power supplies/load current supplies use identical power connectors for the voltage connection.

The coding element prevents the insertion of a power connector into a different type of system power supply/load current supply.

Tools required

3 to 3.5 mm screwdriver

Connecting the supply voltage to a system power supply/load current supply

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/78027451)

To connect the supply voltage, follow these steps:

1. Swing the front cover of the module up until the front cover latches.
2. Press down the unlocking button of the power cable connector (Figure 1). Remove the power cable connector from the front of the module.
3. Loosen the screw on the front of the connector. This loosens the housing latch and the cable relief. With a tightened screw the connector's cover can't be removed (Figure 2).
4. Pry off the connector cover using a suitable tool (Figure 3).



Figure 1-510 Connecting the supply voltage to a system power supply/load current supply (1)

5. Strip the cable jacket to a length of 35 mm and the conductors to a length of 7 to 8 mm. Attach the end sleeves.
6. Connect the wires in the connector according to the connection diagram (Figure 4).
7. Close the cover (Figure 5).

8. Retighten the screw (Figure 6). This effects a strain relief on the lines.

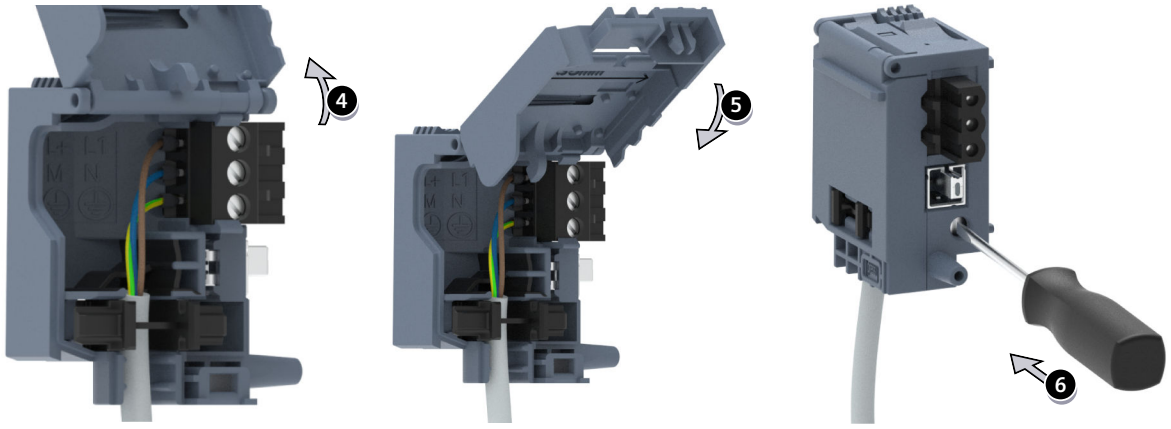


Figure 1-511 Connecting the supply voltage to a system power supply/load current supply (2)

9. Insert the power connector into the module, until the latch engages.

Reference

You can find more information on connecting the 24 V DC output voltage of the load power supply (PM) in the manuals for the relevant modules.

For more information on configuring system power supplies, refer to the System and load current supply (Page 158) section.

8.8 Connecting the CPU/interface module to the load current supply

Introduction

The load current supply is fitted with a plug-in 24 V DC output terminal (behind the front cover at the bottom). You connect the cables for the supply voltage to the CPU/interface module at this terminal.

Requirements

- Only wire the connection plug when the supply voltage is turned off.
- The connection plug for connecting the supply voltage to the CPU/interface module is already mounted.

You can find additional information in the section Connecting the supply voltage (Page 207).

Tools required

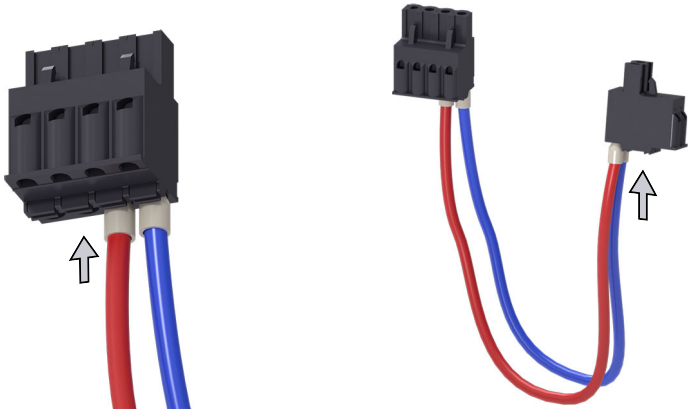
3 to 3.5 mm screwdriver

Connecting the CPU/interface module to a load current supply

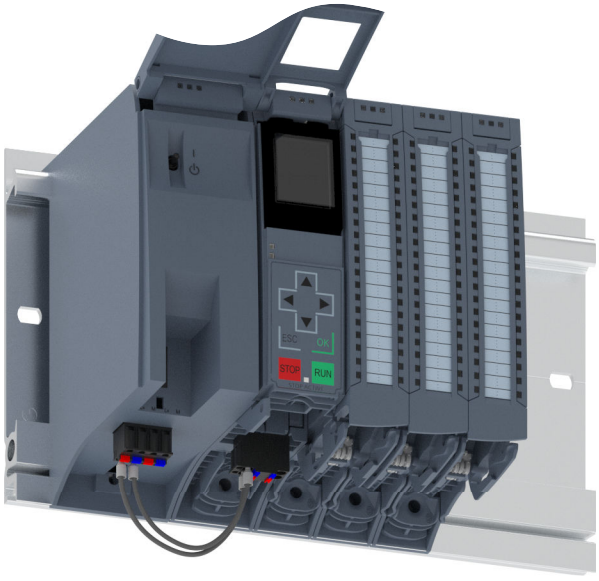
Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/78027451)

To connect the supply voltage, follow these steps:

1. Open the front cover of the load power supply. Pull the 24 V DC output terminal downwards.
2. Connect the 24 V DC output terminal to the wires of the 4-pole connection plug of the CPU/interface module.



3. Connecting the load current supply to the CPU/interface module.



NOTE

Position of the connection socket at the CPU

The connection socket for the 4-pole connection plug is located on the underside of the device for the following CPUs/interface modules:

- Standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0
- Interface modules IM 155-5 PN BA as of article number 6ES7155-5AA00-0AA0 and IM 155-5 PN ST as of article number 6ES7155-5AA01-0AB0

In the case of all CPUs with older article numbers, the connection socket is located on the front of the device under the front flap.

Additional information can be found in the associated manuals for the CPUs/interface modules.

8.9 Connecting interfaces for communication

Connecting interfaces for communication

Connect the communication interfaces of the CPU/interface module using standardized plug connectors.

Use prefabricated connecting cables for the connection. If you want to prepare communication cables yourself, the interface assignment is specified in the manuals of the corresponding modules. Observe the mounting instructions for the connectors.

Special consideration: Unlock connectors Industrial Ethernet FastConnect RJ45 plug 180 2x 2 or Industrial Ethernet FastConnect RJ45 plug 180 4x 2 and disconnect from PROFINET interface of CPU/IM

Tools required

- Industrial Ethernet FastConnect RJ45 Plug 180 2x 2 (6K1901-1BB10-2Ax0): **2.5 mm screwdriver**
- Industrial Ethernet FastConnect RJ45 Plug 180 4x 2 (6GK1901-1BB12-2Ax0): **3.0 mm screwdriver**

Procedure

1. Press the screwdriver parallel to the connector into the unlocking.
2. Disconnect the connector from the PROFINET interface.

NOTE

Do not unlock the connector under tension!

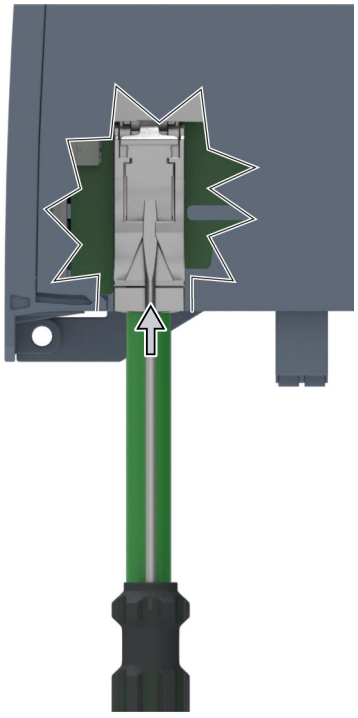


Figure 1-512 Unlocking the FastConnect connector

8.10 Front connector for the I/O modules

Introduction

The sensors and actuators of your plant are connected to the automation system by means of front connectors. Wire the sensors and actuators to the front connector. Plug the front connector with the wired sensors and actuators onto the I/O module.

You can wire the front connector as follows:

- In the "pre-wiring position", which allows a convenient wiring
- Completely, before you insert it into the I/O module.

You can remove the front connector easily from the I/O module with the wiring attached. This means it is not necessary to loosen the wiring when you replace the module.

Device versions of the front connector



① ② ③

① Front connector 35 mm with screw terminals
② Front connector 25 mm with push-in terminals
③ Front connector 35 mm with push-in terminals

Figure 1-513 Device versions of the front connector

Properties of the front connectors

The three different front connectors are characterized as follows:

- 40 clamping points each
- Connection system: Screw terminal (for 35 mm modules only) or push-in terminal
- Module width: 35 mm or 25 mm

- If you want to supply load groups with the same potential (non-isolated), use the potential bridges supplied for the front connector (with 35 mm width) for digital I/O modules. The bridges are used to connect the terminals 9 and 29, 10 and 30, 19 and 39 as well as 20 and 40 facing each other. Advantage: Reduction of the wiring effort.

  NOTE

  Use of potential bridges

  The use of potential bridges depends on the relevant module used.

  It is not permitted to use potential bridges for 230 V modules. Use the potential bridges only with a maximum supply voltage of 24 V DC. The current capacity per potential bridge is 8 A maximum.

  Because of the different assignment, you may not use the potential bridges with analog I/O modules.

  The front connectors for 25 mm modules have no potential bridges.

  Observe the instructions and wiring rules in the product manual of the respective I/O module when using potential bridges.

- In the delivery state a coding element is located in the module. When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector. When the front connector is removed from the I/O module, one part of the coding element remains in the front connector, and the other part remains in the I/O module. The insertion of a front connector that is not suited to the module is thereby mechanically prevented. This ensures, for example, that the front connector with the coding element for a digital module cannot be inserted into an analog module.

Properties of the front connectors on fail-safe modules

In as-delivered condition, a fail-safe module not only has a mechanical coding element but also an electronic coding element. The electronic coding key is a rewritable memory for the PROFIsafe address. When the front connector is inserted in the F-module, the electronic coding element engages completely in the front connector. If you remove the front connector from the F-module, the memory with the PROFIsafe address of the fail-safe module remains in the front connector (see section Replacing a front connector (Page 356)).

Reference

You can find additional information on the coding element in the section Coding element on the I/O module and on the front connector (Page 352).

Additional information on the use of the potential bridges can be found in the product manual for the respective I/O module.

8.10.1 Wiring front connectors for I/O modules without shield contact element

Requirements

- The I/O modules are installed on the mounting rail.
- The supply voltages are turned off.
- The cables are prepared according to the clamping technology used; take the Wiring rules (Page 203) into account for this purpose.

Tools required

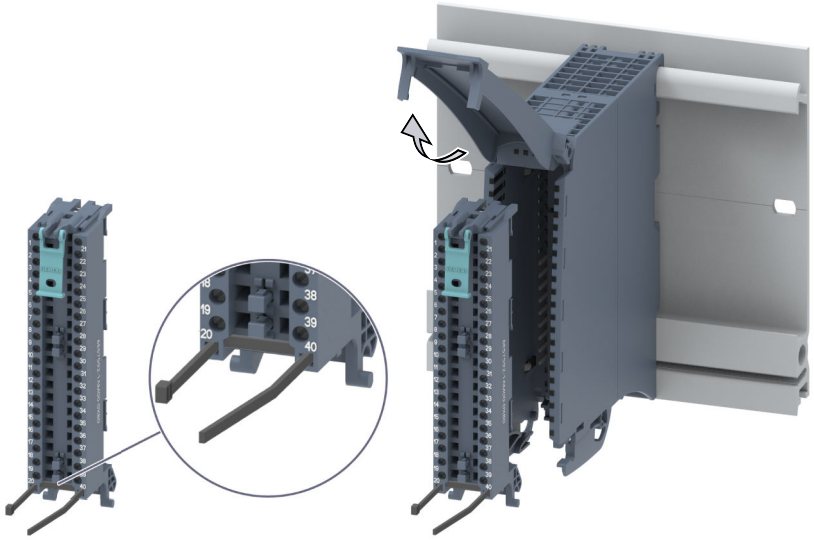
- Stripping tool
- 3 to 3.5 mm screwdriver

Preparing and wiring front connectors for I/O modules without shield contact element

Proceed as follows to wire the front connector:

1. Shut down the load current supply.
2. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 1).
3. Swing the front cover of the wired I/O module up until the front cover latches (Figure 2). Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/67462859)
4. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel the front connector upward until the front connector latches (Figure 3).

   Result: In this position, the front connector still protrudes from the I/O module (Figure 4). However, front connector and I/O module are not yet electrically connected. By means of the pre-wiring position, you can easily wire the front connector.



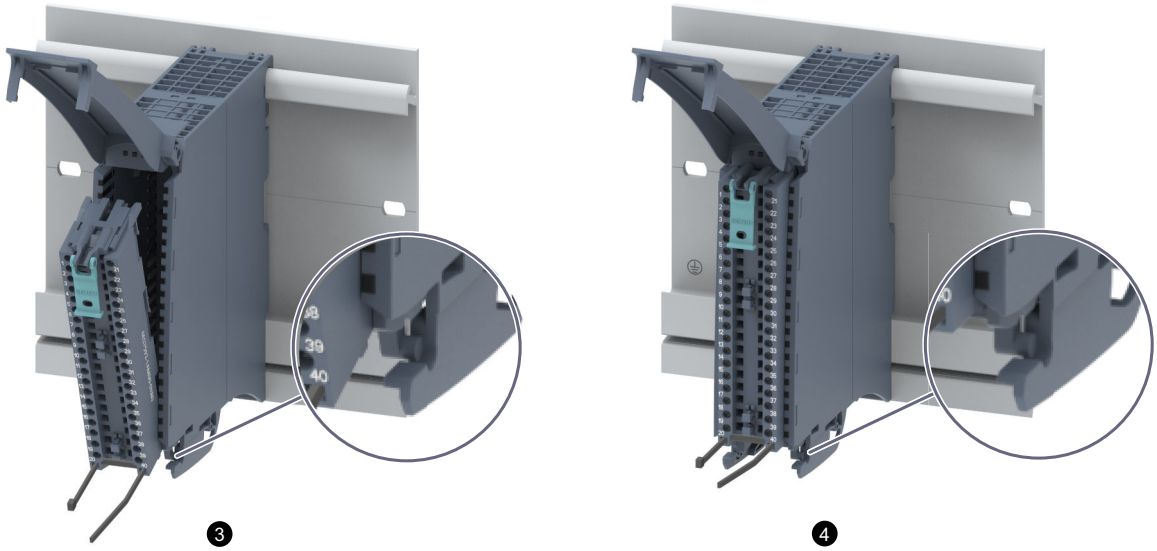


Figure 1-514 Wiring front connectors for I/O modules without shield contact element

5. Begin to completely wire the front connector.
6. Put the strain relief around the cable harness, and pull the strain relief for the cable harness tight.

Use of the potential bridges on 35 mm digital modules

With the delivered potential bridges, for digital modules with a maximum rated voltage of 24 V DC, you can bridge the terminals for the voltage supply and thus reduce the wiring effort. The bridges are used to connect the following pairs of opposing terminals: 9 and 29, 10 and 30, 19 and 39 as well as 20 and 40.

Reference

Additional information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

8.10.2 Wiring front connectors for I/O modules with shield contact element

Requirements

- The I/O modules are installed on the mounting rail.
- The supply voltages are turned off.
- The wires are prepared according to the clamping technology used. To do this, follow the Wiring rules (Page 203).

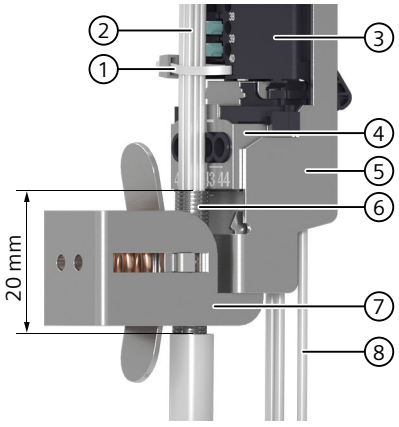
Tools required

- Stripping tool
- 3 to 3.5 mm screwdriver
- Flat pliers

Details view

The shielding bracket, the power supply element, and the shielding clamp are included in the scope of delivery for the analog and technology modules.

The following figure shows the details view of a front connector with shield connection element:



①	Shield clamp	⑥	Power supply element
②	Cable sheathing removed (approx. 20 mm)	⑦	Shielding bracket
③	Strain relief (cable tie)	⑧	Supply lines
④	Signal cables	①+⑦	Shield contact
⑤	Front connectors		

Figure 1-515 Details view for front connectors with shield connection elements

Preparing front connectors for I/O modules with shield contact element

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/67462859)

To prepare the front connector for wiring, follow these steps:

1. Remove the connection separator from the lower part of the connector (Figure 1).
2. Insert the power supply element (Figure 2).
3. Insert the shielding bracket from below into the guiding groove of the front connector until the shielding bracket latches into place (Figure 3).

4. Place the included cable strain relief (cable tie) for the cable harness into the front connector (Figure 4).



Figure 1-516 Preparing front connectors for I/O modules with shield contact element (1)

5. Swing the front cover up until the front cover latches (Figure 5).

6. Bring the front connector into the pre-wiring position. To do this, hook the front connector into the bottom of the I/O module and swivel it upwards until the front connector latches (Figure 6).

   Result: In this position, the front connector still protrudes from the I/O module (Figure 7). However, front connector and I/O module are not yet electrically connected.



Figure 1-517 Preparing front connectors for I/O modules with shield contact element (2)

7. Wire the power supply element (Figure 8).
   Terminals 41/42 and 43/44 are galvanically connected to each other. If you connect the supply voltage to 41 (L+) and 44 (M), you can then loop-through the potential to the next module (max. 8 A) with terminals 42 (L+) and 43 (M).

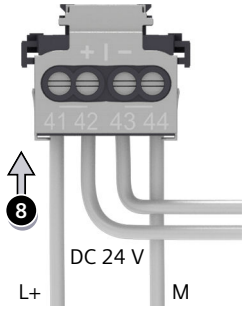


Figure 1-518 Preparing front connectors for I/O modules with shield connection element (3)

Wiring front connectors for I/O modules with shield contact element

To wire a front connector, follow these steps:

1. Strip the cable shielding.
2. Begin to completely wire the front connector (Figure 1).

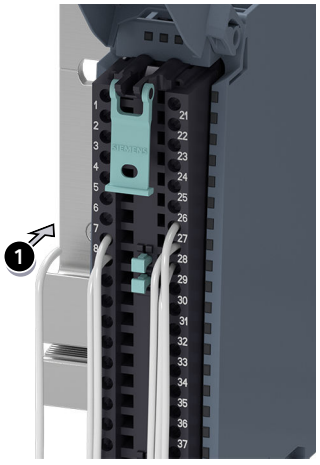


Figure 1-519 Wiring front connectors for I/O modules with shield connection element (1)

3. Put the strain relief (cable tie) around the cable harness, and pull the strain relief for the cable harness tight (Figure 2).

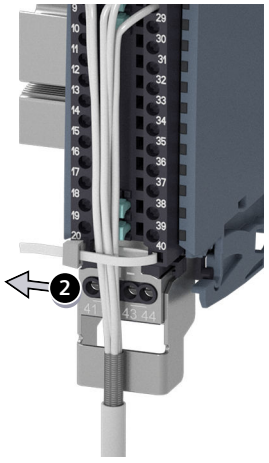


Figure 1-520 Wiring front connectors for I/O modules with shield connection element (2)

4. Insert the shield clamp from below into the shielding bracket in order to connect the cable shielding (Figure 3).

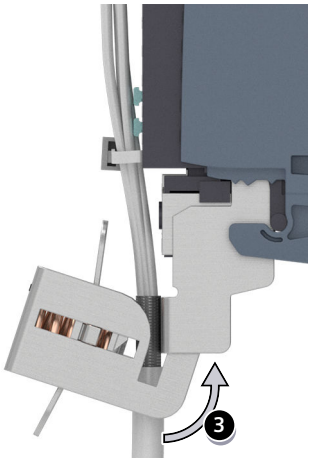


Figure 1-521 Wiring front connectors for I/O modules with shield connection element (3)

Functions of the shield contact

The shield contact:

- Is needed to apply cable shields (e.g., for analog modules)
- Interference currents on cable shields are diverted from the shield connection to ground via the mounting rail. The shielding connection is not required at cable entry into the switchboard.
- The shield support has a cable storage area of 18 mm x 15 mm.

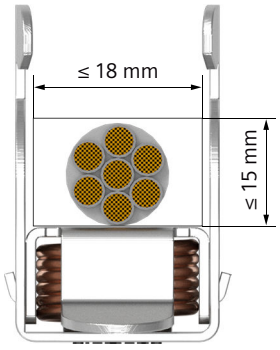


Figure 1-522 Shield clamp

Reference

Additional information on wiring the inputs and outputs can be found in the manuals for the I/O modules.

8.10.3 Bringing the front connector into final position

Bring the front connector from the pre-wiring position into final position

Proceed as follows to bring the front connector from the pre-wiring position into final position:

1. Grip the front connector by the unlocking strap.
2. Pull on the strap until the front connector is released from its latched position.
3. Tilt the top section of the front connector and raise it slightly. The front connector slides over the guide channel into its final position.

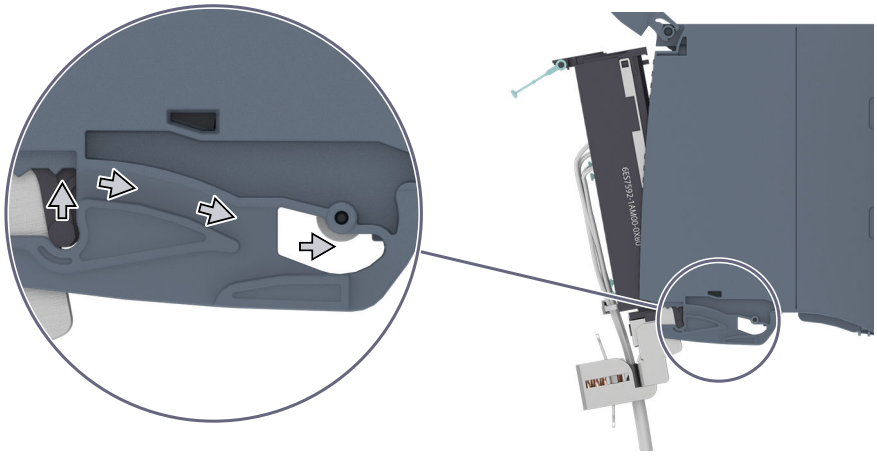


Figure 1-523 Bring the front connector from the pre-wiring position into final position

4. Push the front connector back into the I/O module until it latches. The front connector is now electrically connected with the I/O module.
5. Swivel the front cover down into place. Various latch positions are possible depending on the space requirement of the cable harness so that the required cable storage space can grow as needed.

Bringing the front connector directly into final position

Proceed as follows to bring the front connector directly into final position:

1. Grip the front connector by the unlocking strap.
2. Push the guide pin of the front connector into the guide channel that has been displaced downwards. The front connector slides over the guide channel into its final position.

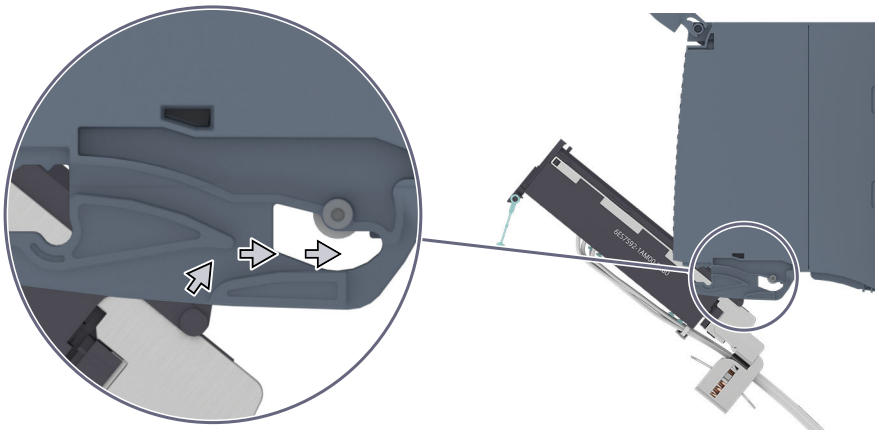


Figure 1-524 Bringing the front connector directly into final position

3. Tilt the front connector and press it into the I/O module until it latches. The front connector is now electrically connected with the I/O module.
4. Swivel the front cover down into place. Various latch positions are possible depending on the space requirement of the cable harness so that the required cable storage space can grow as needed.

8.11 Marking the I/O modules

8.11.1 Labeling strips

Introduction

Mark the pin assignment of the I/O modules using labeling strips. You can label the labeling strips as desired and slide them into the outside of the front cover.

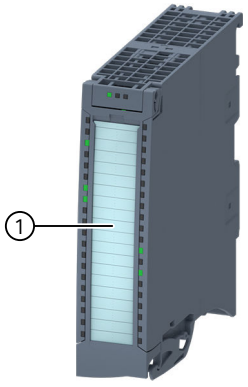
The labeling strips are available in the following models:

- Pre-prepared strips that are included with the I/O module as delivered.
- DIN A4 sheets, pre-perforated strips for machine printing; see section Accessories/spare parts (Page 406)

Preparing and installing the labeling strip

Proceed as follows to prepare and install the labeling strips:

1. Label the labeling strip.
   You can print labeling strips for the modules in your project with STEP 7. The labeling strips are exported to Microsoft Word DOCX files and printed from the text editing program. You can find more information in the online help.
2. With a pre-perforated strip: Separate the labeling strip from the sheet.
3. Slide the labeling strip into the outside of the front cover.



① Labeling strips

Figure 1-525 Marking with labeling strips

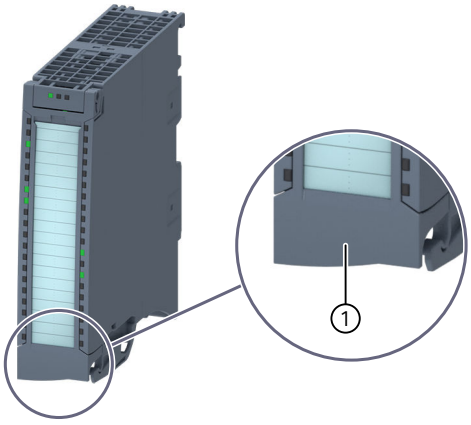
8.11.2 Optional marking

Introduction

The I/O modules have a free area on the front cover. You can label or mark the free area yourself.

Optional marking

The front cover provides about 30 mm x 10 mm of space in its lower part for an optional identifier label.



① Free space, for example for equipment identifiers

Figure 1-526 Optional marking

Configuring

9

Introduction

By configuring the individual hardware components, assigning their parameters, and connecting them, you communicate to the S7-1500 automation system/ET 200MP distributed I/O system its preset configuration and operating principle. You perform the work needed for this in the device and network views in STEP 7.

"**Configuring**" is understood to mean the arranging, setup and networking of devices and modules within the device view or network view of STEP 7. STEP 7 graphically represents modules and racks. Just like "real" module racks, the device view allows the insertion of a defined number of modules.

When the modules are inserted, STEP 7 automatically assigns the addresses and a unique hardware identifier (HW identifier). You can change the addresses later. The HW identifiers cannot be changed.

At startup, the system components compare the configured preset configuration with the actual configuration of the system. By means of parameter assignment, you can specify the response of the CPU to errors in the hardware configuration.

"**Assigning parameters**" is understood to mean setting the properties of the components used (CPU, modules).

STEP 7 compiles the hardware configuration (the result of "configuring" and "assigning parameters") and downloads it to the CPU. The CPU then connects to the configured components and transfers their configuration and parameters. Modules can be replaced very easily because when a new module is inserted, STEP 7 transfers its configuration and parameters again.

9.1 Configuring the CPU

Requirements for configuration of the CPU

Configuration software	Installation information
STEP 7 as of V12.0 [1)]	STEP 7 online help

1) The following CPUs can be configured as of V12: CPU 1511-1 PN, CPU 1513-1 PN, CPU 1516-3 PN/DP
Note that all other CPUs can be configured only as of a later version (for example, V12 SP1). Refer to the manual for the CPU to find out whether the version of the CPU you are using is configurable in STEP 7.

Spare parts compatibility for CPUs with article numbers ≥ 6ES751x-xxx03-0AB0

The following applies to the CPUs as of article number 6ES751x-xxx**10**-0AB0:
The CPUs have 2 ports at the PROFINET interface X2, but do not have a PROFIBUS DP interface. Therefore, these CPUs are not compatible with the CPUs with article numbers 6ES751x-xxx**0**x-0AB0 with regard to spare parts.

The following applies to the CPUs as of the article numbers 6ES751x-xxx0**3**-0AB0:
The CPUs are compatible for use with CPUs with article numbers ≥ 6ES751x-xxx0**1**-0AB0 with regard to spare parts.

You cannot download STEP 7 projects that have a hardware configuration with CPU article number 6ES751x-xxx0**0**-0AB0 to a CPU with article number 6ES751x-xxx0**3**-0AB0.

Solution: When replacing a CPU 6ES751x-xxx0**0**-0AB0 with a successor type 6ES751x-xxx0**3**-0AB0, you must upgrade the STEP 7 project to ≥ 6ES751x-xxx01-0AB0. For the upgrade, use STEP 7 ≥ V13 SP1 Update 3.

Replace CPUs with article numbers ≥ 6ES751x-xxx10-0AB0 in STEP 7

S7-1500 CPUs as of article numbers 6ES751x-xxx10-0AB0 have 2 ports at the PROFINET interface X2, but do not have a PROFIBUS DP interface. If, for example, you replace a CPU 1517-3 PN/DP by a CPU 1517-3 PN (article number: 6ES7517-3AQ**10**-0AB0), use the function "Change device" for the exchange in STEP 7. More information on this function is available in the STEP 7 online help.

Configuring CPUs with article numbers < 6ES751x-xxx03-0AB0 in older STEP 7 versions

CPUs with article numbers < 6ES751x-xxx0**3**-0AB0 are compatible with their predecessor version in terms of spare parts. Manipulation protection, particularly with respect to the SIMATIC Memory Card and RUN/STOP function, is retained.

When replacing a CPU (for example, 6ES7515-2AM01-0AB0) with a compatible successor type (for example, 6ES7515-2AM02-0AB0), the STEP 7 project does not have to be changed, nor is it necessary to upgrade the STEP 7 project.

You can still configure modules with new article numbers in STEP 7 as the predecessor version (for example, 6ES7515-2AM01-0AB0). Because the new article number (for example, 6ES7515-2AN03-0AB0) is not yet contained in previous STEP 7 versions, you can also configure the CPU as a predecessor version, i.e. with the predecessor article number (for example, 6ES7515-2AM01-0AB0).

References

- If you want to configure new CPUs whose article numbers are not yet included in the hardware catalog of STEP 7, please refer to the following FAQ in the Internet (https://support.industry.siemens.com/cs/ww/en/view/109760846).
- If you want to load project data, but the firmware version installed in the CPU cannot be selected in STEP 7, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109744163).
- If the supplied module has an article number different to the one which was ordered, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109763472).

- If you are searching for the successor product for a totally discontinued module and information on its compatibility, take the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109826566/en) into account.
- You can find an overview of the most important documents and links to STEP 7 in the following FAQ on the Internet (https://support.industry.siemens.com/cs/de/de/view/65601780/en).

9.1.1 Reading out the configuration

Introduction

When there is a connection to an existing CPU that is being installed, you can load the configuration of this CPU, including centrally present modules, from the device into your project using the "Hardware detection" function. You do not need to manually configure the CPU and the centrally present modules, as the physical configuration is read out automatically.

If you have already configured a CPU and the centrally present modules and you want to load the current configuration and parameters in a new project, it is advisable to use the "Upload device as new station" function. For additional information about this function, refer to section Backing up and restoring the CPU configuration (Page 326).

Procedure for reading out an existing configuration

1. Create a new project and configure an "Unspecified CPU 1500".

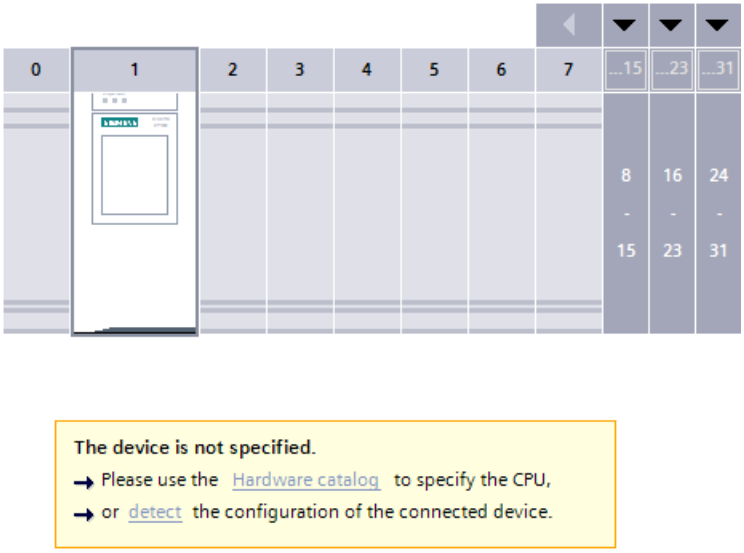


Figure 1-527 Unspecified S7-1500 CPU in the device view

NOTE

To open the "Hardware detection for PLC_x" dialog, click the "Detect" link. An example can be found in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/de/view/41885693/en).
An alternative procedure is described in step 2 and step 3.

2. In the device view (or network view), select the "Hardware detection" command in the "Online" menu.

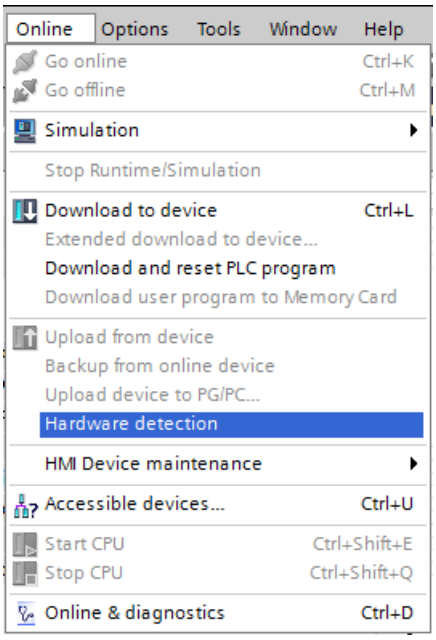


Figure 1-528 Hardware detection in the Online menu

STEP 7 opens the "Hardware detection for PLC_x" dialog box.

3. In the "Hardware detection for PLC_x" dialog, click "Refresh". Then, select the CPU and click "Detect".

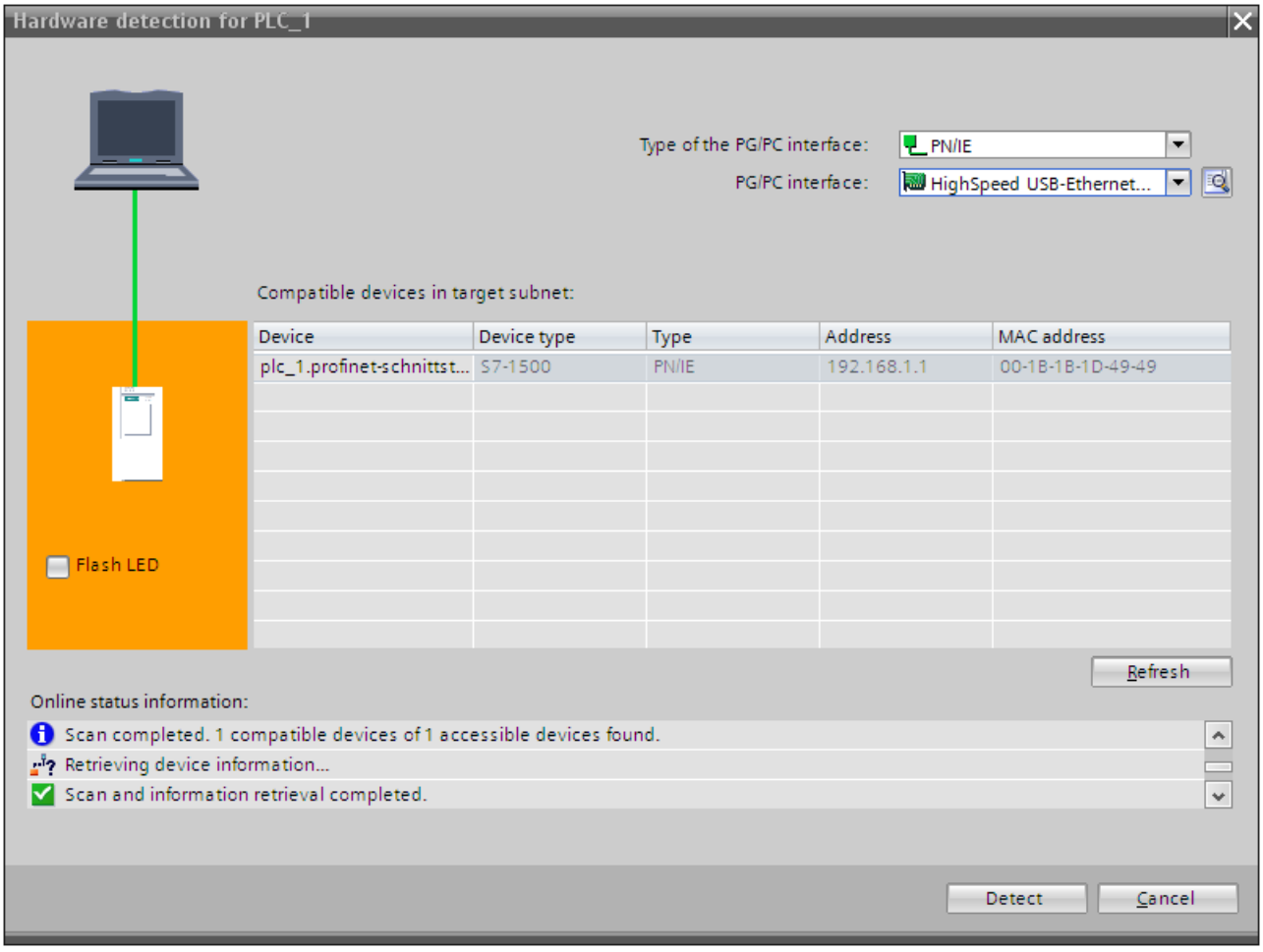


Figure 1-529 Hardware detection dialog box

Result of the hardware detection

STEP 7 has read out the hardware configuration and the modules and transferred them to your project. STEP 7 assigns a valid default parameter assignments for all modules. You can change the parameter assignment subsequently.

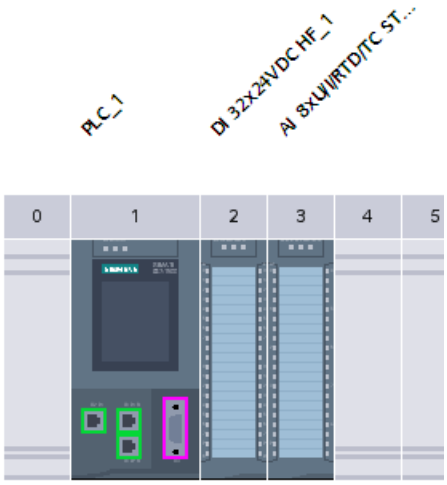


Figure 1-530 Result of the hardware detection in the device view

NOTE

If you want to go online after the hardware detection, you have to first download the detected configuration to the CPU; otherwise, an error may occur due to inconsistent configurations.
You can find an example of downloading a project to the CPU with STEP 7 in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/de/view/42637263/en).

Properties of the CPUs

The properties of the CPUs have special significance for system behavior. For a CPU you can make the following settings in STEP 7, for example:

- Startup characteristics
- Parameter assignment of the interfaces, for example, IP address, subnet mask
- Web server, e.g., activation, user administration, and languages
- OPC UA server
- Global Security Certificate Manager
- Cycle times, e.g., maximum cycle time
- Properties for the operation of the display
- System and clock memory
- Protection level for access protection with assigned password parameter
- Time and day settings (daylight saving/standard). For additional information, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/de/view/43566349/en).

The properties that can be set and the corresponding value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the STEP 7 online help and in the manuals of the relevant CPUs.

9.1.2 Address assignment

9.1.2.1 Addressing - overview

Introduction

In order to address the automation components or modules, they must have unique addresses. The following section explains the various address areas.

I/O address

I/O addresses (input/output addresses) are required in the user program to read inputs and set outputs.

STEP 7 automatically assigns input and output addresses when modules are configured. Each module uses a continuous range of input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q address	Type	Article no.
	0	100				
PS 25W 24VDC_1	0	0			PS 25W 24VDC	6ES7 505-0KA00-0AB0
▸ PLC_1	0	1			CPU 1518-4 PN/DP	6ES7 518-4AP00-0AB0
DI 32x24VDC HF_1	0	2	0...3		DI 32x24VDC HF	6ES7 521-1BL00-0AB0
DQ 8x230VAC/5A ST_1	0	3		0	DQ 8x230VAC/5A ST	6ES7 522-5HF00-0AB0
AI 8xU/I/RTD/TC ST_1	0	4	4...19		AI 8xU/I/RTD/TC ST	6ES7 531-7KF00-0AB0
AQ 4xU/I ST_1	0	5		1...8	AQ 4xU/I ST	6ES7 532-5HD00-0AB0

Figure 1-531 Example with input / output addresses from STEP 7

STEP 7 assigns the address areas of the modules by default to the process image partition 0 ("Automatic updating"). This process image partition is updated in the main cycle of the CPU.

Device address (e.g., Ethernet address)

Device addresses are addresses of modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required to address the various devices on a subnet, for example, to download a user program.

Hardware identifier

STEP 7 automatically assigns a hardware identifier (HW identifier) for identification and addressing of modules and submodules. The HW identifier is used, for example, for diagnostics alarms or for instructions, to identify the faulty module or the addressed module.

The "System constants" tab contains all hardware identifiers and their symbolic names (of HW identifier) for the selected module.

The HW identifiers and names of all modules of a device are also available in the default tag table on the "System constants" tab.

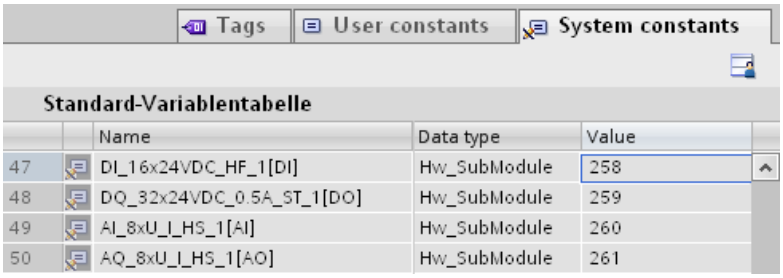


Figure 1-532 Example of a default tag table from STEP 7

9.1.2.2 Addressing digital modules

Introduction

The following section describes the addressing of the digital modules. In your user program, you require the addresses of the channels of the digital module.

Digital module addresses

The address of a digital module's input or output is composed of the byte address and the bit address. The channels of the digital module are assigned bit addresses.

Example: **I 1.2**

The example consists of:

I	Input	-
1	Byte address	The byte address depends on the module start address
2	Bit address	You read the bit address from the module

When you insert a digital module into a free slot, STEP 7 assigns a default address. You can change the proposed default address in STEP 7.

Example for the assignment of channel addresses (digital module)

The following figure shows how the addresses of the individual channels of the digital input module are determined.

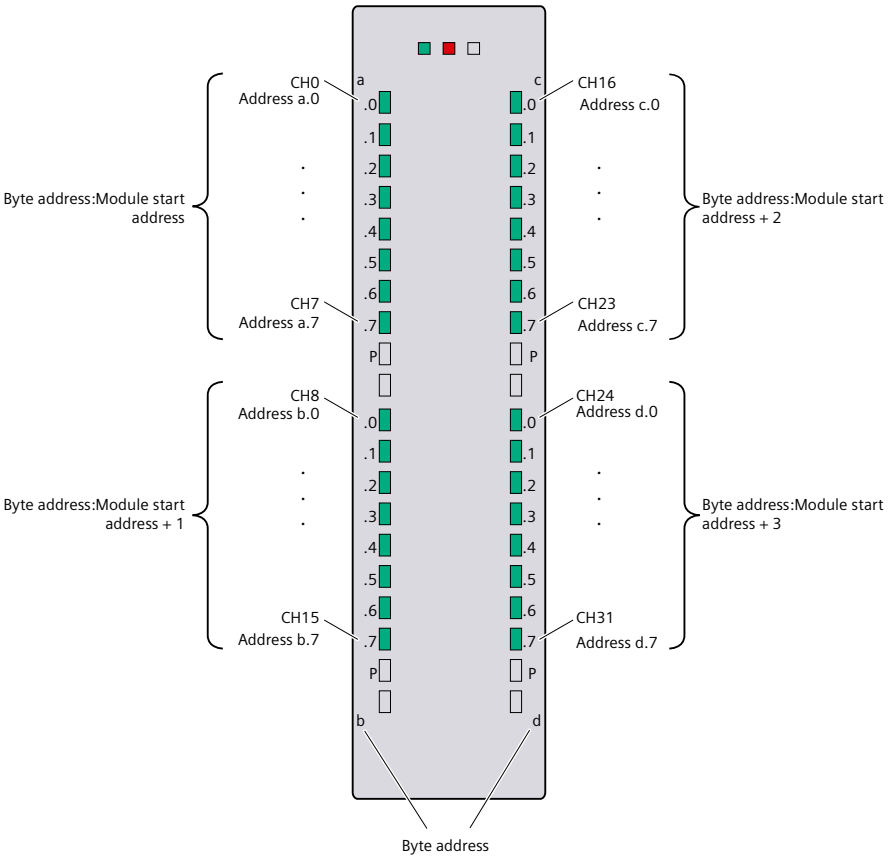


Figure 1-533 Example for the assignment of channel addresses (digital module)

NOTE

You can assign symbolic names to the addresses at the following locations in STEP 7:

- PLC tag table
- Properties of the module in the "IO Tags" tab.

Value status

The value status is additional binary information of a digital input or output signal. It is entered simultaneously with the process signal in the process image input and provides information about the validity of the input or output signal.

The value status of a module informs you whether the value of the corresponding channel can be read or output. You can respond to this information with simple binary operations in the user program without having to evaluate the diagnostics information of the module for this. Configured diagnostics in STEP 7 is not necessary for output of the value status.

If you enable the value status for a digital module, then additional bytes are allocated in the input address area. Each bit in the value status is assigned to a channel and provides

information about the validity of the process value. You can find the assignment in the product manual for the respective I/O module.

The value status is influenced by all diagnostics that might falsify the process value, e.g. wire break, short-circuit.

- 1_B: A valid process value is being output or read for the channel.
- 0_B: A substitute value is being output for the channel, or the channel is deactivated, faulty or inaccessible.

You can find more information on evaluation and processing of the value status for fail-safe digital modules in the SIMATIC Safety – Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) manual.

Reference

More information on addressing and address allocation with value status can be found in the manuals of the digital modules, and in the online help for STEP 7. An example of the evaluation of the value status in the user program is available in the function manual Diagnostics (https://support.automation.siemens.com/WW/view/en/59192926).

9.1.2.3 Addressing analog modules

Introduction

The following section describes the addressing of the analog modules. In your user program, you require the addresses of the channels of the analog module.

Analog module addresses

The address of an analog channel is always a word address. The channel address depends on the module start address. STEP 7 automatically assigns the channel addresses during configuration. Based on the module start addresses, STEP 7 assigns the channel addresses in increasing sequence (in the following figure, the module start address is 256).

When you insert an analog module into a free slot, STEP 7 assigns a default address. You can change the assigned default address in STEP 7.

Example for the assignment of channel addresses (analog module)

The following figure shows how the addresses of the individual channels of an analog input module are determined when the module has the start address 256.

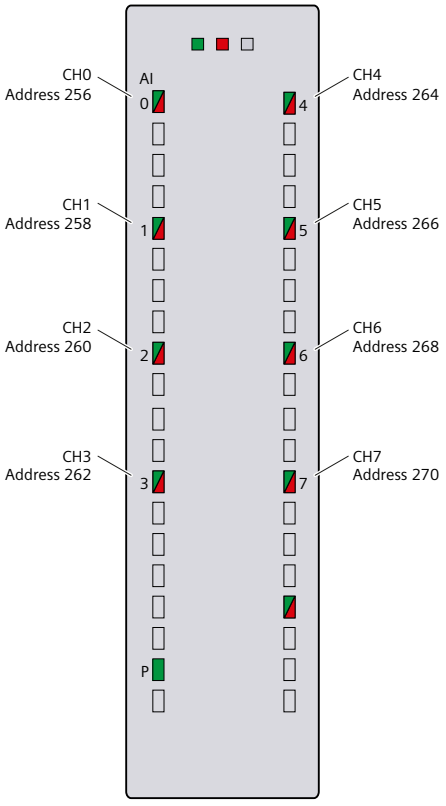


Figure 1-534 Example for the assignment of channel addresses (analog module)

NOTE

You can assign symbolic names to the addresses at the following locations in STEP 7:

- PLC tag table
- Properties of the module in the "IO Tags" tab.

Value status

The value status is additional binary information of an analog input or output value. It is entered simultaneously with the process value in the process image input and provides information about the validity of the analog value.

The value status of a module informs you whether the value of the corresponding channel can be read or output. You can respond to this information with simple binary operations in the user program without having to evaluate the diagnostics information of the module for this. Configured diagnostics in STEP 7 is not necessary for output of the value status.

If you enable the value status for an analog module, then additional bytes are allocated in the input address area. Each bit in the value status is assigned to a channel and provides information about the validity of the process value. You can find the assignment in the product manual for the respective I/O module.

The value status is influenced by all diagnostics that might falsify the process value, e.g. wire break, short-circuit.

- 1_B: A valid process value is being output or read for the channel.
- 0_B: A substitute value is being output for the channel, or the channel is deactivated, faulty or inaccessible.

Reference

More information on addressing and address allocation with value status can be found in the manuals of the analog modules, and in the online help for STEP 7. A detailed description of the value status for analog modules is available in the function manual Analog value processing (https://support.automation.siemens.com/WW/view/en/67989094). An example of the evaluation of the value status in the user program is available in the function manual Diagnostics (https://support.automation.siemens.com/WW/view/en/59192926).

9.1.3 Process images and process image partitions

9.1.3.1 Process image - overview

Process image of the inputs and outputs

The process image of the inputs and outputs is an image of the signal states. The CPU transfers the values from the input and output modules to the process image in this memory area. At the start of the cyclic program, the CPU transfers the process image output as a signal state to the output modules. The CPU then transfers the signal states of the input modules to the process image inputs.

Advantages of the process image

A process image accesses a consistent image of the process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The CPU does not update the process image until the next cycle.

Consistency of the process image

When the process image is updated, the S7-1500 accesses the data of each submodule as consistent data. The maximum data width that is accessed as consistent data for each submodule is dependent on the IO system. For PROFINET IO, for example, this data width is 1024 bytes.

32 process image partitions

By means of process image partitions, the CPU synchronizes the updated inputs/outputs of particular modules with defined user program sections.

In the S7-1500 automation system, the overall process image is subdivided into up to 32 process image partitions (PIP).

The CPU automatically updates PIP 0 (automatic update) in each program cycle and assigns it to OB 1.

You can assign the process image partitions PIP 1 to PIP 31 to the other OBs during configuration of the input/output modules.

The CPU always reads the process image partition of the inputs (PIPI) before processing the associated OB. The CPU outputs the process image of the outputs (PIPQ) at the end of the OB.

The figure below illustrates the updating of a process image partition.

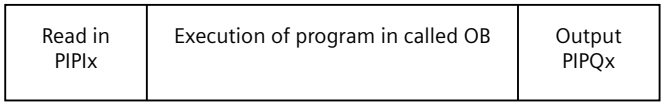


Figure 1-535 process image

9.1.3.2 Update process image partitions in the user program

Requirements

Alternatively, you can also use the following instructions to update process images:

- Instruction "UPDAT_PI"
- Instruction "UPDAT_PO"

You will find the instructions in STEP 7 in the "Instructions" task card under "Extended instructions". The instructions can be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

- The process image partitions must not be assigned to any OB. This means the process image partitions are not automatically updated.

NOTE

Update of PPI 0

PIP 0 (automatic update) cannot be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: Update process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: Update process image partition of the outputs

With this instruction you transmit the process image partition of the outputs to the output modules.

Isochronous mode interrupt OBs

In the isochronous mode interrupt OBs you use the instructions "SYNC_PI" and "SYNC_PO" to update the process image partitions. Additional information on isochronous mode interrupt OBs is available in the STEP 7 online help.

Direct I/O access to the inputs and outputs of the module

You also have direct read and write access to the I/O, as an alternative to access via the process image, should direct access be required for programming reasons. A direct (write) I/O access also writes the process image. This prevents the situation where a subsequent output of the process image overwrites the value written via direct access again.

Reference

Additional information on process image partitions is available found in the function manual, Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

9.2 Configuring ET 200MP distributed I/O system

Introduction

You configure and assign parameters to the ET 200MP (interface module and I/O modules) with STEP 7 or in the configuration software of another manufacturer.

Requirements

Table 1-821 Requirements for installation

Configuration software	Requirements	Installation information
STEP 7 as of V13 [1]	• IM 155-5 PN ST and IM 155-5 DP ST: as of firmware version V2.0.0 • IM 155-5 PN HF: as of firmware version V1.0.0 • IM 155-5 MF HF: Firmware version V5.0.0 or higher • PROFINET: PROFINET GSD files (https://support.industry.siemens.com/cs/ww/de/view/68189683/en?dl=en) • PROFIBUS: PROFIBUS GSD files (https://support.industry.siemens.com/cs/de/de/view/80206700/en?dl=en)	• The TIA Portal supports the following GSDML specifications: – TIA Portal V11: V2.3 – TIA Portal V12SP1: V2.31 – TIA Portal V14: V2.32 – TIA Portal V15: V2.34 • The GSDML versions are largely downwards compatible. • The ET 200MP is already delivered with a GSD file based on specification V2.3. The GSD file can be installed and used in the TIA Portal. STEP 7 online help
STEP 7 V5.5 SP4 HF1 or higher	• PROFINET: PROFINET GSD files (https://support.automation.siemens.com/WW/view/en/19698639/13000-0) • PROFIBUS: PROFIBUS GSD files (https://support.automation.siemens.com/WW/view/en/10805317/13330-0)	STEP 7 online help
Software of another manufacturer		Manufacturer documentation

[1] STEP 7 does not support all the PROFINET features contained in the GSDML specifications. Non-supported features cannot be used with GSD devices.

Reference

You can find an overview of the most important documents and links to STEP 7 in the following FAQ on the Internet (https://support.industry.siemens.com/cs/de/de/view/65601780/en).

Configuring operation on PROFIBUS DP using a GSD file

If you want to configure the operation on the PROFIBUS DP with GSD file, you need to note the following additional requirements:

Table 1-822 Requirements for PROFIBUS DP with GSD file

I/O modules	Required firmware version IM 155-5 DP ST as of ...	Required firmware version I/O modules as of ...
Input/output modules 35 mm	V1.0.0	V2.0
Input/output modules 25 mm	V2.0.0	V1.0
Technology modules (TM)	V2.0.0	V1.1
Communications modules CM PtP	V1.0.0	V1.0.1

9.3 Assigning PROFIsafe address to fail-safe modules with SIMATIC Safety

The PROFIsafe address is saved permanently on the electronic coding element of the S7-1500/ET 200MP fail-safe modules. You can find additional information on the electronic coding element in the section Replacing the coding element at the power connector of the system power supply and load current supply (Page 358).

NOTE

The supply voltage L+ must be applied to the F-module during the assignment of the PROFIsafe address (F-destination address together with F-source address).

For additional information on assigning the PROFIsafe address (F-destination address together with the F-source address), refer to the SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) programming and operating manual and the online help.

Basics of program execution

10

10.1 Events and OBs

Triggers

The table below gives an overview of the possible event sources for start events and their OBs.

Table 1-823 Triggers

Event sources	Possible priorities (default priority)	Possible OB numbers	Default system reaction [1]	Number of OBs
Startup [2]	1	100, ≥ 123	Ignore	0 to 100
Cyclic program [2]	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt [2]	2 to 24 (2)	10 to 17, ≥ 123	Not applicable	0 to 20
Time-delay interrupt [2]	2 to 24 (3)	20 to 23, ≥ 123	Not applicable	0 to 20
Cyclic interrupt [2]	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	Not applicable	0 to 20
Hardware interrupt [2]	2 to 26 (16)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Isochronous mode interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error [3]	22	80	Ignore	0 or 1
Maximum cycle time exceeded once			STOP	
Diagnostic interrupt	2 to 26 (5)	82	Ignore	0 or 1
Removal/insertion of modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1
MC_Servo [4]	17 to 26 (26)	91	Not applicable	0 or 1
MC_PreServo [4]	corresponds to MC_Servo priority	67	Not applicable	0 or 1
MC_PostServo [4]	corresponds to MC_Servo priority	95	Not applicable	0 or 1
MC_Interpolator [4]	16 to 26 (24)	92	Not applicable	0 or 1
MC_PreInterpolator [4]	corresponds to MC_Interpolator priority	68	Not applicable	0 or 1
MC_LookAhead [4]	15 to 16 (15)	97	Not applicable	0 or 1

Event sources	Possible priorities (default priority)	Possible OB numbers	Default system reaction [1]	Number of OBs
MC_Transformation [4]	17 to 25 (25)	98	Not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

1) If you have not configured the OB.

2) For these event sources, apart from the permanently assigned OB numbers (see column: possible OB numbers), you can also assign OB numbers from the range ≥ 123 in STEP 7.

3) If the maximum cycle time has been exceeded twice within a cycle, the CPU always switches to STOP regardless of whether you have configured OB80.

4) For more information about these event sources and the runtime behavior, see the S7-1500/S7-1500T Motion Control Function Manuals.

Response to start events

The occurrence of a start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. The event enters the queue according to its priority.
- If the event comes from an event source to which you have not assigned an OB, the CPU executes the default system reaction.

NOTE

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

Assignment between event source and OBs

The type of OB determines where you assign OB to event source:

- For hardware interrupts and isochronous mode interrupts: The assignment is made during the configuration of the hardware or when the OB is created.
- With MC_Servo, MC_PreServo, MC_PostServo, MC_Interpolator and MC_PreInterpolator: Automatic assignment of OBs 91/92 by STEP 7 as soon as you add a technology object.
- For all other OB types: Assignment when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment changes, and not the configured assignment. The configured assignment takes effect after loading, and upon each startup.

The CPU ignores hardware interrupts to which you did not assign an OB in your configuration or which occur after the DETACH instruction. The CPU does not check whether an OB is assigned to this event when an event arrives, but only prior to the actual processing of the hardware interrupt.

OB priority and runtime behavior

If you have assigned an OB to the event, the OB has the priority of the event. S7-1500 CPUs support the priority classes 1 (lowest) to 26 (highest). The following items are essential to the execution of an event:

- Call and execution of the assigned OB
- The update of the process image partition of the assigned OB

The user program processes the OBs exclusively on a priority basis. This means the program processes the OB with the highest priority first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. The user program processes events of the same priority in order of occurrence.

NOTE

Communication

The communication (for example, test functions with the PG) always works with priority 15. To avoid unnecessarily prolonging the program runtime in the case of time-critical applications, make sure that these OBs are not interrupted or delayed by the communication. Assign a priority > 15 for these OBs.

Programming guideline and programming style guide

The programming guideline contains many recommendations and tips for optimal programming of the S7-1500 automation system.

The programming guidelines described in the programming style guide help you to create a uniform program code. You can better maintain and reuse the uniform program code. This allows you to detect or avoid errors early on, for example, through compilers.

You can find the programming guideline and programming style guide on the Internet (https://support.industry.siemens.com/cs/us/en/view/81318674).

Reference

More information on organization blocks is available in the STEP 7 online help.

10.2 Asynchronous instructions

Introduction

Program execution makes a distinction between synchronous and asynchronous instructions.

The "synchronous" and "asynchronous" properties relate to the temporal relationship between the call and execution of the instruction.

The following applies to synchronous instructions: When the call of a synchronous instruction is complete, execution of the instruction is also complete.

This is different in the case of asynchronous instructions: When the call of an asynchronous instruction is complete, execution of the asynchronous instruction is not necessarily complete yet. This means the execution of an asynchronous instruction can extend over multiple calls.

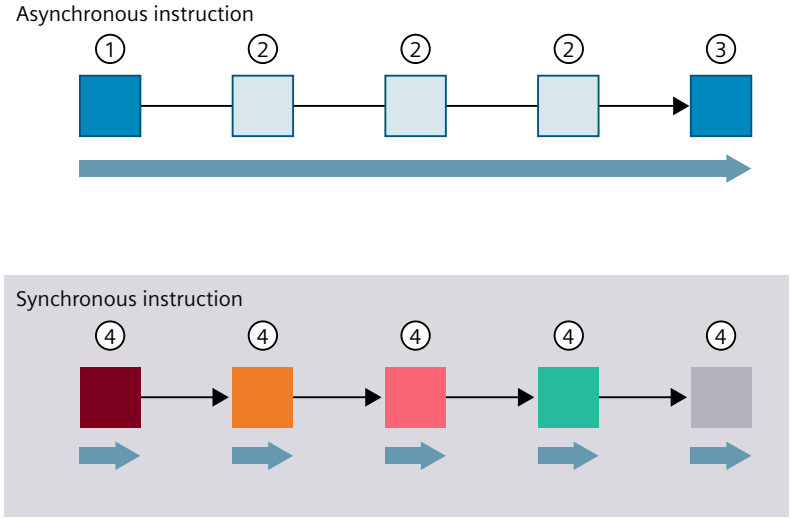
The CPU processes asynchronous instructions in parallel with the cyclic user program. Asynchronous instructions generate jobs in the CPU for their processing.

Asynchronous instructions are usually instructions for transferring data, for example data records for modules, communication data, or diagnostics data.

Difference between synchronous/asynchronous instructions

The figure below shows the difference between the processing of an asynchronous instruction and a synchronous instruction. In this figure the CPU calls the asynchronous instruction five times before its execution is complete, for example, a data record has been completely transferred.

In the case of a synchronous instruction, this is completely executed with each call.



① First call of the asynchronous instruction, start of execution
② Intermediate call of the asynchronous instruction, execution continues.
③ Last call of the asynchronous instruction, completion of execution
④ A job is fully processed by a synchronous instruction with each call.
➡ Duration of a fully processed job

Figure 1-536 Difference between asynchronous and synchronous instructions

Parallel processing of asynchronous instruction jobs

A CPU can process several asynchronous instruction jobs in parallel. The CPU processes the jobs in parallel under the following conditions:

- Jobs for an asynchronous instruction are started while other jobs for that instruction are still running.
- The maximum number of simultaneously running jobs for the instruction is not exceeded.

The figure below shows the parallel processing of two jobs of the WRREC instruction. The two instructions are executed simultaneously for a certain duration.

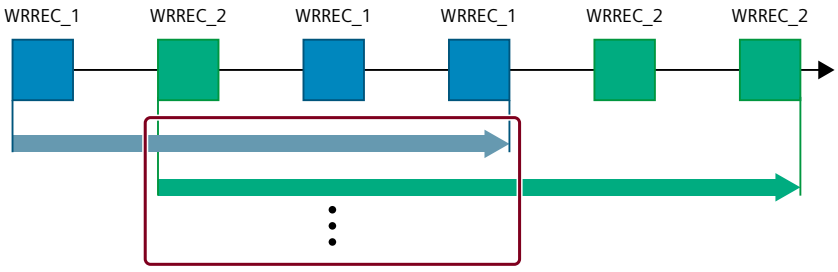


Figure 1-537 Parallel processing of the asynchronous instruction WRREC

NOTE

Dependencies between asynchronous instructions

The call sequence in the user program may differ from the processing sequence of the asynchronous instructions. This can lead to problems with dependencies between asynchronous instructions.

Solution: To ensure correct timing of processing, use the status outputs of the asynchronous instructions in a sequencer. The next asynchronous instruction should only start when an asynchronous instruction is completed and this is acknowledged via the parameter DONE.

Example: For the RecipeImport and RecipeExport recipe phases, you need a CSV file for the recipe data. If you use the same CSV file for import and export, then the two asynchronous instructions are interdependent. In a sequencer, link the status of the DONE parameter of the RecipeImport instruction in the transition to the next step where the RecipeExport is executed. The link thus ensures correct processing.

Assigning calls of an instruction to a job

To execute an instruction over multiple calls, the CPU must be able to uniquely relate a subsequent call to a running job of the instruction.

To relate a call to a job, the CPU uses one of the following two mechanisms, depending on the type of the instruction:

- Using the instance data block of the instruction (for "SFB" type)
- Using job-identifying input parameters of the instruction. These input parameters must match in each call during processing of the asynchronous instruction.
  Example: A job of the "Create_DB" instruction is identified by input parameters LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB and SRCBLK.

  The following table shows which input parameters you use to identify which instruction.

Table 1-824 Identifying input parameters for asynchronous instructions

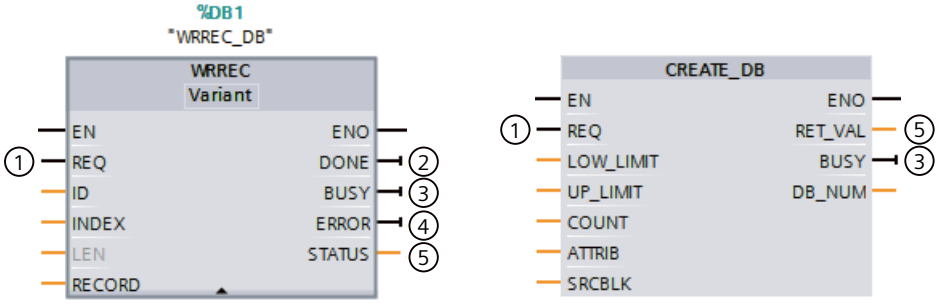
Instruction	Job is identified by
DPSYC_FR	LADDR, GROUP, MODE
D_ACT_DP	LADDR
DPNRM_DG	LADDR
WR_DPARM	LADDR, RECNUM
WR_REC	LADDR, RECNUM

Instruction	Job is identified by
RD_REC	LADDR, RECNUM
CREATE_DB	LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB, SRCBLK
READ_DBL	SRCBLK, DSTBLK
WRIT_DBL	SRCBLK, DSTBLK
RD_DPARA	LADDR, RECNUM
DP_TOPOL	DP_ID

Status of an asynchronous instruction

An asynchronous instruction shows its status via the block parameters STATUS/RET_VAL and BUSY. Many asynchronous instructions also use the block parameters DONE and ERROR.

The figure below shows the two asynchronous instructions WRREC and CREATE_DB.



① The input parameter REQ starts the job to execute the asynchronous instruction.
② The output parameter DONE indicates that the job was completed without error.
③ The output parameter BUSY indicates whether the job is currently being executed. When BUSY=1, a resource is allocated for the asynchronous instruction. When BUSY= 0, the resource is free.
④ The output parameter ERROR indicates that an error has occurred.
⑤ The output parameter STATUS/RET_VAL provides information on the status of the job execution. The output parameter STATUS/RET_VAL receives the error information after the occurrence of an error.

Figure 1-538 Block parameters of asynchronous instructions using the instructions WRREC and CREATE_DB as examples.

Summary

The table below provides you with an overview of the relationships described above. It shows in particular the possible values of the output parameters if execution of the instruction is not complete after a call.

NOTE

You must evaluate the relevant output parameters in your program after each call

Table 1-825 Relationship between REQ, STATUS/RET_VAL, BUSY and DONE during a "running" job.

Seq. no. of the call	Type of call	REQ	STATUS/RET_VAL	BUSY	DONE	ERROR
-	Idle	0	W#16#7000	0	0	0
1	First call	1	W#16#7001	1	0	0
			Error code (for example, W#16#80C3 for lack of resources)	0	0	1
2 to (n - 1)	Intermediate call	Not relevant	W#16#7002	1	0	0
n	Last call	Not relevant	W#16#0000, if no errors have occurred.	0	1	0
			Error code if errors occurred.	0	0	1

Use of resources

Asynchronous instructions use resources in the CPU during their execution. The resources are limited depending on the type of CPU and instruction. The CPU can only simultaneously process a set maximum number of asynchronous instruction jobs. The resources are available again after a job has been processed successfully or with errors.

Example: For the RDREC instruction, an S7-1500 CPU can process up to 20 jobs in parallel.

If the maximum number of concurrent jobs for an instruction is exceeded, the following occurs:

- The instruction returns the error code 80C3 (lack of resources) in the block parameter STATUS.
- The CPU stops execution of the job until a resource becomes free again.

NOTE

Lower-level asynchronous instructions

Some asynchronous instructions use one or more lower-level asynchronous instructions for their processing. This dependence is shown in the tables below.

Please note that each lower-level instruction typically occupies one resource in the instruction's resource pool.

Extended instructions: maximum number of simultaneously running jobs

Table 1-826 Maximum number of simultaneous jobs for asynchronous extended instructions and lower-level instructions used

Extended instructions	1505SP (F) 1505SP T(F)	1511(F) 1511C 1511T(F)	1507S(F) 1512C 1513(F)	1515(F) 1515T(F)	1516(F) 1516T(F)	1517(F) 1517T(F)	1518(F) 1518T(F) 1518(F) MFP
Distributed I/O							
RDREC	20						
RD_REC	10						

Extended instructions	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**	**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**	**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
WRREC	20						
WR_REC	10						
D_ACT_DP	8						
ReconfigIOSystem	uses RDREC, WRREC, D_ACT_DP,						
DPSYC_FR	2						
DPNRM_DG	8						
DP_TOPOL	1						
ASI_CTRL	uses RDREC, WRREC						
PROFIenergy							
PE_START_END	uses RDREC, WRREC						
PE_CMD	uses RDREC, WRREC						
PE_DS3_Write_ET200S	uses RDREC, WRREC						
PE_WOL	uses RDREC, WRREC, TUSEND, TURCV, TCON, TDISCON						
Module parameter assignment							
RD_DPAR	10						
RD_DPARA	10						
RD_DPARM	10						
WR_DPARM	10						
Diagnostics							
Get_IM_Data	10						
GetStationInfo	10						
Recipes and data logging							
RecipeExport	10						
RecipeImport	10						
DataLogCreate	10						
DataLogOpen	10						
DataLogWrite	10						
DataLogClear	10						
DataLogClose	10						
DataLogDelete	10						
DataLogNewFile	10						
Data block functions							
CREATE_DB	10						
READ_DBL	10						
WRIT_DBL	10						
DELETE_DB	10						
File handling							
FileReadC	10						
FileWriteC	10						

Extended instructions	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**	**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**	**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
Reference information							
ResolveSymbols	10						
GetSymbolForReference	10						

Basic instructions: maximum number of simultaneously running jobs

Table 1-827 Lower-level instructions used for asynchronous basic instructions

Basic instructions	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**	**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**	**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
Array DB							
ReadFromArrayDBL	uses READ_DBL (see Extended instructions)						
WriteToArrayDBL	uses READ_DBL, WRIT_DBL (see Extended instructions)						

Communication: maximum number of simultaneously running jobs

Table 1-828 Maximum number of simultaneous jobs for asynchronous instructions and lower-level instructions used for Open User Communication

Open User Communication	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**		**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**		**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
		Up to V2.9x	**V3.0 and higher**		**Up to V2.9x**	**V3.0 and higher**			
TSEND TUSEND	88	96	128	128	192	256	256	320	384
TRCV TURCV	88	96	128	128	192	256	256	320	384
TCON	88	96	128	128	192	256	256	320	384
TCONSettings	88	96	128	128	192	256	256	320	384
TDISCON	88	96	128	128	192	256	256	320	384
T_RESET	88	96	128	128	192	256	256	320	384
T_DIAG	88	96	128	128	192	256	256	320	384
T_CONFIG	1								
TSEND_C	Uses TSEND, TUSEND, TRCV, TCON, TDISCON								
TRCV_C	Uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON								
TMAIL_C	Uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON								

Table 1-829 Lower-level instructions used for asynchronous instructions for MODBUS TCP

MODBUS TCP	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**	**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**	**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
MB_CLIENT	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON						
MB_SERVER	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON						

Table 1-830 Maximum number of simultaneously running jobs for asynchronous instructions for S7 communication. The S7 communication instructions use a common pool of resources

S7 communication	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**		**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**		**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
		Up to V2.9x	**V3.0 and higher**		**Up to V2.9x**	**V3.0 and higher**			
PUT GET USEND URCV BSEND BRCV	264	288	384	384	576	768	768	960	1 152

Table 1-831 Lower-level instructions used for asynchronous instructions for communications processors

Communications processors	**1505SP (F) 1505SP T(F)**	**1511(F) 1511C 1511T(F)**	**1507S(F) 1512C 1513(F)**	**1515(F) 1515T(F)**	**1516(F) 1516T(F)**	**1517(F) 1517T(F)**	**1518(F) 1518T(F) 1518(F) MFP**
PtP communication							
Port_Config	uses RDDEC, WRREC						
Send_Config	uses RDDEC, WRREC						
Receive_Config	uses RDDEC, WRREC						
Send_P2P	uses RDDEC, WRREC						
Receive_P2P	uses RDDEC, WRREC						
Receive_Reset	uses RDDEC, WRREC						
Signal_Get	uses RDDEC, WRREC						
Signal_Set	uses RDDEC, WRREC						
Get_Features	uses RDDEC, WRREC						
Set_Features	uses RDDEC, WRREC						
USS communication							
USS_Port_Scan	uses RDDEC, WRREC						
MODBUS (RTU)							
Modbus_Comm_Load	uses RDDEC, WRREC						
ET 200S serial interface							
S_USSI	uses CREATE_DB						
SIMATIC NET CP							
FTP_CMD	uses TSEND, TRCV, TCON, TDISCON						

Maximum number of simultaneously running jobs for asynchronous instructions for OPC UA.

The maximum number of simultaneously running jobs for asynchronous instructions for OPC UA can be found in the respective equipment manual in the technical specifications section or on the Internet (https://sieportal.siemens.com/su/blVMV).

For the OPC UA instructions for session management or data access, you need the following values from the technical specifications to calculate the maximum number of jobs running at the same time:

- Number of connections, max.
- Number of simultaneous calls of the client instructions for session management, per connection, max.
- Number of simultaneous calls of the client instructions for data access, per connection, max.

In addition to the OPC UA instructions, the following table shows the use and calculation of the maximum number of jobs running at the same time.

OPC UA instruction	Use	Calculation
OPC_UA_Connect	Session management	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for session management, per connection, max."
OPC_UA_NamespaceGetIndexList		
OPC_UA_NodeGetHandleList		
OPC_UA_MethodGetHandleList		
OPC_UA_TranslatePathList		
OPC_UA_NodeReleaseHandleList		
OPC_UA_MethodReleaseHandleL-ist		
OPC_UA_Disconnect		
OPC_UA_ConnectionGetStatus		
OPC_UA_ReadList	Data access	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for data access, per connection, max."
OPC_UA_WriteList		
OPC_UA_MethodCall		The value can be taken directly from the technical specifications.

Technology: maximum number of simultaneously running jobs

Table 1-832 Maximum number of simultaneously running jobs for asynchronous instructions for technology. The instructions for technology use a common pool of resources.

Technology	1511(F) 1511C 1512C 1513(F) 1511T	1505SP (F) 1515(F) 1516(F) 1515T 1505SP T(F) 1516T(F)	1507S (F)	1517(F) 1517T(F)	1518(F) 1518(F) MFP 1518T(F)
S7-1500 Motion Control					
All Motion Control instruc-tions, such as MC-Power	300	1 500	3 000	4 800	6 400

Reference

You can find more information on block parameter assignment in the STEP 7 online help.

Protection

11

11.1 Overview of the protection functions

Advantages and customer benefits of protection functions

The protection functions listed protect your investments from unauthorized access and manipulation, helping to secure plant availability.

Protection functions

To set up secure networks, the SIMATIC S7-1500 automation system offers an integrated security concept:

Table 1-833 Overview of protection functions

Protection function	Description	S7-1500	ET 200MP
Integrity protection	The CPUs come with integrity protection functions as standard. These help detect any manipulations: • In the engineering data on the SIMATIC Memory Card; see also information on the integrity protection of the SIMATIC Memory Card as of CPU FW version V3.1 in the next section • In the engineering data during data transfer between TIA Portal and CPU • In the engineering data during data transfer between HMI system and CPU • In the encrypted firmware	✓	---
Protection of confidential configuration data	Protection of confidential CPU configuration data	✓	---
Central user management (as of FW version V4.0)	Connection of a central server (UMC server) that is responsible for the administration and authentication of users. The central user management UMC (User Management Component) allows management of user groups and users independently of TIA Portal for extensive automation solutions.	✓	---
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can use the local user management in the editor to manage all project users along with their rights (e. g. access rights) for project users and roles in the TIA Portal.	✓	---
Access protection (up to FW version V3.0)	Protection against unauthorized configuration changes using authorization levels	✓	---

Protection function	Description	S7-1500	ET 200MP
Know-how protection	Protection against unauthorized access and modifications to algorithms with password protection	✓	---
Copy protection	Protection against duplication of programs by linking individual blocks to the serial number of the original memory card on the SIMATIC Memory Card	✓	---
Protection by locking the CPU/interface module	Protection against unauthorized access by locking the front cover with a seal or a lock	✓	✓

You can find more information about security mechanisms of the SIMATIC automation systems in the Security with SIMATIC S7 controllers (https://support.industry.siemens.com/cs/ww/en/view/77431846) document and in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual.

Integrity protection of the SIMATIC Memory Card, as of CPU FW version V3.1 or higher

With CPUs as of FW version V3.1, the integrity protection of the SIMATIC Memory Card depends on the password for protecting confidential configuration data that you assigned during the configuration of the CPU. This results in the following changes when using SIMATIC Memory Cards:

- To transfer a CPU to a card reader/USB memory device via drag and drop:
  For CPUs as of FW version V3.1, you need to enter the password of the CPU you want to use with the SIMATIC Memory Card. If you enter an incorrect password, the CPU does not start booting after power on and reports the content of the SIMATIC Memory Card as faulty.
- To insert a CPU from a card reader/USB memory device:
  In order to be able to verify the integrity of the included configuration in STEP 7, you must enter the password of the CPU from which the project was loaded. In this case, STEP 7 checks the data on the SIMATIC Memory Card and reports potential damage.
  Entering the password is optional. If you do not want to use the integrity check, you do not need to enter the password (restore project).

For CPUs as of FW version V4.1, you can select whether you also want to protect the entire configuration of the CPU in addition to protecting the configuration data. The data is stored encrypted in the SIMATIC.S7S folder on the SIMATIC Memory Card and can only be decrypted with the password for protection of confidential configuration data.
If you revoke or add the setting for protection of all data, the contents of the SIMATIC.S7S folder on the SIMATIC Memory Card will be deleted at the next download to the CPU. Other files, such as recipes or backup files on the SIMATIC Memory Card, are not deleted. After the deletion, the CPU performs a restart.

You can find more information about the folder structure on the SIMATIC Memory Card in the "Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101)" Function Manual.

Secure communication

There is an increasing need to transfer data to external computers in encrypted form via Intranet or public networks.

SIMATIC S7-1500 CPUs and ET 200 CPUs with firmware version 2.0 or higher support the Internet PKI (RFC 5280) with STEP 7 as of V14. This makes the configuration and the operation of secure communication possible, for example:

- Hypertext Transfer Protocol Secure (HTTPS)
- Secure Open User Communication
- Secure communication with OPC UA

A public key infrastructure (PKI) can issue, distribute and check digital certificates. For S7-1500 CPUs, you create certificates for various applications in the CPU properties in STEP 7, for example: TLS certificates for Secure Open User Communication, web server certificates, OPC UA certificates.

SIMATIC S7-1500 CPUs and ET 200 CPUs from firmware version 2.9 support with STEP 7 and WinCC as of Version 17 innovated and standardized secure PG/PC and HMI communication – referred to as Secure PG/HMI communication for short.

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the S7-1500 CPU from external sources and via the network:

- Deactivation of the Web server
- Disabling the OPC UA server (you can find more information on the security mechanisms for OPC UA server in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual)
- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication
- Deactivation of SNMP

When you use the Web server, protect your S7-1500 automation system against unauthorized access:

- By setting password-protected access rights for specific users in the user administration.
- By using the pre-set option "Permit access only via HTTPS".
  The option allows access to the web server only with the secure hypertext transmission protocol HTTPS.

When you use the OPC UA server, protect your S7-1500 automation system against unauthorized access:

- By not setting up OPC UA server access for the "Anonymous" user.
- By disabling the "Automatically accept client certificates during runtime" option.

Security functions in communications processors

Communications processors support security functions, such as access protection using a firewall, protection against data manipulation using VPN, FTPS, HTTPS, SNMPv3, and secure NTP.

More information

You can find more information on the protection functions described in the STEP 7 online help.

Siemens products and solutions are only one element of a comprehensive industrial security concept. Observe the additional information on Industrial Security (http://www.siemens.com/industrialsecurity).

11.2 Protection of confidential configuration data

As of STEP 7 V17, you have the option of assigning a password for protecting confidential configuration data of the respective CPU. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols.

You can find detailed information on protecting confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

11.3 Local user management

11.3.1 Useful information on the local user administration and access control

As of TIA Portal version V19 and CPU firmware version V3.1, S7-1500 CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC).

For HMI devices, authentication is not possible via either local or central users (TIA Portal V19/V20).

From the versions mentioned above onwards, you manage all project users along with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles of the project in the TIA Portal:

- To manage users along with their rights, for example to control access rights, navigate to the "Security settings > Users and roles" area in the project tree.

TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs.

After loading the configuration, the user management becomes effective in the respective CPUs. After loading, every CPU "knows" who may access which service and execute certain functions.

This new feature is also called "local user management and access control" below.

NOTE

Support of central users and groups for CPU function rights

UMC (User Management Component) can also be used to manage users centrally in TIA Portal. With this component, you can manage central users and groups on connected UMC servers, e.g. by connecting an MS Active Directory. The authentication is then implemented via UMC. The central user management for CPU-specific function rights via UMC is supported as of TIA Portal V20 and CPU FW version V4.0 (see Useful information on central user management and access control (Page 271)).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - however, only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example regarding the "Defense in Depth" security concept, in particular the remarks on plant security and hardening measures.

You can find detailed information in the Industrial cybersecurity (Page 40) section.

Users, roles and function rights

Users and roles were already being managed in the predecessor version by TIA Portal under "Security settings > Users and roles". In addition to the existing user management options, e.g. for HMI devices, you can also manage all CPU function rights in this editor starting from TIA Portal Version V19.

The CPU function rights are valid during runtime. Therefore, these rights are located in the "Runtime rights" tab in the editor for users and roles. For each CPU in the project, there is a section with all CPU function rights to choose from – listed according to CPU services such as PG/HMI communication (engineering access, access levels), web server, and OPC UA.

Besides the user management for projects, additional user management possibilities were available for the web server and OPC UA server in the CPU properties (static user management for CPUs up to FW version V3.0):

- Users for the OPC UA server (authentication)
- User for the web server (authentication and access control)

These additional user management options have been integrated in the local user management in the project tree as of TIA Portal V19 and CPU FW version V3.1.

Introduction to the local user management and access control

For S7-1500 CPUs up to firmware version V3.0, users were managed under the respective CPU properties, separated according to services such as "Web server" and "OPC UA". Web server users were managed in the "Web server" area, OPC UA users in the "OPC UA" area.

To restrict the PG/HMI access to the CPU at different levels, you configured passwords for the corresponding access levels. With this approach, for example, HMI access could be permitted without restriction, but write access could be made dependent on the knowledge of a password. You assigned the passwords for the different access levels in the "Protection & Security" area of the CPU properties. The access protection therefore always related to groups that have the appropriate passwords - not to individual users.

With the introduction of local user management and access control in TIA Portal version V19, you use the "Security settings > Users and roles" area in the project tree in TIA Portal to manage all users, together with their roles and function rights, of a CPU. The same holds for the access protection for engineering/HMI access, which as of TIA Portal version V19 no longer relies on access levels with password protection by default but instead on the user management.

More information on the new access protection is available here (Page 265).

As already introduced, e.g. for engineering rights, you use role assignments for combining individual function rights. In a further step, you assign the roles to individual users. All the function rights which were assigned to a user via roles and which the user can exercise for the corresponding CPU are listed In the "Assigned rights" tab.

The following figure shows an example of the available and activated function rights of a CPU. At least one user must have full access to the CPU. Otherwise, the configuration cannot be compiled. A role with full access to the CPU must be created for this.

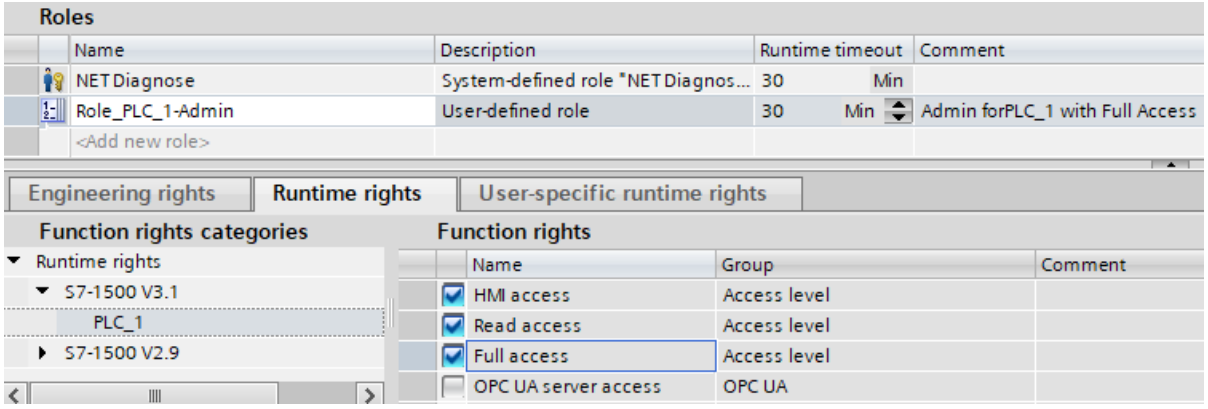


Figure 1-539 Assigning function rights of a CPU to a role

The following figure shows the assignment of the role with full access to a user ("Admin").

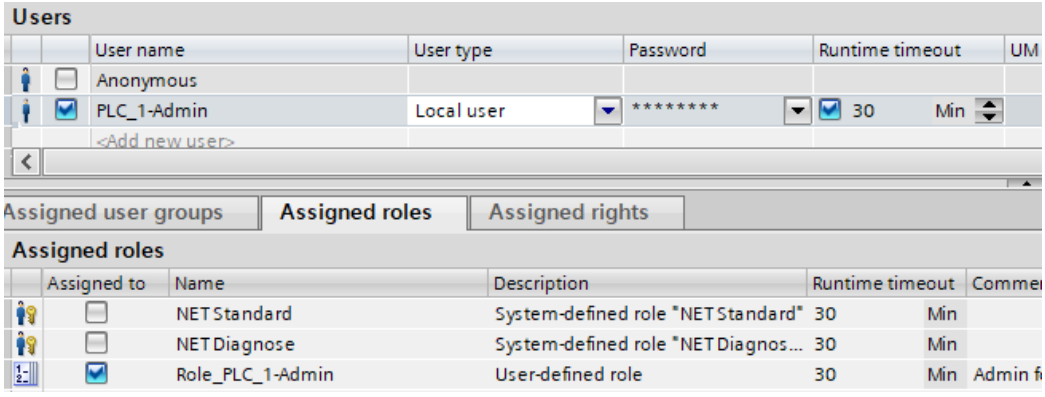


Figure 1-540 Assigning a role to a user

Requirement

CPU parameterization: To make use of users, roles and function rights for a CPU, the "Enable access control" option must be selected in the "Protection & Security > Access control" area.

In the "Configuration of user management" area, the "Local user management" option is preset, whereby the users are loaded to the CPU.

If you select the "Central user management" option, you have to add additional parameters such as the UMC server address and server ID (see Useful information on central user management and access control (Page 271)).

No project protection is required for user management.

Default characteristics

The "Activate access control" option is preset for the access control. Users can be configured with their assigned passwords and their roles and function rights.

Downloading to device

If you want to download changes to the user configuration in RUN mode, the hardware configuration in the CPU and in the STEP 7 project must be unchanged. Otherwise, a transition to STOP is required to download the user configuration together with the changed hardware configuration.

Save your STEP 7 project and then configure only the desired changes in the user configuration. Load your project into the CPU.

Changes to the access rights for the "Anonymous" user can only be loaded in STOP mode.

A fail-safe S7-1500 CPU may only load a user to whom the runtime right "Full access including fail-safe" is assigned. Otherwise, STEP 7 displays an error message when loading the configuration.

Explanations of the options for the user management download (Load preview):

- If you select the option "Keep online user management data", the local user management is not downloaded to the CPU.
- If you select the option "Download all user management data (reset to project)", all passwords changed online via WebAPI are deleted. After the download, the configured local user data is valid.
- If you select the option "Update user management data, but keep online passwords" and have not changed existing user names, the passwords changed online via WebAPI are retained. Only changes to function rights and/or roles take effect. Newly configured users are downloaded with their settings and deleted users are no longer available after the download to the CPU.
  If you have changed a user name in the project and assigned a password to this user in the project, this setting becomes valid after the download. The previously valid user name with the password changed online is deleted during the download.

Runtime timeout

You can set a runtime timeout for both the role and the user in 'Security Settings > Users and Roles'.

For an S7-1500 CPU, these settings are taken into account by the various services as follows:

- By means of the Web API you can, for example, create a web page or application that takes the settings for the runtime timeout into account. Standard web pages do not take the settings for runtime timeout into account and use the default value.
- The other services (PG/HMI communication and OPC UA server) do not use the runtime timeout; the logged-in user is not logged out after the set time.

11.3.2 Advantages of the local user administration and access control

The advantages of the new local user management for S7-1500 CPUs and the changes associated with it are described in the following.

Quick activation/deactivation of local user management

The options for user administration are located in the "Protection & Security > Access control" tab:

- Access control deactivated: Every user has full access to all functions with the exception of the GDS Push function for the online transfer of certificates.

  ⚠ WARNING

  Disabled access control carries the risk of unauthorized access and thus the risk of personal injury and property damage.
  Only use this setting in a protected environment, such as during commissioning.

- Access control enabled: The configured users with their assigned roles and concomitant linked function rights become effective after loading.

Access protection for PG/HMI accesses, now with user authentication

While it was possible to assign passwords for access levels for S7-1500 CPUs with firmware versions <V3.1, you can configure users with corresponding function rights for the current CPUs. This means that the authentication options for PG/HMI access correspond to the options offered by OPC UA or web server accesses.

All in one place

Irrespective of the service for which you configure users, roles and rights for a CPU: You have to manage the data at the same location.

All users, no matter if you manage their engineering rights for the project or their local runtime rights for each CPU in the project, can be found in the editor for users and roles in the project tree.

Powerful password functions

- Support for compliance with complexity rules for password creation:
  Already at the password creation stage, you can have the TIA Portal check for compliance with complexity rules, such as rules on password length, uppercase/lowercase letters (project tree, "Security settings > Settings" area).
  The complexity rules are also saved in the CPU when the user management is loaded. When the password is changed online, the CPU determines and considers these rules. This prevents a user from overriding the complexity rules set by the configuration engineer and assigning a non-secure password.

- The period of validity of passwords is adjustable:
  To ensure that a user does not have access to the CPU with a compromised password for an unlimited time, you can parameterize a period of validity. Before the period of validity expires, the remaining time is then displayed on login so that each user has the possibility to change their password in time.

Loading the user management during operation

As of firmware version V3.1, you can load certain security-relevant configuration data both in STOP mode and in RUN mode. This means that loading the hardware configuration does not necessarily lead to a CPU STOP.

You can make the following changes in STOP mode as well as in RUN mode (Download to device > Hardware configuration):

- Local user management extended/changed
- TIA Portal-configured certificates modified
- Syslog configuration changed

If you made additional changes to the hardware configuration (for example, modules added, parameters reassigned, etc.), then the CPU automatically requests the STOP state before loading the configuration.

So if you, for example, load just one user with modified roles/function rights to the CPU, this process does not require the CPU to be in STOP state.

The preview dialog for loading contains a security area so that you can determine when loading how the CPU should deal with user data that has changed in the meantime (not when loading for the first time). This allows changes to user data (e.g. password changes during runtime) to be retained.

Loading the device as a new station - with user data

If you load a previously configured CPU into a new project, for example, because you do not have the original project, the user data is also loaded into the project and is available for further editing of the CPU settings.

Changing of passwords during operation

You can use the web server API to write an application with which each user can change their password at runtime, provided that the original password was entered correctly and the new password corresponds to the set password guideline.

Requirement: You have enabled access control for the CPU.

A user can change their own password at any time, even if the password has expired. If the password has expired, the user must change the password. Login will not be possible with an expired password.

API methods used:

- Api.ChangePassword
- Api.GetPasswordPolicy

You can find more information about the API methods in the Web server Function Manual (https://support.industry.siemens.com/cs/de/en/view/59193560).

NOTE

Passwords changed at runtime take priority over loaded passwords

If you have changed your password during running operation and subsequently load your project, the password assigned during runtime takes precedence over the password set in the project (default setting).

If you want to overwrite the passwords changed during runtime by loading the project, you have to select the option "Load all user management data (reset to project data)". In this case, **all** passwords changed during runtime will be lost.

11.3.3 From the access level to the function right of users

The following section shows how to implement access protection with the new local user management for CPUs.

Access levels as function rights

With S7-1500 CPUs up to FW version V3.0, access could only be controlled via passwords. With CPUs as of FW version V3.1, you can create the appropriate users and roles with the necessary function rights for access control. The assignment between access level and the associated function right results from the already known access levels:

- Users who are to have full access must have a role with the function right "Full access", or "Full access incl. failsafe" for F-CPUs.

  A CPU configuration can only be compiled and loaded if at least one user has the function right "Full access" or "Full access incl. failsafe".
- Users who are to have read access must have a role with the function right "Read access".
- Users who are to have HMI access must have a role with the function right "HMI access".

If a user does not have any of these specified function rights, that user also has no access to the CPU.

The hierarchical organization of the access levels also remains the same for the corresponding function rights:

- A user with full access also has the function rights "Read access" and "HMI access".
- A user with read access also has the function right "HMI access".

NOTE

Compatibility of the "ENDIS_PW" instruction

The "ENDIS_PW" instruction can only be used to disable or enable passwords for access levels. The "ENDIS_PW" instruction has no effect on assigned rights for users or roles.

Continuing to use access levels

Even though the new local user management replaces the usual access protection via corresponding function rights of individual users, there is still the possibility to continue to use this familiar access protection. This is required, for example, for HMI devices which only support access levels and which do not benefit yet from possibilities of the new user management.

If you require the configuration of an access level, for example, to ensure an HMI device access even without user or password access, you have to activate the "Use legacy access control via access levels" option in the CPU properties.

NOTE

Users for OPC UA and for the web server

Independent of the access protection, you always have to configure the users for the web server and OPC UA server in the project tree ("Security settings > Users and roles" area).

Restrictions on continued use of the access levels

When using the "Legacy access control" option, you cannot select the access level directly in the table for setting the access levels. This selection can only be set for the new local user management in one way: Via the access protection function rights of the "Anonymous" user.

The local user "Anonymous" is created in a project by the system by default. With the help of this user, you determine the behavior of the CPUs in the project for someone who logs in without a user name and password. For security reasons, the anonymous user is deactivated and needs to be activated before use.

The area where you set the access levels leads you via a link to the editor for the required settings for the "Anonymous" user.

Examples:

- If the "Anonymous" user is deactivated or if the "Anonymous" user is activated and no function rights have been assigned to that user, then nobody can log in without a user name and password (corresponds to the access level "No access (complete protection")).
- If the "Anonymous" user is activated and the "Full access" function right for a CPU is assigned to that user via a corresponding role, the result of this setting is "No protection". You can achieve the same effect with regard to access protection by setting "No access protection" in the "Protection & Security" area of the CPU properties.

Procedure

To activate the "Legacy access control" and set the required access level, follow these steps:

1. In the CPU properties, go to "Protection & Security > Access control".
2. Select the option "Activate access control" and, in addition, select the check box "Use legacy access control via access levels" check box.

   The access level selection cannot be used in this setting. You have to set the access level via the "Anonymous" user of the CPU.

   The "Anonymous" user is deactivated by default. This means that the resulting access level for users without a password is "No access (complete protection)" (default setting).
3. Go to "Security Settings > Users and roles" in the project tree.

4. Activate the "Anonymous" user, if you want to set a different access level than "No access (complete protection)". You can assign a role with function rights that grants access to the CPU without password input, only to the activated "Anonymous" user.
5. You cannot assign function rights for a CPU directly to a user. You must first assign a role: Therefore switch to the "Roles" tab and add a new role. Assign a meaningful name, e.g. "PLC1-Read-Access-Role". If you assign this role to a user, this user should have read access to PLC1 during operation.
6. Assign the required function right for the access to the CPU with the name "PLC1" to the role "PLC1-Read-Access-Role" - in this case "Read access".
7. Switch to the "User" tab and assign the "PLC1-Read-Access-Role" role to the activated "Anonymous" user.

   Result: The "Anonymous" user has read access for PLC1. This means that the access level tables of the CPU "PLC1" in the project are preset to "Read access" (cannot be changed) and users who are not logged in only have read access.

   For full access, or full access including fail-safe, you have to configure a password for the full access in the table for the access protection. Users who need full access to the CPU during runtime via an action, e.g. because a project is to be loaded onto the CPU, must legitimize themselves for this action with this password.

Tip

To make the user rights transparent, use meaningful names for the respective roles. You create users and roles for the entire project; you must select the function rights of a role individually for each CPU in the project. With a descriptive name you can, for example, immediately see which CPUs have read access and which CPUs are fully protected.

11.3.4 Information about compatibility

In the following sections, you will find information on the behavior of the CPUs with the local user administration, e.g. when replacing modules in STEP 7 and for further use of projects and programs without local user administration.

Replacement part scenario

If you replace a CPU with a firmware version < V3.1 with a CPU with a firmware version V3.1 or higher, the program stored on the memory card runs like the original CPU. The behavior with regard to the configured access levels, the users for the OPC UA server and the web server corresponds to the behavior of the previous CPU.

In this case, the "Change password function" via the web server API is not accepted by the CPU because the CPU has been configured for firmware version < V3.1 and has no local user administration.

Replace CPU (upgrade)

If you replace a CPU (FW < V3.1) with a current CPU (FW V3.1 or higher) in the TIA Portal, this has the following effects on the configured user data:

- The user data from the OPC UA server and web server is transferred to the "Users and roles" editor in the project navigation.

NOTICE
Passwords are lost when replacing the CPU Before replacing the CPU, make sure that the passwords are available. They must be entered again in the "Users and roles" editor. Otherwise, you have to assign new passwords and inform the users.

- A corresponding role is created for each web server user in the "Users and roles" editor; the name of the role contains the CPU name, the "Web" string and the already configured web server user name. In this way, by assigning these roles in the "Users and roles" editor, you can easily restore the original rights for each CPU.
- The "OPC UA server access" role is created for each OPC UA server user.
- OPC UA guest access and the web server "Everybody" are migrated to the "Anonymous" user.
- Each OPC UA user and each web server user is listed in the "User" column in the editor for users and roles. If the names are the same (web server and OPC UA user), only one user is created.
- With a protected project, you can select which action the CPU performs:
  - Migrate user (requirement: You are logged in as a user with the right to manage users and roles and the right to edit the project/configuration)
  - Remove user
  - Cancel
- The "Legacy access control via access levels" option is set for access protection.

Replace CPU (downgrade)

If you replace a CPU (as of FW V3.1) with a previous CPU (< FW V3.1) in the TIA Portal, this has the following effects on the configured user data:

- The local user administration is no longer available.
- Users with function rights for the web server are not transferred.
- Users of the OPC UA server remain with their user rights in the "Users and roles" editor. No users are moved to the "OPC UA" area of the CPU parameters.
- It is no longer possible for users to change passwords during runtime (via web server API).

11.4 Temporary account lock in case of brute force attacks

Useful information about brute force attacks

In a brute force attack, combinations of credentials (for example, user name and password) are systematically tried out with the aim of gaining access to a user account. Trying all options requires a lot of computing effort and time until a correct combination of user name and password is found.

Brute force attacks are particularly effective with weak or simple passwords.

Protecting a CPU from brute force attacks

As of STEP 7 V19, you can define password policies in the project tree under "Security settings" and thus ensure that strong passwords are assigned.

As of STEP 7 V21, there is the additional option of setting up a temporary account lock for CPUs as of FW version V4.1. You can only configure the temporary account lock for local user accounts. For central user accounts, protection against brute force attacks is configured directly on the UMC server.

You specify a maximum number of failed login attempts per time unit (monitoring time). If the specified number of failed login attempts is reached within the monitoring time, the period of the account lock (lockout duration) begins. During this time period, every login attempt is unsuccessful, regardless of whether the login data is correct or incorrect.

The indicator for hits ("correct password") is masked. The attacker does not receive any feedback about the temporary lock.

Configuring the locking of the local user account in STEP 7

To configure the locking of the local user account, follow these steps:

1. Place the required CPU from the hardware catalog in the network view.
2. Select the CPU in the network view.
3. In the Inspector window, navigate to "Properties > General > Protection & Security > Lockout of user account at runtime".
4. Select the "Lockout of the user account after failed login attempts" check box.
   The fields below become editable.
5. Edit the other fields according to the following options:
   - Max. failed login attempts:
     Determine the number of incorrect login attempts accepted by the CPU for a user account. If this number is reached within the monitoring time, the affected user account will be locked.
     Default: 5 failed login attempts
   - Monitoring time:
     Determine the time period between failed login attempts for a user account. The time period starts again after each failed login. If a valid login attempt is made within the time period, the time is reset.
     Default: 2 minutes

– Lockout duration:
  Determine the time period for which the user account should be locked. The time period starts when the set number of failed login attempts for a user account is reached within the monitoring time. During the lockout duration, the CPU rejects all login attempts. If an unsuccessful login attempt is made during the lockout duration, the set lockout duration starts again.
  Default: 2 minutes

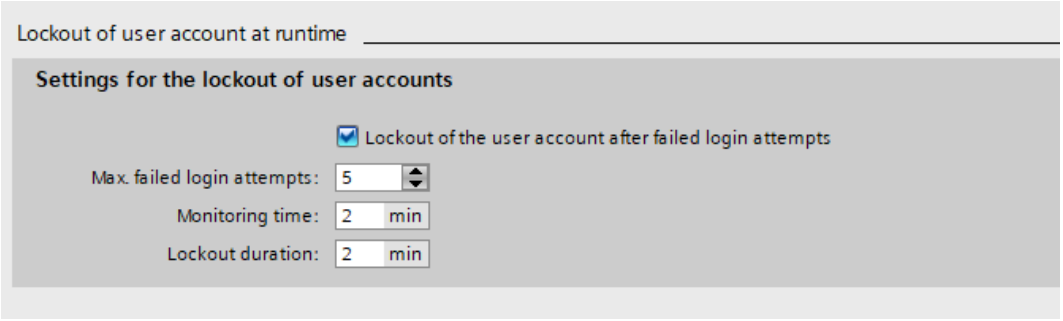


Figure 1-541 Configure the locking of the user account during runtime

6. Load the configuration into the CPU.

Result: You have configured the settings for locking user accounts and loaded them into the CPU.

The following figure shows an example of the procedure for locking a user account. A maximum number of 4 incorrect login attempts was set here.

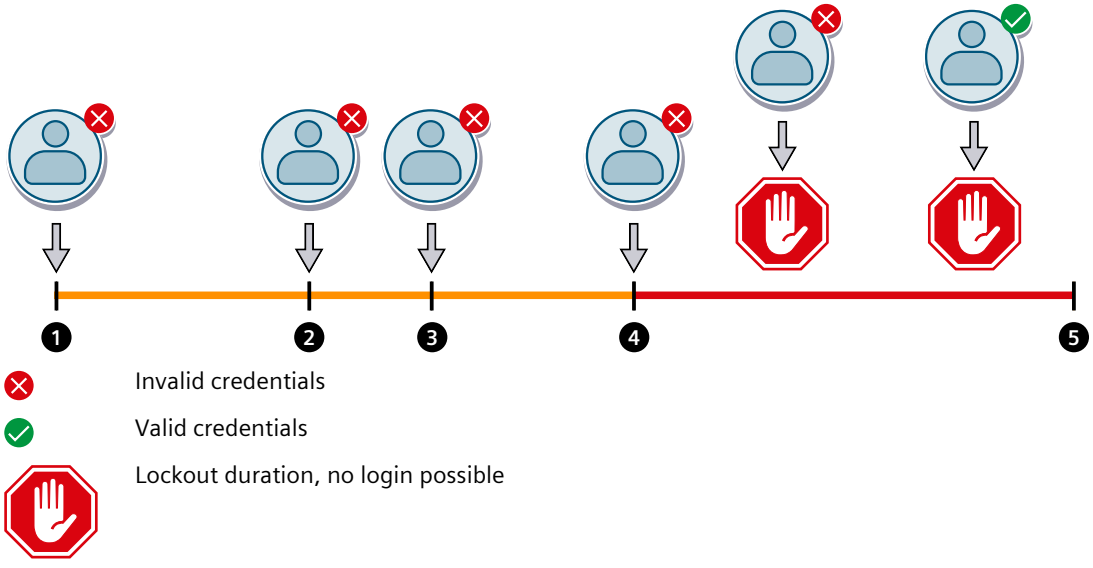


Figure 1-542 Procedure in the event of incorrect login attempts to a CPU

1. Failed login attempt no. 1:
   The set monitoring time starts. The counter for the number of failed login attempts is set to 1.
2. Failed login attempt no. 2 within the monitoring time:
   The set monitoring time starts again. The counter for the number of failed login attempts is incremented by 1.

3. Failed login attempt no. 3 within the monitoring time:
   The set monitoring time starts again. The counter for the number of failed login attempts is incremented by 1.
4. Failed login attempt no. 4 within the monitoring time:
   The set number of failed login attempts within the monitoring time has been reached. The set lockout duration starts.
   As long as the lockout duration is running, the CPU responds to each login as if it were an incorrect login attempt (no login possible). A login attempt with incorrect credentials during the lockout duration leads to a restart of the lockout duration.
5. After lockout duration elapses:
   Login attempts are again accepted by the CPU. The counter for the number of failed login attempts is reset to 0.

Influence of events on the temporary account lock

The following states and events belong to the temporary account lock:

- Incorrect login attempt detected
- Ongoing monitoring time
- Current lockout duration

The following events reset all states of the temporary account lock for all local users:

- Transition from POWER-ON to POWER-OFF
- Download to CPU
- System state transition from RUN-Solo to RUN-Redundant (S7-1500R/H systems)

The following events have **no** influence on the temporary account lock:

- Changing the password of local users during runtime via Web API.
- System state transition from RUN-Redundant to RUN-Solo (S7-1500R/H systems)

11.5 Central user management

11.5.1 Useful information on central user management and access control

As of TIA Portal version V20 and CPU firmware version V4.0, S7-1500 CPUs have a feature whereby authentication of users can be left to a central UMC server.

As of the versions specified above, you manage users centrally and combine multiple users with the same roles/function rights into one group.

The central authentication service is performed in this case by the UMC (User Management Component).

You set up linking between user/group and assigned roles and function rights in the editor "Users and roles" in TIA Portal - as with the local user management.

For HMI devices, the authentication is not possible via either local or central users (TIA Portal V19/V20).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - however, only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example regarding the "Defense in Depth" security concept, in particular the remarks on plant security and hardening measures.

You can find detailed information in the Industrial cybersecurity (Page 40) section.

Advantages of central user management

Central user management allows management of users and user groups independently of TIA Portal. This enables the user management to be scaled from a few users and CPUs in a single project (local user management) up to extensive automation solutions with multiple projects, users and user groups (central user management) – without increased workload.

If you use the central user management (UMC), you can, for example, configure user groups on the UMC server set up for this purpose. The users of a group then have the same roles and function rights on the CPU.

During operation, users can be added to or removed from a group or passwords can be changed on the UMC server. The CPU configurations do not need to be changed and reloaded.

⚠ WARNING

Decoupling the user management from the CPU involves risks

When central user management is used, the CPU or TIA project has no way of checking the central user administration. UMC administrators must carefully check the effect of their changes with regard to modified roles and function rights.

Changes to central users at the time of the change do not affect the existing connection to the CPU at this time. These include, for example, the following changes:

- Delete a user on the UMC server
- Users are moved to other groups on the UMC server and thus get other roles and rights.

The changed user configuration will only take effect when you log in again.

Requirements

The configuration in the editor for users and roles (TIA Portal) provides you with a wide scope of usage scenarios in connection with UMC:

- Programming device with TIA Portal is connected to a UMC domain. In this case, the users and groups can be synchronized in the editor for users and roles.
- Programming device with TIA Portal is not connected to a UMC domain but the names of the user groups/central users used in operation are known and can be added without contact to the UMC server.

  The names of the user groups/central users can also be entered without connection to the UMC domain and synchronized with the UMC domain later.

  The synchronization is not necessary for authentication of CPU users via a UMC server. The group names or user names only have to match to make use of the authentication service.

A CPU which needs to authenticate the querying users (for example, via web, PG/HMI communication, or OPC UA) for diverse online functions requires the following information for accessing the authentication service:

- The UMC server address
  Example: https://central.umc.testnet:443/ra
  (443 = Port for https, ra = remote authentication)
- A server ID (fingerprint of the server certificate).
  You can determine the fingerprint of a certificate through Windows (open the certificate, "Details" tab, "Fingerprint" field).

As an alternative to the server ID, you can configure a list of CA certificates. These certificates are used by the CPU to verify the certificate returned by the UMC server when a connection is established. In order for the verification to be successful, the entire certificate chain down to the root certificate must have been loaded. The verification does not work for end-entity certificates or for intermediate certificates without a certificate chain to the root certificate.

Further requirements for operation (Runtime):

- User groups and users have been set up on the UMC server.
- A connection can be established between the CPU and UMC server via the configured UMC server address.
- CPU time is current. As with local user management, central users are informed about the remaining validity of their password. CPU and UMC server must have the same date and time settings.

NOTE

No logon possible if the UMC server is not available or the CPU time is reset

- If you use only UMC users and UMC user groups to access the CPU during operation and the UMC server becomes unreachable, for example, due to connection abort, then no one can log on anymore.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/function rights.
- If you use UMC user groups or UMC users to access the CPU during operation, the CPU time must be up-to-ate.
  If the CPU time has been reset, for example, by restoring the factory settings, and no NTP time synchronization has been configured, it is also not possible to log on via the central user management. Authentication of the UMC server using certificates requires an up-to-date CPU time.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/function rights to set the time (for example, from the "Web server – Maintenance" group).
  - Alternatively, you can synchronize the CPU time using NTP servers (for information on configuration; see section Time synchronization (Page 330)).

Basic procedure for using the User Management Component (UMC)

The following basic steps are required to use the User Management Component (UMC):

1. Installation of UMC on one or more computers in the system.
2. Assigning a corresponding UMC version as a UMC ring server or UMC server. This creates a UMC system consisting of one or multiple UMC computers.
3. Creating users and user groups in UMC. These can exist only in UMC or can be imported from a Microsoft Active Directory.
4. Connection of the UMC agent that is installed on the computer with the TIA Portal installation. The connection can be established with the TIA Administrator or with the Windows command line.
5. Use of UMC users and UMC user groups, for example, in the context of the TIA Portal project creation.
6. Authentication of UMC users after logging on via UMC.

NOTE

Enabled "Anonymous" user is always loaded
An enabled "Anonymous" user with its configured roles/function rights is loaded even if you only enabled the central user management. Local user management does not have to be additionally enabled for the "Anonymous" user to take effect.

Additional information on the UMC server

More information on setting up (installing, configuring) a UMC server as well as creating central users and groups can be found here (https://support.industry.siemens.com/cs/us/en/view/109780337).

11.5.2 Configuring central user management in the editor for users and roles

The procedure for configuring the central user management in TIA Portal version V20 with an S7-1500 CPU is described below (firmware version as of V4.0).

We distinguish between the following use cases:

- The project is configured in the environment that has access to the UMC server.
- The project is created in an environment that has no access to the UMC server.
  This is, for example, the case for a machine that is configured independently of the later place of installation and environment. The parameters for the user management must still be modified at the installation location.

Requirements - TIA Portal has access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is an online connection to the UMC server.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click the "Add new UMC user group" button.



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the user groups, select the user groups to be imported into the editor.
6. Assign the desired roles to the groups.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User" tab.
3. Click "Add user".



4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the central users, select the users to be imported into the editor.
6. Assign the desired roles to the users.

Requirements - TIA Portal has no access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is no online connection to the UMC server at the time in which user management is configured.

NOTE

Case sensitivity of user name

Although the UMC server does not differentiate between upper and lower case of the user name/group name when logging on, deviations in case prevent the user from logging on for users/groups configured offline or unsynchronized in the TIA Portal.

Recommendation:

- Before login, synchronize users and user groups in the TIA Portal and download this configuration to the CPU. In this case, the case of the user name is not relevant during logon.
- If possible, import users/groups as described above.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click in the <Add new user group> field in the "Name" column.
   The TIA Portal enters a default name.
4. Modify the default name - this name will be used in the target environment of UMC.
   The name can also be modified in the target environment during commissioning.

Result: The groups are set up but not synchronized, i.e. no UM domain ID is assigned.

When a connection to the UMC server exists in the target environment, the following process takes place when a central user logs on:

- The CPU forwards the authentication request to the UMC server.
- After a successful check, the UMC server returns a list of groups to which the logged-on user belongs.
- The CPU determines the assigned roles and function rights for the user based on the group names.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Click in the <Add new user> field in the "User name" column.
   The user type "Local user" is preset.
3. Modify the default user name - this name will be used in the target environment of UMC.
4. In the column "User type" change the entry to "Central user".

Result: The central user has been set up but not yet synchronized, meaning that no UM domain ID is assigned.

In the target environment with a connection to a UMC server, you can still adjust the provisional group and central user names using the TIA Portal.

Changing the user type - Effects

- When you change the user type (central user > local user), the data for the connection to the UMC server is lost (UM domains ID).
- When the user type is changed from local user to a central user, the configured password and the comment are lost.

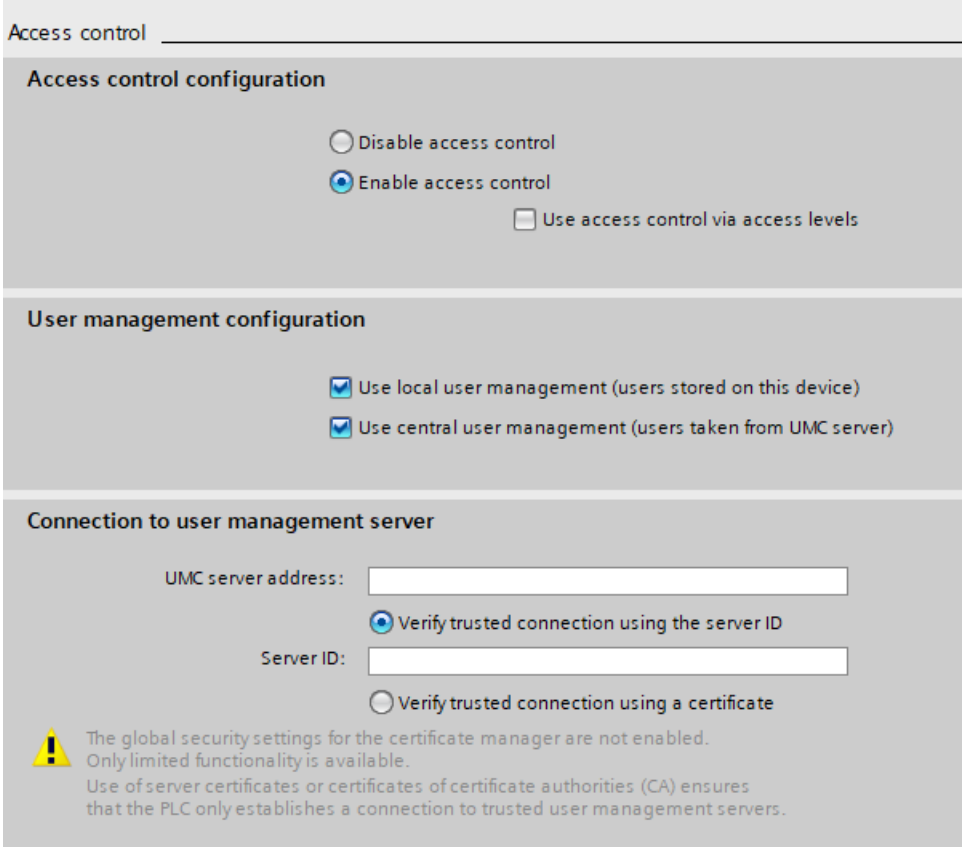
11.5.3 Configuring central user management for an S7-1500 CPU

The procedure for configuring the S7-1500 CPU is described below (firmware version as of V4.0).

Procedure - CPU configuration for central user management

To configure the central user management for an S7-1500 CPU, follow these steps:

1. Place the CPU and navigate to the area "Protection & Security > Access control".
2. Ensure that access control has been enabled (access control via protection levels may be enabled or disabled).
3. Activate the option "Use central user management (users taken from UMC server)".
   In addition, the local user management can also be activated in order to still be able to access the CPU if the connection to the UMC server fails, for example.
4. Add the specifications to the UMC server address and server ID for authentication of the UMC server.
   As an alternative to the server ID, you can also add the CA certificate or intermediate certificate for authentication. The CPU must have the entire certificate chain for verification of the server certificate including root certificate.



Changing the connection data for the UMC server

A user with a role that grants full access to the CPU can download modified connection data (UMC server address and server ID) in both STOP and RUN modes of the CPU.

11.5.4 Logon of central users

The processes for the logon of central users are described below from the perspective of different applications.

Requirements

- A UMC server is connected to the CPU (firmware version V4.0 or higher) and is accessible.
- The required central users and groups have been set up for the UMC server.
- The CPUs are configured accordingly for the central user management (roles and function rights) and the configuration is loaded.

Logging onto a protected CPU

If you access a CPU online and the operation requires function rights from users, a dialog appears, as with the local user management, which queries the user type. As of TIA Portal version V20, you can log on as a central user.

Causes of a failed logon of a central user

Besides known causes, such as a wrong user name (not configured) or wrong password, the logon may, for example, fail due to network problems (UMC server not reachable) or an oversized response frame.

Tip

To handle such cases, set up a local user who can read the diagnostic buffer in the event of a failed logon and determine the exact cause.

In the diagnostic buffer, the causes are represented by an error code that you can interpret using the following table.

Each entry in the diagnostic buffer also leads to a corresponding syslog message so that connected evaluation systems can record the processes.

Table 1-834 Error codes for failed login

Error code	Meaning
#8000 0001	Missing configuration. The UMC server endpoint is not specified.
#8000 1000	Unspecified UMC system error.
#8000 1001	No DNS address configured.
#8000 1002	The DNS server is not reachable, for example, because it was shut down as the remote port is not reachable due to firewall settings.
#8000 1003	During data exchange with the UMC server: The interface is currently receiving new parameters.

Error code	Meaning
#8000 1004	The UMC server is not reachable. The UMC server does not respond to the ARP frame or there are problems with the TCP handshake to establish a connection.
#8000 1005	The IP address of the UMC server is not reachable due to missing routing information.
#8000 1006	The UMC server refuses to establish the connection. Connection was closed unexpectedly.
#8000 2xxx	Internal, unrecoverable TLS error.
#8000 3001	Validation of the UMC server certificate failed. Possible causes: Verification against the chain of trust not possible. Certificate not valid or expired. Verification of Identity failed (subject alternative name, FQDN, IPv4 check). Server ID verification failed (fingerprint).
#8000 4001	UMC server does not respond (timeout).
#8000 4002	HTTP response frame too long (system limit exceeded).
#8000 4003	Invalid HTTP response.
#8000 5xxx	Encoded HTTP status code of the HTTP request. Example of an encoding of Status Code 500 (#1F4) = Internal Server Error: Coding: #8000 5000 + #1F4 (=500) = #8000 51F4
#8000 6001	Syntax error in JSON response frame from UMC server.
#8000 6002	JSON response frame from the UMC server too long (system limit exceeded).
#8000 6003	Unexpected JSON format. The message has a valid JSON format, but it is not a valid UMC authentication response from the UMC server.
#8000 7xxx	Login failed (unknown error).

Logging on as an OPC UA client or as a web client

When an OPC UA client logs on to the OPC UA server of the S7-1500 CPU, the user name and password are transferred via the UserNameIdentityToken.

The user name and password are also queried for web clients if you want to use the full functionality of the web server of the S7-1500 CPU. See also the Web server function manual, section "Authentication". The following process applies to OPC UA clients and web clients:

- For central users, the CPU forwards the authentication query to the UMC server.
- If the authentication is successful, the UMC server returns the assigned groups to which the user belongs.
- The CPU generates the corresponding session context and grants the authorizations (function rights from the determined roles).
- The client can then execute the access in the context of the session in accordance with the granted function rights.

How does the CPU (OPC UA server or the website of the web server) detect whether the user is a local or central user?

You have the freedom to configure a user both as a local user and as a central user. This results in an ambiguity about which service is responsible for the authentication and which user ultimately gains access. Since access permission for the user depends solely on the password in this case, you should use strong passwords, for example, created by a password generator.

The following rules apply to ensure unambiguousness for the responsible authentication service (local or central user management):

- For logon of a local user, add the prefix "L:" (uppercase or lowercase) in front of the user name.
  Example: L:username

  If you do not use a prefix for the user names, central user management is automatically responsible (when central and local user management are used at the same time). If you use only one type of user management, access is unambiguous even without a prefix.
- A user name must not begin with the string "L:" (uppercase or lowercase).

11.6 Configuring access protection for the CPU

Introduction

The following section describes how to use the various access levels of the CPUs. The description applies to S7-1500 CPUs up to firmware version V3.0.

In later firmware versions, use the local user management (Page 259) in the editor for users and roles in the project tree. The access levels are represented there by function rights of the same name which you assign to individual users via roles.

The CPU provides you with various access levels to limit access to specific functions.

By setting up access levels and passwords, you limit the functions and memory areas that are accessible without a password. The individual access levels as well as their associated passwords are specified in the object properties of the CPU.

Rules for passwords

Ensure that passwords are sufficiently secure. Passwords must not follow a machine-recognizable pattern.

Apply the following rules:

- Assign a password that is at least 8 characters long.
- Use different cases and characters: uppercase/lowercase, numbers and special characters.

Access levels of the CPU

Table 1-835 Access levels and access restrictions

Access levels	Access restrictions
Full access including fail-safe (no protection)	Users of STEP 7 and HMI applications have access to all standard and fail-safe functions. A password is not required.
Complete access (no protection)	Users of STEP 7 have access to standard functions. HMI applications can access all functions (fail-safe and standard). **Required password:** For additional access to the fail-safe functions, the user must enter the password for "Full access incl. fail-safe" in STEP 7.
Read access	In this access level, only read access to the hardware configuration and the blocks is possible without a password. HMI access and access to diagnostics data is also possible. Neither blocks nor the hardware configuration can be downloaded to the CPUs without the password. Additionally, the following is not possible without the password: Writing test functions and firmware update (online).
HMI access	The access restrictions that apply to read access also apply to HMI access. Additionally, the following is **not** possible without the password: Test functions, changing the operating mode (RUN/STOP), firmware update and display of online/offline comparison status.
No access (complete protection)	When the CPU has complete protection, no read or write access to the hardware configuration and the blocks is possible (without access authorization in the form of a password). HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

Reference

An enumeration of which functions are available in the different access levels is available in the "Setting options for the protection" entry in the STEP 7 online help.

Properties of the access levels

Each access level allows unrestricted access to certain functions without entering a password, e.g. identification using the "Accessible devices" function.

The default of the CPUs is "No access (complete protection)". In the default access level, the user may neither read nor change the hardware configuration and the blocks. To obtain access to the CPUs, use an alternative parameter assignment in the properties of the CPU:

- A password for the protection level "No access (complete protection)"
- A different protection level, e.g. "Full access (no protection)"

Communication between the CPUs (via the communication functions in the blocks) is not restricted by the access level of the CPU, unless PUT/GET communication is deactivated in the "No access" (complete protection) access level.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

NOTE

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes on the CPU via network access. Access levels are used to restrict the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC Memory Card are not write-protected or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC Memory Card.

Behavior of functions with different access levels

The STEP 7 online help contains a tabular list of the online functions that are possible in the various access levels.

Configuring access levels

To configure the access levels for an S7-1500 CPU up to FW version V3.0, follow these steps:

1. Open the properties of the S7-1500 CPU in the Inspector window.
2. Open the "Protection & Security" entry in the area navigation.
   A table with the possible access levels appears in the Inspector window.

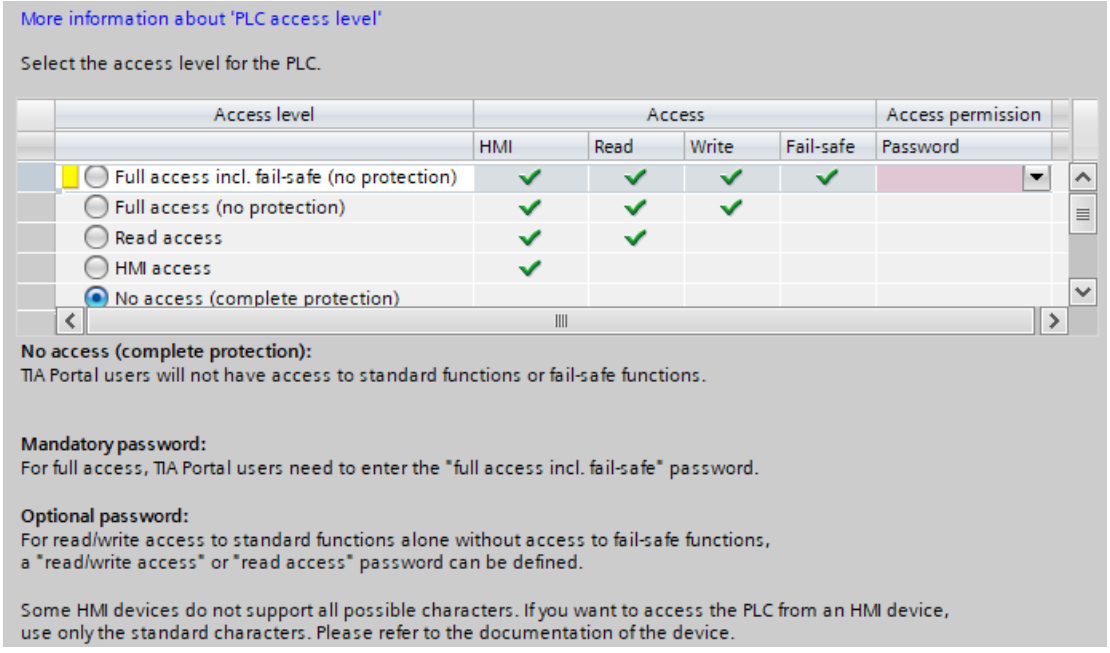


Figure 1-543 Possible access levels of an S7-1500 CPU up to FW version V3.0

3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the respective access level show you which operations are still available without entering the password. In the example (Figure: Possible access levels), access is not possible without a password.
4. In the "Enter password" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to guard against incorrect entries.
5. Assign additional passwords as required for other access levels.
6. Download the hardware configuration for the access level to take effect.

The CPU logs the following actions with an entry in the diagnostic buffer:

- Input of the correct or, possibly, wrong password
- Changes to access level configuration

Behavior of a password-protected CPU during operation

Protection of an S7-1500 CPU up to FW version V3.0 takes effect for an online connection after you have downloaded the settings to the CPU. If you set a higher access level and download it to the CPU, all other online connections will be interrupted. You must then establish a new online connection.

Before an online function is executed, STEP 7 checks the necessary permission and, if necessary, prompts the user to enter a password. The functions protected by a password can only be executed by one programming device/PC at any one time. Another programming device/PC cannot log on.

Logon authorization to the protected data applies for the duration of the online connection or for as long as you have STEP 7 open. The menu command "Online > Delete access rights" cancels the access authorization.

You can limit access to a password-protected CPU in RUN locally on the display. This prevents access even with the password.

Access level for F-CPUs

For the fail-safe CPUs up to FW version V3.0, there is an additional access level in addition to the four described access levels. For more information on this access level, refer to the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

11.7 Using the display to set additional password protection

Blocking access to a password-protected CPU

On the display of an S7-1500 CPU, you can block access to a password-protected CPU (local block of the password). If the mode selector is set to RUN, the block is effective.
The access block requires a configured protection level in STEP 7 and works independently of the password protection. This means that even if someone accesses the CPU via a connected programming device and has entered the correct password, access to the CPU remains

disabled.
The access block can be set separately for each access level on the display. Then, for example, the read access is allowed locally, but the writing access is not allowed locally.

Procedure

If you want to block access to the CPU via the display, you need to configure an access level with a password in STEP 7.

When you set the local access protection for an S7-1500 CPU on the display, proceed as follows:

1. On the display, select Settings > Protection menu.
2. Confirm the selection using "OK", and configure for each access level, whether access at the RUN mode selector switch is allowed or not:
   - Allow: Access to the CPU is possible with the corresponding password in STEP 7.
   - Deactivated in RUN: If the mode selector is set to RUN, no additional logon to the CPU is possible with the rights of this access level. Access is denied despite the fact that the user knows the password. Access with the password is enabled again in the STOP operating state.

Access protection for the display

Configure a password for the display in STEP 7 in the properties of the CPU. This protects local access protection with a local password.

11.8 Using the user program to set additional access protection

Access protection by means of the user program

In addition to access protection via the display, you have another option. You can also restrict access to a password-protected CPU using the ENDIS_PW instruction in STEP 7.

You can find more information on this instruction in the STEP 7 online help under "ENDIS_PW: Limit and enable password legitimation ".

11.9 Know-how protection

Application

You can use know-how protection to protect one or more OB, FB or FC blocks as well as global data blocks in your program from unauthorized access. Enter a password to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block. Know-how protection does not involve the CPU (offline access in STEP 7).

Password provider

As an alternative to manual password input, you can assign a password provider to STEP 7. When using a password provider, you select a password from a list of available passwords. When a protected block is opened, STEP 7 connects to the password provider and retrieves the corresponding password.

To connect a password provider you have to install and activate it. A settings file in which you define the use of a password provider is also required.

A password provider offers you the following advantages:

- The password provider defines and manages the passwords. When know-how protected blocks are opened, you work with symbolic names for passwords. For example, a password is marked with the symbolic name "Machine_1" n the password provider. The actual password behind "Machine1" remains hidden from you.
  A password provider therefore offers optimum block protection as the users do not know the password themselves.
- STEP 7 automatically opens know-how protected blocks without the direct entry of a password. This saves you time.

You can find more information on connecting a password provider in the STEP 7 online help.

Readable data

If a block is know-how protected, only the following data is readable without the correct password:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling within a program
- Online/offline comparison
- Load

Global data blocks and array data blocks

You protect global data blocks (global DBs) from unauthorized access with know-how protection. If you do not have the valid password, you can read the global data block but not change it.

Know-how protection is not available for array data blocks (array DBs).

Setting up block know-how protection

To set up block know-how protection, follow these steps:

1. Open the properties of the respective block.
2. Select the "Protection" option under "General".

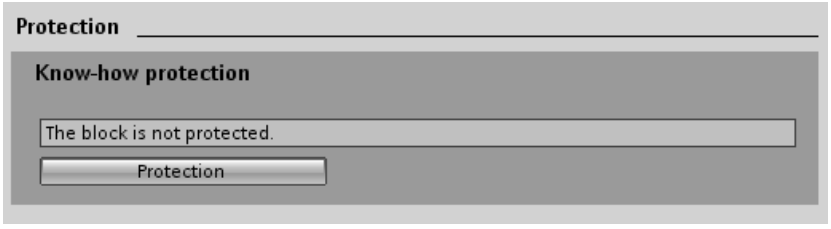


Figure 1-544 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Define protection" dialog.

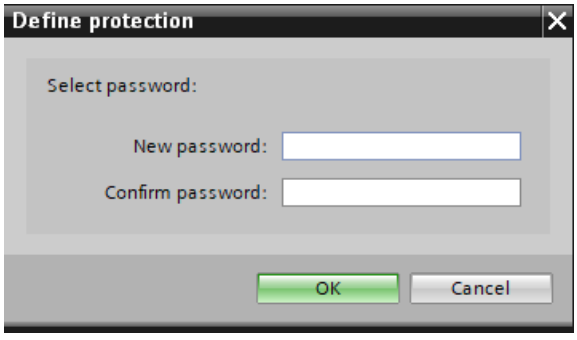


Figure 1-545 Setting up block know-how protection (2)

4. Enter the new password in the "New password" field. Enter the same password in the "Confirm password" field.
5. Click "OK" to confirm your entry.
6. Close the "Know-how protection" dialog by clicking "OK".

Result: The blocks selected will be know-how-protected. Know-how protected blocks are marked with a lock symbol in the project tree. The password entered applies to all blocks selected.

NOTE

Password provider
Alternatively, you can set up know-how protection for blocks with a password provider.

Opening know-how protected blocks

To open a know-how protected block, follow these steps:

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected blockopens.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. You need to enter the password again the next time you open the block. If you close the "Access protection" dialog with "Cancel", the block will open but the block code will not be displayed. You will not be able to edit the block.

If you copy the block or add it to a library, for example, this does not cancel the know-how protection of the block. The copies will also be know-how-protected.

Changing know-how protection for blocks

To change the know-how protection for blocks, follow these steps:

1. Select the block for which you want to change the know-how protection. The protected block must not be open in the program editor.
2. To open the "Change protection" dialog, select the "Know-how protection" command in the "Edit" menu.
3. To change the password for the know-how protection, enter the current password under "Old password".
4. Then enter a new password under "New password" and confirm the password under "Confirm password".
5. Click "OK" to confirm your entry.

Result: The password for the know-how protection of the selected block has been changed.

Removing know-how protection for blocks

To remove block know-how protection, follow these steps:

1. Select the block from which you want to remove know-how protection. The protected block must not be open in the program editor.
2. Select the "Know-how protection" command in the "Edit" menu.

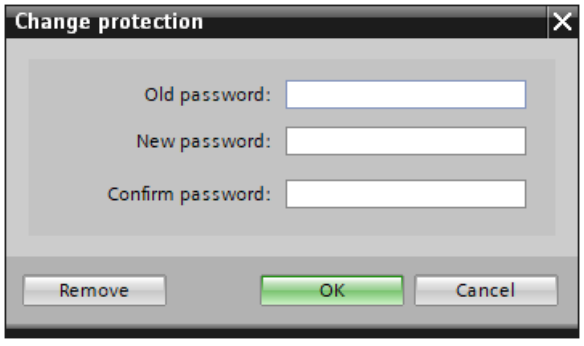


Figure 1-546 Removing know-how protection for blocks

3. To remove the block protection, enter the current password under "Old password". Leave the fields for the new password empty.
4. Click "Remove" to confirm your entry.

Result: Know-how protection for the selected block has been canceled.

11.10 Copy protection

Application

The copy protection allows you to protect your program against unauthorized duplication. With copy protection you associate the blocks with a specific SIMATIC memory card or CPU. The link to the serial number means that you can only use the block in conjunction with the corresponding SIMATIC memory card or CPU.

Copy and know-how protection

Recommendation: To prevent an unauthorized reset of the copy protection, provide a copy-protected block with additional know-how protection. First set up the copy protection for the block and after this the know-how protection. You can find additional information on setting up know-how protection in the section Know-how protection (Page 284).

Setting up copy protection

To set up copy protection, follow these steps:

1. Open the properties of the respective block.
2. Select the "Protection" option under "General".
3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.

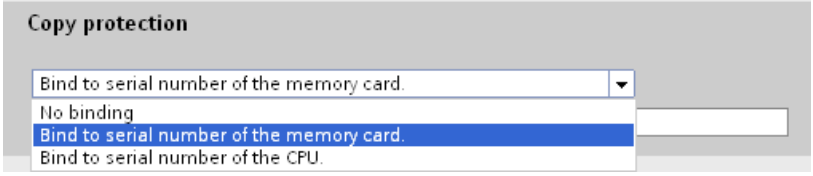


Figure 1-547 Setting up copy protection

4. Activate the option "Serial number is inserted when downloading to a device or a memory card" if STEP 7 is to automatically insert the serial number during the uploading process (dynamic binding). Assign a password using the "Define password" button to link the use of a block additionally to the input of a password.
   If you want to manually bind the serial number of the CPU or the SIMATIC memory card to a block (static binding), activate the "Enter serial number" option.
5. You can now set up the know-how protection for the block in the "Know-how protection" area.

NOTE

If you download a copy-protected block to a device that does not match the specified serial number, the entire download operation is not possible. This means that you also cannot download blocks without copy protection.

Removing copy protection

To remove copy protection, follow these steps:

1. Remove the Know-how protection (Page 284), if it is set.
2. Open the properties of the respective block.
3. Select the "Protection" option under "General".
4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.

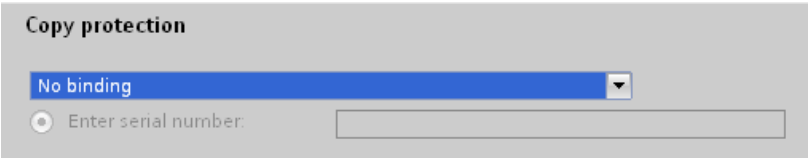


Figure 1-548 Removing copy protection

11.11 Protection by locking the CPU/interface module

Locking options

Provide additional protection for your CPU/Ihr interface module from unauthorized access (for example to the SIMATIC memory card) by using a secure front cover.

You have e.g. the following options:

- Attach a seal
- Secure the front cover with a lock (shackle diameter: 3 mm)

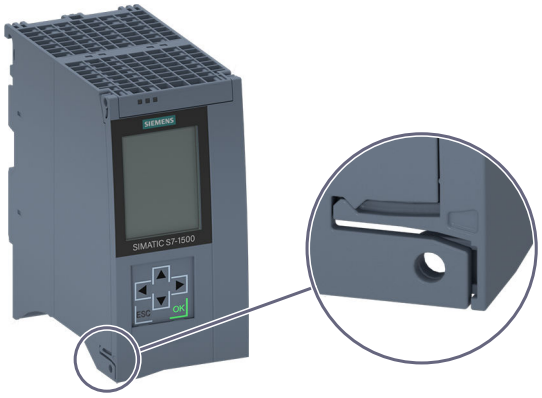


Figure 1-549 Locking latch on a CPU

Flexible automation concepts 12

12.1 Standard machine projects

Introduction

Standard machine projects are STEP 7 projects that use a set of innovative functions allowing simple configuration and commissioning of flexible automation solutions for standard machines or for machines with a modular structure.

A hardware configuration consisting of an S7-1500 CPU as the IO controller and any connected IO devices represents a "PROFINET IO system master". This master is configured with a maximum configuration based on which various options can be derived for different standard machines, for example with different configuration variants of the IO system.

Greater flexibility at all levels

Standard machine projects have the following central characteristics:

- From one project (IO system master) with an engineered maximum configuration, different variants of a standard machine can be loaded (IO system options). The standard machine project covers all variants (options) of the IO system.
- An IO system option can be integrated in an existing network locally using simple tools.

Flexibility is provided in more ways than one:

- With suitable configuration, adaptation of the IP address parameters of the IO controller is possible locally using simple tools. This allows a standard machine to be integrated in different plants with little effort or to be included in a network several times.
  IO systems with this property are known as **multiple use IO systems**.
- With suitable configuration and programming, different setups of IO system options can be operated locally that differ in terms of the selection of IO devices used or in terms of the arrangement of the IO devices.
  Since the specific configuration of the IO system is controlled by the user program, this is known as **configuration control for IO systems**.
- Independently of the functions described above, with suitable configuration and programming, you can use different station options of central devices or distributed I/O devices in one project. The devices can be different in terms of the selection and arrangement of the modules.
  Since the concrete configuration of the station is controlled by the user program, this is also known as **configuration control**.

Additional information

You can find additional information on configuration control in the section Configuration control (option handling) (Page 291).

You can find additional information on multiple-use IO systems and on configuration control for IO systems in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.

12.2 Configuration control (option handling)

Introduction

With configuration control (option handling), you handle various standard machine configuration levels in one project. You do not need to change the hardware configuration or the user program.

Operating principle of configuration control

Configuration control enables you to operate different configuration levels of a standard machine with a single configuration of the S7-1500 automation system/ET 200MP distributed I/O system.

- A station master (maximum configuration) is configured in a project. The station master comprises all modules needed for all possible equipment components of a modular standard machine.
- Provision is made in the user program of the project for various station options for the different configuration levels of the standard machine and for selection of a station option. A station option uses, for example, only some of the modules of the station master and these modules are not inserted in the configured order.
- Manufacturers of standard machines select a station option for a configuration level of the standard machine and does not have to change the project or load a changed configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. The configuration control has no effect on the parameter assignment of the modules.

The configuration control allows you to flexibly vary the centralized/distributed configuration. As a precondition for this, the station option must be able to be derived from the station master.

The following figure shows three configuration levels of a standard machine with the corresponding station options of the S7-1500 automation system.

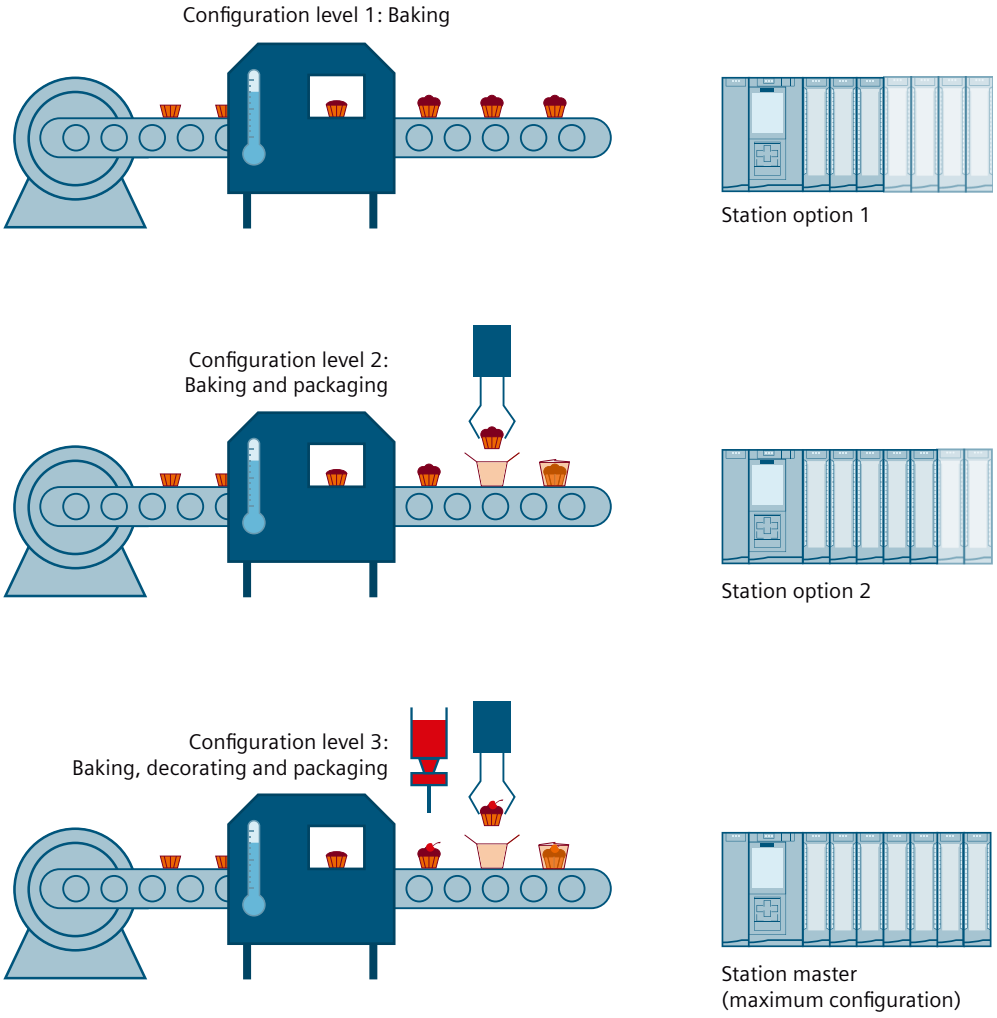


Figure 1-550 Various configuration levels of a standard machine with the corresponding station options of the S7-1500 automation system

Benefits

- Easy project handling and commissioning through use of a single STEP 7 project for all station options.
- Easy handling during maintenance, versioning and upgrades.
- Hardware savings: I/O modules are installed that are necessary for the current station option of the machine.
- Potential savings when building, commissioning and creating documentation for standard machines.

Procedure

To set up the configuration control, proceed as follows:

Table 1-836 Procedure for commissioning the SIMATIC S7-1500

Step	Procedure	See...
1	Enable configuration control in STEP 7	Section Configuring (Page 293)
2	Create control data record	Section Creating the control data record (Page 294)
3	Transfer control data record	Section Transferring the control data record in the startup program of the CPU (Page 304)

Library for configuration control

A library for configuration control is available for download (https://support.industry.siemens.com/cs/ww/en/view/29430270) on the internet. The library contains data types with the structure of the control data records for the S7-1500/ET 200MP automation system. You can implement the configuration control for your flexible automation solution economically using these data types.

12.2.1 Configuring

Requirements

In the case of the S7-1500, configuration control is possible both with centrally inserted modules and with the ET 200MP distributed I/O system via PROFINET IO.

For S7-1500 automation system:

- STEP 7 Professional as of Version V13
- CPU S7-15XX as of firmware version V1.5
- The startup parameter "Comparison preset to actual configuration" is set to "Startup CPU even if mismatch" (default setting).
  You can find the "Comparison preset to actual configuration" parameter in the Inspector window of the CPU properties under "General">"Startup".

For ET 200MP distributed I/O system:

- STEP 7 Professional as of Version V13
- IM 155-5 PN ST/HF
- You have assigned the interface module to an IO controller/DP master in STEP 7
- The startup parameter "Comparison preset to actual module" is set to "Startup CPU even if mismatch" (default setting).
  You can find the "Comparison preset to actual module" parameter in the Inspector window of the interface module properties in the "Startup" field under "General">"Module parameters".

Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the CPU/interface module.

- For an S7-1500 CPU, you can find the "Allow to reconfigure the device via the user program" parameter in the "Configuration control" area.
- For an IM 155-5 PN interface module, you can find the "Allow to reconfigure the device via the user program" parameter in the "Configuration control" field under "General">"Module parameters".

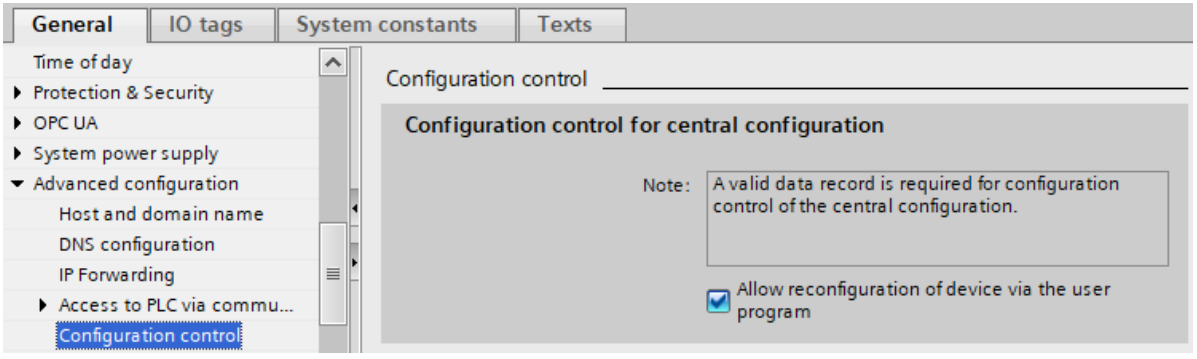


Figure 1-551 Enabling configuration control using an S7-1500 CPU as an example

12.2.2 Creating the control data record

Required steps

To create a control data record for the configuration control, follow these steps:

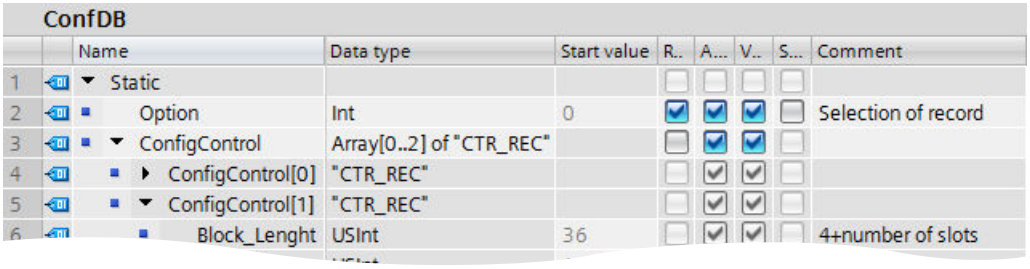
1. Create a PLC data type that contains the structure of the control data record.
   You can find the structure of the control data record:
   - For the S7-1500 automation system in section Control data record for the S7-1500 Automation System (Page 296).
   - For the ET 200MP distributed I/O system in section Control data record for the ET 200MP distributed I/O system (Page 297).

CTR_REC

	Name	Data type	Default value	A...	V...	S...	Comment
1	Block_Lenght	USInt	36	☑	☑	☐	4+number of slots
2	Block_ID	USInt	196	☑	☑	☐	
3	Version	USInt	4	☑	☑	☐	S7-1500
4	Subversion	USInt	0	☑	☑	☐	
5	Slot 0	USInt	0	☑	☑	☐	Slot 0 Power module
6	Slot 1	USInt	1	☑	☑	☐	Slot 1 CPU
7	Slot 2	USInt	2	☑	☑	☐	assigned "real" Slot
8	Slot 3	USInt	3	☑	☑	☐	assigned "real" Slot
9	Slot 4	USInt	4	☑	☑	☐	assigned "real" Slot
10	Slot 5	USInt	5	☑	☑	☐	assigned "real" Slot
11	Slot 6	USInt	6	☑	☑	☐	assigned "real" Slot

Figure 1-552 Creating control data record 196 using an S7-1500 CPU as an example

2. Create a global data block.
3. Create an array of the data type of the above created PLC data type in the data block.
   The following figure shows a data block containing three control data records for an S7-1500 CPU.

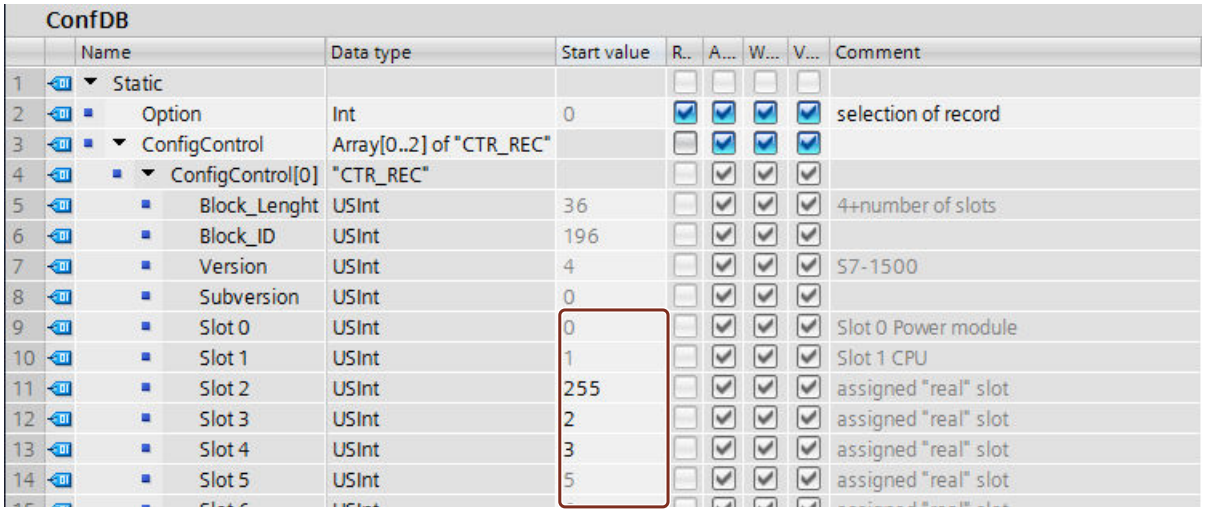


ConfDB

	Name	Data type	Start value	R..	A...	V..	S...	Comment
1	Static							
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..2] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	Block_Lenght	USInt	36	☐	☑	☑	☐	4+number of slots

Figure 1-553 Data block for configuration control

4. In the "Start value" column of the control data records, enter which module is located at which slot.



ConfDB

	Name	Data type	Start value	R..	A...	W...	V...	Comment
1	Static			☐	☐	☐	☐	
2	Option	Int	0	☑	☑	☑	☑	selection of record
3	ConfigControl	Array[0..2] of "CTR_REC"		☐	☑	☑	☑	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☑	
5	Block_Lenght	USInt	36	☐	☑	☑	☑	4+number of slots
6	Block_ID	USInt	196	☐	☑	☑	☑	
7	Version	USInt	4	☐	☑	☑	☑	S7-1500
8	Subversion	USInt	0	☐	☑	☑	☑	
9	Slot 0	USInt	0	☐	☑	☑	☑	Slot 0 Power module
10	Slot 1	USInt	1	☐	☑	☑	☑	Slot 1 CPU
11	Slot 2	USInt	255	☐	☑	☑	☑	assigned "real" slot
12	Slot 3	USInt	2	☐	☑	☑	☑	assigned "real" slot
13	Slot 4	USInt	3	☐	☑	☑	☑	assigned "real" slot
14	Slot 5	USInt	5	☐	☑	☑	☑	assigned "real" slot

Figure 1-554 Assigning slots

Rules

Observe the following rules:

- The CPU/interface module ignores slot entries in the control data record outside the station master.
- The control data record must contain the entries up to the last slot of the station option.
- Each slot of a station option may only be present once in the control data record.
- Each slot of a station option may only be assigned to one slot in the station master.

- System power supplies (PS) can also be subject to configuration control.

NOTE
Configuration control for system power supplies
In the case of a configuration (station option) loaded using a data record, STEP 7 does not automatically check compliance with the power budget.
Ensure that the power supplied in each power segment of the station option is greater than or equal to the power drawn.
You can find more information in the section Power balance calculation (Page 167).

Using communication modules

- Point-to-point communication modules:
  Point-to-point communication modules can be used without any restrictions for the configuration control.
- PROFINET/Ethernet and PROFIBUS communication modules:
  CPUs as of firmware version V1.7 support configuration control when using PROFINET/Ethernet or PROFIBUS communication modules. If communication modules for PROFINET/Ethernet or PROFIBUS, such as a CM 1542-5 (DP master or DP slave), are inserted in the central configuration, these communication modules cannot be influenced by the configuration control. You must therefore leave these modules in the slots preassigned in the station master and enter the slot numbers from the station master in the control data record ("Station option slot = Station master slot"). In a station option, all slots up to the communication module furthest from the CPU must be present in the control data record. Maximum flexibility is achieved by inserting the communication modules directly to the right of the CPU.

12.2.2.1 Control data record for the S7-1500 Automation System

Slot assignment

The following table shows the slot assignment of the modules for the S7-1500 automation system:

Table 1-837 Slot assignment

Slot	Modules	Comment
0	System power supply (optional)	Upstream of CPU
1	CPU	Slot 1 is always the CPU
2 - 31	I/O modules/system power supplies, depending on the station option	Downstream of CPU

Control data record

For configuration control of the S7-1500 automation system, you define a control data record 196 V4.0, which contains a slot assignment. The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-838 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + number of slots	Header
1	Block ID	196	
2	Version	4	
3	Version	0	
4	Slot 0 of the station master	Slot assignment in the station option	**Control element** Contains information on which module is inserted in which slot. The following rule determines which value you must enter in the respective byte: • If the module is included in the station option, enter the slot number of the module. • If the module is not included in the station option, enter 255.
5	Slot 1 of the station master	Slot assignment 1 in the station option (always 1, because the CPU is always in slot 1)	
6	Slot 2 of the station master	Slot assignment in the station option	
7	Slot 3 of the station master	Slot assignment in the station option	
:	:	:	
4 + (max. slot number)	Maximum slot of the station master	Slot assignment in the station option	

12.2.2.2 Control data record for the ET 200MP distributed I/O system

Slot assignment

The following table shows the slot assignment of the modules for the ET 200MP distributed I/O system:

Table 1-839 Slot assignment

Slot	Modules	Comment
0	System power supply (optional)	Upstream from interface module
1	Interface module	Interface module (slot 1) is not an element of the configuration control, but instead controls the configuration control.
2 - 31	I/O modules/system power supplies, depending on the station option	Downstream from the interface module

Control data record

For configuration control of the ET 200MP distributed I/O system, you define a control data record 196 V3.0, which contains a slot assignment. The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-840 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + number of slots	Header
1	Block ID	196	
2	Version	3	
3	Version	0	
4	Slot 0 of the station master	Slot assignment in the station option	**Control element** Contains information on which module is inserted in which slot. The following rule determines which value you must enter in the respective byte: • If the module is included in the station option, enter the slot number of the module. • If the module is not included in the station option, enter 127.
5	Slot 2 of the station master	Slot assignment in the station option	
6	Slot 3 of the station master	Slot assignment in the station option	
:	:	:	
4 + (max. slot no. - 1)	Maximum slot of the station master	Slot assignment in the station option	

12.2.2.3 Feedback data record of the ET 200MP distributed I/O system

Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0.

Slot assignment

The feedback data record exists only when configuration control is configured and always refers to the maximum quantity framework **without interface module**, i.e., 31 slots.

The following table shows the slot assignment of the modules:

Table 1-841 Slot assignment

Slot	Modules	Comment
0	System power supply (optional)	Upstream from interface module
2 - 31	I/O modules/system power supplies, depending on the station option	Downstream from the interface module

Partial reading of the feedback data record is possible.

Feedback data record

Table 1-842 Feedback data record

Byte	Element	Code	Explanation
0	Block length	66	Header
1	Block ID	197	
2	Version	2	
3		0	
4	Status slot 0	0/1	Status = 1: • Module from station master is inserted in the station option • Slot is marked as not available in the control data record Status = 0: • Module pulled • Incorrect module inserted in the station option*
5	Reserved	0	
6	Status slot 2	0/1	
7	Reserved	0	
:	:	:	
64	Slot n status	Maximum slot	
65	Reserved	0	

* Not possible if the slot is marked as not available.

NOTE

The data in the feedback data record is always mapped for all modules. In a Shared Device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record was sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

Error messages

In the case of an error when reading the feedback data record, the RDREC instruction returns the following error messages via the STATUS block parameter:

Table 1-843 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 197 is not correct.
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error The following events cause a parameter error: • Incorrect block ID in the header (not equal to 197) • Invalid version identifier in the header • A reserved bit was set • Multiple slots in the station master are assigned to the same slot in the station option

12.2.2.4 Examples of configuration control

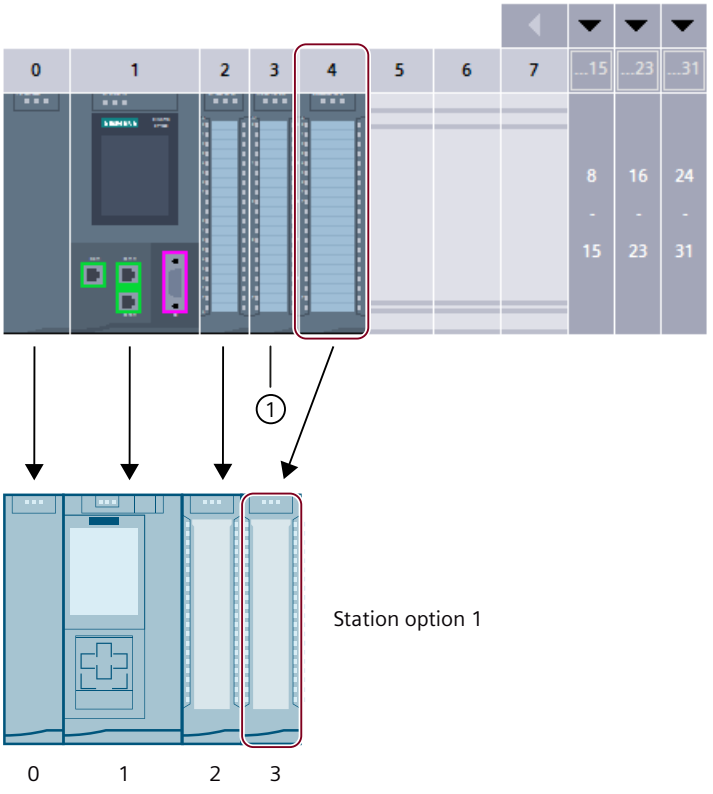
A station master consisting of a system power supply, CPU, and three I/O modules is configured in STEP 7 in the following section.

The module at slot 3 is not present in the station option 1 and is "hidden" by the configuration control.

In station option 2, the order of the modules in slots 3 and 4 is interchanged. The modified order of the modules is made known to the CPU by a modified control data record.

Station option 1 with module that is not present

The module that is located in slot 3 in the station master is not present in the station option 1. Slot 3 must be designated in the control data record accordingly with 255 (= not present).



ConfDB

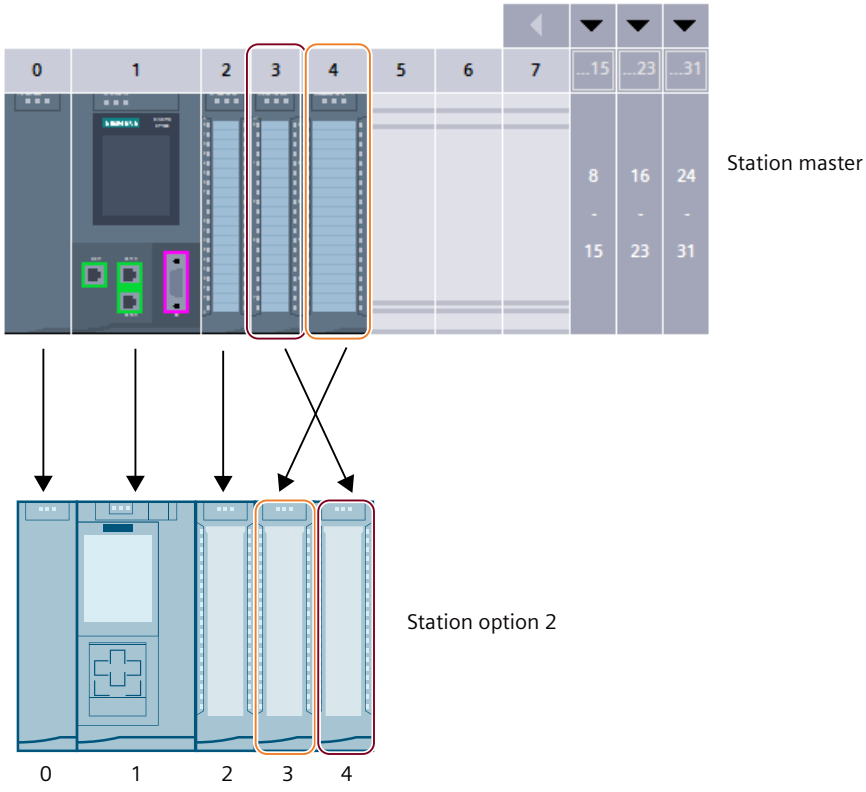
	Name	Data type	Start value	R..	A...	V..	S...	Comment
1	Static							
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..2] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	Block_Lenght	USInt	36	☐	☑	☑	☐	4+number of slots
7	Block_ID	USInt	196	☐	☑	☑	☐	
8	Version	USInt	4	☐	☑	☑	☐	S7-1500
9	Subversion	USInt	0	☐	☑	☑	☐	
10	Slot 0	USInt	0	☐	☑	☑	☐	Slot 0 Power module
11	Slot 1	USInt	1	☐	☑	☑	☐	Slot 1 CPU
12	Slot 2	USInt	2	☐	☑	☑	☐	assigned "real" Slot
13	Slot 3	USInt	255	☐	☑	☑	☐	assigned "real" Slot
14	Slot 4	USInt	3	☐	☑	☑	☐	assigned "real" Slot
15	Slot 5	USInt	5	☐	☑	☑	☐	assigned "real" Slot
16	Slot 6	USInt	6	☐	☑	☑	☐	assigned "real" Slot

① Module is not present in the station option 1.

Figure 1-555 Example: Hardware configuration of station option 1 with the associated control data record in STEP 7

Station option 2 with modified order of modules

The order of the modules in slot 3 and 4 is interchanged.



ConfDB

	Name	Data type	Start value	R..	A...	V..	S...	Comment
1	Static							
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..2] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	ConfigControl[2]	"CTR_REC"		☐	☑	☑	☐	
7	Block_Lenght	USInt	36	☐	☑	☑	☐	4+number of slots
8	Block_ID	USInt	196	☐	☑	☑	☐	
9	Version	USInt	4	☐	☑	☑	☐	S7-1500
10	Subversion	USInt	0	☐	☑	☑	☐	
11	Slot 0	USInt	0	☐	☑	☑	☐	Slot 0 Power module
12	Slot 1	USInt	1	☐	☑	☑	☐	Slot 1 CPU
13	Slot 2	USInt	2	☐	☑	☑	☐	assigned "real" Slot
14	Slot 3	USInt	4	☐	☑	☑	☐	assigned "real" Slot
15	Slot 4	USInt	3	☐	☑	☑	☐	assigned "real" Slot
16	Slot 5	USInt	5	☐	☑	☑	☐	assigned "real" Slot
17	Slot 6	USInt	6	☐	☑	☑	☐	assigned "real" Slot

Figure 1-556 Example: Hardware configuration of station option 2 with the associated control data record in STEP 7

Detailed application example

You can find a detailed application example for the configuration control in S7-1500 in here (https://support.industry.siemens.com/cs/ww/en/view/29430270) under "Application example for ET 200SP (PROFINET) and S7-1500 by using the library".

12.2.3 Transferring the control data record in the startup program of the CPU

Required steps

Transfer the created control data record 196 to the CPU/interface module using the WRREC (Write data record) instruction.

Parameters of the WRREC instruction

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

ID	Hardware identifier • For configuration control for centrally arranged modules, use the HW identifier for the CPU. If you have selected the CPU in the network view or device view, you can find the HW identifier on the **System constants** tab of the Inspector window. Use the value of the system constant "Local Configuration". • For configuration control for distributed I/O, use the HW identifier of the interface module. If you have selected the interface module in the network view or device view, you can find the HW identifier on the **System constants** tab of the Inspector window. Use the value of the system constant "<Name_of_interface_module> Head".
INDEX	Data record number: 196 (decimal)
RECORD	Control data record to be transferred. For the structure of the control data record, see section Creating the control data record (Page 294).

Error messages

In case of error, the WRREC instruction returns the following error messages via the STATUS block parameter:

Table 1-844 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 196 is not correct.
$80B5_H$	Configuration control parameters not assigned.
$80E2_H$	Data record was transferred in the wrong OB context. The data record must be transferred in the startup program.

Error code	Meaning
$80B8_H$	Parameter error Reasons for a parameter error are: • Incorrect block ID in the header (not equal to 196) • Invalid version identifier in the header • A reserved bit was set • A station master slot was assigned an invalid slot in the station option • Multiple slots in the station master are assigned to the same slot in the station option • For shared device on submodule level: violation of defined restrictions

Special requirements relating to the transfer of the control data record to the CPU

- If you have enabled configuration control, the CPU is not ready for operation without a control data record. The CPU returns from startup to STOP if a valid control data record is not transferred in the startup OB (for example, OB 100). The central I/O is not initialized in this case. The cause for STOP mode is entered in the diagnostics buffer.

  NOTE
  If an incorrect control data record is transferred to the CPU in the startup OB, the startup of the CPU may be prevented.
  In this case, perform a reset to factory settings of the CPU and then transfer a correct control data record.

- The CPU processes the WRREC instruction for transferring the control data record asynchronously. For this reason, you must call WRREC in the startup OB (for example, OB 100) repeatedly in a loop until the output parameters "BUSY" and "DONE" indicate that the data record has been transferred.
  - Tip: To program the loop, use the SCL programming language with the REPEAT ... UNTIL instruction.

```
REPEAT
 "WRREC_DB"(REQ := "start_config_control",
            ID := "Local Configuration",
            INDEX := 196,
            LEN := "conf_LEN",
            DONE => "conf_DONE",
            BUSY => "conf_BUSY",
            RECORD := "ConfDB".ConfigControl["ConfDB".Option],
//Selection of control data record*
            ERROR => "conf_ERROR",
            STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

  *Selection of the station option in the user program: In order for the CPU to know which station option you want to operate, you must set up a possibility to select between the various control data records in the user program. You can implement the

selection, for example, via an Int tag that references an array element. Please note that the variable used to select the control data record must be stored in the retentive memory area. If the tag is not retentive, it will be initialized during startup of the CPU and will thus be unavailable for selection of the station option.

– In the graphical programming languages, you implement the loop using instructions for program control.

  Example in FBD: Use the LABEL (jump label) and JMP (jump at RLO=1) instructions to program a loop.

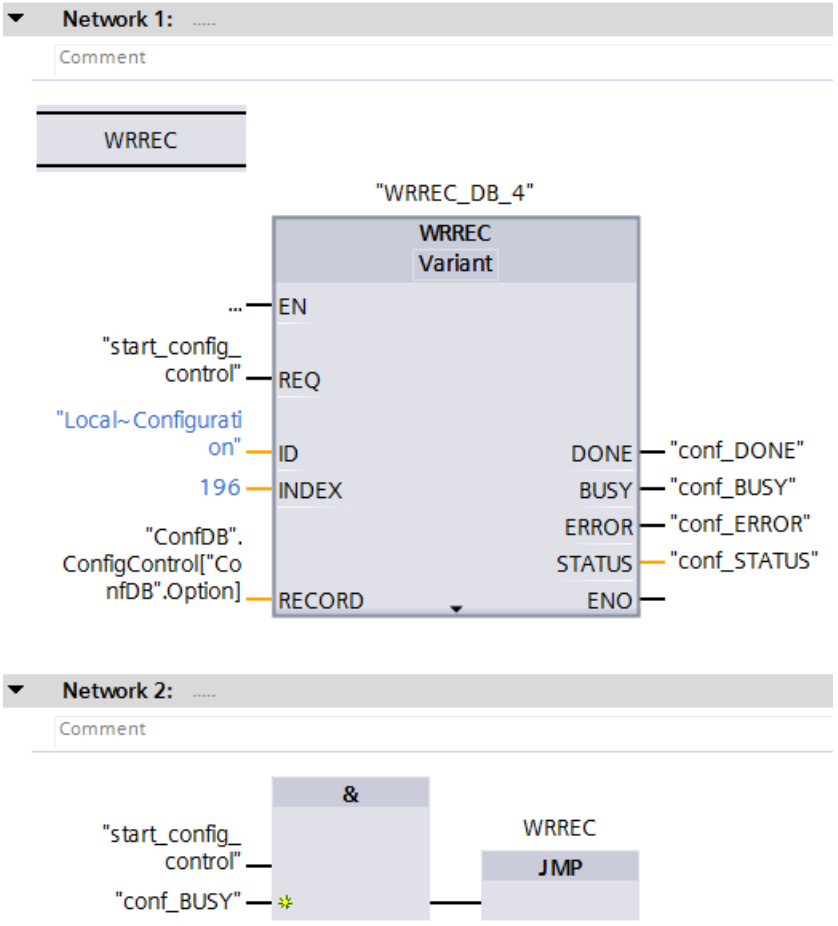


Figure 1-557 WRREC

- The control data record is stored retentively in the CPU. Note:
  – The retentivity of the control data record is independent of the retentivity settings in the STEP 7-memory area. The memory area in which the control data record is configured does then not have to be configured as retentive for this purpose.
  – If you write a control data record with modified configuration, the original data record 196 is deleted and the new data record 196 is saved retentively. The CPU will then restart with the modified configuration.

Special requirements relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200MP station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If the configuration is unchanged, you do not have to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration, this will result in a station failure in the distributed I/O system. The original data record196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

12.2.4 Behavior during operation

Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module outputs diagnostics data. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows an incorrect module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

Response to modules that are not present

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct writing access to the outputs that are not present or writing access to the process image of outputs that are not present: Remains without effect; no access error is signaled.
- Direct reading access to the inputs that are not present or reading access to the process image of inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: The output parameter STATUS of the instruction RDREC supplies the value $80A3_H$ "General CM error".

Commissioning 13

13.1 Overview

Introduction

This section includes information on the following topics:

- Check before powering on for the first time
- Procedure for commissioning the S7-1500 automation system
  - Removing/inserting the SIMATIC memory card
  - First power-on of the CPU
- Procedure for commissioning the S7-1500 distributed I/O system
  - First power-on of the ET 200MP on PROFINET IO
  - First power-on of the ET 200MP on PROFIBUS DP
- Operating modes of the CPU STARTUP, STOP, RUN and operating mode transitions
- CPU memory reset: Automatic and manual
- Backing up and restoring the CPU configuration
- Time synchronization
- Identification and maintenance data
- Shared commissioning of projects

Commissioning requirements

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

NOTE

Check coding element in the I/O module

Make sure that the coding element is present in the I/O module before you plug in the front connector for the first time. This reduces the risk of plugging a wired front connector into the wrong type of module when replacing a module.

Software tools for commissioning

The following software tools support you during commissioning:

- SIEMENS PRONETA in commissioning PROFINET systems.
- SIMATIC automation tool in commissioning the S7-1500 automation system / ET 200MP distributed I/O system.

You can find more information on SIEMENS PRONETA and the SIMATIC Automation Tool in the section Software (Page 152).

13.2 Check before powering on for the first time

Before the first power-on, check the installation and the wiring of the S7-1500 automation system/ET 200MP distributed I/O system.

Questions for the check

The following questions provide instructions for checking your system in the form of a checklist.

Racks

- Are the mounting rails firmly installed on the wall, in the framework, or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- If applicable, are all further protective conductor connection points on the S7-1500 automation system / ET 200MP distributed I/O system connected to the protective conductor? Has the protective conductor been tested?
- Has the connection between reference ground and ground been correctly made on all mounting rails?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?

Module installation and wiring

- Are all the modules inserted / installed in accordance with the mounting plan and corresponding to the configuration with STEP 7 and screwed firmly to the mounting rail?
- Are the coding elements present in the I/O modules?
- Are all the front connectors wired according to the circuit diagram, in the final position, and inserted on the correct module?
- Are the correct modules installed and connected to each other with U connectors?
- Are U connectors projecting either at the left-hand or right-hand over the outer modules on the S7-1500 automation system/ET 200MP distributed I/O system?

System power supply or load current supply

- Are all system power supplies and load current supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

13.3 Procedure for commissioning the S7-1500 automation system

Requirements

- The CPU is in the "Factory settings" state or has been reset to factory settings. You can find more information in the section Resetting the CPU to factory settings (Page 365).
- The SIMATIC memory card is as delivered or has been formatted.

Commissioning procedure

For the first commissioning of an S7-1500 automation system, we recommend the following procedure:

Table 1-845 Procedure for commissioning the SIMATIC S7-1500

Step	Procedure	See...
1	Configure hardware in STEP 7 and perform power balance calculation (see also "Requirements: CPU as bus device")	Section Power balance calculation (Page 167)
2	Create user program	STEP 7 online help
3	Insert required modules	Section Installation (Page 171)
4	Wiring and checking the assembly (system power supplies, front connectors, etc.)	Section Wiring (Page 192)
5	Insert SIMATIC memory card in the CPU	Section Removing/inserting a SIMATIC memory card on the CPU (Page 311)
6	Switch on the CPU and system power supply	Section First power-on of the CPU (Page 313)
7	Check LEDs	The meaning of the LEDs can be found in the manuals of the modules.
8	Evaluate information on the CPU's display	Section CPU display (Page 341)
9	Load hardware configuration and user program to the CPU	Online and diagnostics functions in STEP 7
10	Test inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, modifying the outputs in STOP mode. Section Test and service functions (Page 374)

Requirements: CPU as bus device

Note the following requirements for operation of a CPU as bus device:

- PROFIBUS interface
  - The integrated PROFIBUS interface of the CPU is configured using STEP 7 (device address and bus parameters configured).
  - The CPU is connected to the subnet.
  - The terminating resistors at the segment boundaries are switched on.

  You can find more information in the PROFIBUS function manual (https://support.industry.siemens.com/cs/ww/en/view/59193579)

- PROFINET interface
  - The integrated PROFINET interface of the CPU is configured using STEP 7 (IP address and device name configured).
  - The CPU is connected to the subnet.

  You can find more information in the PROFINET function manual (https://support.automation.siemens.com/WW/view/en/49948856)

Procedure for commissioning a SIMATIC Safety F-system

The procedure for commissioning an F-system is essentially the same as for commissioning a standard system. You use the Safety Administration Editor to commission SIMATIC Safety and activate the safety mode. The Safety Administration Editor is assigned to the fail-safe CPU in the STEP 7 project tree.

You can find more information on commissioning a SIMATIC Safety F-system and the Safety Administration Editor in the programming and operating manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

13.3.1 Removing/inserting a SIMATIC memory card on the CPU

Requirements

The CPU only supports pre-formatted SIMATIC memory cards. If applicable, delete all previously stored data before using the SIMATIC memory card. More information about deleting the contents of the SIMATIC memory card can be found in the Function Manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101).

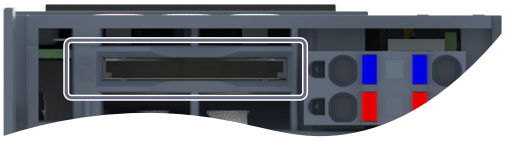
In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. For this purpose, slide the slider on the SIMATIC memory card out of the lock position.

If the inserted SIMATIC memory card is write-protected, the CPU display outputs the symbol ⚠ in the menu "Memory card" > "Overview". In addition, the display shows a message in the lower level of the menu.

Inserting the SIMATIC memory card

To insert a SIMATIC memory card, follow these steps:

1. Open the front cover of the CPU.
2. Ensure that the CPU is either switched off, or in the STOP mode.
3. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.



① Standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0: The slot for the SIMATIC memory card is located on the bottom of the CPU.

Figure 1-558 Slot for the SIMATIC memory card

4. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removing the SIMATIC memory card

To remove a SIMATIC memory card, follow these steps:

1. Open the front cover.
2. Switch the CPU into STOP mode.
3. Press the SIMATIC memory card into the CPU with light pressure. Once it has clicked into place, remove the SIMATIC memory card.

Only remove the SIMATIC Memory Card in POWER OFF or STOP mode of the CPU. Ensure that:

- No writing functions are active in STOP . Writing functions are online functions with the PG/PC, for example loading/deleting a block and test functions.
- No writing functions were active before POWER OFF.

If you remove the SIMATIC memory card during a write process, the following problems can occur:

- The data content of a file is incomplete.
- The file is no longer readable, or no longer exists.
- The entire content of the card is corrupted.

Please also note the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59457183) for removal of the SIMATIC memory card.

Reactions after removing/inserting the SIMATIC memory card

Inserting and removing the SIMATIC memory card in STOP mode triggers a re-evaluation of the SIMATIC memory card. The CPU hereby compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset. The retentive data is deleted and CPU then goes to STOP.

The CPU evaluates the SIMATIC memory card and indicates this by flashing the RUN/STOP LED.

NOTE

Using the SIMATIC memory card as a firmware update card

If you use the SIMATIC memory card as a firmware update card, removing and inserting the card will not result in the loss of retentive data.

Reference

You can find more information on the SIMATIC memory card in the Function Manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101).

13.3.2 First power-on of the CPU

Requirements

- An S7-1500 automation system has been installed.
- The system has been wired.
- The SIMATIC Memory Card is inserted in the CPU.

Procedure

Proceed as follows to commission the CPU:

- Switch on the system power supply and load current supply.

Result:

- The CPU executes a flash test:
  - All LEDs flash at 2 Hz
  - RUN/STOP LED flashes alternately yellow/green
  - ERROR LED flashes red
  - MAINT LED flashes yellow
- The CPU performs the system initialization and evaluates the SIMATIC Memory Card:
  - RUN/STOP LED flashes yellow at 2 Hz
- After the system initialization has been completed, the CPU goes to STOP mode:
  - The RUN/STOP LED lights up yellow

13.4 Procedure for commissioning the ET 200MP distributed I/O system

13.4.1 Commissioning the ET 200MP for PROFINET IO

Introduction

The commissioning of your automation system depends on the plant configuration.

Commissioning procedure

To commission the ET 200MP as IO device for PROFINET IO, proceed as follows:

Table 1-846 Procedure for commissioning the ET 200MP as an IO device for PROFINET IO

Step	Procedure	See...
1	Install ET 200MP	Section Installation (Page 171)
2	Connect ET 200MP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 192)
4	Configure IO controller	CPU manual or documentation of the IO controller
5	Switch on supply voltages for the IO controller	CPU manual or documentation of the IO controller
6	Switch on supply voltages for IO devices	Interface module (https://support.automation.siemens.com/WW/view/en/67295970/1-33300) manual
7	Download configuration to the IO controller	STEP 7 online help
8	Switch IO controller to RUN mode	CPU manual or documentation of the IO controller
9	Check LEDs	Interface module (https://support.automation.siemens.com/WW/view/en/67295970/1-33300) manual
10	Test inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, modifying the outputs. See section Test and service functions (Page 374)

NOTE

The operating mode transitions for the IO controller from RUN to STOP or from STOP to RUN can take several milliseconds, until the mode transition for the inputs and outputs of all I/O modules for the ET 200MP station is completed. This delay also applies to isochronous mode.

13.4.2 Commissioning the ET 200MP for PROFIBUS DP

Introduction

The commissioning of your automation system depends on the plant configuration.

Commissioning procedure

To commission the ET 200MP as a DP device on PROFIBUS DP, follow these steps:

Step	Procedure	See...
1	Install the ET 200MP (with IM 155-5 DP ST)	Section Installation (Page 171)
2	Set the PROFIBUS address on the interface module	Manual for the interface module (https://support.automation.siemens.com/WW/view/en/77910801/133300)
3	Connect the ET 200MP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 192)
4	Configure DP master (including PROFIBUS address)	Documentation of the DP master
5	Switch on supply voltages for DP master	Documentation of the DP master
6	Switch on supply voltages for DP devices	Interface module (https://support.automation.siemens.com/WW/view/en/77910801/133300) manual
7	Download configuration to the DP master	STEP 7 online help
8	Switch DP master to RUN	Documentation of the DP master
9	Check LEDs	Interface module (https://support.automation.siemens.com/WW/view/en/77910801/133300) manual
10	Test inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, modifying the outputs. Section Test and service functions (Page 374)

NOTE

During operating mode transitions of the DP master from RUN to STOP or from STOP to RUN, it can take several milliseconds until the mode transition is complete for the inputs and outputs of all the I/O modules of the ET 200MP.

13.5 Operating modes

Introduction

Operating states describe the behavior of the CPU at a specific time. The following operating states are possible via the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, for example, via the PROFINET IO interface (X1).

The status LEDs on the front side of the CPU indicate the current operating mode.

13.5.1 STARTUP mode

Response

Before the CPU starts to execute the cyclic user program, a start-up routine is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the start-up routine. That is, you can set up one or several startup OBs in your program, or none at all.

Points to note

- The CPU resets the process image input.
- All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operating mode.
- Before processing the start-up routine, the CPU transfers the I/O inputs to the process image input.
- After processing the start-up routine, the CPU releases the peripheral outputs.

NOTE

To read the current state of inputs during STARTUP, you can access inputs via the process image or via direct I/O access.
To initialize outputs during STARTUP, you can write values via the process image or via direct I/O access. The values are output at the outputs during the transition to the RUN mode.

- The CPU always starts up in a warm restart.
  - The non-retentive bit memories, timers and counters are initialized.
  - The non-retentive tags in data blocks are initialized.
- During startup, no cycle time monitoring is running yet.
- The CPU processes the startup OBs in the order of the startup OB numbers. The CPU processes all programmed startup OBs, regardless of the selected startup mode (figure "Setting the startup behavior").

- If a corresponding event occurs, the CPU can start the following OBs in startup:
  - OB 82: Diagnostics interrupt
  - OB 83: Removal/insertion of modules
  - OB 86: Rack error
  - OB 121: Programming error (only for global error handling)
  - OB 122: Time-out (for global error handling only)
    You can find a description of how to use global and local error handling in the STEP 7 online help.

  The CPU does not start all other OBs until the transition to RUN mode.

Response when expected and actual configurations do not match

The configuration downloaded to the CPU represents the expected configuration. The actual configuration is the actual configuration of the automation system. If the expected configuration and actual configuration deviate from one another, the CPU's behavior is specified by the setting of the hardware compatibility. For more information about the hardware compatibility, see section Operating mode transitions (Page 321).

Cancellation of the startup

If errors occur during startup, the CPU cancels the startup and returns to STOP mode.

The CPU does not perform startup or interrupts the startup under the following conditions:

- You have not inserted a SIMATIC memory card or an invalid one is inserted.
- You have not downloaded a hardware configuration to the CPU.

Configuring startup behavior

You configure the behavior of the CPU in the Startup group of the CPU properties.

Setting the startup behavior

To set the startup behavior, follow these steps:

1. Select the CPU in the device view of the STEP 7 hardware network editor.
2. In the properties under "General" select the "Startup" area.

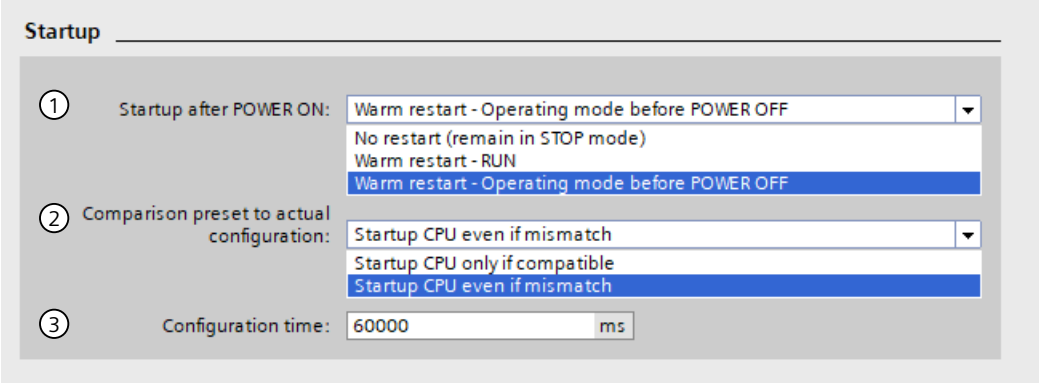


Figure 1-559 Setting the startup behavior

① Sets the startup type after POWER ON

② Defines the startup behavior for the case where a module in a slot does not correspond to the configured module. This parameter applies to the CPU and to all the modules for which no other setting was selected.

- Startup CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module. Compatible means that the module matches the number of inputs and output and must match with respect to its electrical and functional properties.
- Startup CPU even if mismatch: At this setting the CPU starts up irrespective of the type of module plugged.

For locally used modules you can configure the hardware compatibility in the parameter "Comparison preset to actual module" individually for each slot. When you change the setting of the hardware compatibility for a module, the setting made at the CPU does not apply for this module.

③ Specifies a maximum period (default: 60000 ms) in which the central and distributed I/O must be ready for operation. The communications modules (CM/CP) are supplied with voltage and communication parameters during the CPU startup. This parameter assignment time grants a period within which the I/O modules connected to the communication module (CM/CP) must be operationally ready.
The CPU goes into RUN mode when the central and the distributed I/O is operationally ready within the parameter assignment time.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the hardware compatibility.

Example for the "Comparison preset to actual configuration" parameter

"Startup CPU only if compatible"

The DI 32x24VDC HF input module with 32 digital inputs can be a compatible replacement for a DI 16x24VDC HF input module with 16 digital inputs. The pin assignment and all electrical and functional properties are identical.

"Startup CPU even if mismatch"

Instead of a configured digital input module, you insert an analog output module or no module is present in this slot and thus in all subsequent slots. Although the configured inputs cannot be accessed, the CPU starts up.

Note that the user program cannot function correctly in this case. Therefore, take appropriate measures!

13.5.2 STOP mode

Response

The CPU does not execute the user program in STOP mode.

All outputs are disabled or react according to the parameter settings for the respective module: They provide a substitute value as set in the parameters or retain the last value output and thus hold the controlled process in a safe operating mode.

13.5.3 RUN mode

Response

In "RUN" mode the cyclic, time-driven, and interrupt-driven program execution is performed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. For more information, see section Process images and process image partitions (Page 239).

Execution of the user program

Once the CPU has written the outputs and read the inputs, it runs through the cyclic program from the first instruction to the last instruction. Events with higher priority, such as hardware interrupts, diagnostic interrupts and communication, can interrupt the cyclic program flow and prolong the cycle time.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time has expired, even if the user program is completed sooner.

The operating system monitors the execution time of the cyclic program for a configurable upper limit known as the maximum cycle time. You can restart this time monitoring at any point in your program by calling the RE_TRIGR instruction.

If the cyclic program exceeds the maximum cycle time, the operating system starts the time error OB (OB 80). If the OB is not available, the CPU goes to STOP mode. If the cycle monitoring time is exceeded a second time, e.g. while the time error OB is being processed, the CPU goes to STOP mode.

Causes for loss of RUN mode

The following table provides a summary of causes that result in a loss of the RUN mode.

Cause	Reason	Comments
Triggering the STOP mode	Time error without calling OB 80	Maximum cycle time was exceeded.
	Time error when calling OB 80	The cycle time was exceeded twice in the same cycle.
	Programming error (without OB 121)	-
	Programming error in OB 121	-
	For motion control: Overflow of events	MC_Interpolator (OB 92)
		MC_Servo (OB 91)
	For motion control: Temperature monitor tripped	After a warning, the system switches to STOP mode
	For F-CPUs: Error responses occurred	75D1 / 75DC: Safety program: Internal CPU error
		75D2: Safety program: Maximum cycle time exceeded
		75D6: Safety program: Data corruption before output to F-I/O
		75D7: Safety program: Data corruption before output to partner F-CPU/other F-runtime group
		75D9: Safety program: Permissible time in deactivated safety mode exceeded
		75DF: Safety program: Data corruption before output to OPC UA SafetyConsumer instance
		75E6: Safety program: Inconsistent
		75EE: Safety program: Modifying jobs on F-I/O not completed
	Central module for S7-1500 unplugged/plugged	-
	Switched to STOP mode	Via STP instruction, mode selector switch/button, display, STEP 7, HMI, web server or SAT tool
CPU failure	CPU defective	-
	Power supply failed	-
	Negative power segment overview occurred	-
	SIMATIC Memory Card unplugged	-
Interrupting the RUN mode	Set breakpoint reached	-

Reference

More information about cycle and response times is available in the Function Manual Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

13.5.4 Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:

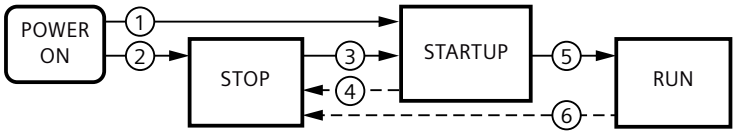


Figure 1-560 Operating modes and operating mode transitions

The table below shows the effects of the operating mode transitions:

Table 1-847 Operating mode transitions

No.	Operating mode transitions		Effects
①	POWER ON → STARTUP	After switching on, the CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The preceding "POWER OFF" was triggered by an interruption in the power supply. • Startup type "Warm restart - RUN" is set. or • Startup type "Warm restart mode before POWER OFF" is set and the CPU was in RUN mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
②	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are inconsistent. or • Startup type "No restart" is set. or • Startup type "Warm restart mode before POWER OFF" is set and the CPU was in STOP mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
③	STOP → STARTUP	The CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • You set the CPU to "RUN" mode via the programming device or the display and the mode switch in is RUN position. or • You set the mode selector from STOP to RUN or press the operating mode button RUN.[1)]	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
④	STARTUP → STOP	In the following cases the CPU returns from "STARTUP" to "STOP" mode when: • The CPU detects an error during startup. • You set the CPU to "STOP" via the programming device, display or mode selector switch / keys.[1)] • The CPU executes a STOP command in the Startup OB.	These operating mode transitions have no effect on data.
⑤	STARTUP → RUN	In the following cases, the CPU goes from "STARTUP" to "RUN" mode when: • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.	

[1)] Standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0: You switch the mode using keys (RUN and STOP).

No.	Operating mode transitions		Effects
⑥	RUN → STOP	In the following cases, the CPU goes from "RUN" mode back to "STOP" mode: • The CPU detects an error that prevents it from continuing to operate. • You have inserted CMs/CPs that have not yet been configured. • The CPU processes a STOP command in the user program. • You set the CPU to "STOP" via the programming device, display or mode selector switch / operating mode button.[1)]	These operating mode transitions have no effect on data.

1) Standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0: You switch the mode using keys (RUN and STOP).

NOTE

RUN → STOP in configurations with centrally inserted communication modules (CM) and/or communications processors (CPs)

Centrally inserted communications modules (CMs) and/or communications processors (CPs) that have not yet been configured and downloaded to the CPU can cause a transition from "RUN" mode back to "STOP" mode.

Remove unconfigured CMs/CPs or configure and download the configuration of these CMs to the CPU before you set the CPU to "RUN" mode.

13.6 CPU memory reset

Basics of a memory reset

The CPU must be in STOP mode for a memory reset.

A memory reset returns the CPU to its "initial state".

Memory reset means:

- An existing online connection between your programming device/PC and the CPU is terminated.
- The content of the work memory and the retentive and non-retentive data are deleted (with manual memory reset).
- The diagnostics buffer, time of day, and IP address are retained.
- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). The CPU copies this data from the load memory to the work memory.

  Result:

  – If you set an IP address in the hardware configuration ("Set IP address in the project" option) and a SIMATIC memory card with the project is in the CPU, this IP address is valid after the memory reset.
  – Data blocks no longer have current values but rather their configured start values.
  – Force jobs remain active.

Detecting a CPU memory reset

The RUN/STOP LED flashes yellow at 2 Hz. After completion, the CPU switches to STOP. The RUN/STOP LED is on (constant yellow light).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Table 1-848 Memory objects after memory reset

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Retentive tags of technology objects (e.g. adjustment values of absolute encoders)	Retained
Diagnostics buffer entries	Retained
IP address	Retained
Device name	Retained
Counter readings of the runtime meters	Retained
Time of day	Retained
CPU operating state: RUN/STOP	The CPUs retain the STOP state.

NOTE

Password for protection of confidential configuration data

The password for protection of confidential configuration data is retained after a memory reset of the CPU. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find more information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) Function Manual.

13.6.1 Automatic memory reset

Possible causes of automatic memory reset

The CPU executes an automatic memory reset if an error occurs that prevents normal further processing.

Examples of such errors:

- User program is too large and cannot be loaded to the work memory in full.
- The project data on the SIMATIC memory card are damaged, for example because a file was deleted.
- You remove or insert the SIMATIC memory card. The backed-up retentive data differs in structure from the data in the configuration on the SIMATIC memory card.

13.6.2 Manual memory reset

Reason for manual memory reset

Memory reset is required to reset the CPU to the "original state".

CPU memory reset

Three options are available for performing a CPU memory reset:

- Via the operating mode keys/mode switches
- Using the display
- Using STEP 7

Procedure via the mode selector keys (standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0)

NOTE

Memory reset ↔ Reset to factory settings

The procedure described below also corresponds to the procedure for resetting to factory settings:

- Key operation with inserted SIMATIC memory card: CPU executes a memory reset
- Key operation without inserted SIMATIC memory card: CPU executes reset to factory settings

To perform a memory reset of the CPU using the mode selector keys, follow these steps:

1. Press the STOP mode selector key.
   Result: The STOP ACTIVE and RUN/STOP LED light up yellow.
2. Press the STOP operating mode button until the RUN/STOP LED lights up for the 2nd time and remains continuously lit after 3 seconds. After this, release the button.
3. Press the STOP mode button again within the next 3 seconds.

Result: The CPU executes memory reset.

For information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 365).

Procedure using the mode selector

NOTE

Memory reset ↔ Reset to factory settings

The procedure described below also corresponds to the procedure for resetting to factory settings:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

To perform a memory reset of the CPU using the mode selector, follow these steps:

1. Set the mode selector to the STOP position.
   Result: The RUN/STOP LED lights up yellow.
2. Set the mode selector to the MRES position. Hold the switch in this position until the RUN/STOP LED lights up for the second time and remains continuously lit after three seconds. After this, release the selector.
3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

For information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 365).

Procedure using the display

To navigate to the desired "Memory reset" menu command, select the following sequence of menu commands and confirm after each selection with "OK".

- Settings → Reset → Memory reset

Result: The CPU executes memory reset.

Procedure using STEP 7

To perform a memory reset of the CPU via STEP 7, follow these steps:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU is set to STOP mode and performs memory reset.

13.7 Backing up and restoring the CPU configuration

Backup from online device
You may make changes in the operation of your plant. For example, you may add new devices, replace existing ones or adapt the user program. If these changes result in undesirable behavior, you can restore the plant to an earlier state. Before you download a changed configuration to the CPU, first use the option "Backup from online device" to create a complete backup of the current device state. If you have assigned a password to protect confidential PLC configuration data, then this password is not saved.

When restoring a backup with a set password to protect confidential configuration data, the following applies:
The password in the CPU must match the password in the backup.
Transfer the password to the CPU before restoring the backup. You can transfer the password either via a SIMATIC Memory Card or online in STEP 7 via "Online & Diagnostics". If the password in the CPU does not match the password entered in STEP 7, the SIMATIC Memory Card will be rejected when restoring. The CPU generates an entry in the diagnostics buffer.

You can find more information in the Protection of confidential configuration data (Page 259) section and in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) Function Manual.

Upload from device (software)
With the option "Upload from device (software)", you load the software project data from the CPU to an existing CPU in the project.

Upload device as new station
If you are operating a new PG/PC in the plant, the STEP 7 project that was used to create the plant configuration might not be available. In this case, you can use the option "Upload device as new station" to load the data to a project in your PG/PC.

Snapshot of the monitor values
To allow you to restore the actual values at a later date, back up the actual values of the data blocks using the option "Snapshot of the observed values".

Overview of backup types

The table below shows the backup of CPU data depending on the selected type of backup and its specific characteristics:

Table 1-849 Types of backup

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Current values of all DBs (global and instance data blocks) [1]	✓	✓	✓	✓
Blocks of the type OB, FC, FB and DB	✓	✓	✓	--
PLC tags (tag names and constant names)	✓	✓	✓	--
Technology objects	✓	✓	✓	--
Hardware configuration	✓	--	✓	--
Actual values (bit memories, timers and counters)[1]	✓	--	--	--

1 Only the values of the tags that are set as retentive are saved.

2 Contents of the DataLogs, Recipes and UserFiles folders

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Content of the SIMATIC memory card	✓	--	✓[2]	--
Archives, recipes	✓	--	--	--
Entries in the diagnostics buffer	--	--	--	--
Current time	--	--	--	--
Properties of the type of backup				
Backup possible for fail-safe CPUs	✓	✓	✓	✓
Backup can be edited	--	✓	✓	✓
Backup possible in operating mode	STOP	RUN, STOP	RUN, STOP	RUN, STOP

1 Only the values of the tags that are set as retentive are saved.

2 Contents of the DataLogs, Recipes and UserFiles folders

Example: Backup from online device

The following example shows how to carry out a complete backup of the current device state of the CPU in STEP 7. The S7-1500 automation system is in RUN mode. Before the backup, the CPU goes into STOP mode.

To start the backup, proceed as follows:

1. Right-click to select the CPU in the project tree.
2. Select the "Backup from online device" command from the shortcut menu.
   The "Upload preview" dialog window sets out the key information on the backup process to be run. For a backup you have to switch the CPU to the STOP mode.
3. In the "Action" column, select the "Stop module" command from the drop-down menu.
4. Click "Upload from device". The CPU changes to STOP mode. The backup of the CPU data starts. The backup is saved in the project tree in the folder of the CPU under "Online backups".

Example: Restoring a backup of an online device

If you have saved the CPU data beforehand, you can transfer the backup back to the device. The saved backup is then restored to the CPU.

The S7-1500 automation system is in RUN mode. Before the restoration, the CPU goes into STOP mode.

To start the backup restore, proceed as follows:

1. Open the CPU's folder in the project navigator. The lower-level objects are displayed.
2. Open the "Online backups" folder.
3. Select the backup you want to restore.
4. In the "Online" menu, select the "Download to device" command.
5. The "Load preview" dialog window sets out the key information on the restore process to be run. For a restoration you have to switch the CPU to the STOP mode.
6. In the "Action" column, select the "Overwrite" command from the drop-down menu.

7. Click "Download". The CPU changes to STOP mode. The backup is transferred to the CPU and restored. The "Load results" dialog then opens. In this dialog, you can check whether or not the loading operation was successful and take any further action that may be necessary (no action, start modules).
8. Click "Finish".

Rules for backup and restore

Observe the following rules when backing up/restoring:

- Complete the process quickly and without interruptions.
- The CPU and the programming device must be located in a protected network.
- Decide in advance whether you want to back up/restore the data of a CPU in STEP 7 or via the web server of the CPU.
  If you start the process in STEP 7, you must also finish the process in STEP 7. The same applies to the procedure via the web server.
  - To perform the operation in STEP 7, the user requires either the "PLC administrator" role or a role with the "Full access" function right.
  - The user requires a role with the "Create a backup of the CPU" or "Restore the CPU using a backup file" function right to carry out the procedure via the web server of the CPU.
- The user who starts the process must also complete the process.
- If a user cancels the process or the CPU cancels the process due to an error, only the user who canceled the process can resume the process. To do so, the following intermediate steps are required:
  - Reset to factory settings
  - Start a new backup/restore

Reference

You can find additional information on the different backup methods in the STEP 7 online help.

Emergency address (Emergency IP)

The emergency address (emergency IP address) of a CPU is intended for diagnostic and download functions, for example, when the CPU is no longer accessible via the IP protocol after a wrong project is downloaded. For information on the emergency address, please refer to the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Storage of multilingual project texts

When you configure a CPU, texts of different categories result, for example:

- Object names (names of blocks, modules, tags, etc.)
- Comments (for blocks, networks, watch tables, etc.)
- Messages and diagnostic texts

Texts are provided by the system, for example texts in the diagnostics buffer, or they are created during configuration, for example messages.

Texts exist in the project in one language or, after a translation process, in multiple languages. You can maintain project texts in all languages available to you in the project tree (Languages & resources > Project texts). The texts produced when configuring can be downloaded to the CPU.

The following texts are downloaded in the selected languages with the project data to the CPU and are also used by the Web server/CPU display:

- Diagnostics buffer texts (cannot be changed)
- Status texts for the module status (cannot be changed)
- Message texts with associated text lists
- Tag comments and step comments for S7 GRAPH and PLC Code Viewer
- Comments in watch tables

The following texts are also downloaded in the selected languages with the project languages to the CPU but are not used by the Web server/CPU display:

- Comments in tag tables (for tags and constants)
- Comments in global data blocks
- Comments of elements in block interfaces of FBs, FCs, DBs and UDTs
- Network titles in blocks written in LAD, FBD or STL
- Block comments
- Network comments
- Comments of LAD and FBD elements

The S7-1500 CPUs support the storage of multilingual project texts in up to three different project languages. If the project texts for a project language nevertheless exceed the memory space reserved for them, the project cannot be downloaded to the CPU. The download is aborted with a notice that not enough memory space is available. In such a case, take measures to reduce the required storage space, for example by shortening comments.

You will find information on parameterization of multilingual project texts in STEP 7 in the STEP 7 online help.

Size of files and size of the SIMATIC Memory Card

NOTE

SIMATIC Memory Card

Make sure that there is enough available storage space on your SIMATIC Memory Card for downloading projects.

To download and back up projects, the project size and the size of the files on the SIMATIC Memory Card must be less than 2 GB.

Do not manipulate any contents in the OMSSTORE folder on the SIMATIC Memory Card.

You can find information on reading out the memory usage of the CPU and the SIMATIC memory card in the Structure and Use of the CPU Memory (https://support.industry.siemens.com/cs/de/de/view/59193101/en) Function Manual.

13.8 Time synchronization

Introduction

All CPUs are equipped with an internal clock. The clock shows:

- The time of day with a resolution of 1 millisecond
- The date and the day of the week

The CPU take into account the time change caused by daylight saving time.

You can synchronize the time of the CPUs with an NTP server in NTP mode.

Principle of operation

In NTP mode, the device sends time queries at regular intervals (in client mode) to the NTP server in the subnet (LAN). Based on the replies from the server, the most reliable and most accurate time is calculated and the time of day on the CPU is synchronized. The advantage of this mode is that it allows the time to be synchronized across subnets. You can synchronize the time of day of up to a maximum of four NTP servers. You address a communications processor or an HMI device, for example, as sources for time synchronization via the IP addresses.

The update interval defines the interval between the time queries (in seconds). The value of the interval ranges between 10 seconds and one day. In NTP mode, it is generally UTC (Universal Time Coordinated) that is transferred. UTC corresponds to GMT (Greenwich Mean Time).

NTP server for the CPU S7-1500

You can assign up to 4 NTP servers to a CPU S7-1500.

You have the following options to reset the IP addresses of the NTP servers:

- Configure IP addresses of the NTP servers in STEP 7.
- Set IP addresses of the NTP servers with the "T_CONFIG" instruction.
- Obtain IP addresses of the NTP servers via DHCP.
  As of firmware version V2.9, the CPU can also obtain the NTP servers via DHCP. You can find more information on the procedure and the DHCP communication protocol in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Configuring IP addresses of the NTP servers in STEP 7

To configure the IP addresses of the NTP servers in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. Configure the time synchronization in the "Properties > General > Time" parameter group.
3. Set the "Set NTP server in the project" value at the "Time synchronization" parameter.
4. Enter the IP addresses of up to four NTP servers for "NTP Server 1" to "NTP Server 4".
5. Set the time interval of time queries for "Update interval". Set the update interval to between 10 s and 86400 s.

Setting the IP addresses of the NTP servers with the "T_CONFIG" instruction

Requirement:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

Proceed as follows to set the IP addresses of the NTP servers with the T_CONFIG instruction:

1. Enter the IP addresses of up to four NTP servers in a tag of the data type IF_CONF_NTP.
2. Connect the tag of the data type IF_CONF_NTP to the block parameter CONF_DATA of the instruction T_CONFIG.
3. Call the T_CONFIG instruction in the user program.

Result: The CPU adopts the addresses of the NTP servers from the T_CONFIG instruction.

If necessary, you can change the addresses of the NTP servers several times with T_CONFIG.

Reference

For more information on time-of-day synchronization - time synchronization in automation, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/de/en/view/86535497).

13.8.1 Example: Configuring the IP address of the NTP server in STEP 7 or setting it in the user program

Automation task

You are using your own NTP server in your network with the IP address 192.168.1.15. Your own server provides you with the following advantages:

- Protection against unauthorized accesses from outside
- Every device that you synchronize with your own NTP server uses the same time.

You want to synchronize the S7-1500 CPU with this NTP server.

The following sections describe how to configure the IP address of the NTP server in STEP 7 or set it in the user program.

Configuring the IP address of the NTP server in STEP 7

Procedure

1. Select the S7-1500 CPU in STEP 7.
2. Configure the time synchronization in the "Properties > General > Time" parameter group.
3. Set the "Set NTP server in the project" value at the "Time synchronization" parameter.
4. For "NTP Server 1", enter the IP address of the NTP server: 192.168.1.15.
5. Download the hardware configuration to the CPU.

Result

The S7-1500 synchronizes the time with the NTP server 192.168.1.15.

Set IP addresses of the NTP server with the "T_CONFIG" instruction

Requirement:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

To set the IP address for the NTP server, use the following block parameters of the "T_CONFIG" instruction:

- Req: A positive edge at the block parameter "Req" starts a job of the "T_CONFIG" instruction.
- Interface: Enter the HW ID of the PROFINET interface 1 of the CPU at the block parameter "Interface". In this example, the HW ID is "64".
- Conf_Data: Area in which you save the IP addresses of the NTP server. Use the data type "IF_CONF_NTP" for this purpose.

Procedure

Proceed as follows to set the IP address of the NTP server in the user program to "192.168.1.15":

1. Create a global data block in the project tree under "Program blocks > Add new block". Name the global data block "NTP".
2. Create an "NTP_Server" tag of the data type "IF_CONF_NTP" in the global data block "NTP".

NTP

	Name	Data type	Start value	Comment
1	Static			
2	NTP_Server	IF_CONF_NTP		
3	Id	UInt	17	
4	Length	UInt	22	
5	Mode	UInt	0	
6	NTP_IP	Array[1..4] of IP_V4		
7	NTP_IP[1]	IP_V4		
8	ADDR	Array[1..4] of Byte		IPv4 address
9	ADDR[1]	Byte	192	IPv4 address
10	ADDR[2]	Byte	168	IPv4 address
11	ADDR[3]	Byte	1	IPv4 address
12	ADDR[4]	Byte	10	IPv4 address
13	NTP_IP[2]	IP_V4		
14	NTP_IP[3]	IP_V4		
15	NTP_IP[4]	IP_V4		
16	change_NTP-Server	Bool	false	
17	done	Bool	false	
18	busy	Bool	false	
19	error	Bool	false	
20	status	DWord	16#0	
21	err_loc	DWord	16#0	

Figure 1-561 Example data block with IF_CONF_NTP

3. Create a "T_CONFIG" instruction in the user program.
4. Connect the "T_CONFIG" instruction as follows.

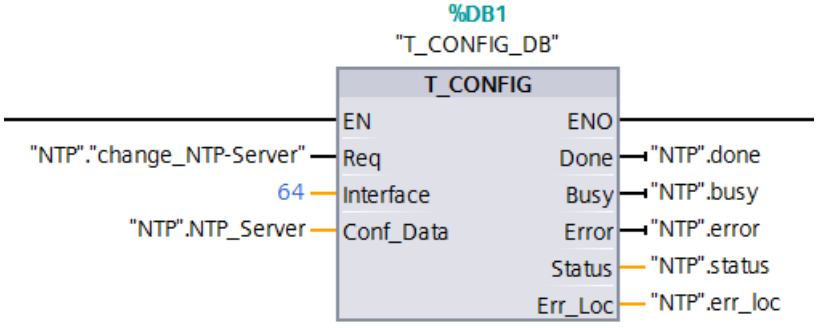


Figure 1-562 Example T_CONFIG: Setting the NTP server

5. In the user program, assign the IP address 192.168.1.15 to the data type "IF_CONF_NTP":
```
"NTP".NTP_Server.NTP_IP[1].ADDR[1] := 192;
"NTP".NTP_Server.NTP_IP[1].ADDR[2] := 168;
"NTP".NTP_Server.NTP_IP[1].ADDR[3] := 1;
"NTP".NTP_Server.NTP_IP[1].ADDR[4] := 15;
```
6. Generate a positive edge for the tag "change_NTP-Server" in the user program:
```
"NTP"."change_NTP-Server" := true;
```

Result
The S7-1500 synchronizes the time with the NTP server 192.168.1.15.

13.9 Identification and maintenance data

13.9.1 Reading out and entering I&M data

I&M data

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I data) or
- Readable/writable (M data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-specific information, for example installation location. Maintenance data for the S7-1500/ET 200MP is created during configuration and downloaded to the automation system/distributed I/O system.

All modules of the S7-1500/ET 200MP support identification data I&M0 through I&M3.

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a plant
- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

Maintenance data (I&M4): Storage of a CRC test value for IM 155-5 MF HF interface modules to ensure data integrity of data used by the interface module.

Options for reading out I&M data

- Via the user program
- Using the display of the CPU
- Via STEP 7 or HMI devices
- Via the CPU web server

Reading I&M data via the user program

You have the following options for reading module I&M data in the user program:

- Using the RDREC instruction
  The data record structure for centrally inserted modules as well as for distributed modules that are accessible via PROFINET IO/PROFIBUS DP is described in the section Record structure for I&M data (Page 336).
- Using the Get_IM_Data instruction

Reference

The description of the instructions can be found in the STEP 7 online help.

Reading I&M data from displays

To read the I&M data "Plant designation" or "Location identifier" of the CPU via the display, follow these steps:

1. Navigate to the "Overview/PLC" menu on the display of the CPU.
2. Select "Plant designation" or "Location identifier" and confirm with "OK".

To read the I&M data "Plant designation" or "Location identifier" of a centrally used module, follow these steps:

1. Navigate to the "Modules" menu on the display of the CPU.
2. Select the menu command "Local modules" and confirm with "OK".
3. Select the slot of the module (e.g., slot 3: DI 32 x 24VDC HF) and confirm with "OK".
4. Select the "Status" and confirm with OK.
5. Select "Plant designation" or "Location identifier" and confirm with "OK".

To read the I&M data "Plant designation" or "Location identifier" of a module used in distributed mode, follow these steps:

1. Navigate to the "Modules" menu on the display of the CPU.
2. Select the corresponding distributed I/O system (for example PROFINET IO system) and confirm with "OK".
3. Select the corresponding device (for example ET 200SP-Station_1) and confirm with "OK".
4. Select the slot of the module (e.g., slot 1: DI 16 x DC24V ST_1) and confirm with "OK".
5. Select the "Status" and confirm with OK.
6. Select "Plant designation" or "Location identifier" and confirm with "OK".

Reading I&M data via STEP 7

Requirement: There must be an online connection to the CPU/interface module.

To read I&M data using STEP 7, follow these steps:

1. In the project tree, select the CPU/the interface module.
2. Go to "Online & diagnostics".
3. In the "Diagnostics" folder, select the "General" area.

Enter maintenance data via STEP 7

STEP 7 assigns a default module name. You can enter the following information:

- Plant designation (I&M 1)
- Location identifier (I&M 1)
- Installation date (I&M 2)
- Additional information (I&M 3)

To enter maintenance data via STEP 7, follow these steps:

1. In the device view of STEP 7, select the CPU/interface module or a module.
2. Go to properties, "General", and select the "Identification & Maintenance" area
3. Enter the data.

During the loading of the hardware configuration, the maintenance data (I&M 1, 2, 3) are also loaded.

Procedure for reading I&M data via the Web server

The procedure is described in detail in the Web server Function Manual (https://support.automation.siemens.com/WW/view/en/59193560).

13.9.2 Record structure for I&M data

Reading I&M records via user program (centrally and distributed via PROFINET IO)

Use **Read data record** ("RDREC" instruction) to access specific identification data. Under the associated record index you obtain the corresponding part of the identification data.

The records are structured as follows:

Table 1-850 Basic structure of data records with I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H I&M4: 0024_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H I&M4: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/Index $AFF0_H$: 54 I&M1/Index $AFF1_H$: 54 I&M2/Index $AFF2_H$: 16 I&M3/Index $AFF3_H$: 54 I&M4/Index $AFF4_H$: 54	- - - - -

Table 1-851 Record structure for I&M identification data

Identification data	Access	Default setting	Explanation
Identification data 0: (record index AFF0$_H$)			
VendorIDHigh	read (1 bytes)	00$_H$	Name of the manufacturer (42$_D$ = Siemens AG)
VendorIDLow	read (1 bytes)	2A$_H$	
Order_ID	read (20 bytes)	6ES7155-5MU00-0CN0	Article number of module (e.g. IM 155-5 MF HF)
IM_SERIAL_NUMBER	read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	read (2 bytes)	1	Corresponding to hardware version
IM_SOFTWARE_REVISION	read	Firmware version	Provides information about the firmware version of the module
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_Enhancement	(1 byte)	00$_H$ - FF$_H$	
• IM_SWRevision_Bug_Fix	(1 byte)	00$_H$ - FF$_H$	
• IM_SWRevision_Internal_Change	(1 byte)	00$_H$ - FF$_H$	
IM_REVISION_COUNTER	read (2 bytes)	0000$_H$	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	read (2 bytes)	0000$_H$	Generic Device
IM_PROFILE_SPECIFIC_TYPE	read (2 bytes)	0001$_H$	CPU
		0003$_H$	I/O modules
IM_VERSION	read	0101$_H$	Provides information on the ID data version (0101$_H$ = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	read (2 bytes)	000E$_H$	Provides information about the available identification data and maintenance data (I&M1 to I&M3)
Maintenance data 1: (Record index AFF1$_H$)			
IM_TAG_FUNCTION	read/write (32 bytes)	-	Enter an identifier for the module here, that is unique plant-wide.
IM_TAG_LOCATION	read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (Record index AFF2$_H$)			
IM_DATE	read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (Record index AFF3$_H$)			
IM_DESCRIPTOR	read/write (54 bytes)	-	Enter a comment about the module here.
Maintenance data 4: (Record index AFF4$_H$)			
USI	Read (4 bytes)	0x63726331	UserstructureIdentifier: Internal, fixed value
CHK_OVERALL	Read (4 bytes)	-	Overall CRC via all individual CRCs
CHK_OVERALL_SUBS	Read (4 bytes)	0 or value*	Overall CRC via all assigned modules of the IM
CHK_STATIC_LOCAL	Read (4 bytes)	-	CRC via static data of the IM

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the associated modules support I&M4 data.

Identification data	Access	Default setting	Explanation
CHK_STATIC_SUBS	Read (4 bytes)	0 or value*	CRC via all static data of the modules of the IM
CHK_OVERALL_SETUP	Read (4 bytes)	-	Overall CRC via all setup data of the IM and modules of the IM
CHK_REMANENT_LOCAL	Read (4 bytes)	-	CRC via retentive data of the IM
CHK_REMANENT_SUBS	Read (4 bytes)	0 or value*	CRC via all retentive data of the modules of the IM
CHK_WORKING_LOCAL	Read (4 bytes)	-	CRC via the parameters in STEP 7 for the IM
CHK_WORKING_SUBS	Read (4 bytes)	0 or value*	CRC via all parameters in STEP 7 for the modules of the IM
NOT USED	Read (14 bytes)	0	14 reserved bytes

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the associated modules support I&M4 data.

Reading I&M records with record 255 (distributed configuration via PROFIBUS)

Use **Read data record** ("RDREC" instruction) to access specific identification data.

The modules support standardized access to identification data using DR 255 (index 65000 to 65003). For more information on the DR 255 data structure, refer to the specifications of the Profile Guidelines Part 1: Identification & Maintenance Functions - Order no.: 3.502, Version 1.2, October 2009.

The specifications are available, for example, on the PROFIBUS & PROFINET International (PI) website on the Internet (https://www.profibus.com/).

13.9.3 Example: Read out firmware version of the CPU with Get_IM_Data

Automation task

You want to check whether the modules in your automation system have the current firmware. The firmware version of the modules can be found in the I&M0 data. The I&M0 data is the basic information for a device. The I&M0 data contains information, for example:

- Manufacturer ID
- Article number and serial number
- Hardware and firmware version.

To read out the I&M0 data, use the "Get_IM_Data" instruction. You read the I&M0 data of all modules in the user program of the CPU with "Get_IM_Data" instructions and store the I&M data in a data block.

Conditions and parameters

To read out the I&M data of the CPU, use the following block parameters of the "Get_IM_Data" instruction:

- LADDR: Enter the HW ID of the module at the block parameter "LADDR".
- IM_TYPE: Enter the I&M data number (e.g. "0" for I&M 0 data) at the block parameter "IM_TYPE".
- DATA: Area for storing the read I&M data (for example. in a global data block). Store the I&M 0 data in an area of the data type "IM0_Data".

This example shows how to read out the I&M 0 data of a CPU 1511-1 PN. To read out the I&M 0 data of a different module, simply use the HW ID of the module at the parameter LADDR.

Solution

To read out the I&M 0 data of the CPU, follow these steps:

1. Create a global data block to store the I&M 0 data.
2. Create a structure of the data type "IM0_Data" in the global data block. You can assign any name to the structure ("imData") in this case.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value
1	Static		
2	imData	IM0_Data	
3	done	Bool	false
4	busy	Bool	false
5	error	Bool	false
6	status	Word	16#0

Figure 1-563 Example: Data block for I&M data

3. Create the Insert the "Get_IM_Data" instruction in the user program, e.g. in OB 1.
4. Connect the "Get_IM_Data" instruction as follows:

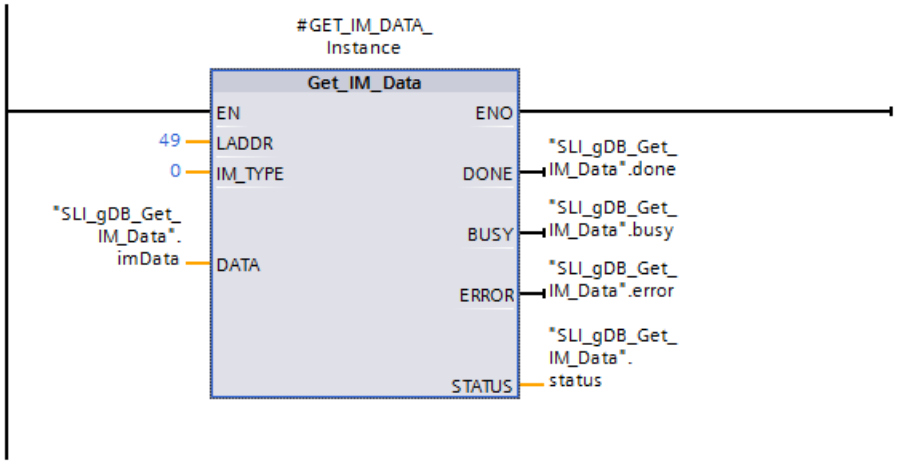


Figure 1-564 Example: Reading out I&M0 data

5. Call the "Get_IM_Data" instruction in the user program.

Result

The "Get_IM_Data" instruction has stored the I&M0 data in the data block.

You can view the I&M0-Daten online in STEP 7, for example, in the data block with the "Monitor all" button. The CPU in the example is a CPU 1511-1 PN (6ES7511-...) with firmware version V1.5.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value	Monitor value
1	Static			
2	imData	IM0_Data		
3	Manufacturer_ID	UInt	0	42
4	Order_ID	String[20]	''	'6ES7 511-...'
5	Serial_Number	String[16]	''	'S C-DOS710132013'
6	Hardware_Revision	UInt	0	3
7	Software_Revision	IM0_Version		
8	Type	Char	' '	'V'
9	Functional	USInt	0	1
10	Bugfix	USInt	0	5
11	Internal	USInt	0	0
12	Revision_Counter	UInt	0	0
13	Profile_ID	UInt	0	0
14	Profile_Specific_Ty...	UInt	0	0
15	IM_Version	Word	16#0	16#0101
16	IM_Supported	Word	16#0	16#001E
17	done	Bool	false	TRUE
18	busy	Bool	false	FALSE
19	error	Bool	false	FALSE
20	status	Word	16#0	16#0000

Figure 1-565 Example: I&M0 data of an S7-1500 CPU

13.10 Shared commissioning of projects

Team Engineering

In Team Engineering, several users from various engineering systems work on a project at the same time and access one S7-1500 CPU.

The users can edit separate parts of a master project independently of one another at the same time. The CPU show the changes of the other editors in a synchronization dialog during the loading of the configuration into the CPU and synchronizes the changes automatically, if possible.

Certain online functions can also be executed in parallel from several engineering systems on a shared CPU, such as:

- Monitoring blocks on the CPU
- Modifying blocks on the CPU
- Trace functions

You can find detailed information on the topic of Team Engineering in the STEP 7 online help.

CPU display

14

Introduction

The section below gives an overview of the mode of operation of the CPU display. Detailed information on the individual options, a training course and a simulation of the selectable menu items is available in the SIMATIC S7-1500 Display Simulator (https://support.industry.siemens.com/cs/ww/en/view/109761758).

Display

The S7-1500 CPU has a display and operating keys. The display of the CPU shows you the control and status information in different menus. You use operating keys to navigate through the menus and make a variety of settings in the process.

Advantages

The display of the CPU offers the following advantages:

- Reduced downtimes through diagnostic messages in plain text
- Time savings during commissioning, maintenance and downtime of the plant by changing the interface settings (e.g. IP address) of CPU and connected CMs/CPs. No programming device is required.
- Shorter downtimes due to read/write access to force tables and read/write access to watch tables.
  This allows the current values of the individual tags of a user program or a CPU to be monitored and changed by the monitoring and force tables. You can find more information on the watch and force tables in section Test functions and fault correction (Page 374) and in the STEP 7 online help.
- On site, an image (backup copy) of the functioning plant can be
  - Backed up on the SIMATIC Memory Card of the CPU
  - Restored from the SIMATIC Memory Card of the CPU

You do not require an additional PG/PC.

- For F-CPUs: Overview of status of safety mode and of F-parameters of F-CPU and F-I/O.

Password protection for the display

In the properties of the CPU, configure a password in STEP 7 for the display operation. Local access protection is thus protected via a local password.

Operating temperature for the display

To increase the service life of the display, the display switches off when the permitted operating temperature is exceeded. When the display has cooled down again, it switches on automatically again. When the display is switched off, the LEDs continue to show the status of the CPU.

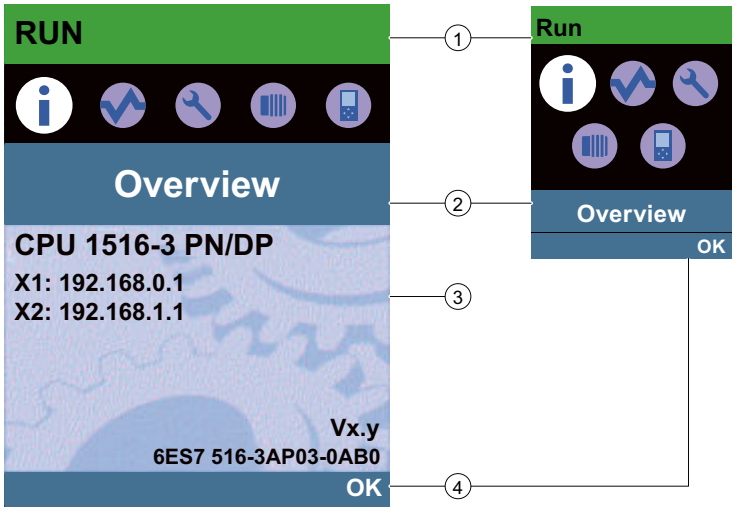
Information about the temperatures at which the display switches off and back on again is available in the technical data of the manuals of the CPUs.

NOTE

The S7-1500 CPU has no internal temperature measurement. Reading out the internal temperature of the S7-1500 CPU is not supported.

Display

The following figures show an example of a CPU with large display (left: for example, CPU 1516-3 PN/DP) and a CPU with small display (right: for example, CPU 1511-1 PN).



① CPU status information
② Names of the menus
③ Data display field
④ Navigation aid, e.g. OK/ESC or the page number

Figure 1-566 Example views of the displays

Regarding ①: CPU status information

The following table shows the CPU status information that can be retrieved via the display.

Table 1-852 CPU status information

Color and icons for the status data	Meaning
Green	RUN
Orange	• STOP • STOP - firmware update
Red	FAULT
White	• Connection established between CPU and display.
	• Access protection configured. • Incorrectly displayed with the following configuration: You have not configured access control and the "Anonymous" user does not have full access rights (e.g. read-only access) to the CPU.
	• At least one interrupt is active in the CPU. • No SIMATIC Memory Card inserted in the CPU. • The serial number to which a know-how-protected block is bound does not match the serial number of the CPU or the SIMATIC Memory Card. • No user program loaded.
	Force job is active in the CPU.
	F-capability activated. Safety operation active (for fail-safe CPUs) The symbol is grayed out when safety mode is deactivated.
	Fail-safe CPU (for fail-safe CPUs).

Regarding ②: Names of the menus

The following table shows the available menus of the display.

Table 1-853 Names of the menus

Main menu items	Meaning	Description
	Overview	The "Overview" menu contains information about: • The properties of the CPU • The properties of the inserted SIMATIC Memory Card • Whether a know-how protection or a linking of the serial number exists. The following information is displayed for F-CPUs: • The status of the safety mode • The collective signature • The date of the last changes
	Diagnostics	The "Diagnostics" menu includes: • The display of diagnostic messages. • Read/write access to force and watch tables. • Display of cycle time. • Display of CPU memory utilization. • Display of interrupts.
	Settings	In the "Settings" menu you: • Assign the IP addresses and the PROFINET device name of the CPU. • Set the network properties of each CPU interface. • Set the date, time, time zones, operating modes (RUN/STOP) and protection levels. • Disable/enable display with display password • Perform a CPU memory reset. • Perform a reset to factory settings. • Format the SIMATIC Memory Card. • Delete the user program. • Back up/restore the CPU configuration to/from the SIMATIC Memory Card.

Main menu items	Meaning	Description
		• View the status of the firmware update. • Convert the SIMATIC Memory Card to a program card
	Modules	The "Modules" menu contains information about the central and distributed modules that are used in your configuration. Peripherally deployed modules are connected to the CPU via PROFINET and/or PROFIBUS. You can set the IP addresses for the CPU or a CP/CM here. Fail-safe parameters are displayed for F-modules.
	Display	In the "Display" menu you can configure settings related to the display, such as language setting, brightness and energy-saving mode. The energy-saving mode dims the display. The standby mode selectors the display off.

Menu icons

The following table shows the icons that are displayed in the menus.

Table 1-854 Menu icons

Icon	Meaning
	Editable menu item.
	Select the desired language here.
	A message is available in the next lower level page.
	There is an error in the next lower level page.
	The marked module is not accessible.
	Navigate to the next lower level page.
	In edit mode you make the selection using two arrow keys: • Down/up: jumps to the selection or is used to select the desired digits/options.
	In edit mode you make the selection using four arrow keys: • Down/up: jumps to the selection or is used to select the desired digits. • Left/right: jumps one spot forward or backward.
	The alarm is not yet acknowledged.
	The alarm is acknowledged.

Control keys

You operate the display using the following keys:

- Four arrow keys: "up", "down", "left", "right"
  If you press and hold an arrow key for 2 seconds, this generates an automatic scroll function.
- One ESC key

- One OK key

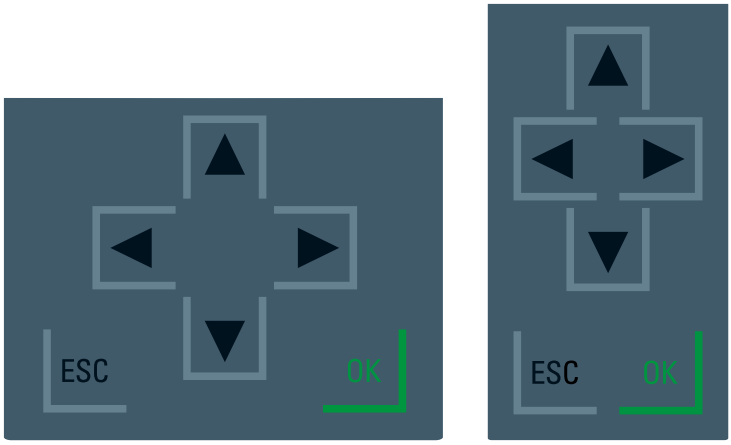


Figure 1-567 Control keys

NOTE
If the display is in energy-saving mode or in standby mode, you can exit this mode by pressing any key.

Functions of the "OK" and "ESC" keys

- For menu commands in which an entry can be made:
  - OK → valid access to the menu command, confirmation of input, and exit from the edit mode
  - ESC → Restore original content (changes are not saved) and exit edit mode
- For menu commands in which no entry can be made:
  - OK → to next submenu command
  - ESC → back to previous menu command

Hold ESC for about 3 seconds on any screen of the display. Result: You automatically return to the home page.

Tooltips

Some of the values shown on the display can exceed the available display width. The values in question include:

- Station name
- Plant designation
- Location identifier
- PROFINET device name

The available display width is frequently exceeded on CPUs with small displays.

If you focus on the relevant value on the display and press the "Left" arrow key, a tooltip appears. The tooltip shows the name of the value in complete length. To hide the tooltip again, press the "Left" arrow key again or the "ESC" key.

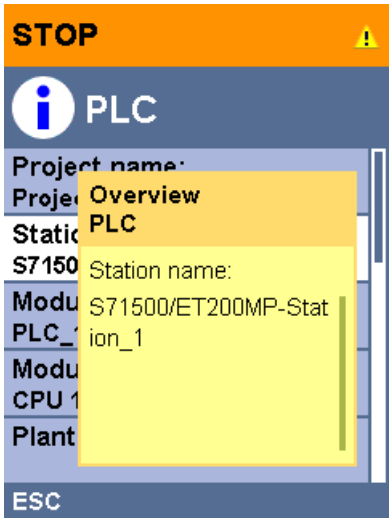


Figure 1-568 Tooltip function

Uploading image to the display via STEP 7

In the STEP 7 device view, you download an image from your file system to the CPU display with the "Display > User-defined logo" function.

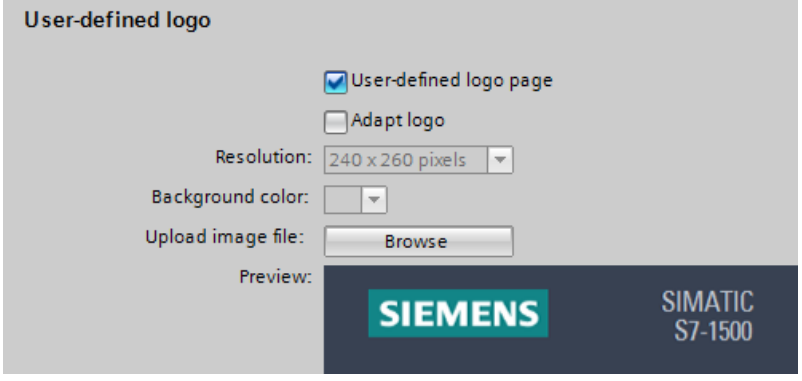


Figure 1-569 Uploading image to CPU

To display the uploaded image in the correct aspect ratio, use images with the following dimensions depending on the CPU.

Table 1-855 Dimensions

CPU	Dimensions	Supported formats
CPU 1511(F)-1 PN CPU 1511C-1 PN CPU 1511T(F)-1 PN	128 x 120 pixels	Bitmap, JPEG, GIF, PNG
CPU 1512C-1 PN	128 x 120 pixels	Bitmap, JPEG, GIF, PNG
CPU 1513(F)-1 PN	128 x 120 pixels	Bitmap, JPEG, GIF, PNG

CPU	Dimensions	Supported formats
CPU 1515(F)-2 PN CPU 1515T(F)-2 PN	240 x 260 pixels	Bitmap, JPEG, GIF, PNG
CPU 1516T(F)-3 PN CPU 1516(F)-3 PN/DP CPU 1516T(F)-3 PN/DP	240 x 260 pixels	Bitmap, JPEG, GIF, PNG
CPU 1517(F)-3 PN CPU 1517(F)-3 PN/DP CPU 1517T(F)-3 PN CPU 1517T(F)-3 PN/DP	240 x 260 pixels	Bitmap, JPEG, GIF, PNG
CPU 1518(F)-3 PN CPU 1518(F)-4 PN/DP CPU 1518T(F)-3 PN CPU 1518T(F)-4 PN/DP CPU 1518(F)-4 PN/DP MFP	240 x 260 pixels	Bitmap, JPEG, GIF, PNG

If the uploaded image exceeds the specified dimensions, the display shows only part of the image. The "Adapt logo" option in STEP 7 allows you to reduce the image to the specified dimensions. However, note that the original aspect ratio of the image is not retained in such cases.

Displaying image on the display

To display the uploaded image on the display of the CPU, press the ESC key in the main screen of the display. When you upload an image and are in the main screen, the display automatically shows the image after 60 seconds. To hide the image again, press any key on the display.

Available language settings

You can set the following languages separately for menu and message texts:

- Chinese
- German
- English
- French
- Italian
- Japanese
- Korean
- Portuguese (Brazil)
- Russian
- Spanish
- Turkish

You select the required language directly on the display in the "Display" menu or in STEP 7 in the hardware configuration of the CPU under "User interface languages".

To display message texts on the display, follow these steps:

1. Download the message texts to the CPU as a software component.
   - To do so, select the "Consistent download" option under "Text libraries" in the "Load preview" dialog.
2. You set the project language you would like to be displayed as the interface language by means of parameter assignment.
   - To do so, select a CPU and navigate to the "Multiple languages" area ("Properties > General > Multilingual support") in the Inspector window.
   - Assign the required project languages to the interface languages.

Reference

Important information/special requirements for the display of F-CPUs can be found in Product Information F-CPUs S7-1500
(https://support.industry.siemens.com/cs/ww/de/view/109478599/en)

Maintenance 15

15.1 Removing and inserting I/O modules

Requirement

Remove or insert front connectors and I/O modules only when the voltage is switched off.

NOTICE
Physical damage can occur If you install or uninstall front connectors and/or I/O modules with switched-on voltage, this can lead to undefined conditions in your plant. The S7-1500 automation system/ET 200MP distributed I/O system may be damaged as a result. Therefore only install/uninstall front connectors and/or I/O modules with switched-off voltage. Therefore during the planning of a plant always make sure to comply with the necessary, pertinent standards and safety guidelines.

Replacement part scenario

Replacing the CPU in a replacement part scenario has an impact on the password for protection of confidential configuration data. When you replace the CPU, observe the rules for the replacement part scenario in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

If you replace an existing CPU with a higher-grade CPU, you must also make the change in your STEP 7 project accordingly. You can only replace CPUs with CPUs of the same family. Then load the customized STEP 7 project into the CPU.

15.2 Replacing the display/front cover

Replacing display (Standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0)

The display is pluggable. You can remove or replace the display during operation (RUN). Removing or replacing of the display does not have any influence on the running CPU.

To remove the display from the CPU, follow these steps:

1. Flip the front cover up.
2. Press with a 3.5 mm screwdriver from the front into the unlatching mechanism of the display. This is found in the middle directly above the display.
3. Press the screwdriver lightly from above and lever out the display from the support.

4. Remove the display in an upward direction.
5. You have removed the display.
6. Place the new display in the CPU and press the display firmly in the top area until it audibly engages.
7. Flip the front cover down into place.

The figure below shows an example of the operation at the CPU 1511-1 PN.

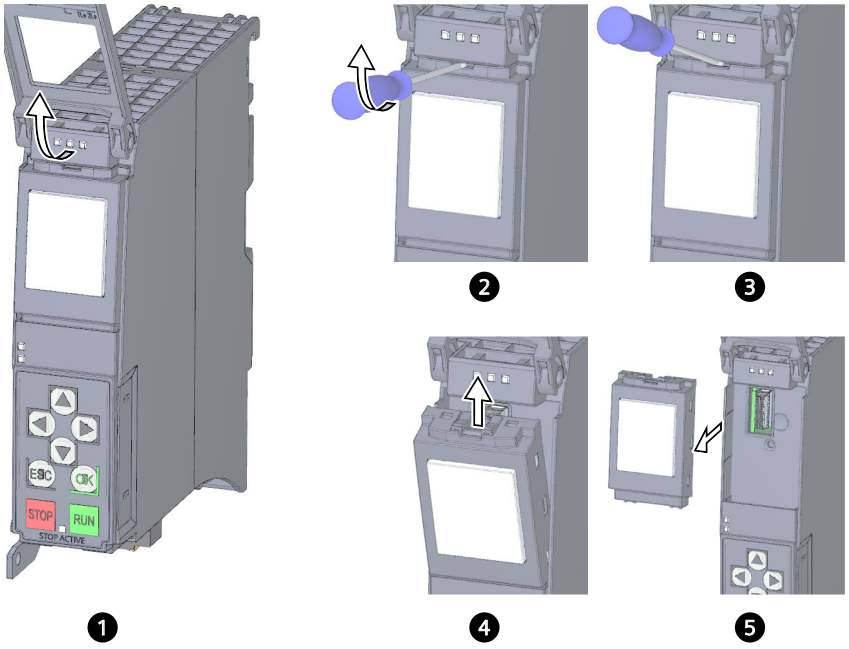


Figure 1-570 Remove display

WARNING

Personal injury or material damage can occur in zone 2 hazardous areas
In Zone 2 hazardous areas, personal injury or damage to property can occur if you pull or plug the display of an S7-1500 automation system during operation.
Before you remove or fit the display, always switch off the power supply to the S7-1500 automation system in hazardous area zone 2.

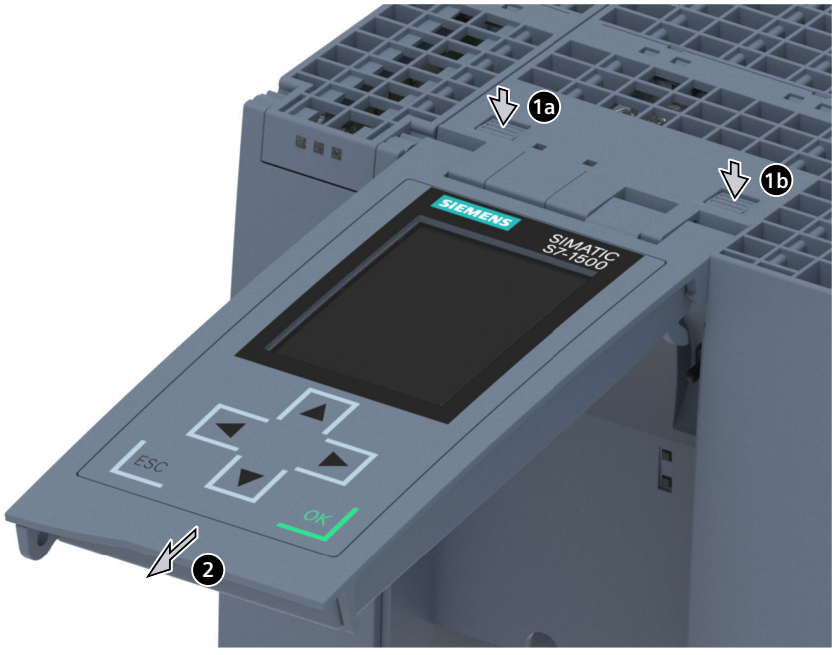
Exchanging the front cover

The front cover is pluggable. If necessary, you can take off the front cover or replace the front cover during runtime (RUN). Removing or replacing the front cover does not affect the CPU in operation.

To remove the front cover from the CPU, follow these steps:

1. Flip up the front cover until the front cover stands at a 90° angle to the front of the module.
2. In the upper area of the front cover, simultaneously press on the anchor(s). At the same time, pull the front cover forward and away.
3. Insert the new front panel (at a 90° angle to the module) from the front into the anchor(s) until they audibly engage.
4. Flip the front cover down into place.

The figure below shows an example view of the CPU 1516-3 PN/DP, article number: 6ES7516-3AN01-0AB0.



① Fasteners for removing and fitting the front panel
② Pull the front cover off towards the front

Figure 1-571 Removing and fitting the front panel

⚠ WARNING

Personal injury or material damage can occur in zone 2 hazardous areas
If you pull or plug the front panel of an S7-1500 automation system during operation, personal injury or damage to property can occur in zone 2 hazardous areas.
Before you remove or fit the front panel, always switch off the power supply to the S7-1500 automation system in hazardous area zone 2.

15.3 Replacement of I/O modules and front connectors

15.3.1 Coding element on the I/O module and on the front connector

Function

All front connectors for the I/O modules of the S7-1500 automation system/ET 200MP distributed I/O system are identical. The coding element prevents a front connector from being inserted on a module with a different electrical pin assignment.

Delivery state of the I/O module

In the delivery state, the coding element is located in the I/O module.

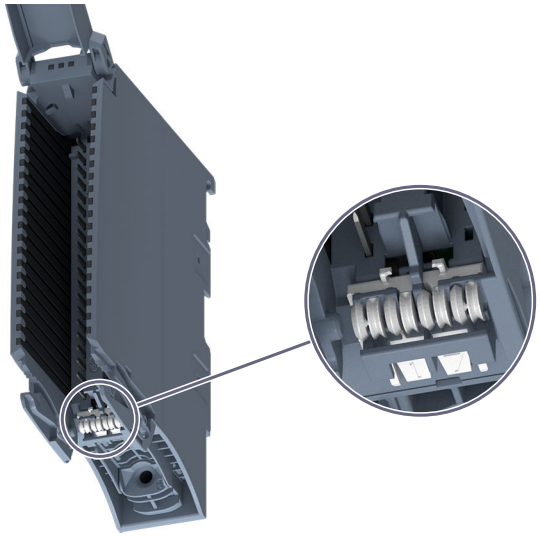


Figure 1-572 Coding element in the I/O module (delivery condition)

Coding element in the front connector

When the front connector is inserted into the I/O module for the first time, one half of the coding element latches into the front connector. When you remove the front connector from the I/O module, this half of the coding element remains in the front connector, while the other half remains in the I/O module.

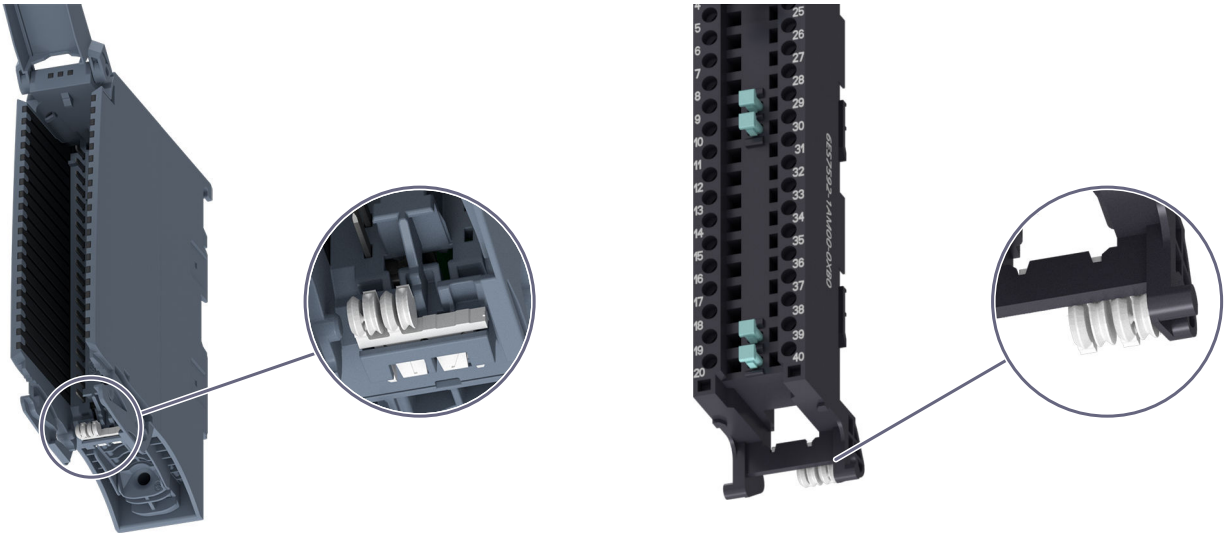


Figure 1-573 Coding element in the I/O module/front connector

You can insert a coded front connector on modules with the same electrical pin assignment.
Refer to section Application planning (Page 155).

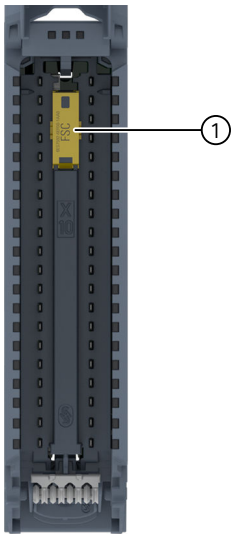
NOTICE
Physical damage can occur If the coding element is changed or removed, it will be possible to insert the front connector on modules in which the electrical connection is not properly wired. This can destroy the module and/or the connected sensors and actuators. Even hazardous plant states are possible. Do not change the coding element unless you want to use the front connector on a different module and you change the process wiring accordingly.

Use cases for replacing the coding element

- Replacing an I/O module, for example, due to a defect or incorrect configuration
- Replacing a front connector

Additional electronic coding element for fail-safe modules

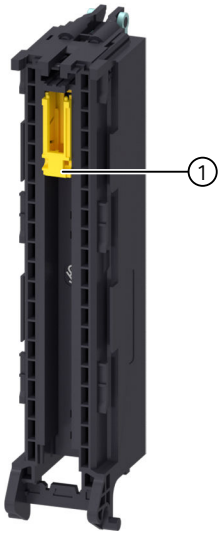
In as-delivered condition, a fail-safe module not only has a mechanical coding element but also an electronic rewritable memory for the PROFIsafe address.



① Electronic coding element

Figure 1-574 F-module with electronic coding element (as delivered)

When the front connector is inserted in the F-module, the electronic coding element engages completely in the front connector. If you remove the front connector from the F-module, the memory with the PROFIsafe address of the fail-safe module remains in the front connector.



① Electronic coding element

Figure 1-575 Front connector with electronic coding element

15.3.2 Replacing an I/O module

Introduction

- When the front connector is first inserted into the I/O module, a part of the coding element clips onto the front connector.
- In the case of fail-safe modules, the electronic coding element with the PROFIsafe address of the F-module also engages completely in the front connector.

When you replace an I/O module with the same type of module, the correct coding element or coding elements in the case of F-modules are already present in the front connector.

Result: Before inserting the previous front connector, you must remove the coding element or coding elements from the new I/O module.

Procedure

To replace the I/O module, follow these steps:

The I/O module to be replaced is uninstalled.
You can find information on removing the I/O module in section Installing I/O modules (Page 189).

1. For a new I/O module, use a screwdriver to break out the half of the mechanical coding element that is designated for the front connector.

   NOTE

   The arrangement of the mechanical coding element depends on the module type: First, check the position of the coding element on the front connector before you break out the matching half from the I/O module.

   For a new fail-safe module you must also remove the electronic coding element from the F-module.

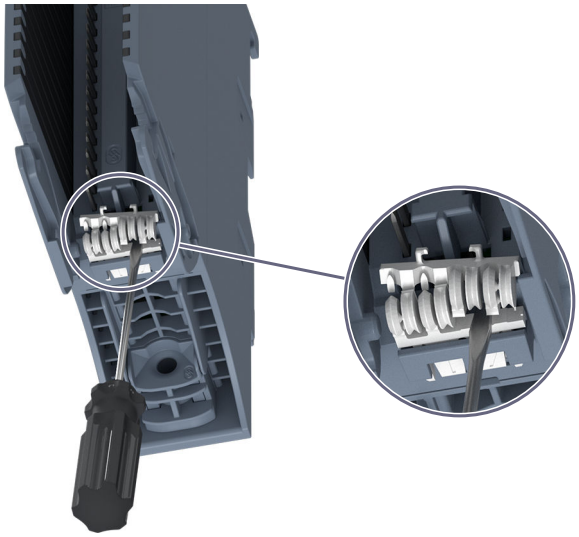


Figure 1-576 Breaking the coding element out of the I/O module

2. Insert the existing front connector into the new I/O module (same module type) until your hear it click into place.

15.3.3 Replacing a front connector

Introduction

- When the front connector is first inserted into the I/O module, a part of the mechanical coding element engages on the front connector.
- In the case of fail-safe modules, the electronic coding element with the PROFIsafe address of the F-module also engages completely in the front connector.

When you replace a defective front connector with a new front connector, you must transfer the coding element(s) to the new front connector.

Procedure

You have already removed the front connector from the module and loosened the wiring. If you are using the front connector for an analog module, you also need to remove the power supply element and shield element. Proceed as follows to replace the front connector:

1. Carefully remove the mechanical coding element from the front connector. Take care not to damage the coding element.

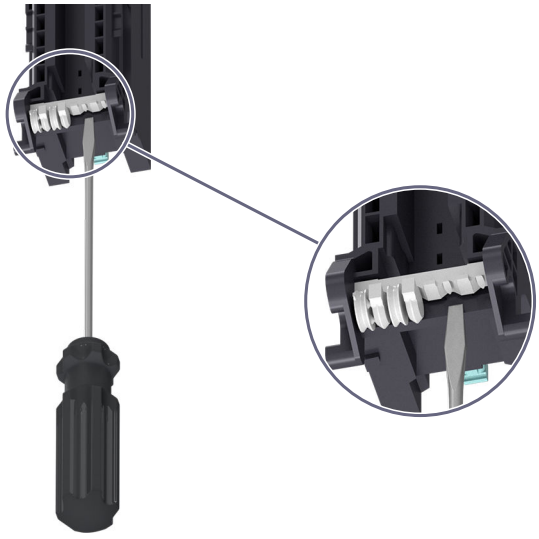


Figure 1-577 Removing the mechanical coding element from the front connector

NOTE

The coding elements are dependent on the module type.

2. Insert the removed mechanical coding element into the new front connector.

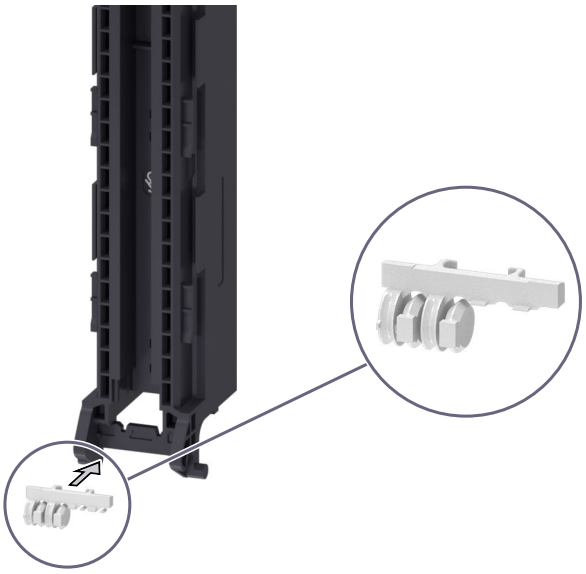


Figure 1-578 Inserting the mechanical coding element into a new front connector

3. Additionally for F-modules:
   - Carefully remove the electronic coding element from the front connector. Take care not to damage the coding element.
   - Insert the removed electronic coding element into the new front connector.



Figure 1-579 Removing the electronic coding element from the front connector and inserting it into a new front connector

4. Insert the new front connector into the existing I/O module, until your hear it click into place.
5. Wire the new front connector.

15.4 Replacing the coding element at the power connector of the system power supply and load current supply

Introduction

The coding consists of a 2-part coding element.

Ex factory a part of the coding element is inserted into the back side of the power connector. The other part is firmly inserted in the system power supply or load power supply.

This prevents the insertion of a power connector of a system power supply or load power supply into a module of a different type.

⚠ DANGER

Do not manipulate the coding element, or leave it off

- Changing or replacing the coding element can result in dangerous system states.
- To avoid damage, do not change or replace the coding element.
- You must not remove the coding element.

Replacement parts scenario

Insertion of the coding element into a new power connector in the case of a replacement part.

⚠ DANGER

Dangerous voltage

When installing the coding element, you must take into account the supply voltage of the system power supply and load power supply: 24 V DC, 24/48/60 V DC or 120/230 V AC/DC

Only install the coding element with switched-off voltage.

You must insert the coding element in such a way that the power connector matches the power supply module in terms of voltage.

Procedure

To replace the coding element on the power connector of the system power supply and load current supply, follow these steps:

1. Orient yourself using the labeling on the power cable connection.

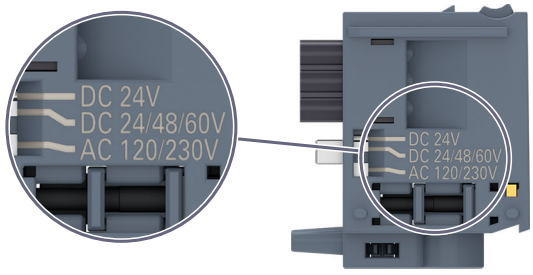


Figure 1-580 Labeling on the power connector

2. Orient yourself using the red marking on the coding element.
3. The coding element has 3 red markings. Turn the coding element in such a way that one of the 3 red markings corresponds to the voltage indicated on the connector.
4. Insert the coding element into the back side of the power cable connector, until you hear it click into place. The figure below shows you how to insert a coding element into a power cable connector for 24 V DC.

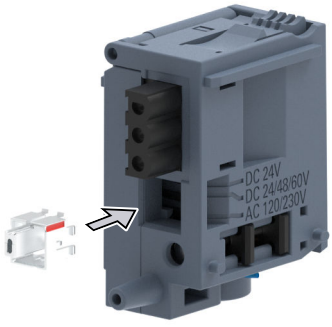


Figure 1-581 Inserting a coding element into a power connector

15.5 Firmware update

Introduction

Update the firmware of the CPU/interface module, display and the I/O modules using firmware files. The retentive data is retained after the execution of the firmware update.

We recommend that you always update to the latest firmware version available for the respective article number. The previous versions of the firmware are only intended as a backup to enable you to downgrade to the original version.

A firmware update has no effects on the user program of the CPU on which the update was performed. However, a downgrade can have effects on the user program if you use new functions in the user program which were not yet supported by the firmware of the CPU.

NOTE

Possible older firmware versions for CPU with firmware version as of V3.0

You can load a CPU with firmware version as of V3.0 with a STEP 7 project based on an earlier firmware version:

- For CPUs with article numbers 6ES751x-xxx03-0AB0: Firmware versions V2.9 to V1.8
- For CPUs with article number 6ES751x-xRx03-0AB0: Firmware versions V2.9 to V2.6
- For all other article numbers of the CPUs (firmware version lower than 4.0): Firmware versions V2.9 to V1.5

The CPU with firmware version as of V3.0 then responds like the CPU with the previous firmware version and supports only the functionality of this earlier version. This also applies to the configuration limits.

The following entry (https://support.industry.siemens.com/cs/de/en/view/109478459) lists all firmware versions for the S7-1500 CPUs including displays. You will also find a description of the new functions of the respective firmware versions.

Requirement

- You have downloaded the data/files for the firmware update from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps).
  On this web site, select:
  - For the S7-1500 automation system: Automation Technology > Automation Systems > Industrial Automation Systems SIMATIC > Controllers > SIMATIC S7 Advanced Controller > SIMATIC S7-1500.
  - For the ET 200MP distributed I/O system: Automation Technology > Automation Systems > Industrial Automation Systems SIMATIC > SIMATIC ET 200 I/O systems > ET 200 systems for the cabinet > ET 200MP.

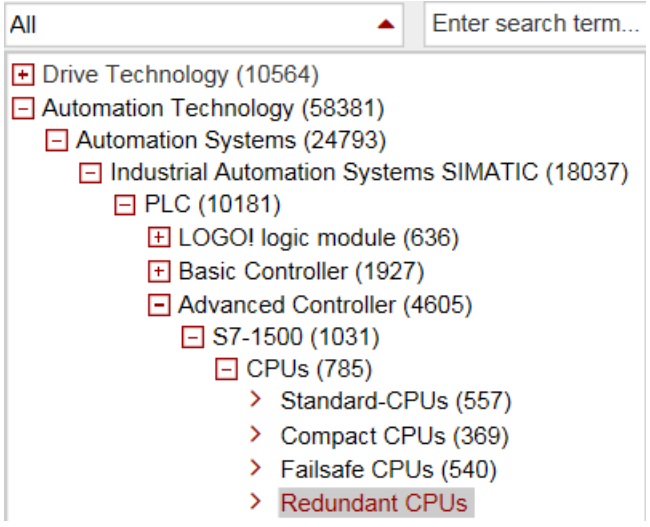


Figure 1-582 Product tree using the S7-1500 as an example:

From this position, navigate to the specific type of module that you want to update. To continue, click on the "Software downloads" link under "Support". Save the desired firmware update files.

Before installing the firmware update, make sure that the modules are not being used.

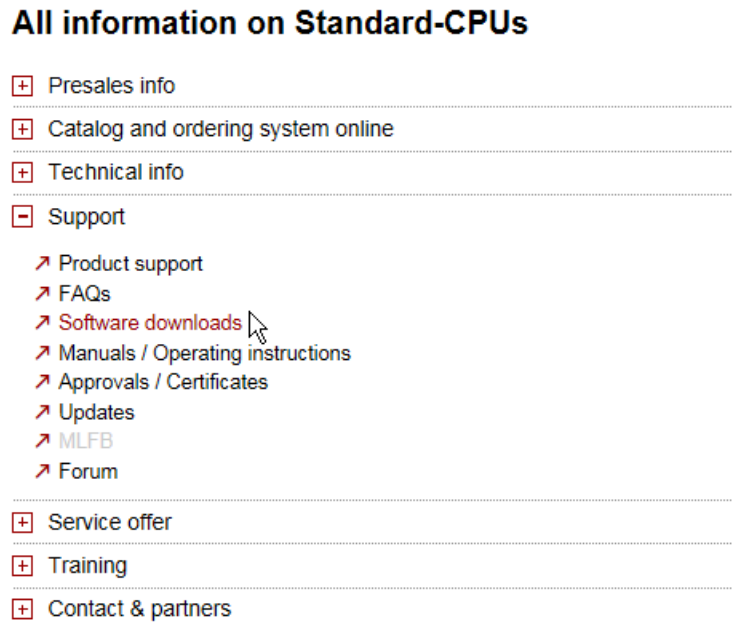


Figure 1-583 Selecting the software downloads

Additional requirement for fail-safe modules

WARNING

Check the firmware version for F-approval

When using a new firmware version, always check that the version is approved for use in the respective module.

The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify which firmware version is approved.

Special feature when updating the firmware of CPUs with Linux-based operating system

For the 1518(F)-4 PN/DP MFP CPUs, also observe the procedure for firmware updates from the CPU 1518-4 PN/DP MFP (https://support.industry.siemens.com/cs/ww/en/view/109749061) manual.

Options for the firmware update

The firmware update has to be carried out manually. There are the following options for performing a firmware update:

- Online in STEP 7 via Online & Diagnostics
- Online in STEP 7 via accessible devices (PROFINET)
- Via SIMATIC memory card: for CPU, display, and all centrally inserted modules
- Via the integrated Web server
- Online via the SIMATIC Automation Tool

The table below gives an overview of the various options for a firmware update.

Table 1-856 Overview of firmware update options

Firmware update	CPU	Central I/O module	Interface module	Distributed I/O module
STEP 7 (V12 or higher)	✓	✓	✓	✓
Accessible devices	✓	✓	✓	✓
SIMATIC memory card	✓	✓	--	--
Web server of the CPU	✓	✓	✓	✓
SIMATIC Automation Tool	✓	✓	✓	✓

Downtime during the firmware update

When you start a firmware update, for example online in STEP 7 via "Online & Diagnostics", the CPU goes into STOP mode and executes the firmware update. The time from start of the firmware update until RUN of the CPU with the new firmware takes a few minutes (typically < 3 minutes).

Installation of the firmware update

⚠ WARNING

Impermissible plant states possible
Installation of the firmware update causes the CPU to carry out a restart and go into STOP mode. The interface module changes into the station failure state. STOP or station failure can have an adverse effect on the operation of an online process or a machine.
Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.
Ensure before installing the firmware update that the CPU is not controlling any active process.

Procedure: online in STEP 7 via Online & diagnostics

Requirement: There is an online connection between the CPU/module and PG/PC.

Proceed as follows to perform an online firmware update via STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" menu command from the shortcut menu.
3. In the "Functions" folder, select the "Firmware update" group.
   For a CPU, you can select whether you want to update the CPU or the CPU's display.
4. Click the "Browse" button to select the firmware update files in the "Firmware update" area.
5. Select the matching firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module. If you must change the CPU mode, STEP 7 prompts you to do so with dialogs.

Updating the firmware

The "Run firmware after update" check box is always selected.

After a successful loading process the CPU includes imports the firmware and subsequently operates with the new firmware.

NOTE

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure: online in STEP 7 via accessible devices

To perform a firmware update online via accessible devices, follow these steps:

1. From the "Online" menu, select the "Accessible devices" menu item.
2. In the Accessible devices dialog, search for the accessible devices for the selected PROFINET interface.
3. To go to a device in the project tree, select the desired device from the list of accessible devices and click the "Show" button.
4. In the project tree, select the "Online & diagnostics" option of the relevant device and perform the firmware update under the category Functions/Firmware Update (CPU, Display, Local modules).

You can find information on how to perform a firmware update when your project has no connection to a CPU in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109779881).

Procedure via the SIMATIC memory card

Proceed as follows perform a firmware update via the SIMATIC memory card:

1. Insert a SIMATIC memory card into the SD card reader of your PG/PC.
2. To store the update file on the SIMATIC Memory Card, select the SIMATIC Memory Card in the "Card Reader/USB memory" folder in the project tree.

3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you are deleting the content of the SIMATIC memory card or adding the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card with the firmware update files into the CPU.

   The firmware update begins shortly after the SIMATIC memory card has been plugged.

   The display indicates that the CPU is in STOP mode, and that a firmware update is being executed: "STOP - FW UPDATE". The display shows the progress of the firmware update. The CPU shows any errors that occur during the firmware update on the display.

   The display shows a results screen after the completion of the firmware update.
6. Remove the SIMATIC Memory Card after the firmware update is complete.
   The RUN LED on the CPU lights up in yellow and the MAINT LED flashes yellow.
   If you subsequently wish to use the SIMATIC Memory Card as a program card, leave the SIMATIC Memory Card in the CPU. To do so, after completion of the firmware update, select the "Convert memory card" menu item on the display.

   Alternatively, you can convert the SIMATIC memory card to a program card via STEP 7.

NOTE

If your hardware configuration contains several modules, the CPU updates all affected module in the slot sequence, i.e. in ascending order of the module position in the STEP 7. device configuration.

NOTE

Memory size of the SIMATIC memory card

If you perform a firmware update via the SIMATIC memory card, you must use a large enough card based on the CPU used and the associated I/O modules.

Check the specified file sizes of the update files when downloading them from Siemens Industry Online Support. The file size information is especially important when you perform the firmware update not only for the CPU but also, e.g., for the associated I/O modules, communication modules. The total size of the update files must not exceed the available memory size of your SIMATIC memory card.

You can find more information on the capacity of SIMATIC Memory Cards in the section Accessories/spare parts (Page 406) and in the function manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/en/view/59193101).

Procedure: via the integrated Web server

The procedure is described in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) Function Manual.

Procedure: online via the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Special feature at a firmware update of analog modules

When you carry out a firmware update for analog modules, you have to supply 24 V DC load supply to the module through the infeed element.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module.

Possibilities for verifying the firmware update:

- Online via STEP 7 (e.g. Signature), SIMATIC Automation Tool or web server
- Offline via LED display, I&M0 data or display (if existing)

Reference

For more information on the topic of firmware update, refer to the STEP 7 online help and the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/89257657).

15.6 Reset to factory settings

15.6.1 Resetting the CPU to factory settings

Introduction

"Reset to factory settings" restores the CPU to its delivery state. The function deletes all information that was stored internally on the CPU.

Recommendation:

Switch the CPU to its as-delivered condition if:

- You remove a CPU and use it elsewhere with a different program.
- You store the CPU.

NOTE

Standard and F-CPUs with article number 6ES751x-xxx02-0AB0, compact CPUs with article number 6ES751x-xxx01-0AB0

"Reset to factory settings" restores the status of the operating mode button to the factory setting, i.e. the CPU remains in STOP mode. To set the CPU to RUN mode, local operation via the RUN button is required.

It does not matter here whether you perform the "Reset to factory settings" via the operating mode button, the display or STEP 7.

Options for resetting a CPU to factory settings

To reset the CPU to its delivery state, follow these steps:

- Via the operating mode keys/mode switches
- Using the display
- Using STEP 7
- Using the SIMATIC Automation Tool

Procedure via the mode selector keys (standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0)

Make sure that the CPU is in STOP mode (the CPU display shows STOP mode or RUN/STOP LED lights up yellow).

NOTE

Reset to factory settings ↔ Memory reset

The procedure described below also corresponds to the procedure for a memory reset:

- Key operation with inserted SIMATIC memory card: CPU executes a memory reset
- Key operation without inserted SIMATIC memory card: CPU executes reset to factory settings

Perform a reset to factory settings as follows:

1. Press the STOP mode selector key.
   Result: The STOP-ACTIVE and RUN/STOP LED light up yellow.
2. Remove the SIMATIC Memory Card from the CPU. Wait until the RUN/STOP LED stops flashing.
3. Press the STOP operating mode button until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (after 3 seconds). After this, release the button.
4. Press the STOP mode selector key again within the next three seconds.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the STOP-ACTIVE and RUN/STOP LED light up yellow, then the CPU has been reset to factory settings, and is in STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

NOTE

The IP address of the CPU is also deleted when the CPU is reset to the factory settings using the mode selector keys.

Procedure using the mode selector

Make sure that the CPU is in STOP operating state: The CPU display indicates the STOP operating mode. The RUN/STOP LED lights up yellow.

NOTE

Reset to factory settings ↔ Memory reset

The procedure described below corresponds to the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

Restore the factory settings of the CPU as follows:

1. Set the mode selector to the STOP position.
   Result: The RUN/STOP LED lights up yellow.
2. Remove the SIMATIC Memory Card from the CPU. Wait until the RUN/STOP LED stops flashing.
3. Set the mode selector to the MRES position. Hold the mode selector in this position until the RUN/STOP LED lights up for the second time and remains lit (this takes three seconds). After this, release the selector.
4. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in the STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

NOTE

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the mode selector.

Procedure using the display

Make sure that the CPU is in STOP operating state: The CPU indicates STOP mode. The RUN/STOP LED lights up yellow.

To reach the desired menu command, "Factory setting", select the following sequence of menu commands. Confirm with "OK" after each selection.

- Settings → Reset → Factory settings

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, then the CPU has been reset to factory settings, and is in STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

NOTE

Resetting the CPU to factory settings via the display also deletes the IP-address of the CPU and the password for protecting confidential PLC configuration data.

Procedure using STEP 7

To reset a CPU to factory settings via STEP 7, follow these steps:

Make sure that there is an online connection to the CPU.

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. If you want to keep the IP address, select the "Keep IP address" option button. If you want to delete the IP address, select the "Delete IP address" option button.

NOTE

"Delete IP address" deletes all IP addresses, regardless of how you established the online connection.

If a SIMATIC Memory Card is inserted, selecting the "Delete IP address" option has the following effect:

- The IP addresses are deleted and the CPU is reset to factory settings.
- The existing configuration (including IP address) on the SIMATIC Memory Card is then loaded into the CPU. If no configuration is stored (for example, after the SIMATIC Memory Card has been erased or formatted), no new IP address is assigned.

4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes a "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up in yellow, the CPU has been reset to factory settings and is in STOP mode. The "Reset to factory settings" event is entered into the diagnostics buffer.

Procedure using the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 1-857 Result after resetting to factory settings

Memory object	Contents
Actual values of the data blocks, instance data blocks	Initialized
Bit memories, timers and counters	Initialized
Retentive tags of technology objects (for example, adjustment values of absolute encoders)	Initialized
Entries in the diagnostics buffer	Are initialized, including a startup entry, that informs about the resetting to factory settings.

1) Only for standard, F-CPUs with article number 6ES751x-xxx02-0AB0, compact CPUs with article number 6ES751x-xxx01-0AB0

Memory object	Contents
Entries in the syslog storage	Now only contains a startup entry that informs about the reset to factory settings.
IP address	Depends on the procedure: • Using mode switch: is deleted • Using display: is deleted • Using STEP 7: Depends on the setting of the "Retain IP-address"/"Delete IP-address" option button.
Device name	Set to "CPU"
Counter readings of the runtime meters	Initialized
Time of day	Is set to "00:00:00, 01.01.2012"
CPU operating mode	The CPU is set to STOP.
Operating mode of the CPU	"STOP Active" is activated [1)]
Deleting passwords for protecting confidential PLC configuration data	Depends on the procedure: • Using the mode selector / mode selector keys: Retained • Using the display: is deleted • Using STEP 7: Depends on the setting of the "Delete password for the protection of confidential PLC configuration data" option button

1) Only for standard, F-CPUs with article number 6ES751x-xxx02-0AB0, compact CPUs with article number 6ES751x-xxx01-0AB0

If there was a SIMATIC Memory Card inserted in the CPU prior to the reset to factory settings, the CPU loads the configuration contained on the SIMATIC Memory Card (hardware and software):

- A configured IP address is then valid again.
- If you have backed up adjustment values of absolute encoders on the SIMATIC Memory Card with the "MC_SaveAbsoluteEncoderData" instruction, these become valid after the reset to factory settings with SIMATIC Memory Card inserted in the CPU.

NOTE

Password for protecting confidential configuration data after resetting the CPU to factory settings

- **Via the mode switch / mode selector keys (SIMATIC Memory Card is not inserted):** The password for protection of confidential configuration data is retained.
- **Using the display:** The password for protection of confidential configuration data is deleted.
- **Using STEP 7:** The password for protection of confidential configuration data is retained. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find more information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) Function Manual.

Reference

More information on "Reset to factory settings" can be found in the Function Manual Structure and use of the CPU memory (https://support.automation.siemens.com/WW/view/en/59193101) in the section on memory areas and retentivity, and in the online help for STEP 7. For information on the memory reset of the CPU, refer to the section CPU memory reset (Page 322).

15.6.2 Resetting interface module (PROFINET IO) to factory settings

Introduction

The interface module can be reset to its factory state using "Reset to factory settings".

Method of resetting an interface module to factory settings

- Via STEP 7 (online via PROFINET IO)

Procedure using STEP 7

To reset an interface module to factory settings via STEP 7, follow these steps:
Make sure that an online connection to the interface module exists.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Click the "Reset" button.
4. Click "OK" in response to the confirmation prompts.

Result: The interface module then performs a "Reset to factory settings".

Result after resetting to factory settings

Table 1-858 Properties of the interface module when shipped

Properties	Value
Parameter	Default setting
IP address	Not present
Device name	Not present
MAC address	Present
I&M data	Identification data (I&M0) present Maintenance data (I&M1, 2, 3) reset
Firmware version	Present

NOTE

Failure of downstream stations is possible

Stations downstream from the interface module can fail when the factory settings are restored on an interface module.

NOTE

Substitute value behavior of the installed I/O modules during reset to factory settings
The I/O modules in the station do not have the configured status after a "reset to factory settings". The interface module does not acquire any input data and does not output any output data.

Reference

You will find more information on the procedure in the STEP 7 online help.

15.7 Fault reactions with fail-safe modules

Safe state (safety concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

NOTE

For fail-safe input and output modules, this safe state is the value "0".

Fault reactions and startup of the F-system

The safety function requires that substitute values (safe state) be output instead of process values for a fail-safe module (**passivation of the fail-safe module**) in the following cases:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- If fail-safe I/O faults or channel faults are detected (e.g., wire break, discrepancy error)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. When the system is powered down and then restarted, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

Channel faults do not trigger any diagnostic reactions or error handling for channels that have been set to "deactivated" in STEP 7, even if this channel is affected indirectly by a channel group fault (channel parameter "activated/deactivated").

Remedying faults in the F-system

To remedy faults in your F-system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

The following steps must be performed:

1. Diagnostic and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Fail-safe value output for F-modules

In the case of F-modules with inputs, if there is passivation, the F-system provides substitute values (0) for the safety program instead of the process data pending at the fail-safe inputs.

In the case of F-modules with outputs, if there is passivation, the F-system transfers substitute values (0) to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized. This also applies when the F-CPU goes into STOP mode. The parameter assignment of fail-safe values is not possible.

Substitute values are used either for the relevant channel only or for all channels of the relevant fail-safe module, depending on:

- The F-system used
- The type of fault that occurred (fail-safe I/O fault, channel fault or communication error)
- The parameter assignment of the F-module

Reintegration of a fail-safe module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in the section Diagnostic messages of the respective F-module.

After reintegration, the following occurs:

- In the case of an F-module with inputs, the process data pending at the fail-safe inputs is made available to the safety program again
- In the case of an F-module with outputs, the output values provided in the safety program are transferred to the fail-safe outputs again

Additional information on passivation and reintegration

For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety, Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) manual.

Reaction of the F-module with inputs to communication errors

F-modules with inputs respond differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F-module. There is no passivation of the channels. The current process values are passivated in the F-CPU.

15.8 Maintenance and repair

The components of the S7-1500 automation system/ET 200MP distributed I/O system are maintenance-free.

NOTE

Repairs to the components of the S7-1500 automation system/ET 200MP distributed I/O system may only be carried out by the manufacturer.

Test and service functions 16

16.1 Test functions

Introduction

You can test the operation of your user program on the CPU. You monitor signal states and values of tags, and preassign tags with values so that you can simulate specific situations for program execution.

NOTE

Using test functions

Using test functions affects the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirements

- There is an online connection to the relevant CPU.
- An executable user program is available in the CPU.

Test options

- Testing with program status
- Testing with breakpoints
- Testing with a watch table
- Testing with a force table
- Testing with a PLC tag table
- Testing with a data block editor
- Testing with the LED flash test
- Testing with a trace function

Testing with program status

The program status allows you to monitor the execution of the program. You can hereby display the values of operands and the results of logic operations (RLO). This allows you to detect and fix logical errors in your program.

NOTE

Restrictions with the "Program status" function

Monitoring loops can significantly increase the cycle time. The increase in cycle time depends on the following factors:

- The number of tags to be monitored
- The actual numbers of loops run through

⚠ WARNING

Testing with program status

A test with the "Program status" function can cause serious damage to property or injury to persons if there are functional disturbances or program errors.

Make sure that you take appropriate measures to exclude the risk of hazardous conditions occurring before running a test with the "Program status" function!

Testing with breakpoints

With this test option, you set breakpoints in your program, establish an online connection, and enable the breakpoints on the CPU. You then execute a program from one breakpoint to another.

Requirements:

- Setting breakpoints is possible in the programming language SCL or STL.
- You can only set breakpoints in the startup OB (OB 100) when the CPU is in STOP mode.

Testing with breakpoints provides you with the following advantages:

- Localization of logic errors step by step
- Simple and quick analysis of complex programs prior to actual commissioning
- Recording of current values within individual executed loops
- Use of breakpoints for program validation also possible in SCL/STL networks within LAD/FBD blocks

NOTE

Restriction during testing with breakpoints

- When you test with breakpoints, there is a risk of overwriting the cycle time of the CPU.
- If you are using technology objects and test them with breakpoints, the CPU switches to STOP mode.

NOTE

F-System SIMATIC Safety

Setting breakpoints in the standard user program results in errors in the safety program:

- Sequence of F cycle time monitoring
- Error in communication with the F-I/O
- Error during safety-oriented CPU-CPU communication
- Internal CPU error

If you nevertheless want to use breakpoints for testing, you must disable safety mode. This will result in the following errors:

- Error in communication with the F-I/O
- Error during safety-oriented CPU-CPU communication

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  You can use the watch tables to monitor the current values of the individual tags of a user program or a CPU on the programming device/PC, on the display of the CPU, and on the web server. A symbolic name for the tags must be specified in the "Name" column of the watch table to allow the display of the CPU and the web server to show the value of the tags.

  You monitor the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs
  – Timers and counters

- Modifying tags

  Use this function to assign fixed values to the individual tags of a user program or CPU on the PG/PC. Modifying is also possible with Test with program status.

  The following operand areas are modifiable:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)
  – Timers and counters

- "Enable peripheral outputs" and "Modify now"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with a force table

The following functions are available in the force table:

- Monitoring of tags

  Force tables are used to monitor the actual values of the individual tags of a CPU user program or a CPU
  - On the PG/PC
  - On the display of the CPU
  - On the web server

  You monitor the table with or without a trigger condition.

  A symbolic name for the tags must be specified in the "Name" column of the force table in order that the display of the CPU and the web server can display the value of the tags.

  You monitor the following tags:
  - Bit memory
  - Contents of data blocks
  - Peripheral inputs
- Modifying tags

  You use this function to assign fixed values to individual tags of a user program or a CPU on the programming device/PC or on the display of the CPU. Modifying is also possible with Test with program status.

  The following tags are modifiable:
  - Bit memory
  - Contents of data blocks
  - Peripheral inputs (e.g. %I0.0:P)
- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.
  - Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) is a "bypassing" of sensors / inputs by the specification of fixed values to the program. The program receives the force value instead of the actual input value (via process image or via direct access).
  - Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) is a "bypassing" of the complete program by the specification of fixed values to the actuators.

With the force table you can simulate different test environments and also overwrite tags in the CPU with a fixed value. This enables you to intervene in the running process in a regulating way.

Difference between modifying and forcing

The fundamental difference between the modifying and forcing functions consists in the storage behavior:

- Modifying: Modifying of tags is an online function and is not stored in the CPU. You can end modifying of tags in the watch table or force table or by terminating the online connection.
- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. The S7-1500 CPU displays an active force job with a corresponding symbol. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with a PLC tag table

You can monitor the current data values of tags in the CPU directly in the PLC tag table. To do so, open the PLC tag table and start the monitoring.

You also have the option of copying PLC tags to a watch table or force table so that you can monitor, control or force them in the table.

Testing with a data block editor

The data block editor offers different options for monitoring and modifying tags. These functions directly access the actual values of the tags in the online program. Actual values are the current values of tags in the CPU work memory at any moment during program execution. The following functions for monitoring and modifying are available in the database editor.

- Monitor tags online
- Modify individual actual values
- Create a snapshot of the actual values
- Overwrite actual values with a snapshot

NOTE

Setting data values during commissioning

During plant commissioning, you often need to adjust data values to adapt the program to local conditions.

To this end, the declaration table offers a few functions for data blocks.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This feature is useful if you are not sure which device in the hardware configuration corresponds to the device currently selected in the software.

If you click on the "Flash LED" button in STEP 7 under Online & diagnostics (online access), an LED flashes on the device currently selected. The RUN/STOP, ERROR, and MAINT LEDs flash on the CPU. The LEDs flash until you cancel the flash test.

Testing with a trace function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, drive parameters or system and user tags of a CPU. The CPU saves the recordings. If necessary, you can display the recordings with STEP 7 and evaluate them.

Procedure: The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

In connection with trace functions, please also note the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102781176).

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

More information on the test functions can be found in the STEP 7 online help.

More information about testing with trace functions is available in the Function Manual Using the trace and logic analyzer function (https://support.automation.siemens.com/WW/view/en/64897128).

16.2 Reading out/saving service data

Service data

In addition to the contents of the diagnostics buffer, the service data contains a great deal more information about the internal status of the CPU or IM. If a problem occurs with the CPU or IM that you cannot resolve with other methods, send the service data to the Industry Online Support via a Service Request. For more information on how to create a support request, see the following entry on the Internet (https://support.industry.siemens.com/cs/ww/en/view/18194667). The service data allows Industry Online Support to quickly analyze problems that have occurred.

NOTE

You cannot execute a download to the device while reading out the service data of the CPU.

Methods of reading service data of a CPU

You have the following options for reading out the service data:

- Web server
- STEP 7
- SIMATIC Memory Card

Methods of reading service data in interface modules

You have the following options for reading out the service data:

- STEP 7
- MFCT (MultiFieldbus Configuration Tool)

Procedure using the Web server

To read service data using the Web server, follow these steps:

1. Open a web browser that is suitable for communication with the CPU.
2. Enter the following address in the address bar of the web browser:
   https://<CPU IP address>/save_service_data, for example,
   https://172.23.15.3/save_service_data
3. The service data page will appear on your screen, with a button for saving the service data.

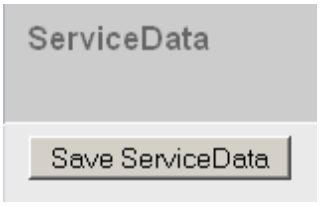


Figure 1-584 Saving service data via the Web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The data is saved in a .dmp file with the following naming convention: "<Article number> <Serial number> <Time stamp>.dmp". You can change the file name.

NOTE

If you have defined your user page as the home page of the Web server, direct access to the service data by inputting the IP address of the CPU is not possible. For more information on reading out service data via a user-defined page, refer to the Web server (https://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure using STEP 7

You can find more information on saving service data of the CPU (and interface module) with the keyword "Saving service data" in the STEP 7 online help.

Procedure with the SIMATIC Memory Card

If no communication with the CPU is possible via Ethernet, use the SIMATIC memory card to read out the service data. In all other cases, read and back up the service data via the web server or STEP 7.
The procedure via the SIMATIC memory card is more complex than the other options. You must also ensure before backing up that there is sufficient memory space on the SIMATIC memory card.

To back up service data using the SIMATIC memory card, follow these steps:

1. Insert the SIMATIC memory card into the card reader of your PC / programming device.
2. Open the job file S7_JOB.S7S in an editor.
3. Overwrite the entry PROGRAM with the string DUMP in the editor.
   To ensure that the file size is exactly 4 bytes, do not use any spaces/line breaks/quotation marks.
4. Save the file under the existing file name.
5. Ensure that the SIMATIC Memory Card is not write-protected and insert the SIMATIC Memory Card in the card slot of the CPU. Up to CPU 1516 you need a card ≥ 32 MB and from CPU 1517 a card ≥ 2 GB.

Result: The CPU writes the service data file DUMP.S7S to the SIMATIC memory card and remains in STOP mode.

Service data transfer is complete when the STOP LED stops flashing and is lit continuously. If service data transfer has been successful, only the STOP LED lights up.

In the event of errors in transfer, the STOP LED is lit continuously and the ERROR LED flashes. In addition, the CPU creates a text file containing information about the error in the DUMP.S7S folder.

Technical specifications 17

Introduction

This chapter lists the technical specifications of the system:

- The standards and test values which the modules of the S7-1500 automation system/ET 200MP distributed I/O system comply with and fulfill.
- The test criteria according to which the S7-1500 automation system/ET 200MP distributed I/O system was tested.

Technical specifications for the modules

The technical specifications of the individual modules can be found in the manuals of the modules themselves. In the event of deviations between the statements in this document and the manuals, the statements in the manuals take priority.

17.1 Standards, approvals and safety instructions

Currently valid markings and approvals

NOTE

Details on the components of the S7-1500 automation system/ET 200MP distributed I/O system

The currently valid markings and approvals are printed on the components of the S7-1500 automation system/ET 200MP distributed I/O system.

Safety information

⚠ WARNING

Personal injury and damage to property may occur

In hazardous areas, injury to persons and material damage may occur if you disconnect plug-in connections during operation of an S7-1500 automation system/ET 200MP distributed I/O system.

Always switch off the power to the S7-1500 automation system/ET 200MP distributed I/O system when disconnecting plug-in connections in hazardous atmospheres.

⚠ WARNING
Explosion hazard If you replace components, compliance with Class I, DIV 2 may become invalid.

⚠ WARNING
Deployment requirements This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

Safety of the plant or the system

NOTICE
Safety is the responsibility of the assembler The safety of any plant or system incorporating the equipment is the responsibility of the assembler of the plant or system.

CE marking

CE

The S7-1500 automation system/ET 200MP distributed I/O system complies with the harmonized European standards (EN) for programmable logic controllers published in the official journals of the European Union. The S7-1500 automation system/ET 200MP distributed I/O system meets the requirements and protection targets of the following directives:

- 2014/35/EU Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits; OJ L 96, 29/3/2014, pp. 357-374
- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
  Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the member states relating to electromagnetic compatibility; Official Journal of the European Union L96, 29/03/2014, pp. 79-106
- 2014/34/EU Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres; Official Journal of the European Union L96, 29/03/2014, pp. 309–356

- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, Official Journal of the European Union L174, 01/07/2011, pp 88-110
- 2006/42/EC "Machinery Directive and Supplementary Directive 95/16/EC" (Machinery Directive) for F-modules S7-1500/ET 200MP
  Directive of the European Parliament and of the Council of 17 May 2006 on machinery and amending Directive 95/16/EC (recast); Official Journal of the EU L157, 9/06/2006, pp. 24-87

EU Declarations of Conformity for the respective authorities are available from the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS
PO Box 1963
D-92209 Amberg

The following address applies to the S7-1500 system power supply (PS):

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS CN TT
No. 99 Tianyuan Road
611731 Chengdu

The EU declarations of conformity are also available for download from the Siemens Industry Online Support website, under the keyword "Declaration of Conformity".

UKCA marking

The S7-1500 automation system / ET 200MP distributed I/O system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The S7-1500 automation system / ET 200MP distributed I/O system meets the requirements and protection targets of the following regulations and related amendments:

- Electrical Equipment (Safety) Regulations 2016 (S.I. 2016 No. 1101), and related amendments
- Electromagnetic Compatibility Regulations 2016 (S.I. 2016 No. 1091), and related amendments
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (S.I. 2016 No.1107), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments
- Supply of Machinery (Safety) Regulations 2008 (S.I. 2008 No. 1597), and related amendments

UK Declarations of Conformity for the respective authorities are available from:

Siemens Aktiengesellschaft
Digital Industries

Factory Automation
DI FA DSP SYS
PO Box 1963
D-92209 Amberg

The following address applies to the S7-1500 system power supply (PS):

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS CN TT
No. 99 Tianyuan Road
611731 Chengdu

The UK Declaration of Conformity is also available for download from the Siemens Industry Online Support website under the keyword "Declaration of Conformity".

cULus approval



Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment) **OR** UL 61010-1 and UL 61010-2-201
- CAN/C22.2 No. 142 (Process Control Equipment) **OR** CAN/CSA. C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201

OR

cULus HAZ. LOC. approval



Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment) **OR** UL 61010-1 and UL 61010-2-201
- CANCSA C22.2 No. 142 (Process Control Equipment) **OR** CAN/CSA. C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201
- ANSI/ISA 12.12.01
- CAN/CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.
- These products need to be connected by means of the front connector Cat. No. 6ES7592...

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

FM approval



Factory Mutual Research (FM) according to

- Approval Standard Class Number 3611, 3600, 3810
- ANSI/UL 121201
- ANSI/UL 61010-1
- CAN/CSA C22.2 No. 213
- CAN/CSA C22.2 No. 61010-1

APPROVED for use in Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for FM

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.
- These products need to be connected by means of the front connector Cat. No. 6ES7592...

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

ATEX approval



According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Type of protection "n") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex nA IIC T4 Gc

DEKRA 12ATEX0004X

OR

According to EN IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 20ATEX0003X

T-CPUs:

According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Type of protection "n") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex nA IIC T4 Gc

DEKRA 16ATEX0092X

OR

According to EN IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 21ATEX0046X

System power supplies (PS):
According to EN IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 23ATEX0077X

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment must be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

UKEX approval



According to EN IEC 60079-7 (Explosive atmospheres – Part Equipment protection by type of protection "n") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 21UKEX0008X

T-CPUs:
According to EN IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 21UKEX0007X

System power supplies (PS):
According to EN IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc

DEKRA 23UKEX6012X

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
- The equipment must be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

IECEx approval



According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex nA IIC T4 Gc

IECEx DEK 13.0010X

OR
According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc

IECEx DEK 19.0087X

T-CPUs:
According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex nA IIC T4 Gc

IECEx DEK 16.0045X

OR
According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc

IECEx DEK 21.0028X

System power supplies (PS):
According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc

IECEx DEK 23.0057X

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in IEC 60664-1.
- The device must be installed in a suitable housing that ensures at least IP54 degree of protection according to IEC 60079-0. The ambient conditions must be taken into consideration for use.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

CCCEx approval



In accordance with GB/T 3836.3 (Explosive atmospheres - Part 3: Equipment protection by type of protection "e"), GB/T 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements).

Ex ec IIC T4 Gc

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in GB/T 16935.1.
- The equipment must be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with GB/T 3836.1. The ambient conditions must be taken into consideration for use.
- It must be ensured that the transient protection is set to a value which does not exceed 140% of the rated peak voltage value at the supply terminals of the device.

RCM Declaration of conformity for Australia/New Zealand



The S7-1500 automation system/ET 200MP distributed I/O system fulfills the requirements of the standard IEC 61000-6-4.

Korea Certification



Please note that this device corresponds to limit value class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Marking for the Eurasian Customs Union



EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU).

IEC 61131-2

The S7-1500 automation system/ET 200MP distributed I/O system meets the requirements and criteria of the standard IEC 61131-2

(Programmable logic controllers, Part 2: Equipment requirements and tests) and the EMC requirements for use in Zone B.

IEC 61010-2-201

The S7-1500 automation system/ET 200MP distributed I/O system meets the requirements and criteria of the standard IEC 61010-2-201

(Safety regulations for electrical equipment for measurement, control, and laboratory use Part 2-201: Particular requirements for control equipment).

PROFINET standard

The PROFINET interfaces of the S7-1500 automation system/ET 200MP distributed I/O system are based on the standard IEC 61158 Type 10.

PROFIBUS standard

The PROFIBUS interfaces of the S7-1500 automation system/ET 200MP distributed I/O system are based on the standard IEC 61158 Type 3.

Marine approval

Classification societies:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)
- KR (Korean Register of Shipping)
- CCS (China Classification Society)
- RINA (Registro Italiano Navale)

Industrial use

The S7-1500 automation system ET 200MP / distributed I/O system is designed for the industrial field. It meets the following standards for this type of use:

- Requirements for interference emission EN IEC 61000-6-4
- Requirements for immunity EN IEC 61000-6-2

Use in mixed areas

Under certain conditions you can use the S7-1500 automation system ET 200MP / distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact on residents.

If you use the S7-1500 automation system / ET 200MP distributed I/O system in a mixed area, you must comply with the radio frequency interference limits of the generic standard EN IEC 61000-6-3. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the S7-1500 automation system / ET 200MP I/O system in grounded control cabinets
- Use of noise filters in the supply lines

An additional individual acceptance test is also required.

Use in residential areas

NOTE

S7-1500 automation system / ET 200MP I/O system not intended for use in residential areas

The S7-1500 automation system ET 200MP / distributed I/O system is not intended for use in residential areas. If you use the S7-1500 automation system / ET 200MP distributed I/O system in residential areas, this may have an impact on radio/TV reception.

Environmental Product Declaration (EPD)

Siemens is committed to the development and production of environmentally compatible and sustainably produced equipment.

With the help of an Environmental Product Declaration (EPD), you can obtain information on the "ecological footprint" of your Siemens product.

The EPD is based on the ISO 14021 "Environmental labels and declarations – Self declared environmental claims – Type II" international standard.

EPDs are based on independently verified data from life cycle assessments, life cycle inventory analyses, or information modules which comply with the ISO 14040 series of standards. The EPD contains comprehensive data relating to ingredients and substances (REACH, RoHS), fire load, energy consumption, packaging, and disposal information for your Siemens product.

Importer addresses

In the following table you can find the importer addresses for specific countries:

Countries	Address
United Kingdom (UK)	Siemens plc. Manchester M20 2UR
Türkiye (TR)	Siemens San. ve Tic. A.Ş. Yakacık Cad. No:111 34870 Kartal/İstanbul

Reference

With SiePortal in the Internet (https://www.siemens.com/automation/service&support), you will find:

- The current Environmental Product Declarations (EPDs) for Siemens products, with a search using the keyword "Environmental Product Declaration"
- Certificates for markings and approvals

17.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

The S7-1500 automation system/ET 200MP distributed I/O system also meets the requirements of the EMC legislation for the European single market. The prerequisite for this is that the S7-1500/ET 200MP system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The S7-1500 automation system/ET 200MP distributed I/O system meets the EMC specifications of the NAMUR guideline NE21.

Pulse-shaped disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system/ET 200MP distributed I/O system with regard to pulse-shaped disturbances.

Table 1-859 Pulse-shaped disturbances

Pulse-shaped disturbance	Tested with	Corresponds to degree of severity
Electrostatic discharge in accordance with IEC 61000-4-2 *)	Air discharge: ±8 kV Contact discharge: ±6 kV	3 3
Burst pulses (fast transient disturbances) in accordance with IEC 61000-4-4 *)	±2 kV (power supply line) ±2 kV (signal cable >30 m) ±1 kV (signal cable <30 m)	3 4 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 **)		
• Asymmetric coupling (phase-ground) ***)	±1 kV (24 V DC supply cable)	2
	±1 kV (24 V DC signal/data line only > 30 m)	2
	2 kV (230 V AC supply cable)	3
• Symmetric coupling (phase-phase) ***)	±0.5 kV (24 V DC supply cable)	2
	±1 kV (230 V AC supply cable)	3
*) The maximum short-term influence of analog modules during the duration of the EMC tests can be ±10% of the full-scale value. **) Analog value deviation beyond the limits of the nominal range and diagnostics possible.		

Pulse-shaped disturbance	Tested with	Corresponds to degree of severity
***) If higher phase-ground or phase-phase values are required, you will need an additional external protective circuit (see Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual).		

Sinusoidal disturbances

The following table shows the electromagnetic compatibility of the S7-1500 automation system/ET 200MP distributed I/O system with regard to sinusoidal disturbances (RF radiation).

Table 1-860 Sinusoidal disturbances with RF radiation

RF radiation in accordance with IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		Corresponds to degree of severity
80 MHz to 2.7 GHz	10 V/m	3
2.7 GHz to 6 GHz	3 V/m	2
80 % AM (1 kHz)		

The maximum short-term influence on analog modules during the duration of the EMC tests can be ±1% of the full-scale value.

The following table shows the electromagnetic compatibility of the S7-1500 automation system/ET 200MP distributed I/O system with regard to sinusoidal disturbances (RF coupling).

Table 1-861 Sinusoidal disturbances with RF coupling

RF coupling in accordance with IEC 61000-4-6	Corresponds to degree of severity
from 10 kHz	3
10 V_{rms}	
80 % AM (1 kHz)	
150 Ω source impedance	

The maximum short-term influence on analog modules during the duration of the EMC tests can be ±1% of the full-scale value.

Emission of radio interference

Interference emission of electromagnetic fields in accordance with EN IEC 61000-6-4/EN 55016-2-3.

Table 1-862 Interference emission of electromagnetic fields

Frequency	Interference emission	Measuring distance
30 MHz to 230 MHz	< 40 dB (µV/m) QP	10 m
230 MHz to 1000 MHz	< 47 dB (µV/m) QP	10 m
From 1 GHz to 3 GHz	< 76 dB (µV/m) P	3 m
From 3 GHz to 6 GHz	< 80 dB (µV/m) P	3 m

Conducted emission

Interference emission via the AC power supply in accordance with EN IEC 61000-6-4/EN 55016-2-1.

Table 1-863 Interference emission via the AC power supply

Frequency	Interference emission
0.15 ... 0.5 MHz	< 89 dB (µV) Q < 76 dB (µV) M
0.5 ... 30 MHz	< 83 dB (µV) Q < 70 dB (µV) M

17.3 Electromagnetic compatibility of fail-safe modules

Pulse-shaped disturbances

The fail-safe I/O modules S7-1500/ET 200MP **without** external protective circuit meet the severity level 2 for the high-energy individual pulse (surge) according to IEC 61000-4-5.

Protecting S7-1500/ET 200MP against overvoltages with fail-safe modules

If your equipment requires protection from overvoltage, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the fail-safe modules to ensure surge immunity for the S7-1500 automation system/ET 200MP distributed I/O system with fail-safe modules.

NOTE
Lightning protection measures always require a case-by-case examination of the entire system. An almost complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.
If you want detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

You can find more information on protection from overvoltage in the Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.

17.4 Shipping and storage conditions

Introduction

The S7-1500 automation system / ET 200MP I/O system meet the specifications regarding transport and storage conditions pursuant to IEC 61131-2. The following information applies to modules that are shipped and/or stored in their original packaging.

Shipping and storage conditions for modules

The S7-1500 automation system/ET 200MP distributed I/O system exceeds the requirements of IEC 61131-2 regarding transport and storage conditions. The following table shows the conditions that apply to modules transported or stored in their original packaging.

- Transport condition class: TTH4
- Storage condition class: STH4

Table 1-864 Shipping and storage conditions

Type of condition	Permissible range
Free fall (in shipping package)	≤ 1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	From 1 140 to 540 hPa (corresponds to an altitude of -1000 to +5000 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations in accordance with IEC 60068-2-6	5 to 9 Hz: 3.5 mm 9 to 500 Hz: 9.8 m/s^2
Shock in accordance with IEC 60068-2-27	250 m/s^2, 6 ms, 1 000 shocks

17.5 Mechanical and climatic ambient conditions

Operating conditions

The S7-1500 automation system/ET 200MP distributed I/O system is suitable for use in weather-proof, fixed locations. The operating conditions are based on the requirements of IEC 61131-2.

- OTH4 (S7-1500 CPUs: For the minimum ambient temperature, see the Climatic ambient temperatures table)

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 1-865 Test of mechanical ambient conditions

Condition tested	Test Standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (Sinus)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. 5 Hz ≤ f ≤ 8.4 Hz, constant amplitude 7 mm 8.4 Hz ≤ f ≤ 150 Hz, constant acceleration 2 g Duration of vibration: 10 frequency sweeps per axis, along each of the 3 mutually perpendicular axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 15 g peak value, 11 ms duration Direction of shock: 3 shocks each in +/- direction, along each of the 3 perpendicular axes
Continuous shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 25 g peak value, 6 ms duration Direction of shock: 1 000 shocks each in +/- direction, along each of the 3 mutually perpendicular axes

Reduction of vibrations

If your S7-1500 automation system/ET 200MP distributed I/O system is exposed to severe shock or vibration, take appropriate measures to reduce the acceleration or the amplitude.

We recommend installing the S7-1500 automation system/ET 200MP distributed I/O system on damping materials (for example, rubber-bonded metal mounting).

Climatic ambient conditions

The following table shows the permissible climatic ambient conditions for the S7-1500 automation system/ET 200MP distributed I/O system during operation.

Table 1-866 Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: Horizontal and vertical mounting	See product data sheets for the respective module on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td)	The lower permissible ambient temperature was extended for the S7-1500 automation system/ET 200MP distributed I/O system to -30 °C. Differences may exist for specific modules and depending on the mounting position and, if applicable, load. You must check the lower permissible ambient temperature for each module in the product data sheets. The product data sheets with daily updated technical specifications can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td) at Industry Online Support. Enter the article number or the short description of the desired module on the website.
		To increase the service life of the display, the display switches off when the permitted operating temperature is exceeded. At certain temperatures, the display switches off an on again. You can find more information in the technical specifications in the CPU manuals.
Temperature variation	10 K/h	-
Relative humidity	from 10 % to 95 %	Without condensation
Barometric pressure	From 1140 to 795 hPa	Corresponds to an altitude of -1 000 m to 2 000 m. See below under "Using the S7-1500 automation system/ET 200MP distributed I/O system over 2 000 m above sea level".
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

Using the S7-1500 automation system/ET 200MP distributed I/O system over 2 000 m above sea level

This information is available in the Use above 2 000 m above sea level and extended temperature range (Page 410) section.

17.6 Information on insulation tests, protection class, degree of protection and rated voltage

Insulation

The insulation is designed in accordance with the requirements of EN 61010-2-201.

NOTE
In the case of modules with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Pollution degree/overvoltage category in accordance with EN 61131-2 and IEC 61010-2-201

- Pollution degree: 2 (macro environment)
- Overvoltage category: II

Protection class according to IEC 61131-2 and IEC 61010-2-201

The S7-1500 automation system/ET 200MP distributed I/O system meets protection class I and contains parts of protection classes II and III.

Degree of protection IP20

Degree of protection IP20 in accordance with IEC 60529 for all modules of the S7-1500 automation system/ET 200MP distributed I/O system:

- Protection against contact with standard test fingers
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The S7-1500 automation system/ET 200MP distributed I/O system works with the rated voltages and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 1-867 Rated voltage of all modules of the S7-1500 automation system/ET 200MP distributed I/O system for operation

rated voltage	Tolerance range
24 V DC	19.2 V DC to 28.8 V DC [1]
48 V DC	40.8 to 57.6 V DC

[1] Static value: Generation as protective extra-low voltage with safe electrical isolation in accordance with IEC 61131-2 or IEC 61010-2-201.

rated voltage	Tolerance range
60 V DC	51.0 to 72.0 V DC
120 V AC	93 V AC to 132 V AC
230 V AC	187 V AC to 264 V AC

[1] Static value: Generation as protective extra-low voltage with safe electrical isolation in accordance with IEC 61131-2 or IEC 61010-2-201.

17.7 Use of the S7-1500/ET 200MP in zone 2 hazardous areas

Reference

You can find more information in the product information Use of modules in a Zone 2 Hazardous Area (https://support.automation.siemens.com/WW/view/en/19692172).

Dimension drawings

A

A.1 Dimension drawings of the mounting rails

Mounting rail 160 mm

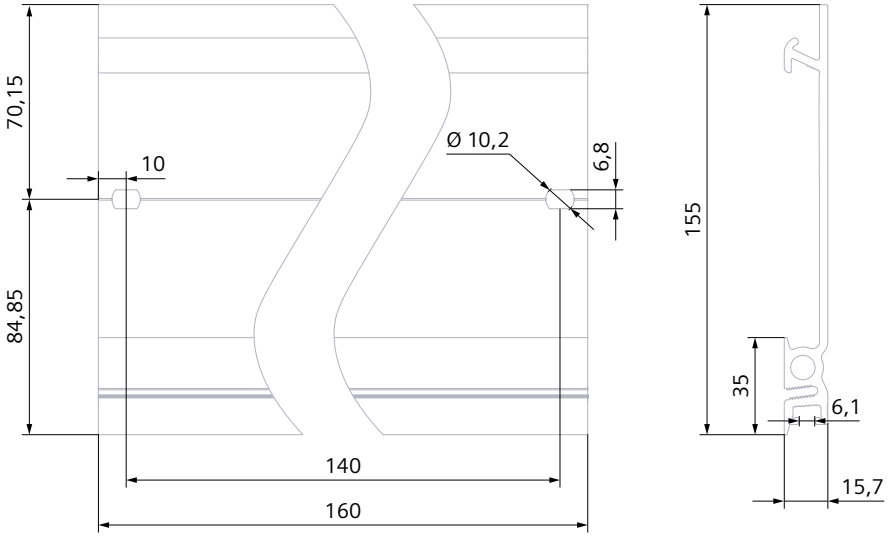


Figure 1-585 Mounting rail 160 mm

Mounting rail 245 mm

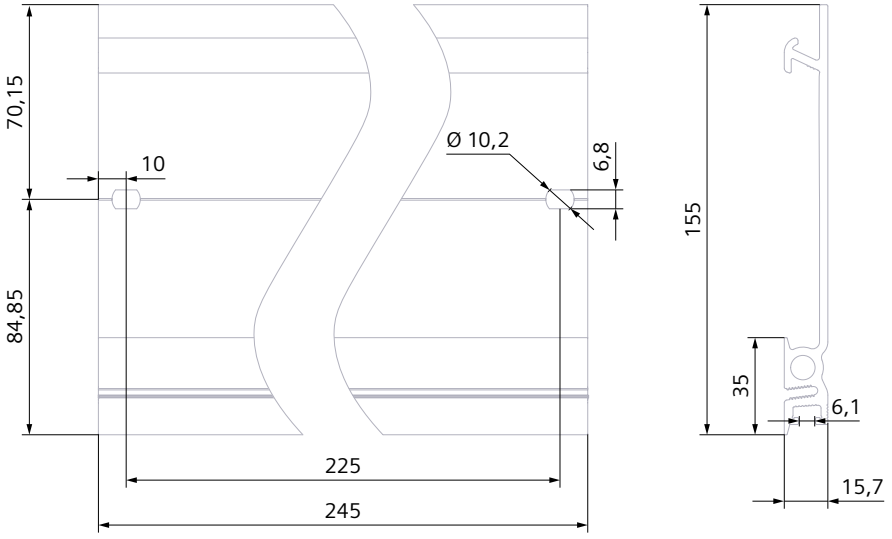


Figure 1-586 Mounting rail 245 mm

Mounting rail 482.6 mm

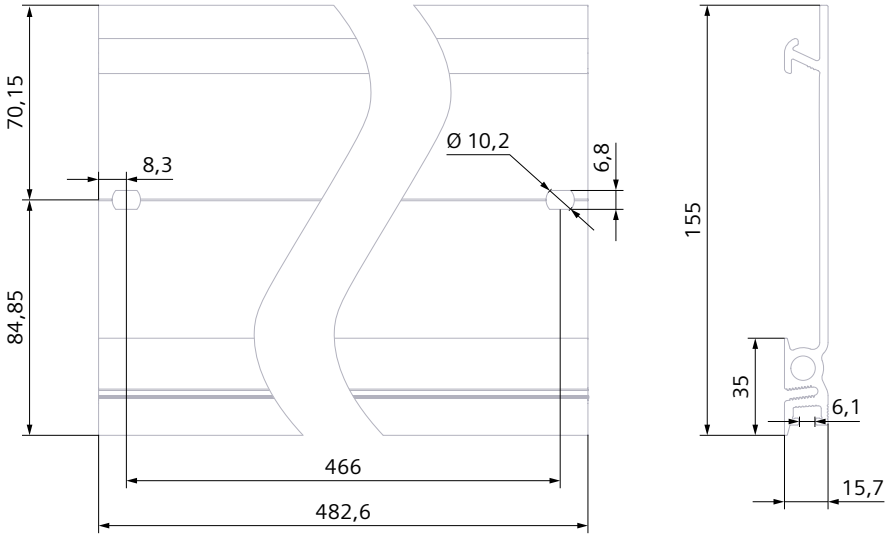


Figure 1-587 Mounting rail 482.6 mm

Mounting rail 530 mm

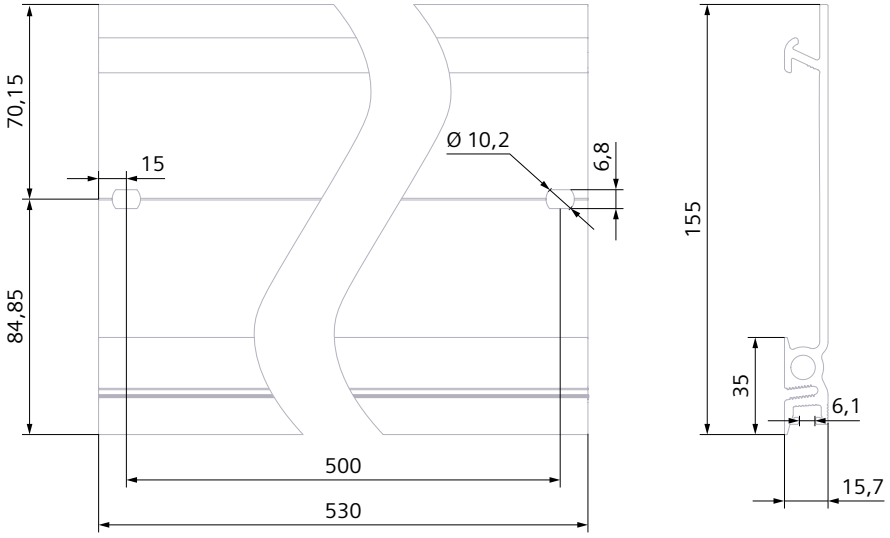


Figure 1-588 Mounting rail 530 mm

Mounting rail 830 mm

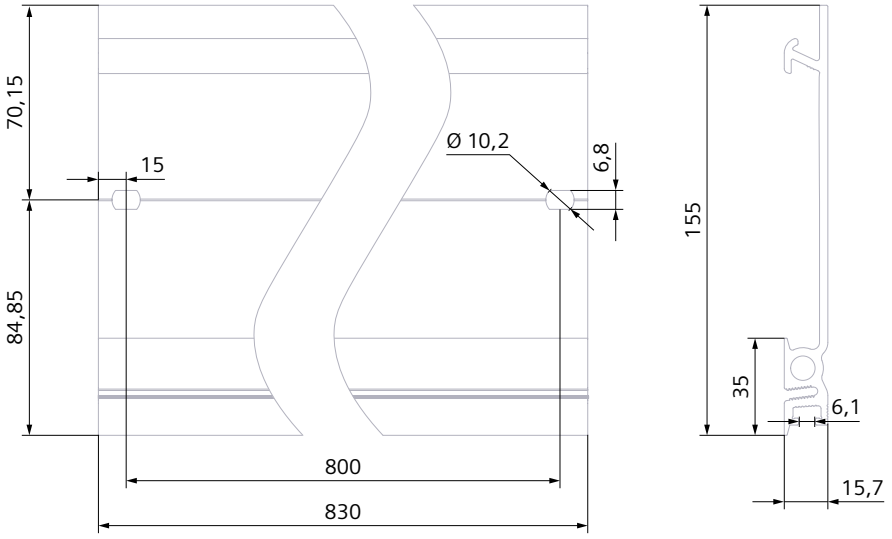


Figure 1-589 Mounting rail 830 mm

Mounting rail 2 000 mm

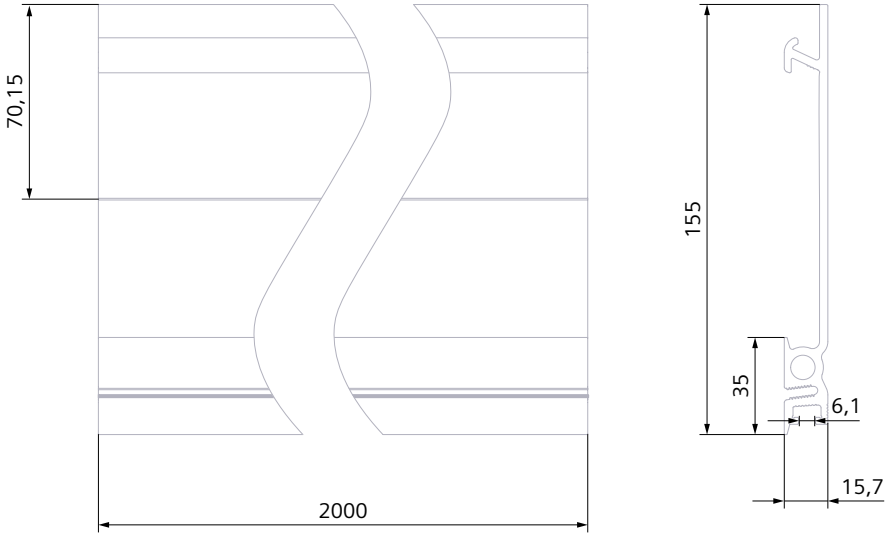


Figure 1-590 Mounting rail 2 000 mm

A.2 Dimension drawing of shielding bracket for 35 mm modules

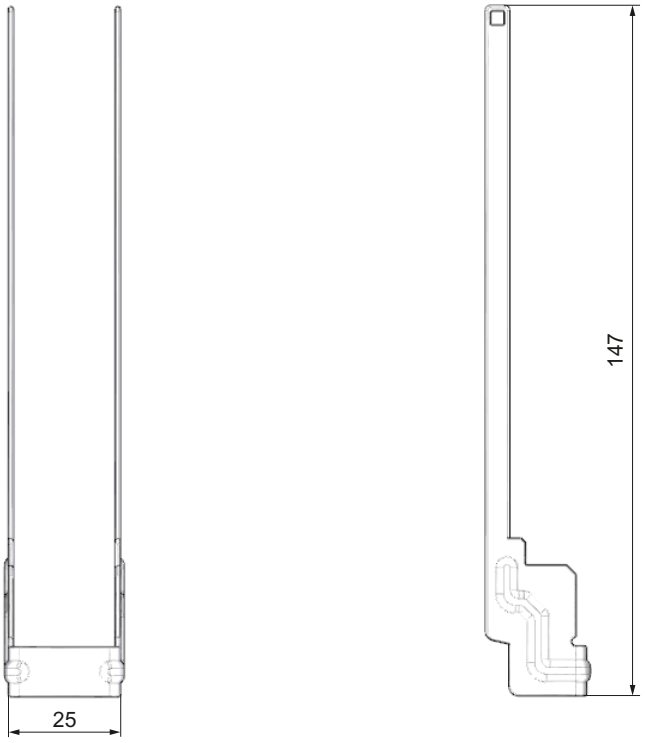


Figure 1-591 Dimension drawing of shielding bracket for 35 mm modules

A.3 Dimension drawing of shielding bracket for 25 mm modules

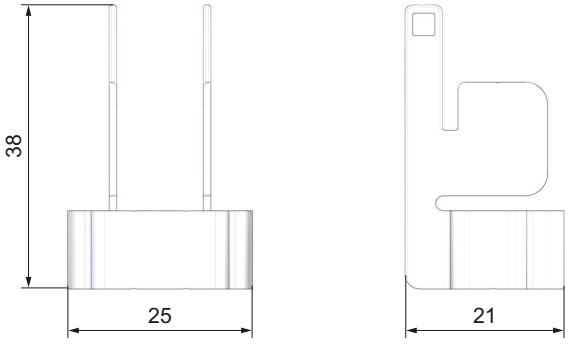


Figure 1-592 Dimension drawing of shielding bracket for 25 mm modules

A.4 Dimension drawing of shielding bracket for 35 mm modules

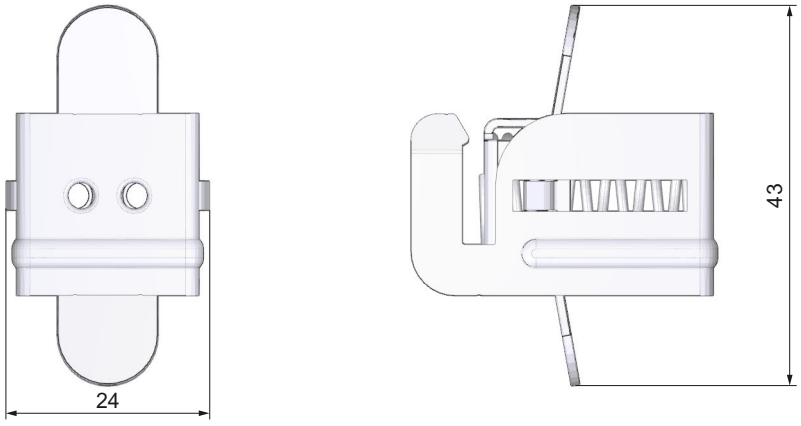


Figure 1-593 Dimension drawing of shielding bracket for 35 mm modules

A.5 Dimension drawing of shielding bracket for 25 mm modules

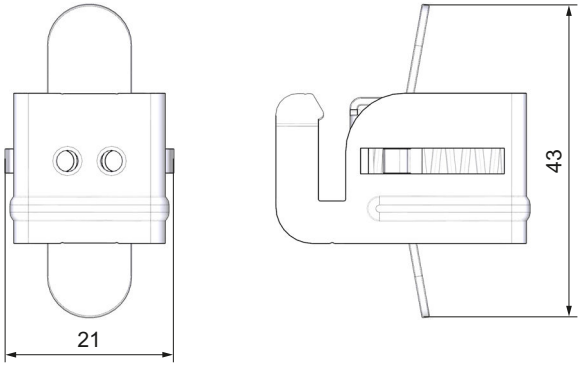


Figure 1-594 Dimension drawing of shielding bracket for 25 mm modules

A.6 Dimension drawing of infeed element for 35 mm modules

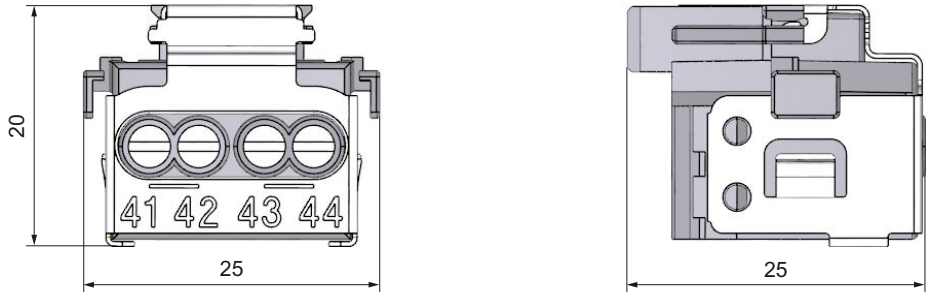


Figure 1-595 Dimension drawing of infeed element for 35 mm modules

A.7 Dimension drawing of infeed element for 25 mm modules

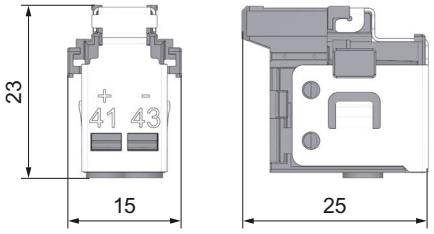


Figure 1-596 Dimension drawing of infeed element for 25 mm modules

A.8 Dimension drawings of the labeling strips

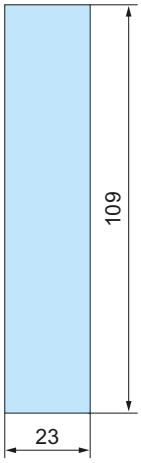


Figure 1-597 Dimension drawing of labeling strips for 35 mm modules

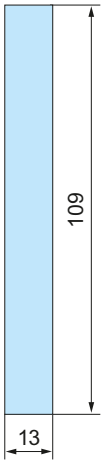


Figure 1-598 Dimension drawing of labeling strips for 25 mm modules

A.9 Dimension drawing of test probe for measurement tap

To perform measurements on the front connector of the S7-1500/ET 200MP automation system, you need a test probe with the following properties:

- Maximum diameter at measuring tip: 1 mm
- Length of measuring tip: ≥ 10 mm

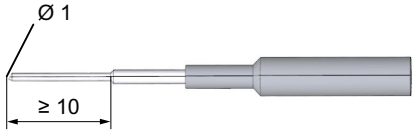


Figure 1-599 Dimension drawing of test probe for measurement tap

Corresponding test probes are available from electrical retailers.

Accessories/spare parts

B

Accessories for the S7-1500 automation system/ET 200MP distributed I/O system

Table 1-868 General accessories

Designation	Article number
Mounting rail	
• Mounting rail, 160 mm (with drill holes)	6ES7590-1AB60-0AA0
• Mounting rail, 245 mm (with drill holes)	6ES7590-1AC40-0AA0
• Mounting rail, 482 mm (with drill holes)	6ES7590-1AE80-0AA0
• Mounting rail, 530 mm (with drill holes)	6ES7590-1AF30-0AA0
• Mounting rail, 830 mm (with drill holes)	6ES7590-1AJ30-0AA0
• Mounting rail, 2 000 mm (without drill holes) for cutting to length	6ES7590-1BC00-0AA0
DIN-rail adapter, 10 adapters, 10 hexagon socket screws and 10 washers	6ES7590-6AA00-0AA0
Active backplane bus	
• For one interface module and 12 I/O modules (ST 1+12)	6ES7590--0BL00-0AA0
• For one interface module and 8 I/O modules (ST 1+8)	6ES7590-0BH00-0AA0
• For one interface module and 4 I/O modules (ST 1+4)	6ES7590-0BD00-0AA0
PE connection element for mounting rail, 2 000 mm (spare part), 20 units	6ES7590-5AA00-0AA0
Front connector (incl. four potential bridges, cable tie, and individual labeling strip) for 35 mm modules	
• Screw-type terminals, 40-pin	6ES7592-1AM00-0XB0
Front connector (incl. four potential bridges, cable tie, and individual labeling strip) for 35 mm modules	
• Push-in terminal (40-pin)	6ES7592-1BM00-0XB0
Front connector (incl. cable tie and individual labeling strip) for 25 mm modules	
• Push-in terminal (40-pin)	6ES7592-1BM00-0XA0
4-pole connection plug for supply voltage (spare part), 10 units	6ES7193-4JB00-0AA0
DIN A4 labeling sheet (10 x for labeling the 35 mm I/O modules)	
• Pre-perforated, Al gray	6ES7592-2AX00-0AA0
DIN A4 labeling sheet (10 x for labeling the 25 mm I/O modules)	
• Pre-perforated, Al gray	6ES7592-1AX00-0AA0
U connector (spare part), 5 units	6ES7590-0AA00-0AA0
I/O shielding set for 35 mm modules (consists of: Power supply element, shielding bracket, and shield connection clamp), (spare part), 5 units	6ES7590-5CA00-0AA0
I/O shielding set for 25 mm modules (consists of: Power supply element, shielding bracket, and shield connection clamp), (spare part), 4 units	6ES7590-5CA10-0XA0

[*] The PROFIBUS FastConnect bus connector 0BB70 is supplied with the IM 155-5 DP ST interface module and can also be ordered as a spare part.

Designation	Article number
Shield clamp (spare part), 10 units	6ES7590-5BA00-0AA0
Display 35 mm (spare part) for standard and F technology, TF-CPUs up to article number 6ES751x-xxx01-0AB0, compact CPUs with article number 6ES751x-xxx00-0AB0	6ES7591-1AA01-0AA0
Display module 35 mm (spare part) for standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0	6ES7591-1AB00-0AA0
Display module 35 mm (spare part) for standard and F-CPUs, technology, TF-CPUs, compact CPUs as of article number 6ES751x-xxx03-0AB0	6ES7591-1AB10-0AA0
Protective cover 35 mm (spare part) with cutout for display and display keys for standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, compact CPUs as of article number 6ES751x-xxx01-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0, 5 units	6ES7591-4AB00-0AA0
Display 70 mm (spare part) for standard and F-technology, TF-CPUs up to article number 6ES751x-xxx01-0AB0	6ES7591-1BA02-0AA0
Display module 70 mm (spare part) for standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0	6ES7591-1BB00-0AA0
Protective cover 70 mm (spare part) with cutout for display and display keys for standard, F-CPUs as of article number 6ES751x-xxx02-0AB0, technology, TF-CPUs as of article number 6ES751x-xxx03-0AB0, 5 units	6ES7591-4BB00-0AA0
Power cable connector with coding element for power supplies (spare part), 10 units	6ES7590-8AA00-0AA0
Potential bridges for front connector (spare part), 20 units	6ES7592-3AA00-0AA0
Universal front cover for 35 mm I/O modules (spare part), 5 units	6ES7528-0AA00-7AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module - article number) • 5 x wiring diagram (per module article number)
Universal front cover for 25 mm I/O modules (spare part), 5 units	6ES7528-0AA00-0AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module - article number) • 5 x wiring diagram (per module article number)
Universal front cover for interface module (spare part), 5 units	6ES7528-0AA70-7AA0 Consists of: • 5 x front cover
Industrial Ethernet FastConnect RJ45 plug 180 degrees, 1 unit	6GK1901-1BB10-2AA0
Industrial Ethernet FastConnect RJ45 plug 180 degrees, 10 units	6GK1901-1BB10-2AB0
Industrial Ethernet FastConnect RJ45 plug 90 degrees, 1 unit	6GK1901-1BB20-2AA0
Industrial Ethernet FastConnect RJ45 plug 90 degrees, 10 units	6GK1901-1BB20-2AB0
PROFIBUS-FastConnect bus connector without programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BA70-0XA0

[*] The PROFIBUS FastConnect bus connector 0BB70 is supplied with the IM 155-5 DP ST interface module and can also be ordered as a spare part.

Designation	Article number
PROFIBUS FastConnect bus connector with programming device socket, up to 12 MBaud, 1 unit *	6ES7972-0BB70-0XA0
PROFIBUS-FastConnect bus connector without programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BA52-0XA0
PROFIBUS FastConnect bus connector with programming device socket, up to 12 MBaud, 1 unit	6ES7972-0BB52-0XA0

* The PROFIBUS FastConnect bus connector 0BB70 is supplied with the IM 155-5 DP ST interface module and can also be ordered as a spare part.

SIMATIC Memory Cards

Article number	Capacity
6ES7954-8LC0x-0AA0	4 MB
6ES7954-8LE0x-0AA0	12 MB
6ES7954-8LF0x-0AA0	24 MB
6ES7954-8LL0x-0AA0	256 MB
6ES7954-8LP0x-0AA0	2 GB
6ES7954-8LT0x-0AA0	32 GB

SIMATIC Memory Cards for S7-1500 Motion Control KinPlus

Article number	Capacity
6ES7954-8LP80-0AA0	2 GB
6ES7954-8LT80-0AA0	32 GB

Online catalog

Additional article numbers for the S7-1500 automation system/ET 200MP distributed I/O system can be found on the Internet (https://mall.industry.siemens.com) in the online catalog and online ordering system.

Accessories for S7 1500/ET 200MP fail-safe modules

Table 1-869 Accessories for fail-safe modules

Designation	Article number
Electronic coding element with rewritable memory for fail-safe modules (spare part), 5 units	6ES7592-6EF00-1AA0
Front cover for 35 mm F-I/O modules (spare part), 5 units	6ES7528-0AA10-7AA0 Consists of: • 5 x front cover • 5 x front labeling strip (per module - article number) • 5 x wiring diagram (per module article number)

Designation	Article number
DIN A4 labeling sheet (10 x for labeling the fail-safe I/O modules), pre-perforated, yellow	6ES7592-2CX00-0AA0

Use over 2000 m above sea level and extended temperature range

C

C.1 Ambient temperature and installation altitude

Extension of the temperature range and the installation altitude

The previously permissible range of ambient temperatures of **0 °C** to 60 °C for the horizontal mounting position has been extended for a large number of modules to a range of ambient temperatures of **-30 °C** to 60 °C or **-25 °C** to 60 °C (in each case without condensation or icing). In addition, depending on the module, the permitted installation altitudes has been extended to installation height of up to 5,000 meters.

The accessory components offered for S7-1500/ET 200MP (labeling strips, shield terminals, mounting rails, front connectors, etc.) can also be used down to -30 °C and for altitudes up to 5 000 m.

The following tables show an overview of the current climatic ambient conditions for ambient temperature and installation altitude of modules of the S7-1500, ET 200MP product families.

Reference

The current status of the respective modules can be found in the online published technical specifications.

In general, the module-dependent extended climatic operating conditions are described in the "Technical specifications" section of the respective modules in the equipment manuals.

C.2 CPUs

Standard CPUs

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1511-1 PN	6ES7511-1AK01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1511-1 PN	6ES7511-1AK02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1511-1 PN	6ES7511-1AL03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1513-1 PN	6ES7513-1AL01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1513-1 PN	6ES7513-1AL02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1513-1 PN	6ES7513-1AM03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1515-2 PN	6ES7515-2AM01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1515-2 PN	6ES7515-2AM02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1515-2 PN	6ES7515-2AN03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1516-3 PN/DP	6ES7516-3AN01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1516-3 PN/DP	6ES7516-3AN02-0AB0	-25 to +60	FS 01	5 000	FS 01

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1516-3 PN/DP	6ES7516-3AP03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1517-3 PN	6ES7517-3AQ10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1517-3 PN/DP	6ES7517-3AP00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1518-3 PN	6ES7518-3AT10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1518-4 PN/DP	6ES7518-4AP00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1518-4 PN/DP O-DK	6ES7518-4AP00-3AB0	0 to +60	FS 01	5 000	FS 08
CPU 1518-4 PN/DP MFP	6ES7518-4AX00-1AB0	0 to +60	FS 01	5 000	FS 08

Compact CPUs

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1511C-1 PN	6ES7511-1CK00-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1511C-1 PN	6ES7511-1CK01-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1511C-1 PN	6ES7511-1CL03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1512C-1 PN	6ES7512-1CK00-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1512C-1 PN	6ES7512-1CK01-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1512C-1 PN	6ES7512-1CM03-0AB0	-30 to +60	FS 01	5 000	FS 01

Fail-safe CPUs

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1511F-1 PN	6ES7511-1FK01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1511F-1 PN	6ES7511-1FK02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1511F-1 PN	6ES7511-1FL03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1511TF-1 PN	6ES7511-1UK01-0AB0	0 to +60	FS 03	5 000	FS 03
CPU 1511TF-1 PN	6ES7511-1UL03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1513F-1 PN	6ES7513-1FL01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1513F-1 PN	6ES7513-1FL02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1513F-1 PN	6ES7513-1FM03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1515F-2 PN	6ES7515-2FM01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1515F-2 PN	6ES7515-2FM02-0AB0	-25 to +60	FS 01	5 000	FS 01
CPU 1515F-2 PN	6ES7515-2FN03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1515TF-2 PN	6ES7515-2UM01-0AB0	0 to +60	FS 03	5 000	FS 03
CPU 1515TF-2 PN	6ES7515-2UN03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1516F-3 PN/DP	6ES7516-3FN01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1516F-3 PN/DP	6ES7516-3FN02-0AB0	-25 to +60	FS 01	5 000	FS 01

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1516F-3 PN/DP	6ES7516-3FP03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1516TF-3 PN	6ES7516-3UP10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1516TF-3 PN/DP	6ES7516-3UN00-0AB0	0 to +60	FS 05	5 000	FS 05
CPU 1517F-3 PN	6ES7517-3FQ10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1517F-3 PN/DP	6ES7517-3FP00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1517F-3 PN/DP	6ES7517-3FP01-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1517TF-3 PN	6ES7517-3UQ10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1517TF-3 PN/DP	6ES7517-3UP00-0AB0	0 to +60	FS 04	5 000	FS 05
CPU 1518F-3 PN	6ES7518-3FT10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1518F-4 PN/DP	6ES7518-4FP00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1518F-4 PN/DP ODK	6ES7518-4FP00-3AB0	0 to +60	FS 04	5 000	FS 05
CPU 1518F-4 PN/DP MFP	6ES7518-4FX00-1AB0	0 to +60	FS 01	5 000	FS 01
CPU 1518TF-3 PN	6ES7518-3UT10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1518TF-4 PN/DP	6ES7518-4UP00-0AB0	0 to +60	FS 10	5 000	FS 10

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand or continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 m < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Technology CPUs

CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CPU 1511T-1 PN	6ES7511-1TK01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1511T-1 PN	6ES7511-1TL03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1515T-2 PN	6ES7515-2TM01-0AB0	0 to +60	FS 01	5 000	FS 03
CPU 1515T-2 PN	6ES7515-2TN03-0AB0	-30 to +60	FS 01	5 000	FS 01
CPU 1516T-3 PN	6ES7516-3TP10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1516T-3 PN/DP	6ES7516-3TN00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1517T-3 PN	6ES7517-3TQ10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1517T-3 PN/DP	6ES7517-3TP00-0AB0	0 to +60	FS 01	5 000	FS 05
CPU 1518T-3 PN	6ES7518-3TT10-0AB0	0 to +60	FS 01	5 000	FS 01
CPU 1518T-4 PN/DP	6ES7518-4TP00-0AB0	0 to +60	FS 01	5 000	FS 08

Spare part displays

Replacement part displays for CPU	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
35 mm	6ES7591-1AA01-0AA0	0 to +60	FS 01	5 000	FS 01
70 mm	6ES7591-1BA02-0AA0				

Spare part display modules

Replacement part display modules for S7-CPUs Width	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
35 mm (for all FW versions of a CPU)	6ES7591-1AB00-0AA0	-25 to +60	FS 01	5 000	FS 01
70/175/210 mm	6ES7591-1BB00-0AA0				
35 mm (only for CPUs as of FW version V3.0)	6ES7591-1AB10-0AA0	-30 to +60	FS 04	5 000	FS 04

C.3 S7-1500 I/O modules

Digital input modules

Digital input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
DI 16x24VDC HF	6ES7521-1BH00-0AB0	-30 to +60	FS 05	5 000	FS 03
DI 16x24VDC HS	6ES7521-7BH00-0AB0	-30 to +60	FS 01	5 000	FS 01
DI 32x24VDC HF	6ES7521-1BL00-0AB0	-30 to +60	FS 05	5 000	FS 03
DI 64x24VDC SNK/SRC BA	6ES7521-1BP00-0AA0	-30 to +60	FS 01	5 000	FS 01
DI 16x24VDC SRC BA	6ES7521-1BH50-0AA0	0 to +60	FS 01	5 000	FS 01
DI 16x24VDC SRC BA	6ES7521-1BH50-0AA0	-25 to +60	FS 03	5 000	FS 05
DI 16x230VAC BA	6ES7521-1FH00-0AA0	0 to +60	FS 01	2,000	FS 01
DI 16x230VAC BA	6ES7521-1FH00-0AA0	-30 to +60	FS 03	2 000	FS 05
DI 16 x 24...125V UC HF	6ES7521-7EH00-0AB0	0 to +60	FS 01	2,000	FS 01
DI 16 x 24...125V UC HF	6ES7521-7EH00-0AB0	-30 to +60	FS 02	2 000	FS 01
DI 16x24VDC BA (25 mm)	6ES7521-1BH10-0AA0	0 to +60	FS 01	5 000	FS 01
DI 16x24VDC BA (25 mm)	6ES7521-1BH10-0AA0	-30 to +60	FS 03	5 000	FS 04

Digital input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
DI 32x24VDC BA (25 mm)	6ES7521-1BL10-0AA0	0 to +60	FS 01	5 000	FS 01
DI 32x24VDC BA (25 mm)	6ES7521-1BL10-0AA0	-30 to +60	FS 03	5 000	FS 04
DI 16xNamur HF	6ES7521-7TH00-0AB0	-30 to +60	FS 01	5 000	FS 01

Fail-safe digital input modules

Fail-safe digital input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
F-DI 16X24VDC	6ES7526-1BH00-0AB0	0 to +60	FS 01	5 000	FS 01

Digital output modules

Digital output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
DQ 16x24VDC/0.5A ST	6ES7522-1BH01-0AB0	-30 to +60	FS 03	5 000	FS 01
DQ 32x24VDC/0.5A ST	6ES7522-1BL01-0AB0	-30 to +60	FS 03	5 000	FS 01
DQ 64x24VDC/0.3A BA	6ES7522-1BP00-0AA0	-30 to +60	FS 01	5 000	FS 01
DQ 64x24VDC/0.3A SNK BA	6ES7522-1BP50-0AA0	-30 to +60	FS 01	5 000	FS 01
DQ 8x24VDC/2A HF	6ES7522-1BF00-0AB0	-30 to +60	FS 04	5 000	FS 06
DQ 8x24VDC/5A HS	6ES7522-5BF00-0AB0	-30 to +60	FS 01	5 000	FS 01
DQ 8x230VAC/2A ST (Triac)	6ES7522-5FF00-0AB0	0 to +60	FS 01	2,000	FS 01
DQ 8x230VAC/2A ST (Triac)	6ES7522-5FF00-0AB0	-25 to +60	FS 03	2 000	FS 01
DQ 16x230VAC/1A ST (Triac)	6ES7522-5FH00-0AB0	0 to +60	FS 01	2,000	FS 01
DQ 16x230VAC/1A ST (Triac)	6ES7522-5FH00-0AB0	-25 to +60	FS 02	2 000	FS 01
DQ 8x230VAC/5A ST (Relay)	6ES7522-5HF00-0AB0	-30 to +60	FS 03	2,000	FS 01
DQ 16x230VAC/2A ST (Relay)	6ES7522-5HH00-0AB0	-25 to +60	FS 02	2,000	FS 01
DQ 16x24...48VUC/125V-DC/0.5A ST	6ES7522-5EH00-0AB0	0 to +60	FS 01	2,000	FS 01
DQ 16x24...48VUC/125V-DC/0.5A ST	6ES7522-5EH00-0AB0	-25 to +60	FS 03	2 000	FS 01

Digital output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
DQ 16x24VDC/0.5A BA (25 mm)	6ES7522-1BH10-0AA0	0 to +60	FS 01	5 000	FS 01
DQ 16x24VDC/0.5A BA (25 mm)	6ES7522-1BH10-0AA0	-30 to +60	FS 03	5 000	FS 01
DQ 32x24VDC/0.5A BA (25 mm)	6ES7522-1BL10-0AA0	0 to +60	FS 01	5 000	FS 01
DQ 32x24VDC/0.5A BA (25 mm)	6ES7522-1BL10-0AA0	-30 to +60	FS 03	5 000	FS 01

Fail-safe digital output modules

Fail-safe digital output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
F-DQ 8x24VDC/2A PPM	6ES7526-2BF00-0AB0	0 to +60	FS 01	5 000	FS 01

Digital input/output modules

Digital input/ output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
DI 16x24VDC / DQ 16x24VDC/0.5A BA	6ES7523-1BL00-0AA0	0 to +60	FS 01	5 000	FS 01
DI 16x24VDC / DQ 16x24VDC/0.5A BA	6ES7523-1BL00-0AA0	-30 to +60	FS 03	5 000	FS 01
DI 32x24VDC / DQ 32x24VDC/0.3A SNK BA	6ES7523-1BP50-0AA0	-30 to +60	FS 01	5 000	FS 01

Analog input modules

Analog input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
AI 8xU/I/RTD/TC ST	6ES7531-7KF00-0AB0	-25 to +60	FS 06	5 000	FS 08
AI 8xU/I/RTD BA	6ES7531-7QF00-0AB0	-30 to +60	FS 03	5 000	FS 05
AI 16xI BA	6ES7531-7MH00-0AB0	-30 to +60	FS 01	5 000	FS 01
AI 16xU BA	6ES7531-7LH00-0AB0	-30 to +60	FS 01	5 000	FS 01
AI 8xU/I HS	6ES7531-7NF10-0AB0	-25 to +60	FS 02	5 000	FS 01
AI 8xU/I HF	6ES7531-7NF00-0AB0	-30 to +60	FS 02	2,000	FS 01
AI 8xU/R/RTD/TC HF	6ES7531-7PF00-0AB0	-30 to +60	FS 02	2,000	FS 01
AI 4xU/I/RTD/TC ST	6ES7531-7QD00-0AB0	0 to +60	FS 01	5 000	FS 01

Analog input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
AI 4xU/I/RTD/TC ST	6ES7531-7QD00-0AB0	-25 to +60	FS 02	5 000	FS 01
AI 8xHART HF	6ES7531-7TF00-0AB0	-30 to +60	FS 01	5 000	FS 01
AI 24xCVM HF	6ES7531-7LK00-0AB0	-30 to +60	FS 01	4 000	FS 01

Fail-safe analog input modules

Fail-safe analog input module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
F-AI 8XI	6ES7536-1MF00-0AB0	0 to +60	FS 01	5 000	FS 01

Analog output modules

Analog output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
AQ 4xU/I ST	6ES7532-5HD00-0AB0	-30 to +60	FS 06	5 000	FS 03
AQ 4xU/I HF	6ES7532-5ND00-0AB0	-25 to +60	FS 02	2,000	FS 01
AQ 8xU/I HS	6ES7532-5HF00-0AB0	-30 to +60	FS 03	5 000	FS 02
AQ 2xU/I ST	6ES7532-5NB00-0AB0	0 to +60	FS 01	5 000	FS 01
AQ 2xU/I ST	6ES7532-5NB00-0AB0	-30 to +60	FS 02	5 000	FS 01
AQ 8xHART HF	6ES7532-8TF00-0AB0	-30 to +60	FS 01	5 000	FS 01

Analog input/output modules

Analog input/ output module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
AI 4x U/I/RTD/TC/AQ 2x U/I ST	6ES7534-7QE00-0AB0	-25 to +60	FS 04	5 000	FS 04

Communication modules

Communication module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
CM 8xIO-Link	6ES7547-1JF00-0AB0	0 to +60	FS 01	5 000	FS 01
CM 8xIO-Link	6ES7547-1JF00-0AB0	-30 to +60	FS 02		
CM PtP RS422/485 BA	6ES7540-1AB00-0AA0	0 to +60	FS 01		
CM PtP RS232 BA	6ES7540-1AD00-0AA0				
CM PtP RS422/485 HF	6ES7541-1AB00-0AB0				
CM PtP RS232 HF	6ES7541-1AD00-0AB0				

Technology modules

Technology module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
TM Count 2x24V	6ES7550-1AA00-0AB0	0 to +60	FS 01	5 000	FS 01
TM PosInput 2	6ES7551-1AB00-0AB0				
TM Timer DIDQ 16x2-4V	6ES7552-1AA00-0AB0				
TM PTO 4	6ES7553-1AA00-0AB0				
TM MFP	6ES7558-1AA00-0AB0				
TM Timer DIDQ 24x2-4V	6ES7552-1AA01-0AB0	-30 to +60	FS 02	5 000	FS 02
TM NPU	6ES7556-1AA00-0AB0	-25 to +60	FS 01	2,000	FS 01

Power supply modules

Power supply module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
PS 25W 24VDC	6ES7505-0KA00-0AB0	-25 to +60	FS 03	5 000	FS 01
PS 60W 24/48/60VDC	6ES7505-0RA00-0AB0	-25 to +60	FS 04	2,000	FS 01
PS 60W 24/48/60VDC HF	6ES7505-0RB00-0AB0	-25 to +60	FS 02	2,000	FS 01
PS 60 W 120/230V AC/DC	6ES7507-0RA00-0AB0	-25 to +60	FS 04	2,000	FS 01

Information on PFDavg, PFH values for fail-safe S7-1500 I/O modules

PFDavg and PFH values for fail-safe S7-1500 I/O modules for operating altitudes up to 5 000 m.

The safety parameters (PFDavg, PFH values) specified in the Equipment Manual for the fail-safe S7-1500 I/O modules already reflect the influence of higher cosmic radiation (soft error rate) for operation up to 5 000 m above sea level.

C.4 ET 200MP

Interface modules

Interface module	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
IM 155-5 DP ST	6ES7155-5BA00-0AB0	-25 to +60	FS 04	5,000	FS 01
IM 155-5 PN BA	6ES7155-5AA00-0AA0	-30 to +60	FS 03	5,000	FS 01
IM 155-5 PN ST	6ES7155-5AA01-0AB0	-25 to +60	FS 03	5,000	FS 01
IM 155-5 PN HF	6ES7155-5AA00-0AC0	-25 to +60	FS 04	5,000	FS 01
IM 155-5 MF HF	6ES7155-5MU00-0CN0	-30 to +60	FS 01	5,000	FS 01

Active backplane buses

Active backplane bus	Article number	Ambient temperature		Installation altitude	
		Temperature range [°C]	As of version	Max. altitude [m]	As of version
Active backplane bus 4 slots	6ES7590-0BD00-0AA0	-30 to +60	FS 01	5,000	FS 01
Active backplane bus 8 slots	6ES7590-0BH00-0AA0				
Active backplane bus 12 slots	6ES7590-0BL00-0AA0				

C.5 Restrictions

Restrictions of the max. ambient temperature specified with regard to the installation altitude

Installation altitude	Derating factor for ambient temperature [1]
-1,000 to 2,000 m	1.0
2,000 to 3,000 m	0.9
3,000 to 4,000 m	0.8
4,000 to 5,000 meters	0.7

[1] Base value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2,000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air in higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. The basis is the standard IEC 61131-2.
- Make sure that the power supplies you use are also rated for altitudes > 2 000 m.
- The displays of the S7-1500 CPUs are designed for an altitude of ≤ 3,000 m. When operating the device at altitudes > 3,000 m, you might experience problems with the CPU display in rare cases; however, these do not affect the mode of operation of the CPU.
- The function "Fail-safe shutdown of standard modules", as described in the Internet (https://support.industry.siemens.com/cs/us/en/view/39198632), is only released up to a maximum of 2,000 m.

Effects on availability

The higher cosmic radiation present during operation at altitudes above 2,000 m will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases this can result in a transition of the module into the safe state, especially for safety modules. However, the functional safety of the module is fully retained.

NOTE

Information on the components of the S7-1500 automation system

The markings and approvals printed on the components of the S7-1500 automation system are currently based on operation at an altitude of up to 2 000 m. The fail-safe components are certified for operation in safety mode up to the specified maximum altitudes (according to "Z10 067803 0020" certificate (https://support.industry.siemens.com/cs/ww/de/view/57141281/en)).

Reference

You can find more information in the Mechanical and climatic ambient conditions (Page 395) section.

SIMATIC S7-1500 data

D

The EU Data Act, a key component of the European data strategy, entered into force on 11 January 2024.

The following information provides an overview of the data that is generated by the SIMATIC S7-1500 automation system and accessible to you.

D.1 Data of the CPUs

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and program data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, system and security events, service data	Time formats, string formats, CSV, binary formats	Depending on application Several hundred bytes per event
Operating data (runtimes, cycle times, CPU utilization)	Numeric formats, time formats, JSON	Depending on application
Log data	Time formats, string formats, CSV	Depending on application

Continuous and real-time data generation

The SIMATIC S7-1500 is able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The CPU operates with defined cycle times in which process data is acquired and processed.

Data storage and storage duration

Local data storage

The SIMATIC S7-1500 stores data in integrated memory areas of the CPU and on the SIMATIC Memory Card.

Local data storage	Storage capacity	Storage duration
Load memory (via SIMATIC Memory Card)	4 MB to 32 GB, depending on SIMATIC Memory Card	Permanent
Code work memory	300 KB to 18 MB, depending on CPU	During operation of the CPU
Data work memory	1.5 MB to 150 MB	During operation of the CPU
Retentive memory	Up to 4.5 MB, depending on CPU	Permanent

More information
You can find more information on memory areas, retentive memory, and memory usage in the Structure and use of the CPU memory Function Manual (https://support.industry.siemens.com/cs/de/de/view/59193101/en).

Remote data storage
Data can be transmitted to external systems via various communication interfaces of the SIMATIC S7-1500, such as PROFINET, Industrial Ethernet.

The SIMATIC S7-1500 can send data to various remote systems, including SCADA systems, SQL databases, cloud platforms (for example, Insights Hub), and file servers.

The SIMATIC S7-1500 can send logging data to a SIEM system in the form of syslog messages.

The storage duration on external systems depends on the configuration of the respective system.

The SIMATIC S7-1500 CPU can be integrated as a data source into the Siemens Industrial Edge concept.

Data access/retrieval, terms of use and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	TIA Portal Web server OPC UA HMI/SCADA systems CPU display	User management Authentication Certificates	Prioritization of control tasks over data access Data throughput rates up to 1 Gbps via PROFINET Encrypted data transmission available (HTTPS, TLS)
Configuration and program data	TIA Portal Web server SIMATIC Memory Card	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Diagnostics data, system and security events, service data	TIA Portal SIMATIC Automation Tool Web server CPU display	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Operating data (runtimes, cycle times, CPU utilization)	TIA Portal Web server HMI/SCADA systems SIMATIC controller profiling	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Log data	TIA Portal Trace and logic analyzer function	User management Authentication	Encrypted data transmission available (HTTPS, TLS)

* "Quality of service" refers to the ability of the SIMATIC S7-1500 to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from CPUs

To delete all data from the data memories of the CPU, the "Reset to factory settings" function is available.

A reset of the CPU to factory settings can be implemented using any of the following:

- Mode selector keys/switches of the CPU
- CPU display
- TIA Portal
- SIMATIC Automation Tool

More information
You can find more information on deleting data in the SIMATIC S7-1500, ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792), "Securely removing data" and "Reset to factory settings" sections.

D.2 Data of the interface, power supply, and I/O modules

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFIBUS, PROFINET, EtherNet/IP, Modbus TCP (only for interface modules as MultiFieldbus devices)

Continuous and real-time data generation

The interface, power supply, and I/O modules are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the higher-level CPU.

Data storage and storage duration

Local data storage

The interface, power supply, and I/O modules store data in integrated memory areas.

Local data storage	Storage capacity	Storage duration
Retentive memory (for I&M data, configuration and parameter data*, service data)	Up to 16 MB for interface modules 1 to 4 MB for power supply and I/O modules	Permanent
Work memory (for process data, diagnostics data, fieldbus metadata, configuration and parameter data, service data)	Up to 1 MB for interface modules Several hundred KB for power supply and I/O modules	During operation of the module

* only interface modules as MultiFieldbus devices and IO-Link masters

Data access/retrieval, terms of use and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for supported modules)	Via fieldbus without authentication Via CPU (Page 420)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughput rates up to 1 Gbps via PROFINET
Configuration and parameter data (upload to programming device/PC)	TIA Portal (via CPU) S7-PCT (for IO-Link masters) MFCT (for supported modules)	Via fieldbus without authentication Via CPU (Page 420)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for supported modules)	Via fieldbus without authentication Via CPU (Page 420)	Standard fieldbus transmission mechanisms
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for supported modules)	Via fieldbus without authentication Via CPU (Page 420)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface, power supply, and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from interface, power supply, and I/O modules

Interface modules
To delete all data from the data memories of the interface module, the "Reset to factory settings" function is available.

The IM can be reset to factory settings using any of the following:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

Power supply modules
No delete function is available for power supply modules.

I/O modules
The data of an IO-Link master can be deleted using S7-PCT by executing the "Reset to factory settings" function.

For all other I/O modules, no delete function is available.

More information
You can find more information on deleting data in the SIMATIC S7-1500, ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792), "Securely removing data" and "Reset to factory settings" sections.

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Product information on the system manuals

Product Information

Cybersecurity information

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General amendments to the documentation

This product information contains amendments to the system manuals. The product information is part of the product supplied. Consider the statements provided in it as more up-to-date than other documentation if uncertainties arise.
This product information is valid for all products which reference this product information.

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A5E53813811-AA, 07/2024

Operation of a system in an environment with low relative humidity

You have the possibility to operate the products in an environment with low relative humidity (calculated values: Dew point temperature -60 °C, 100 % humidity).
To do this, follow the following points in this product information.

Shock, vibrations
In the chapter "Mechanical and climatic environmental conditions" of the system manuals the "Tests for mechanical environmental conditions" table is replaced by the following table:

Table 1 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibrations	Vibration test according to IEC 60068-2-6 (sinusoidal)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each one of the three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes

ESD
Comply with the requirements of the table "Pulse-shaped disturbance variables" in the chapter "Electromagnetic compatibility" of the system manuals.

⚠ WARNING

Loss of the safety function, personal injury, property damage and destruction of the modules
When operating the system in an environment with low relative humidity (RH) < 10 % expect a rise of the electrostatic charge.
Take appropriate measures to ensure that the test levels specified in the "Pulse-shaped disturbance variables" table are not exceeded during this use.

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S7-1500/ET 200MP, S7-1500R/H
Product Information on documentation S7-1500/ET 200MP, S7-1500R/H

Product Information

Introduction

Scope of validity

Scope of validity of the product information

This product information supplements the documentation for SIMATIC S7-1500/ET 200MP, S7-1500R/H and takes precedence over our system manuals, function manuals and equipment manuals.

You can find additional information on the S7-1500 fail-safe CPUs in the Product Information for F-CPUs on the Internet (https://support.industry.siemens.com/cs/us/en/view/109478599).

You can find additional information on SIMATIC S7-1500 Motion Control in the corresponding product information on the Internet (https://support.industry.siemens.com/cs/us/en/view/109794046).

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Amendments to documentation S7-1500/ET 200MP

Standard/compact/technology CPUs Equipment Manuals, Edition 11/2024

Sections Product overview, New functions

New functions for FW version 4.1	Applications	Customer benefits
Backup and restore of the configuration of the CPU by a central user	As of FW version V4.1 of a CPU, a central user can also back up and restore the configuration.	Rules you need to follow for backup and restore. More information is available in the SIMATIC S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual, in the section Backing up and restoring the CPU configuration.
Integrated security		
Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts in the case of CPUs as of FW version V4.1.	The temporary account lockout provides protection against brute force attacks.
SIMATIC S7-1500 data	This appendix provides you with an overview of the data that the CPU generates and makes available to you.	More information is available in the SIMATIC S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual, in the appendix SIMATIC S7-1500 data.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	For more information, please refer to the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
Activating IP forwarding through a data record transfer	For CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU through data record transfer.	
Technology functions of the CPU		
General functions	Distribution of motion job processing over several cores Improved performance	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
Axis functions (only S7-1500T)	Specification of the motion setpoints of a superimposing axis in addition to the basic motion of the axis Extended range of functions	Axis functions (https://support.industry.siemens.com/cs/us/en/view/109817884) Function Manual
Synchronous operation functions (only S7-1500T)	Cam usable as time-based position profile Extended range of functions	Synchronous operation functions (https://support.industry.siemens.com/cs/us/en/view/109817888) Function Manual
	Area scaling at a cam before or during active camming Extended range of functions	
	Cross-PLC synchronous operation with communication via isochronous I-device Extended range of functions	

New functions for FW version 4.1	Applications	Customer benefits
Kinematics functions (only S7-1500T)	New predefined kinematics type "6-axis articulated arm with offset wrist" available Extended range of functions	Kinematics functions (https://support.industry.siemens.com/cs/us/en/view/109817886) Function Manual
	As of firmware version V4.1, the following CPUs support the Motion Control package "S7-1500T Motion Control KinPlus" V10.0: • CPU 1516T/TF-3 PN • CPU 1517T/TF-3 PN	
Interpreter functions (only S7-1500T)	Value of a tag at a breakpoint can be changed in Debug program mode Extended range of functions	Interpreter functions (https://support.industry.siemens.com/cs/us/en/view/109817891) Function Manual
Trace functionality of the CPU		
Creating a long-term trace configuration from a long-term trace measurement	Extended range of functions	Trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
Recording, display and analysis of events in TIA Portal	Diagnostics of Motion Control jobs Extended range of functions	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
PID control		
New version V2.0 of PID_Temp controller	Use for cooling-only applications	PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036) Function Manual
	Temporary shutdown of the heating	
	Manual stopping of the integral-action component	
	Active limiting of the integral-action component and change of output value limits in automatic mode	
	Improved anti-windup behavior in the cascade	

Technical specifications section

Equipment Manual	Technical specifications for FW version V4.1
CPU 1511-1 PN (6ES7511-1AL03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7511-1AL03-0AB0/td?dl=de)
CPU 1511T-1 PN (6ES7511-1TL03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7511-1TL03-0AB0/td?dl=de)
CPU 1513-1 PN (6ES7513-1AM03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7513-1AM03-0AB0/td?dl=de)
CPU 1515-2 PN (6ES7515-2AN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7515-2AN03-0AB0/td?dl=de)
CPU 1515T-2 PN (6ES7515-2TN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7515-2TN03-0AB0/td?dl=de)

Equipment Manual	Technical specifications for FW version V4.1
CPU 1516-3 PN/DP (6ES7516-3AP03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7516-3AP03-0AB0/td?dl=de)
CPU1516T-3 PN (6ES7516-3TP10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7516-3TP10-0AB0/td?dl=de)
CPU 1511C-1 PN (6ES7511-1CL03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7511-1CL03-0AB0/td?dl=de)
CPU 1512C-1 PN (6ES7512-1CM03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7512-1CM03-0AB0/td?dl=de)
CPU 1517-3 PN (6ES7517-3AQ10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7517-3AQ10-0AB0/td?dl=de)
CPU 1517T-3 PN (6ES7517-3TQ10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7517-3TQ10-0AB0/td?dl=de)
CPU 1518-3 PN (6ES7518-3AT10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7518-3AT10-0AB0/td?dl=de)
CPU 1518T-3 PN (6ES7518-3TT10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7518-3TT10-0AB0/td?dl=de)

ET 200MP with IM 155-5 MF HF - MF Shared Device in the sections Ethernet/IP and Modbus TCP
Equipment Manual IM 155-5 MF HF (6ES7155-5MU00-0CN0), Edition 11/2025
Four ARs are available; these are shared by the fieldbuses. For EtherNet/IP and Modbus TCP, only one AR is reserved in each case, regardless of the number of controller connections used.
The maximum amount of I/O data must comply with the rules of the following table:

Number of fieldbus connections			Maximum I/O data per connection[1]		Max. download size with MFCT [1]	
PROFINET	**EtherNet/IP**	**Modbus TCP**	**Inputs**	**Outputs**	**Inputs**	**Outputs**
0	1 to 2	1 to 10	500	246	1440	1440
1	1 to 2	0	EtherNet/IP: 500 Modbus TCP: 500 PROFINET: 1440	EtherNet/IP: 246 Modbus TCP: 246 PROFINET: 1440	Download size[2]: 1440	Download size[2]: 1440
1	0	1 to 10				
1	1 to 2	1 to 10	EtherNet/IP: 500 Modbus TCP: 500 PROFINET: 1440	EtherNet/IP: 246 Modbus TCP: 246 PROFINET: 1440	Download size[2]: 1440	Download size[2]: 1440
2	1 to 2	0				
2	0	1 to 10				
2	1 to 2	1 to 10				

1 Including PROFINET payload qualifier or data status byte for signaling the data validity

2 PROFINET data + download size as displayed in MFCT ≤ 5760

The total size of all input data (PROFINET ARs) + the size of all output data across all PROFINET ARs + the download size should be less than 5760 bytes.

NOTE

The intensive use of Shared Device (multiple fieldbus connections with very large I/O configuration limits) and other functions such as Virtual Module affect the performance of the interface module.
To avoid temporarily exceeding the I/O configuration limits, you must proceed as follows in the case of a reconfiguration that results in changed I/O lengths:

1. Reduce the amount of I/O data in one configuration and download it to the MF device/CPU.
2. Increase the amount of I/O data in the other configuration and download it to the MF device/CPU.

Communication Function Manual, Edition 11/2025

Communications services, Secure Communication, Protection of confidential configuration data
If you connect to the CPU online, the user management loaded onto the CPU applies. A user with the required function rights can start loading from the CPU without needing to enter the password for the protection of confidential configuration data. Recommendation: Always load user management onto your CPU. Otherwise, everyone who can connect to the CPU online has full access to all CPU data.

Enabling/disabling routing, IP forwarding via data record transfer: Example for a CPU 1516-3 PN/DP
You can enable/disable IP forwarding for CPUs as of FW version V4.1 via the user program, regardless of which STEP 7 version is installed.

Connecting inductances to quenching elements
Function Manual Designing interference-free controllers, Edition 06/2014
In contrast to the specifications in section 6 "Special measures for interference-free operation", the following applies to wiring with quenching elements:
The inductances controlled by SIMATIC modules (for example, contactor or relay coils) require wiring with external quenching elements since **no** quenching elements are integrated in the modules.
The wiring examples with quenching elements in section 6 of the Function Manual still apply.

S7-1500/ET 200MP – digital output module DQ 8x24VDC/2A HF
Equipment Manual DQ 8x24VDC/2A HF**, Edition 06/2018, Technical specifications section**

Maximum permitted switching frequency of inductive loads
The following trends show the maximum permissible switching frequency of inductive loads as a function of the inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 500 mA to the total current of the module, even if the actual channel current is smaller.
If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

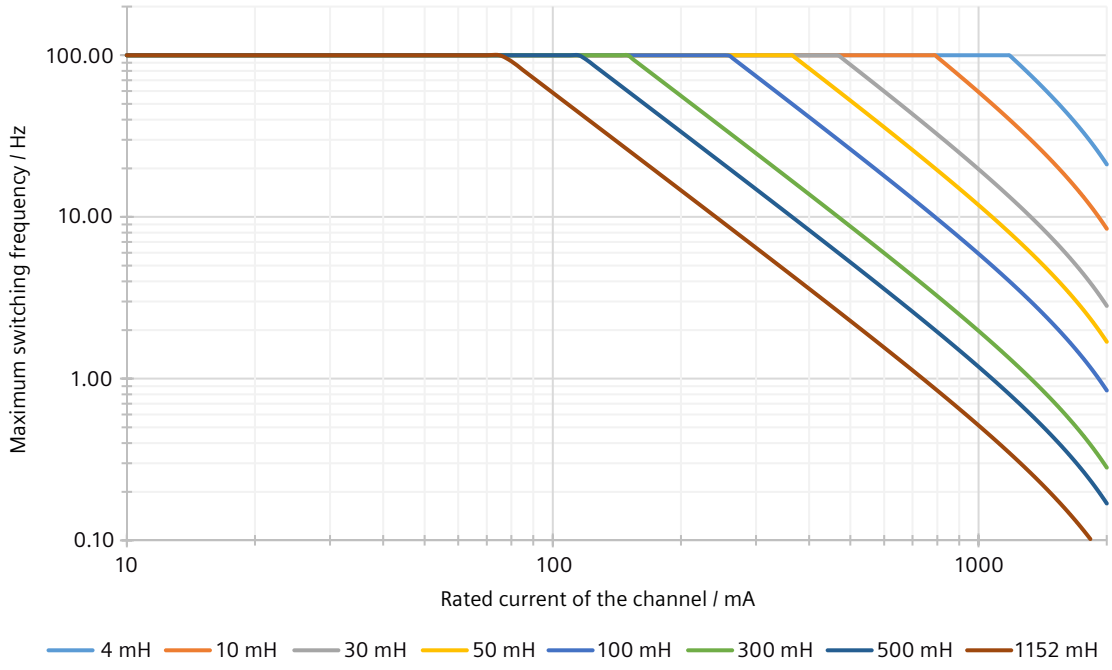


Figure 1 Maximum switching frequency

SIMATIC memory card – Overview
Structure and use of the CPU memory Function Manual 11/2023 edition

NOTE

Supported file/directory names and hierarchy levels on the SIMATIC Memory Card
The following rules apply to file names, directory names and hierarchy levels on the SIMATIC Memory Card:

- Do not use any umlauts (ö, ä, ü, Ö, Ä, Ü) in file and/or directory names.
- Use a maximum of 60 characters for file and/or directory names.
- Use a maximum of 6 hierarchy levels for the directory structure of the SIMATIC memory card (for example: /mountpoint/1/2/3/4/5/6/file.txt).
  The operating system of the CPU guarantees directories of no more than 8 levels, where one level is reserved for the mount point and one for the actual file.

ET 200MP with IM 155-5 PN ST - Channel diagnostics, MSI/MSO
Equipment Manual IM 155-5 PN ST interface module, Edition 11/2017

Channel diagnostics
In contrast to the order specified in the manual, the User Structure Identifiers (USI) are structured as follows:

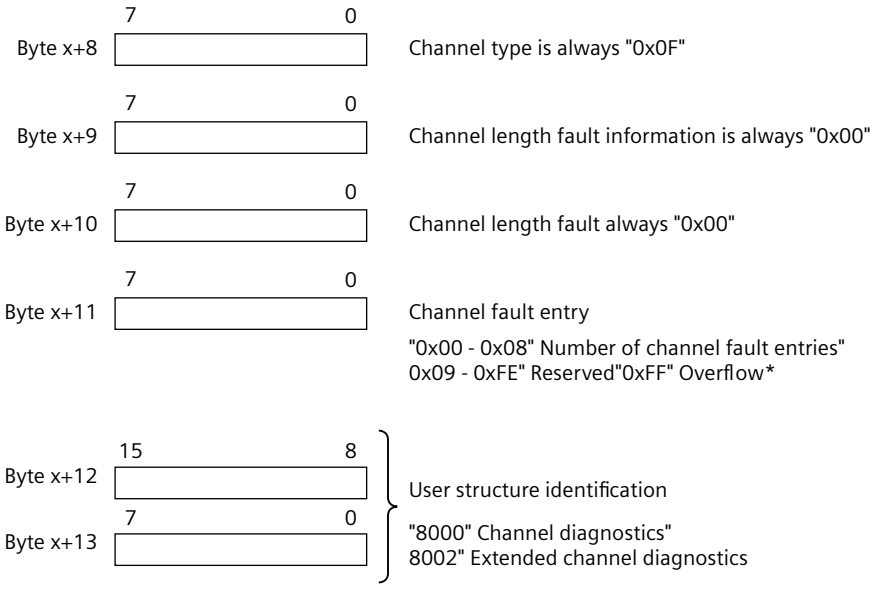
- USI data block
- Reserved bytes
- Manufacturer-specific diagnostics

ET 200MP with IM 155-5 DP ST – Operation on a WIN AC RTX
When operating the ET 200MP (PROFIBUS) on a WIN AC RTX, configuration is only possible via a GSD file (selection in the hardware catalog under "Additional field devices"). Configuration on the basis of a support package is not supported in TIA Portal for this device arrangement.

ET 200MP with IM 155-5 DP ST - operation on Y-Link, interrupts, technical specifications Equipment Manual IM 155-5 DP ST interface module, Edition 08/2013

Operation on Y-Link
As of firmware version V2.0.0, it is possible to operate the IM 155-5 DP ST interface module as a DP slave after the Y-Link.

Interrupts
The bytes x+8 to x+19 of the diagnostic interrupt are assigned as follows:



* The number of existing channel faults is greater than 8.

Figure 2 Structure starting at byte x+8

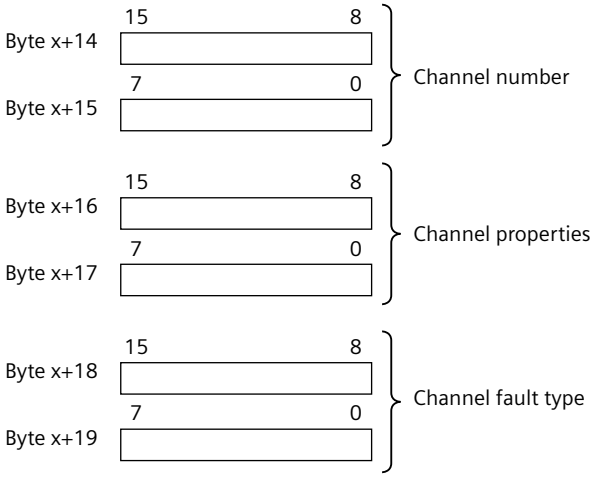


Figure 3 Structure starting at byte x+14

Technical specifications
For the IM 155-5 DP ST, it is possible to assign a maximum of 64 bytes of inputs and a maximum of 64 bytes of outputs to the address space per module.

S7-1500/ET 200MP - Substitute value behavior in shared device mode
Observe the following special characteristics for substitute value behavior in shared device mode with the modules/configurations in the following table:

NOTE

Substitute value behavior in shared device mode
If the system is in shared device mode and one of the IO controllers involved goes into STOP or fails due to a communication breakdown, for example, all submodules of the output module perform the configured substitute value reaction (e.g. shutdown).
This means that even when only one IO controller fails, that the other IO controllers associated with the shared device no longer control the assigned submodule of the output module.

Module/module name	Configuration	Article no.:
DQ 32x24VDC/0.5A BA	4 x 8-channel without value status	6ES7522-1BL10-0AA0
DQ 16x24VDC/0.5A BA	2 x 8-channel without value status	6ES7522-1BH10-0AA0

S7-1500/ET 200MP - Modules with isochronous mode
The following configurations rule out isochronous mode of the module:
- Module-internal shared input (MSI)
- Module-internal shared output (MSO)
- Submodules for shared device

S7-1500/ET 200MP - Calibration of analog modules
Requirements: The module is integrated in the hardware catalog of STEP 7 (TIA Portal) (no GSD file).
The "Calibration" function (calibration in RUN) is only possible with the following configurations.

Module/module name	Configuration	Article no.:
AI 8xU/I/RTD/TC ST QI	1 x 8-channel with value status	6ES7531-7KF00-0AB0
AI 8xU/I/RTD/TC ST	1 x 8-channel without value status	
AI 8xU/I HS QI	1 x 8-channel with value status	6ES7531-7NF10-0AB0
AI 8xU/I HS	1 x 8-channel without value status	
AQ 8xU/I HS QI	1 x 8-channel with value status	6ES7532-5HF00-0AB0
AQ 8xU/I HS	1 x 8-channel without value status	
AQ 4xU/I ST QI	1 x 4-channel with value status	6ES7532-5HD00-0AB0
AQ 4xU/I ST	1 x 4-channel without value status	
AQ 4xU/I HF QI	1 x 4-channel with value status	6ES7532-5ND00-0AB0
AQ 4xU/I HF	1 x 4-channel without value status	
AI 4xU/I/RTD/TC/ AQ 2xU/I ST QI	1 x 6-channel with value status	6ES7534-7QE00-0AB0
AI 4xU/I/RTD/TC/ AQ 2xU/I ST	1 x 6-channel without value status	
AI 4xU/I/RTD/TC ST QI	1 x 4-channel with value status	6ES7531-7QD00-0AB0
AI 4xU/I/RTD/TC ST	1 x 4-channel without value status	
AQ 2xU/I ST QI	1 x 2-channel with value status	6ES7532-5NB00-0AB0
AQ 2xU/I ST	1 x 2-channel without value status	

S7-1500/ET 200MP - Technical specifications

Equipment Manual AI 8xU/I HS (6ES7531-7NF10-0AB0), Edition 12/2016

Equipment Manual AI 4xU/I/RTD/TC ST (6ES7531-7QD00-0AB0), Edition 09/2016

Equipment Manual AI 4xU/I/RTD/TC / AQ 2xU/I ST (6ES7534-7QE00-0AB0), Edition 09/2016
Contrary to the information given in the manuals, the following statements apply:

24 V encoder supply	
Short-circuit protection	Yes
Output current, max.	20 mA; max. 47 mA per channel for a duration < 10 s

The "encoder supply" depends on the module and is described in the technical specifications of the respective device manual. You can find the data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td). Enter the article number or the short designation of the desired module on the website.

S7-1500/ET 200MP - Analog Output Module AQ 8xU/I HS
Equipment Manual AQ 8xU/I HS (6ES7532-5HF00-0AB0), Edition 09/2016, Technical specifications section
Derating depending on mounting position, ambient temperature and output type (per module):
Deviating from the information in the equipment manual, the following statement applies:
The trends illustrated in the equipment manual show the number of channels (CHx) that can be **simultaneously activated** in horizontal and vertical installation of the S7-1500 automation system / ET 200MP distributed I/O system depending on the ambient temperature.

Shared device
Shared device is not possible with the HSP0318 in the combination of active backplane bus and S7-300/400 CPUs as IO controller.
This combination is possible with GSD file (in STEP 7 as of V5.5 and in STEP 7 (TIA Portal)).
Shared device with active backplane bus and S7-1500 CPUs as IO controller is possible with the HSP0318 and with GSD file.

S7-1500/ET 200MP - Digital Input Module DI 16xNAMUR HF
Equipment Manual DI 16xNAMUR HF (6ES7521-7TH00-0AB0), Edition 07/2021, Technical specifications section

Tolerances of the programmable input delay
Deviating from the tolerance range for input delay 0.05 ms specified in the Equipment Manual, the following values apply:

Input delay	**Tolerance range**
0.05 ms	14 µs to 22 µs

This modified tolerance range applies to all operating modes of the module.
The difference in tolerance range from that of other S7-1500 digital input modules is due to the extended counting frequency of the module of up to 20 kHz.

Integrated counting functions
You can optionally parameterize up to 4 inputs as counters with 2 x 20 kHz and 2 x 10 kHz or 4 x 10 kHz.

S7-1500/ET 200MP - Digital output module DQ 8x230VAC/2A ST Triac
Equipment Manual DQ 8x230VAC/2A ST Triac (6ES7522-5FF00-0AB0), Edition 12/2021, Address space section

Table 1 Configuration options

Configuration	Short designation / module name in the GSD file	Configuration software, e.g., STEP 7 (TIA Portal)	
		Integrated in hardware catalog STEP 7 (TIA Portal)	GSD file in STEP 7 (TIA Portal) V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 8-channel without value status	DQ 8x230VAC/2A ST	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x230VAC/2A ST MSO	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel with value status	DQ 8x230VAC/2A ST QI		

S7-1500/ET 200MP - Digital output module DQ 16x230VAC/1A ST Triac
Equipment Manual DQ 16x230VAC/1A ST Triac (6ES7522-5FH00-0AB0), Edition 12/2021, Address space section

Table 2 Configuration options

Configuration	Short designation / module name in the GSD file	Configuration software, e.g., STEP 7	
		Integrated in hardware catalog STEP 7 V13, SP1 or higher with HSP 0119	GSD file in STEP 7 V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 16-channel without value status	DQ 16x230VAC/1A ST	X	X
2 x 8-channel without value status	DQ 16x230VAC/1A ST S	X (PROFINET IO only)	X (PROFINET IO only)
1 x 16-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 16x230VAC/1A ST MSO		
1 x 16-channel with value status	DQ 16x230VAC/1A ST QI		
2 x 8-channel with value status	DQ 16x230VAC/1A ST S QI		

S7-1500/ET 200MP - Digital output module DQ 8x24VDC/2A HF
Equipment Manual DQ 8x24VDC/2A HF (6ES7522-1BF00-0AB0), Edition 06/2018

Minimum pulse duration
The minimum pulse duration of 300 µs applies for a duty cycle > 0.
The following table shows the duty cycles and the values output for a duty cycle of 2 ms:

Duty cycle as a %	Pulse duration
0	0 µs
0.1	300 µs
10.0	300 µs
15.0	300 µs
15.1	302 µs
20.0	400 µs

Example for energy saving by reducing the holding current
The `PWM_Out` tag applies for the outputs QB x+2/3 for Channel 0 or QB x+4/5 for Channel 4.

The following special points apply for the duty cycle and the minimum pulse duration:

- At a duty cycle of 0 no PWM output is active
- At an on-load factor < 300 µs no signal is output

Address space operating mode pulse width modulation
If you have set "Pulse width modulation" mode for Channel 0 and Channel 4 in the operating mode parameter, Bit 0 and Bit 4 are not evaluated. Actuation of the PWM channels is effected via the duty cycle (QB x+2/3 and/or QB x+4/5).

Assignment in the process image output (PIQ)

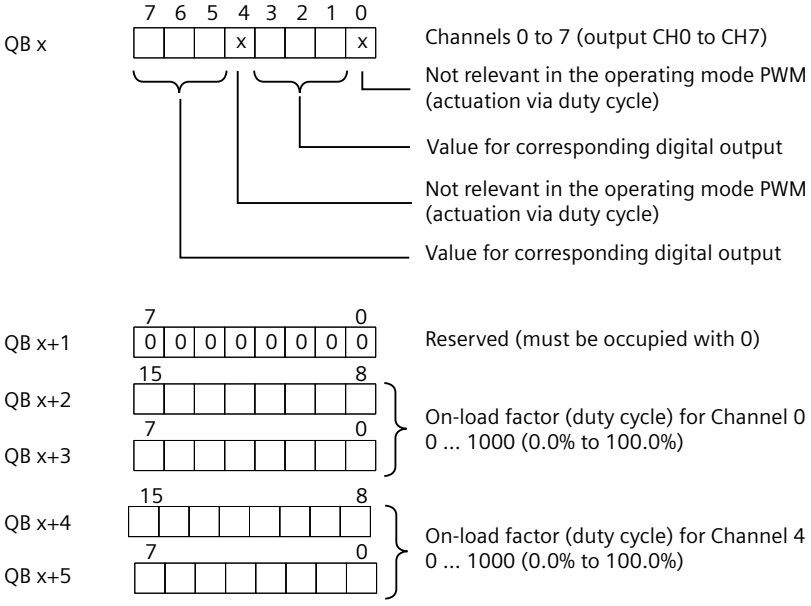


Figure 4 Allocation in the process image output

Transport protocols for syslog messages

Using a TLS or UDP connection
If you want S7-1500 CPUs to transfer their syslog messages to a syslog server, configure either a TLS or UDP connection. Use solely a TLS connection in productive operation. TLS ensures that all syslog messages from the CPU are securely transferred to the syslog server.
You can also use a UDP connection for commissioning and testing scenarios. A UDP connection is not secured. A UDP connection does not even guarantee transferring of all syslog messages to the configured syslog server.

Supplements to the "Protection" section

The following paragraphs supplement the contents in the "Protection" section, Edition 11/2025.

Overview of the protective functions
The link to the document "Security with SIMATIC S7 controllers" in the section is no longer valid.

Recommendation: Several protective functions for increased protection of your system
Use as many of the listed protective functions as possible. These protective functions protect your investments against unauthorized access and manipulation and thus contribute to reliable system availability.

Central user management

Useful information on central user management and access control
Additional information on the warning "Decoupling the user management from the CPU involves risks":
Changes to central users do not affect the existing connection to the CPU at the time the changes are made. In addition to the listed changes, the changes also include deleting a user from the project.

Configuring central user management in the editor for users and roles
Recommendation: It is best to create user groups in your project rather than individual central users.
If you use user groups, the user data only has to be maintained on the connected UMC server. In the case of individual central users, the user data must be maintained in the project in addition and loaded onto the CPU.

Backing up and restoring the CPU configuration

The following paragraphs supplement the contents in the section Commissioning, Backing up and restoring the CPU configuration, Edition 11/2025.

Recommendation: Use password protection for confidential configuration data
Protect the configuration data of a CPU by assigning the password for the protection of confidential configuration data. You thus achieve the best possible protection for the configuration data of a CPU. If possible, manage the password in a password manager.
Also protect the backup files of a CPU against unauthorized access to prevent the manipulation of the backup files.

Information regarding compatibility
In order to use all backup possibilities, use a CPU as of the configured FW version V4.1 and STEP 7 as of V21. Backup files which were generated by a CPU with a configured FW version V4.1 can only be restored on CPUs with a FW version as of V4.1.

Rules for backup and restore
If a user cancels the operation or the CPU cancels the operation due to an error, only the user who canceled the operation can resume it. The intermediate steps "Reset to factory settings" and "Start a new backup/restore" are required for this purpose. The intermediate step "Download from STEP 7" is not required.

Supplements to the "CPU display" section

The following paragraphs supplement the contents in the "CPU display" section, Edition 11/2026.

Advantages
You can save an image (backup copy) of the CPU data to the SIMATIC Memory Card of the CPU locally via the CPU display. Saving an image affects the memory capacity remaining on the SIMATIC Memory Card for the user program.
Consequence: The remaining memory capacity may no longer be sufficient for data that the user program writes to the SIMATIC Memory Card.
Recommendation: Plan in advance for a SIMATIC Memory Card with sufficient memory.

Password protection for the display
The password for the display forms part of the S7-1500 CPU security concept. If possible, manage the password in a password manager. When entering the password, make sure that nobody is able to observe you or read the password.

Other OPC UA functions

Maximum number of simultaneously running jobs for asynchronous instructions for OPC UA
The following table supplements the contents in the section Basics of program editing, Asynchronous instructions, Edition 11/2025
The maximum number of simultaneously running jobs for asynchronous instructions for OPC UA can be found in the respective Equipment Manual in the section Technical specifications section or on the Internet (https://sieportal.siemens.com/su/blVMV).
In the OPC UA instructions for session management or for data access, you require the following values from the technical specifications to be able to calculate the maximum number of jobs running simultaneously:

- Number of connections, max.
- Number of simultaneous calls of the client instructions for session management, per connection, max.
- Number of simultaneous calls of the client instructions for data access, per connection, max.

In addition to the OPC UA instructions, the following table shows the use and calculation of the maximum number of jobs running simultaneously.

OPC UA instruction	Usage	Calculation
OPC_UA_Connect	Session management	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for session management, per connection, max."
OPC_UA_NamespaceGetIndexList		
OPC_UA_NodeGetHandleList		
OPC_UA_MethodGetHandleList		
OPC_UA_TranslatePathList		
OPC_UA_NodeReleaseHandleList		
OPC_UA_MethodReleaseHandleLis		
OPC_UA_Disconnect		
OPC_UA_ConnectionGetStatus		
OPC_UA_ReadList	Data access	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for data access, per connection, max."
OPC_UA_WriteList		
OPC_UA_MethodCall		The value can be taken directly from the technical specifications.

Communication Function Manual, Edition 11/2025

OPC UA communication, Security at OPC UA, Role-based security in OPC UA
A role in the project that you want to use for OPC UA user roles cannot be named "- - -". Otherwise, it will not be possible to map the role in the project to OPC UA user roles. The role is loaded onto the CPU, but has no authorizations.

Communication Function Manual, Edition 11/2024

OPC UA - Global Discovery Push (GDS Push) function: Update problem with downloaded certificates
Under certain conditions, the CPU does not register a downloaded certificate (e.g. a new OPC UA server certificate, or an updated web server certificate). A certificate error may be signaled during a connection attempt in this case.
The update problem occurs only when the CPU still manages certificates that were provided during runtime (GDS Push) and when certificates are then transferred by loading the hardware configuration to the CPU. The certificates loaded via the hardware configuration are not registered by the CPU under these conditions.
Examples:

- You have initially enabled the GDS Push function and selected the option "... use certificates provided during runtime" for the certificate settings and loaded this configuration. The required server certificate as well as the trust lists/CRLs are provided exclusively via GDS Push methods in this case.
- You then change the hardware configuration by adding new certificates or changing existing certificates (e.g. web server certificates or certificates for secure PG/HMI communication). During loading, you have **not** deleted existing certificates provided during runtime so that you can use them later.
  Result: The newly loaded server certificates (e.g. web server certificates or certificates for secure PG/HMI communication) are not registered by the CPU.
- The problem also occurs when you have disabled the GDS Push function and selected the option "... use configured and downloaded certificates" for the certificate settings and loaded this configuration. During loading, you have **not** deleted existing certificates provided during runtime so that you can use them later.
  Result: The newly loaded OPC UA server certificate is not registered by the CPU.

Solution:
When the CPU still has certificates that were provided during runtime and you want to transfer new/changed certificates by loading the hardware configuration to the CPU, proceed as outlined below:

- After loading the configuration, perform a "Memory reset" or restart the CPU (POWER OFF > POWER ON). After performing these measures, the CPU reorganizes the loaded configuration and uses the current certificates.

OPC UA server: Change in behavior when using multi-dimensional arrays in a UDT
From firmware version V2.9.4 onwards, S7-1500 CPUs code multi-dimensional arrays within structures according to OPC UA specification V1.04.
CPUs with older firmware versions code the corresponding structures in another form. If you have used multi-dimensional arrays in structures for CPUs with older firmware versions and are upgrading to the latest firmware version, then you must modify your client programs accordingly.

Amendments to SIMATIC S7-1500R/H documentation

R/H CPUs Equipment Manuals, Edition 11/2024

Sections Product overview, New functions

New functions for FW version 4.1	Applications	Customer benefits
System modification during redundant operation (CiR)	The configuration changes are possible in the PROFINET network of the R/H system. CiR is supported in a ring, line or combined topology.	You can make configuration changes with CiR during running redundant operation. • Add IO device • Reconfigure I/O module

New functions for FW version 4.1	Applications	Customer benefits
OB 83 (pull/plug OB)	As of FW version V4.1, OB 83 (Pull/plug interrupt OB) supports additional events for system modification during redundant operation (CiR).	Additional events: • In the RUN-Redundant system state of an S7-1500R/H system, the re-parameterization of a configured I/O module was started via CiR. • In the RUN-Redundant system state of an S7-1500R/H system, the re-parameterization of a configured I/O module via CiR was successfully completed. • In the RUN-Redundant system state of an S7-1500R/H system, the re-parameterization of a configured I/O module could not be carried out (IO device refuses the new configuration).
Technology object TO_Ident	As of FW version V4.1, the R/H system supports the TO_Ident technology object, the technology object for SIMATIC Ident products.	"TO_Ident" enables the simple parameterization of an Ident system in TIA Portal. It creates an easy-to-parameterize interface between the configured hardware and the function blocks in the "SIMATIC Ident" library.
Number of IO devices that can be used on the H CPUs	As of FW version V4.1, the CPUs 1517H-4 PN/1518HF-4 PN support 512 IO devices in the PROFINET network.	More information is available in the SIMATIC S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual, as of the section System overview.
Switching the system IP address	As of FW version V4.1 of the R/H CPUs, switching the system IP address is also possible when the OPC UA server is activated.	
Firmware update	As of FW version V4.1, the firmware update is supported via accessible nodes.	More information is available in the SIMATIC S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual in the section Firmware update.
Backup and restore configuration of the R/H CPUs from the central user	As of FW version V4.1 of an R/H CPU, a central user can also back up and restore the configuration.	Rules you need to follow for backup and restore. More information is available in the SIMATIC S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual, in the section Backing up and restoring the CPU configuration.
Integrated security		
Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts in the case of CPUs as of FW version V4.1.	The temporary account lockout provides protection against brute force attacks.
SIMATIC S7-1500R/H data	This appendix provides you with an overview of the data that the CPU generates and makes available to you.	More information is available in the SIMATIC S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual, in the appendix SIMATIC S7-1500R/H data.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	For more information, please refer to the

New functions for FW version 4.1	Applications	Customer benefits
Activating IP forwarding through a data record transfer	For CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU through data record transfer.	Communication (https://support.industry.siemens.com/cs/en/de/view/59192925) Function Manual.
GDS (certification management in runtime)	As of FW version V4.1, you can use the OPC UA server on R/H CPUs to transfer certificates during runtime.	The certificate, the trust lists and certificate revocation lists (CRLs) of the OPC UA server and the certificate of the web server can be updated automatically using GDS push management functions.
Configuration limits for OPC UA	As of FW version V4.1, the following configuration limits for OPC UA have been increased: • Maximum number of jobs running simultaneously for asynchronous instructions • OPC UA server methods • Monitored items • Nodes in user-defined interfaces	More information is available in the SIMATIC S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual in the section Asynchronous instructions.
Web server of the R/H CPUs		
System web pages	Introduction of system web pages with functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	You can find more information in the Web server (https://support.industry.siemens.com/cs/en/de/view/109977246) Function Manual.
System IP address	As of FW version V4.1, you can access the web server of the R/H CPUs via the system IP address.	
Trace functionality of the CPU		
Creating a long-term trace configuration from a long-term trace measurement	Extended range of functions	Trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
PID control		
New version V2.0 of PID_Temp controller	Use for cooling-only applications	PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036) Function Manual
	Temporary shutdown of the heating	
	Manual stopping of the integral-action component	
	Active limiting of the integral-action component and change of output value limits in automatic mode	
	Improved anti-windup behavior in the cascade	

Technical specifications section

Equipment Manual	Technical specifications for firmware version V4.1
CPU 1513R-1 PN (6ES7513-1RM03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7513-1RM03-0AB0/td?dl=de)
CPU 1515R-2 PN (6ES7515-2RN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7515-2RN03-0AB0/td?dl=de)
CPU 1517H-4 PN (6ES7517-4HQ10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7517-4HQ10-0AB0/td?dl=de)
CPU 1518HF-4 PN (6ES7518-4JT10-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7518-4JT10-0AB0/td?dl=de)

Prerequisite for CiR (Configuration in Run): STEP 7 V21 Update 1 and firmware version V4.1.2

System Manual S7-1500R/H redundant system, Edition 11/2025

Sections Maintenance, System modification during runtime (CiR), Requirements

NOTE

If you use CiR with S7-1500R/H, at least STEP 7 V21 Update 1 and a firmware version greater than V4.1.0 is required for the R/H CPUs.
Perform updates for STEP 7 and the R/H CPUs!

CiR with S1 devices of the ET 200S/ET 200M type or GSD devices that only support IEC V2.2 LLDP mode

System Manual S7-1500R/H redundant system, Edition 11/2025

Sections Maintenance, System modification during runtime (CiR), Restrictions/Special features
If you plan to add S1 devices of the type ET 200S/ET 200M with CiR, you need to activate the "Use IEC V2.2 LLDP mode" parameter beforehand. To do this, select the corresponding check box in the properties of the PROFINET interface of the R/H CPU in the area "PROFINET interface > Advanced options > Interface options". The same applies to GSD devices that only support IEC V2.2 LLDP mode.
The parameter can only be activated in the STOP system state of the R/H system. Activation with CiR is not possible.

Display of the source address in multicast packages

Communication Function Manual, Edition 11/2025
If an S7-1500 R/H CPU sends UDP multicast messages via a system IP address, the device IP address of the CPU is entered as the source address in the multicast packages instead of the system IP address. Take this behavior into consideration for filters and firewalls.
In case of a reply to the multicast sender, use the system IP address as target.

Configure FTP or Secure FTP in the S7-1500R/H redundant system

Communication Function Manual, Edition 11/2025
The S7-1500R/H redundant system supports the use of CP 1543-1 communications processors as of FW version V3.1. If you use the CP 1543-1 communications processors on the S7-1500R/H redundant system, you can also set up communication via FTP or secure FTP.
You configure the FTP server functionality in the properties of the respective CP. In the FTP configuration of each CP, always assign the R/H CPU to mounting rail_0. Only this R/H CPU can be selected in the selection list. The same applies to CPs that are plugged onto mounting rail_1.

Configuring VPN on the S7-1500R/H redundant system

Communication Function Manual, Edition 11/2025
If you are using the CP 1543-1 communications processors on the S7-1500R/H redundant system, you can also set up communication over a VPN. You can configure a VPN in one of the following ways:

- Both CPs in the same slot of the primary and backup CPU are in the same VPN
- Each CP in the same slot of the primary and backup CPU is located in a specific VPN

Communication over a VPN is only possible via the physical interfaces of the CPs. The virtual interface W1 of the CPUs does not support communication over a VPN.

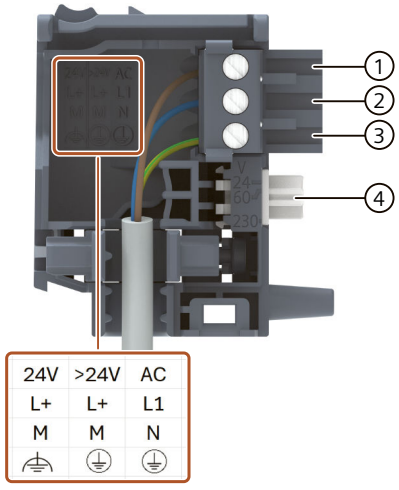
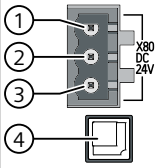
Using the firewall of the CPs
You also configure the access to the CPUs via the device and system IP address of the virtual interfaces W1 in the firewall settings of the CPs.

Supplements to the documentation on power supply modules PS

Supplements relating to the connection plug PS 25W 24VDC

Equipment Manual PS 25W 24VDC (6ES7505-0KA00-0AB0), Edition 11/2020, section Wiring
The following paragraph supplements the Equipment Manual PS 25W 24VDC (6ES7505-0KA00-0AB0) and takes precedence over the Equipment Manual PS 25W 24VDC (6ES7505-0KA00-0AB0).

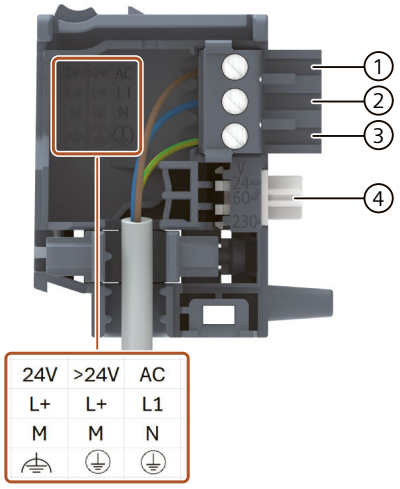
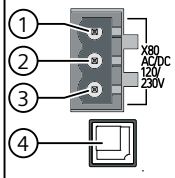
Connection plug
The connection plug for the power supply is plugged in when the power supply module ships from the factory.
The following figure shows the assignment of the connection plug:

Connector	PS connection	Name
		① L ② M ③ Functional earthing conductor ④ Coding element

Supplements relating to the connection plug PS 60W 230VAC

Equipment Manual PS 60W 230VAC (6ES7507-0RA00-0AB0), Edition 11/2020, section Wiring
The following paragraph supplements the Equipment Manual PS 60W 230VAC (6ES7507-0RA00-0AB0) and takes precedence over the Equipment Manual PS 60W 230VAC (6ES7507-0RA00-0AB0).

Connection plug
The connection plug for the power supply is plugged in when the power supply module ships from the factory.
The following figure shows the assignment of the connection plug:

Connector	PS connection	Name
		① L ② N ③ Protective conductor ④ Coding element

SIEMENS
SIMATIC

S7-1500/ET 200MP automation system
Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function
SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity
- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/13716/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/13716/cert?ct=444&ci=5596).
- You can find the EU Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18119/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18119/cert?ct=444&ci=5596).

Firmware
You will find the latest firmware versions (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/search?t=all&search=et%20200mp%20S7-1500&type=Download&lc=en-WW).

Documentation
The complete documentation consists of product information, the system manual, equipment and function manuals. You can find these in the Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/86140384) on the Internet.

Retention of the documentation
Retain this documentation for later use.
1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.
1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384) and on the nameplate of the device.

NOTE
The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Only install products with IP20 degree of protection according to IEC 60529 in enclosures, cabinets, or electrical equipment rooms suitable for the end use that meet at least this degree of protection.

⚠ WARNING

Electric shock due to externally supplied plant units
Even if the main supply to the plant is disconnected, externally supplied plant units can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.
Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Electric shock due to permissible electric potential difference

Due to the permissible electric potential difference, a dangerous voltage may be present at the inputs of modules. An electric shock on contact with live parts can lead to death or serious injury.

Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Safety functional extra low voltage

The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384) of the fail-safe I/O and in the data sheets of the power supplies to be used.

Use a power supply unit with output voltage that does not exceed 36 V DC even in the event of a fault.

Follow the notes and warnings in the respective manual.

⚠ CAUTION

The synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid eye contact with the laser beam. Do not open the housing. Read the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384).

⚠ WARNING

Personal injury due to uncontrolled movement

When using Motion Control, uncontrolled movements can occur which result in personal injury of unknown extent.

Follow the safety instructions described in the Motion Control function manuals (https://support.industry.siemens.com/cs/ww/en/view/86140384).

Electromagnetic Compatibility

The product is intended for operation in the Industrial EMC environment class.

Ensure that your automation system is installed in compliance with EMC requirements, as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384) for the product.

NOTICE

Interference emission / Interference immunity

Operation of the product can cause radio interference in residential areas.

If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

ATEX-/UKEX device intended for use in hazardous area
If the product is intended for use in a potentially explosive atmosphere (gas/air or gas/dust mixture), observe the special information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384). The intended use (e.g. ATEX zone, degree of protection, temperature class) is indicated on the product (in the declaration of conformity and usually also on the nameplate).

NOTE

As a rule, country-specific requirements for the operator also apply when a product is used in a potentially explosive atmosphere (e.g. Directive 1999/92/EC for the EU).

Safety in potentially hazardous atmospheres
SIMATIC systems are suitable for use in zones with occasional presence of hazardous gas atmospheres (equipment group II, Cat. 3, gases, vapors, mists). You can find information, restrictions and special conditions in the respective system manuals. To avoid damage, determine a suitable installation location and select suitable products. It is mandatory to define the following points before planning your automation system:

- Hazardous plant areas
- Potentially existing atmosphere
- Relevant requirements for the products

⚠ WARNING

Explosion hazard
If work in areas with potentially hazardous atmospheres is not carried out correctly, an explosion may occur. Explosions can lead to serious personal injury or damage to the plant.
Only suitably qualified specialists are allowed to plan and perform activities in areas with potentially hazardous atmospheres. In hazardous areas, always de-energize the SIMATIC system before starting activities.

⚠ WARNING

Pulling or plugging a module is prohibited in the hazardous area.
When you pull or plug a module or plug-in connector during operation, there is a risk of sparking. Sparks can cause an explosion in the hazardous area; death or serious physical injury as well as damage to property can result.
Do not pull or plug the module or the plug-in connectors until one of the following two conditions is met: The area is no longer hazardous or the device and its plug-in connectors are de-energized.

Cleaning
If you need to clean the product, use dry ESD cleaning cloths (observing the protective measures for ESD).
Requirement: All supply voltages present on the device are switched off. Observe the five safety rules for working in and on electrical installations.

Maintenance and repair
The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal
For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384).

Functional safety

⚠ WARNING

Danger to humans and the environment
To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components. For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/86140384).

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether it is approved for the respective device.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product

versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

SIEMENS

SIMATIC

ET 200MP
Digital input module F-DI 16x24VDC (6ES7526-1BH00-0AB0)

Equipment Manual

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Preface

Purpose of the documentation

This manual supplements the system manual S7-1500 Automation System. You can find information on the functions that apply generally to the S7-1500 automation system and the ET 200MP distributed I/O system in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

The information provided in this manual and the system manual enables you to commission the S7-1500 automation system and ET 200MP distributed I/O system.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes identified as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which particular attention should be paid.

Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators by means of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this in the appendix.

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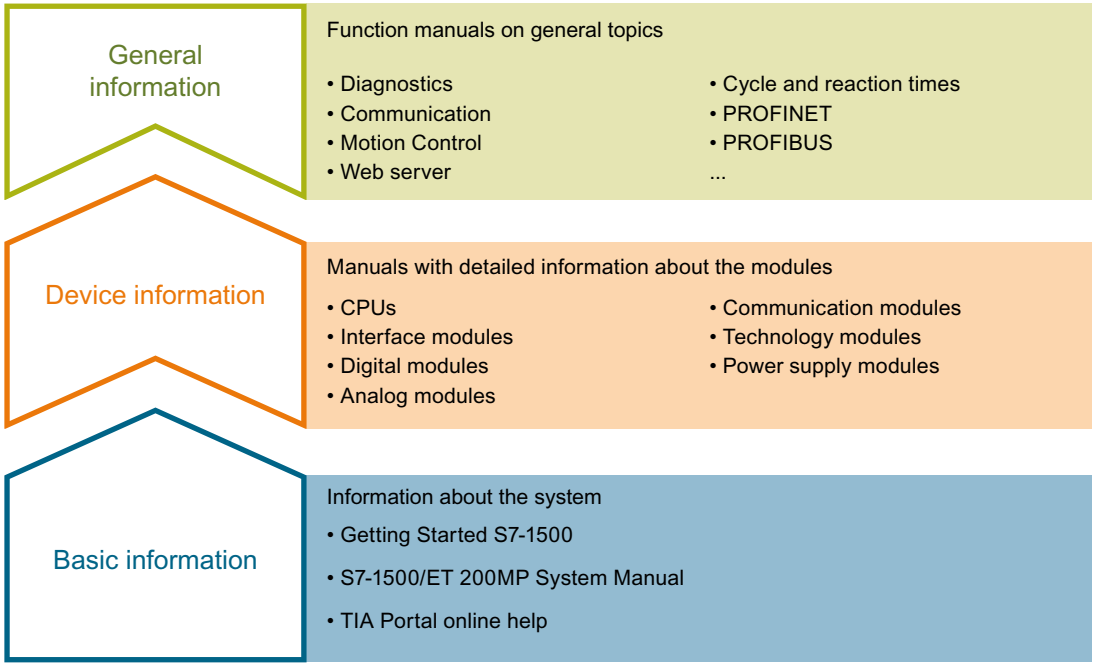
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Documentation guide

1

1.1 Guide to documentation S7-1500 / ET 200MP

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information
The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information
Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information
The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet.

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/86140384).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Order number

6ES7526-1BH00-0AB0

View of the module

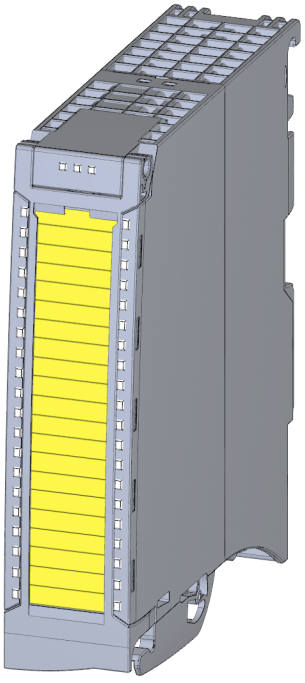


Figure 1-604 View of the F-DI 16x24VDC module

Properties

- Technical properties
  - Fail-safe digital module for use in the S7-1500 automation system and in the ET 200MP distributed I/O system.
  - PROFIsafe
  - PROFIsafe address type 2
  - Supports the RIOforFA-Safety profile (on S7-1500 F-CPUs)
  - 16 inputs (SIL3/Category 3/PLd) or 8 inputs (SIL3/Category 4/PLe)
  - 4 outputs for sensor supply

  - Use of various interconnection types are possible (1oo1 & 1oo2)
  - Supply voltage L+
  - Sink input (P-reading)
  - Suitable for connection of 3/4-wire sensors according to IEC 61131:2007, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms
  - Internal short-circuit-proof sensor supplies for each channel group
  - External sensor supply possible
  - Status display RUN (green LED)
  - Status display module diagnostics (red LED)
  - Status display channel status/channel diagnostics per input (green/red LED)
  - Status display supply voltage (green LED)
  - Diagnostics, e.g., short-circuit, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or module-wide passivation
- Supported functions
  - Firmware update
  - I&M identification data

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, switch off the supply voltage of the affected module before 100 hours expires.
Follow the repair procedure described in section Diagnostic alarms (Page 49).

Accessories

The following accessories are supplied with the module and can also be ordered as spare part:

- Labeling strips
- U-connector
- Universal front cover
- Electronic coding element

Additional components

The following component is to be ordered separately:

- Front connector incl. potential bridges and cable ties

You can find additional information on accessories in the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Connecting

3

3.1 Block diagram

This section includes the block diagram with the general pin assignment of the F-module.

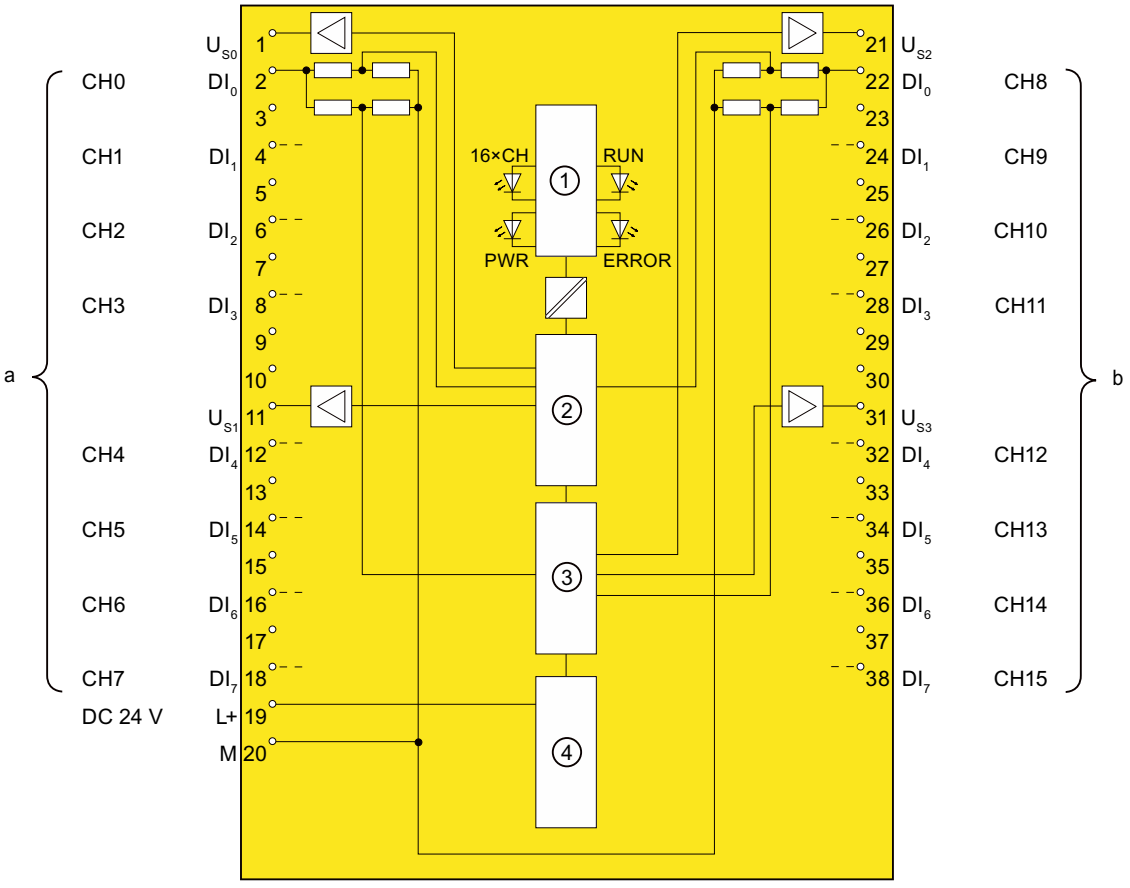
For information on parameter assignment of the F-module, refer to "Parameters/address space (Page 14)".

Information on different connection options is available in the section Applications of the F-I/O module (Page 27).

You can find information on wiring the front connectors and creating the cable shielding, etc., in the Wiring section of the system manual Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792).

Block diagram

The following figure shows the assignment of channels to addresses (input byte a and input byte b).



①	Backplane bus interface	L+	Supply voltage 24 V DC
②	Microcontroller 1	M	Chassis ground
③	Microcontroller 2	CH	Channel or LED channel status, channel diagnostics (green, red)
④	Reverse polarity protection	PWR	LED supply voltage (green)
U_{Sn}	Internal sensor supply n	RUN	RUN LED (green)
DI_n	Input bit n	ERROR	LED module diagnostics (red)

Figure 1-605 Block diagram of the F-DI 16x24VDC

Parameters/address space

4

4.1 Parameters

Parameters

WARNING

Diagnostic functions must be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 27).

Table 1-873 Parameters for F-DI 16x24VDC

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of F-monitoring time	• Disable • Enable	No	Module
F-monitoring time	1 to 65535 ms	No	Module
F-source address	1 to 65534	No	Module
F-destination address	1 to 65534	No	Module
F-parameter signature (without address)	0 to 65535	No	Module
Behavior after channel fault	• Passivate channel • Passivate the entire module	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	No	Module
F-I/O DB-number	—	No	Module
F-I/O DB name	—	No	Module
DI parameters:			
Sensor supply			
Supplied channels	Sensor supply 0: • No channels • Channels [0..3] • Channels [0..7] • Channels [0..15] Sensor supply 1: • No channels • Channels [4..7] Sensor supply 2: • No channels • Channels [8..11] • Channels [8..15]	No	Channel group

Parameter	Value range	Parameter reassignment in RUN	Scope
	Sensor supply 3: • No channels • Channels [12..15]		
Short-circuit test activated	• Disable • Enable	No	Channel
Time for short-circuit test	0.9 ms to 2 s	No	Channel
Startup time of sensors after short-circuit test	0.9 ms to 2 s	No	Channel
Channel parameters			
Channel n, n+8			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent	No	Channel pair
Discrepancy behavior	• Supply value 0 • Supply last valid value	No	Channel pair
Discrepancy time	5 ms to 30 s	No	Channel pair
Reintegration after discrepancy error	• Test 0-signal not necessary • Test 0-signal necessary	No	Channel pair
Channel n			
Channel activated	• Enable • Disable	No	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20.0 ms The provided value range depends on the parameter assignment of the employed sensor supply.	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	No	Channel
Pulse extension	• — • 0.5 s • 1 s • 2 s	No	Channel
Chatter monitoring	• Disable • Enable	No	Channel
Number of signal changes	2 to 31	No	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	No	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Basis for PROFIsafe addresses" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

4.2.1.1 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

4.2.1.2 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use in S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use in S7-1500 F-CPUs
When using the fail-safe module in S7-1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.2 Parameters of the sensor supply

4.2.2.1 Supplied channels

With this parameter, you specify whether and which internal sensor supply supplies which channel groups. The choice taken applies to the entire channel group (CH0-3, 4-7, 8-11, 12-15).

The following options are available, for example:

Parameter assignment:		**Meaning**	**Parameter assignment:**	
Left-hand module side			**Right-hand module side**	
Sensor supply 0 supplies channels ...	**Sensor supply 1 supplies channels ...**		**Sensor supply 2 supplies channels ...**	**Sensor supply 3 supplies channels ...**
0 to 3	4 to 7	Each channel group is supplied by its own internal sensor supply.	8 to 11	12 to 15
0 to 7	-	The channel groups of the left-hand module side are supplied by the internal sensor supply V_{S0}.	8 to 11	12 to 15
0 to 3	4 to 7	The channel groups of the right-hand module side are supplied by the internal sensor supply V_{S2}.	8 to 15	-
0 to 7	-	The channel groups of the left-hand module side are supplied by the internal sensor supply V_{S0}; the channel groups of the right-hand module side are supplied by the internal sensor supply V_{S2}.	8 to 15	-
0 to 15	-	All the channels of the module are supplied by the internal sensor supply V_{S0}.	-	-

You can also supply the sensors by means of an external sensor supply (parameter "None").

The selection of an internal sensor supply is required for using the short-circuit test.

See also

Short-circuit test activated (Page 17)
Connecting (Page 12)

4.2.2.2 Short-circuit test activated

Here you enable the short-circuit detection for the channels of the F-module for which one of the internal sensor supplies is set ("Supplied channels").

The short-circuit test is always possible when you are using simple switches that do not have their own power supply. For switches with their own power supply, for example, 3/4-wire proximity switches or optical sensors with OSSD (Output Signal Switching Device) outputs, you must adapt the "Startup time of sensors after short-circuit test" parameter to match the sensor in use.

The short-circuit detection switches off the internal sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input of another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

NOTE

During the execution time of the short-circuit test (Time for short-circuit test + Startup time of sensors after short-circuit test), the last valid value of the input before the start of the short-circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

4.2.2.3 Time for short-circuit test

Function

When the short-circuit test is enabled, the corresponding internal sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the configured time, a diagnostics alarm is generated.

Note the following during parameter assignment:

- If the channel is passivated, this may be due to excessively high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance is not discharged within the configured time, you need to adjust the "Time for short-circuit test" parameter.

  NOTE

  During the execution time of the short-circuit test (Time for short-circuit test + Startup time of sensors after short-circuit test), the last valid value of the input before the start of the short-circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

- The "Time for short-circuit test" has to be 0.5 ms greater than the set input delay.

4.2.2.4 Startup time of sensors after short-circuit test

Function

In addition to the switch-off time ("Time for short-circuit test"), a startup time must be specified for performing the short-circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after turning on the internal sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

Note the following during parameter assignment:

- This parameter must be greater than the transient recovery time of the employed sensor.
- Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.
- The "Startup time of sensors after short-circuit test" must
  - be set to a value greater than the set input delay
  - be at least 1% of the "time for short-circuit test"
  - be 0.5 ms greater than the set input delay.

Requirement

The short-circuit test is enabled.

4.2.3 Parameters of the channel pairs

4.2.3.1 Sensor evaluation

Overview

Select the type of sensor evaluation with the "Evaluation of the sensors" parameter:

- 1oo1 evaluation
- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent

1oo1 evaluation

With a 1oo1 evaluation, the sensor occupies only one input channel.

1oo2 evaluation, equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- a two-channel equivalent/non-equivalent sensor
- Two single-channel sensors

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly. The evaluation result is provided in the bit of the lower-order channel of the channel pair (channel n).

Discrepancy analysis

When using a two-channel sensor or two single-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

Discrepancy analysis for equivalence or non-equivalence is used for fail-safe inputs to detect errors caused by the time characteristic of two signals with the same functionality. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same level). A check is made to determine whether the difference in levels (when testing for non equivalence: the same level) has disappeared after an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error.

4.2.3.2 Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to fast response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown. In the worst-case scenario, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

4.2.3.3 Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

- Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

4.2.3.4 Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-Signal necessary"
- "Test 0-Signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Test 0-Signal necessary"

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non-equivalent", the result of the channel pair must provide a 0-Signal again.

"Test 0-Signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.4 Parameters of the channels

4.2.4.1 Channel activated

You hereby enable the corresponding channel for signal processing in the safety program.

4.2.4.2 Input delay

Function

To suppress injected interference, you can set an input delay for a channel or a channel pair.

Interference pulses whose pulse time is less than the set input delay (in ms) are suppressed. Suppressed interference pulses are not visible in the process image input (PII).

A high input delay suppresses longer interference pulses, but results in a longer response time.

The set value for the input delay has to be smaller than the configured "Startup time of sensors after short-circuit test" and smaller than the configured "Time for short-circuit test".

With 1oo2 evaluation, the input delay of the lower-order channel (channel n) automatically applies to the higher-order channel (channel n+8).

NOTE

If there is an input delay < 3.2 ms, you have to use shielded cables.

NOTE

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)).
If the interference pulses occur with a short-circuit test, the fail-safe digital inputs are passivated. Increase the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the internal sensor supply.

See also

Response times (Page 57)
Technical specifications (Page 54)

4.2.4.3 Channel failure acknowledge

Use in S7-1500 F-CPUs

This parameter is only relevant if the fail-safe module is operated on an S7-1500 F-CPU, and can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel should react to a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. There you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.4.4 Pulse extension

Function

Pulse extension is a function to extend a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.

The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

The pulse extension can only be configured with 1oo1 evaluation.

4.2.4.5 Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

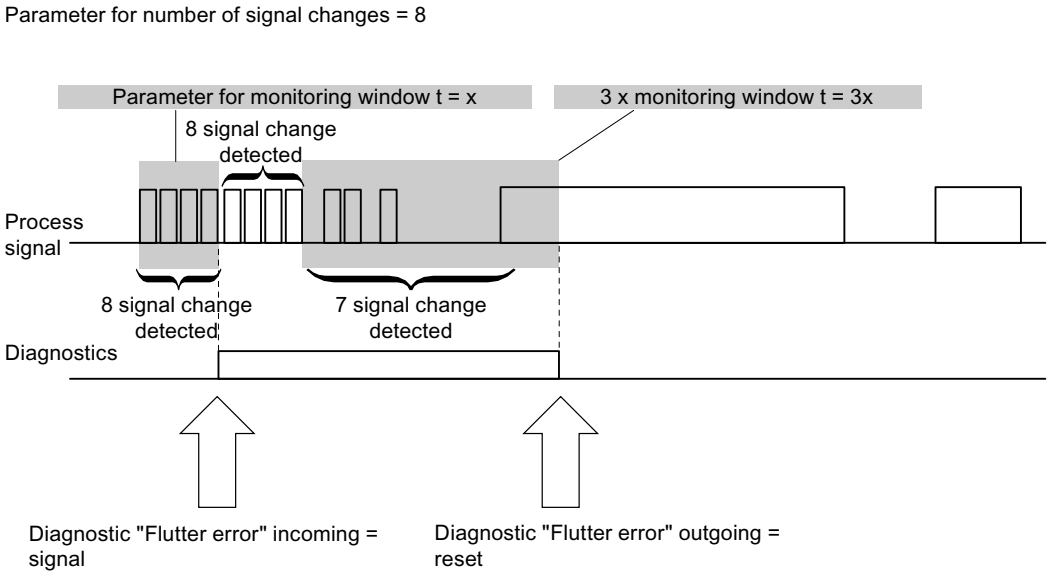


Figure 1-606 Figure chatter monitoring

4.2.4.6 Number of signal changes

Sets the number of signal changes after which a chatter error should be reported (value range: 2 to 31).

4.2.4.7 Monitoring window

Sets the time for the monitoring window of flutter monitoring.
You can set times of 1 s to 100 s in whole seconds for the monitoring window.
Enter 0 to configure a monitoring window of 0.5 s.

4.3 Address space

Address assignment of the digital input module F-DI 16x24VDC

The digital input module F-DI 16x24VDC occupies the following address areas in the F-CPU:

Table 1-874 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 7	QB x + 0 to x + 3
S7-1500 F-CPUs	IB x + 0 to x + 8	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 16x24VDC

The user data occupies the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 16x24VDC:

Table 1-875 Address assignment through user data

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0 Channel group a	DI_7 (CH7)	DI_6 (CH6)	DI_5 (CH5)	DI_4 (CH4)	DI_3 (CH3)	DI_2 (CH2)	DI_1 (CH1)	DI_0 (CH0)
IB x + 1 Channel group b	DI_7 (CH15)	DI_6 (CH14)	DI_5 (CH13)	DI_4 (CH12)	DI_3 (CH11)	DI_2 (CH10)	DI_1 (CH9)	DI_0 (CH8)
IB x + 2 Channel group a	Value status for DI_7 (CH7)	Value status for DI_6 (CH6)	Value status for DI_5 (CH5)	Value status for DI_4 (CH4)	Value status for DI_3 (CH3)	Value status for DI_2 (CH2)	Value status for DI_1 (CH1)	Value status for DI_0 (CH0)
IB x + 3 Channel group b	Value status for DI_7 (CH15)	Value status for DI_6 (CH14)	Value status for DI_5 (CH13)	Value status for DI_4 (CH12)	Value status for DI_3 (CH11)	Value status for DI_2 (CH10)	Value status for DI_1 (CH9)	Value status for DI_0 (CH8)

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels, e.g. CH0 (input bit DI_0 in channel group a) with CH8 (input bit DI_0 in channel group b). With 1oo2 evaluation of the sensors, you may only access the input bit from channel group a in the safety program, in this example CH0.

Additional information

For detailed information about F-I/O access and for evaluation and processing of the value status, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications of the F-DI 16x24VDC

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

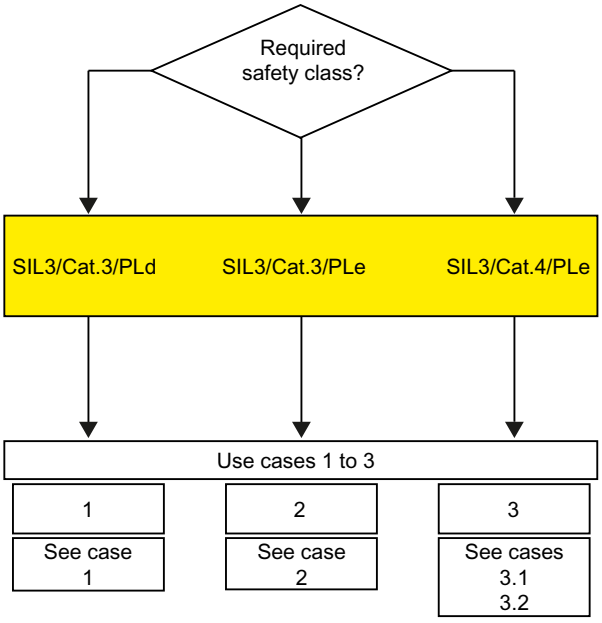


Figure 1-607 Selecting the application – digital input module F-DI 16x24VDC

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the mission time in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 1-876 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Any	3 / 3 / d
2	1oo2 equivalent	Internal, without short-circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short-circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	External or internal, with short-circuit test	

NOTE
You can operate the various inputs of an F-DI module simultaneously in SIL3/Cat.3/PLd **and** in SIL3/Cat.3 or Cat.4/PLe. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules of the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

5.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

The sensor supply can be powered internally or externally.

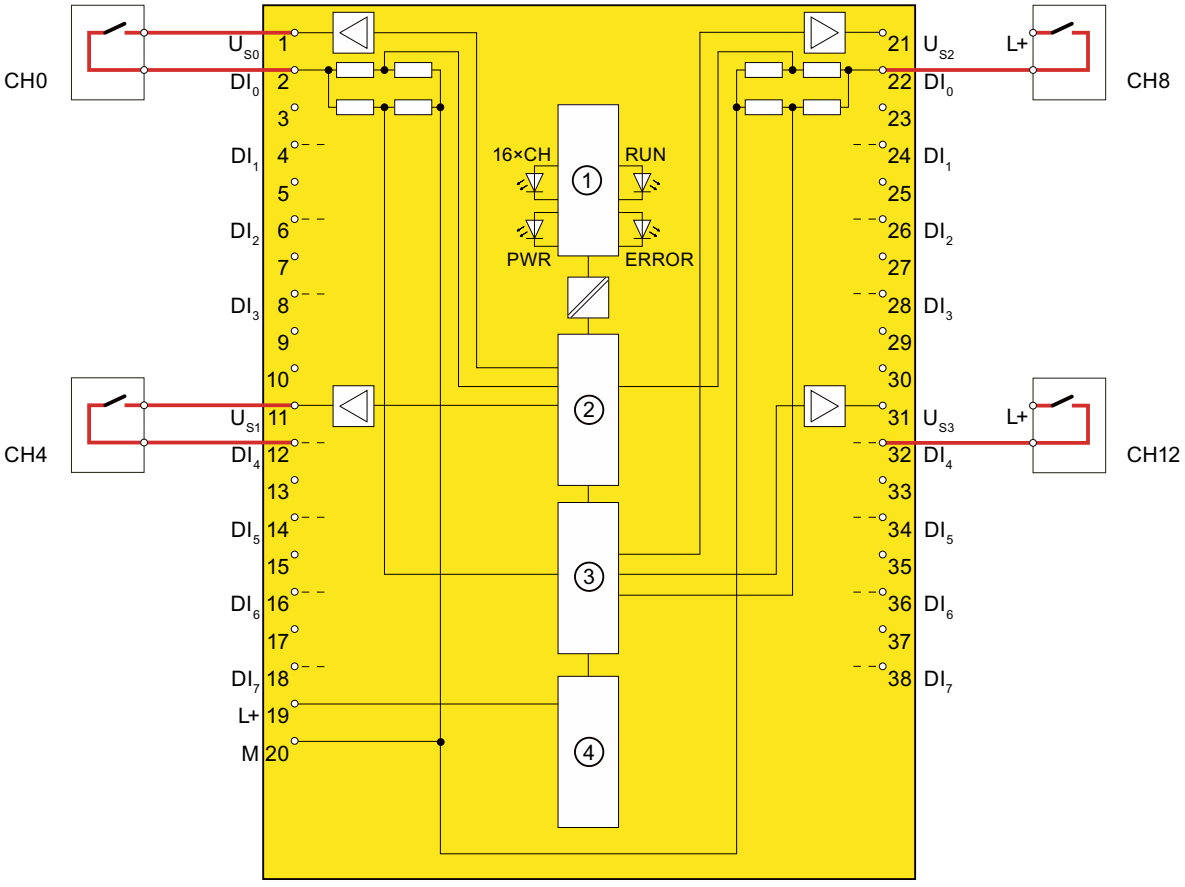
Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal.

The assignment of the input to an internal sensor supply of the module must take place according to the parameter assignment "Supplied channels" (see section Supplied channels (Page 17)).

You can also supply the sensor by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with one-channel connection of a sensor.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

Figure 1-608 One sensor connected via one channel, internal sensor supply (left) or external sensor supply (right)

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-877 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	• Disable • Enable*	Disable

*) optional. The selection of an internal sensor supply, however, is required for using the short-circuit test.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-878 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	**Internal sensor supply and short-circuit test deactivated**	**External sensor supply**
Short-circuit of the input with other channels or other sensor supplies (short-circuit with other channels is detected only if they use a different sensor supply)	Yes*	No	No
Short-circuit between the input and associated sensor supply	No	No	No
Short-circuit with L+ to DI_n	Yes	No	No
Short-circuit with M to DI_n	No	No	No
Discrepancy error	—	—	—
Short-circuit with L+ to U_{Sn}	Yes	No	—
Short-circuit with M to U_{Sn} or defective	Yes	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

WARNING

If the short-circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the cable must be routed short-circuit proof.

See also

Connecting (Page 12)

5.3 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The digital input module F-DI 16x24VDC has 16 fail-safe inputs, DI_0 to DI_{15} (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 and DI_8
- DI_1 and DI_9
- DI_2 and DI_{10}
- DI_3 and DI_{11}
- DI_4 and DI_{12}
- DI_5 and DI_{13}
- DI_6 and DI_{14}
- DI_7 and DI_{15}

The process signals are provided by channels DI_0, DI_1, DI_2, DI_3, DI_4, DI_5, DI_6 and DI_7.

NOTE

You can mix 1oo1 evaluation and 1oo2 evaluation in an F-DI module. You must interconnect and parameterize the inputs according to the fail-safe requirements (SIL3/Cat.3/PLd and SIL3/Cat.3 or Cat.4/PLe).

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

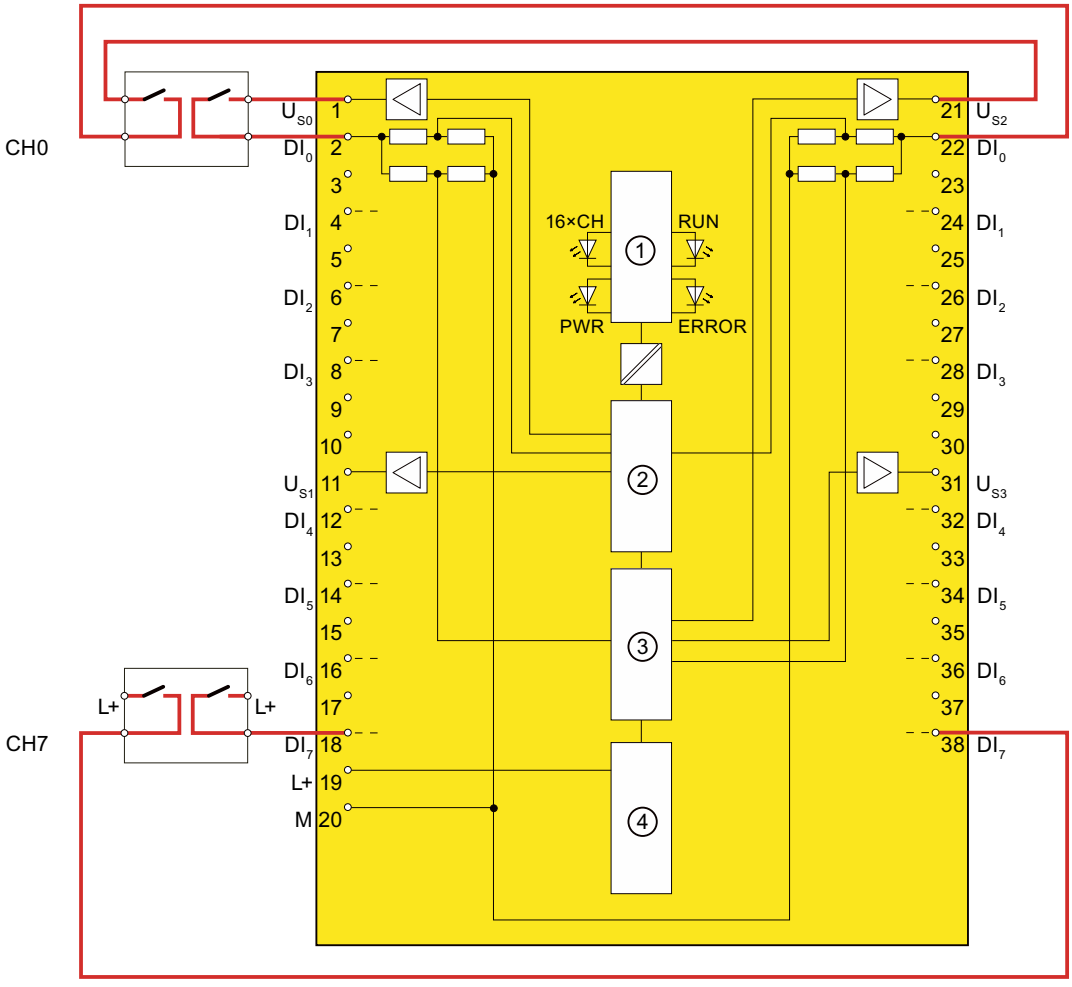
The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor equivalent

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply one or both sensor switches by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with equivalent connection of a two-channel sensor.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

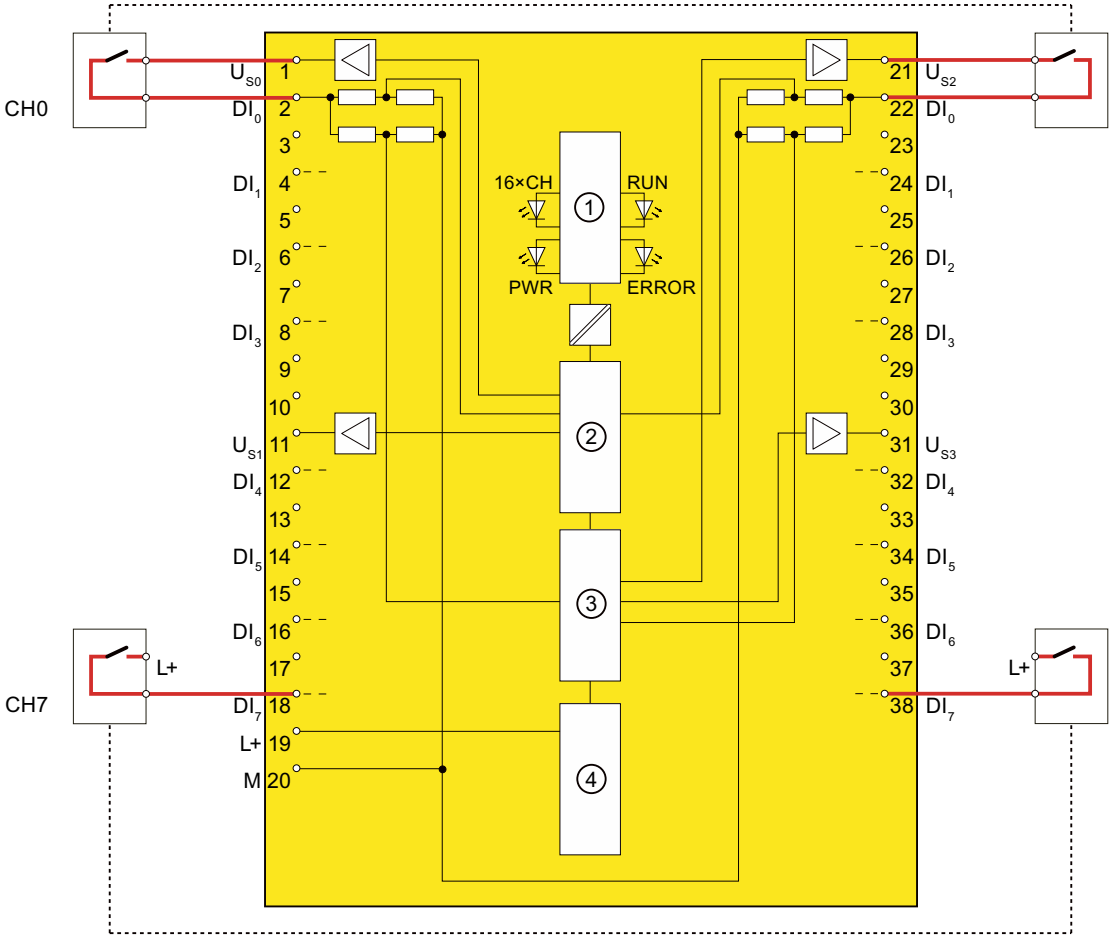
Figure 1-609 One two-channel sensor connected equivalently, internal sensor supply (top) or external sensor supply (bottom)

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply the sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with two-channel connection of two single-channel sensors.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

Figure 1-610 Two single-channel sensors connected via two channels, internal sensor supply (top) or external sensor supply (bottom)

⚠ WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-879 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	Disable	

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-880 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	No	No
Short-circuit with other channels or other sensor supplies	Yes*	Yes
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to U_{Sn}	No	No
Short-circuit with M to U_{Sn} or defective	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

See also

Connecting (Page 12)

5.4 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The digital input module F-DI 16x24VDC has 16 fail-safe inputs, DI_0 to DI_{15} (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- DI_0 and DI_8
- DI_1 and DI_9
- DI_2 and DI_{10}
- DI_3 and DI_{11}
- DI_4 and DI_{12}
- DI_5 and DI_{13}
- DI_6 and DI_{14}
- DI_7 and DI_{15}

The process signals are provided by channels DI_0,DI_1,DI_2, DI_3,DI_4, DI_5, DI_6 and DI_7.

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Sensor supply

The sensor must be supplied internally by at least one channel group for application 3.1.

The sensor can be supplied internally or externally for application 3.2.

Requirements for applications in machine protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed with state-of-the-art engineering and standards to prevent short-circuits.
- The sensors must be wired as shown in sections Application 3.1 (SIL3/Cat.4/PLe) (Page 40) or Use case 3.2 (SIL3/Cat.4/PLe) (Page 42). You only need to detect **one** short-circuit because 2 faults are required to generate it. This means both signal cables in short-circuit have an isolation fault. A multiple short-circuit analysis is not required.

Procedures for locating all short-circuits are also permitted if single short-circuits are not located. One of the two conditions must be met for this purpose:

- Short-circuits may not corrupt the read signals compared to the sensor signals.
- Short-circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

See also

Connecting (Page 12)

5.4.1 Application 3.1 (SIL3/Cat.4/PLe)

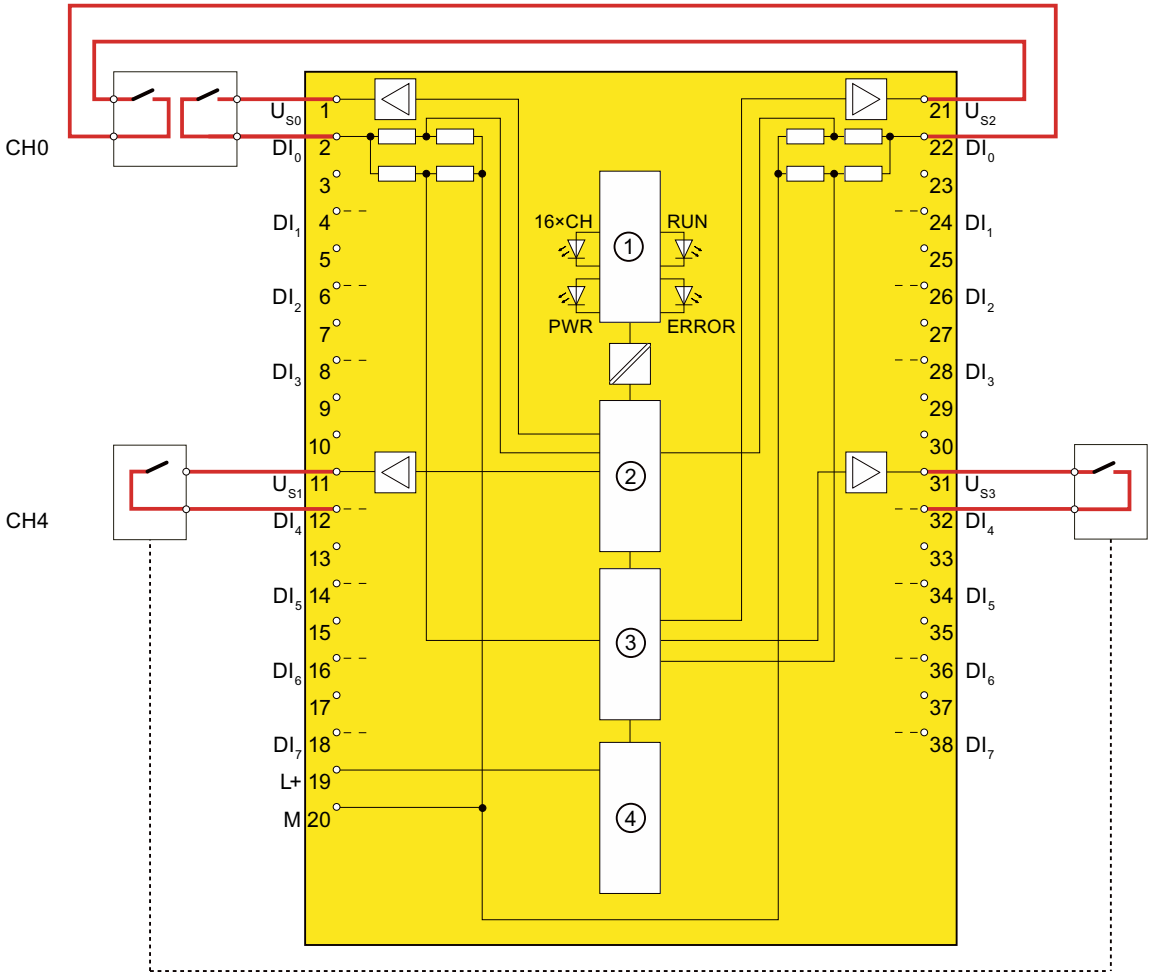
Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation).

Supply the sensors from two different internal sensor supplies.

Alternatively, two single-channel sensors can be connected via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with two-channel connection of one two-channel sensor or two single-channel sensors.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

Figure 1-611 One two-channel sensor connected via two channels (top) or two single-channel sensors connected via two channels (bottom); internal sensor supply

WARNING
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-881 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	1oo2 evaluation, equivalent
Supplied channels	Channels [x...y]
Short-circuit test activated	Enable

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-882 Fault detection

Fault	Fault detection
	Internal sensor supply and short-circuit test activated
Short-circuit within the channel pair	No
Short-circuit with other channels or other sensor supplies	Yes*
Short-circuit with L+ to DI_n	Yes* / Yes (for channel whose short-circuit test is activated)
Short-circuit with M to DI_n	Yes*
Discrepancy error	Yes
Short-circuit with L+ to U_{Sn}	Yes
Short-circuit with M to U_{Sn} or defective	Yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

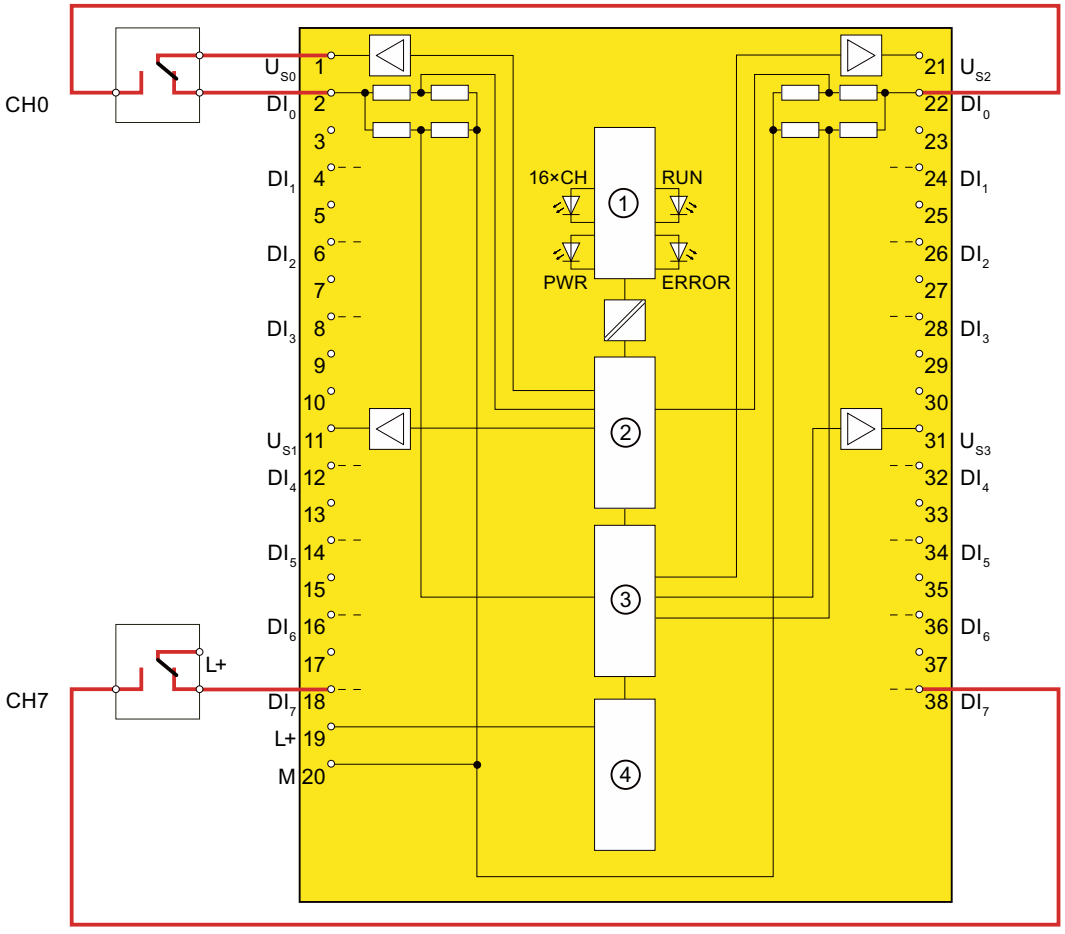
5.4.2 Use case 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a non-equivalent sensor

A non-equivalent sensor is connected to two inputs of the F-module for each process signal (1oo2 evaluation, non-equivalent).

You can also supply the sensor by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with connection of a non-equivalent sensor.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

Figure 1-612 One non-equivalent sensor connected, internal sensor supply (top) or external sensor supply (bottom)

⚠ WARNING

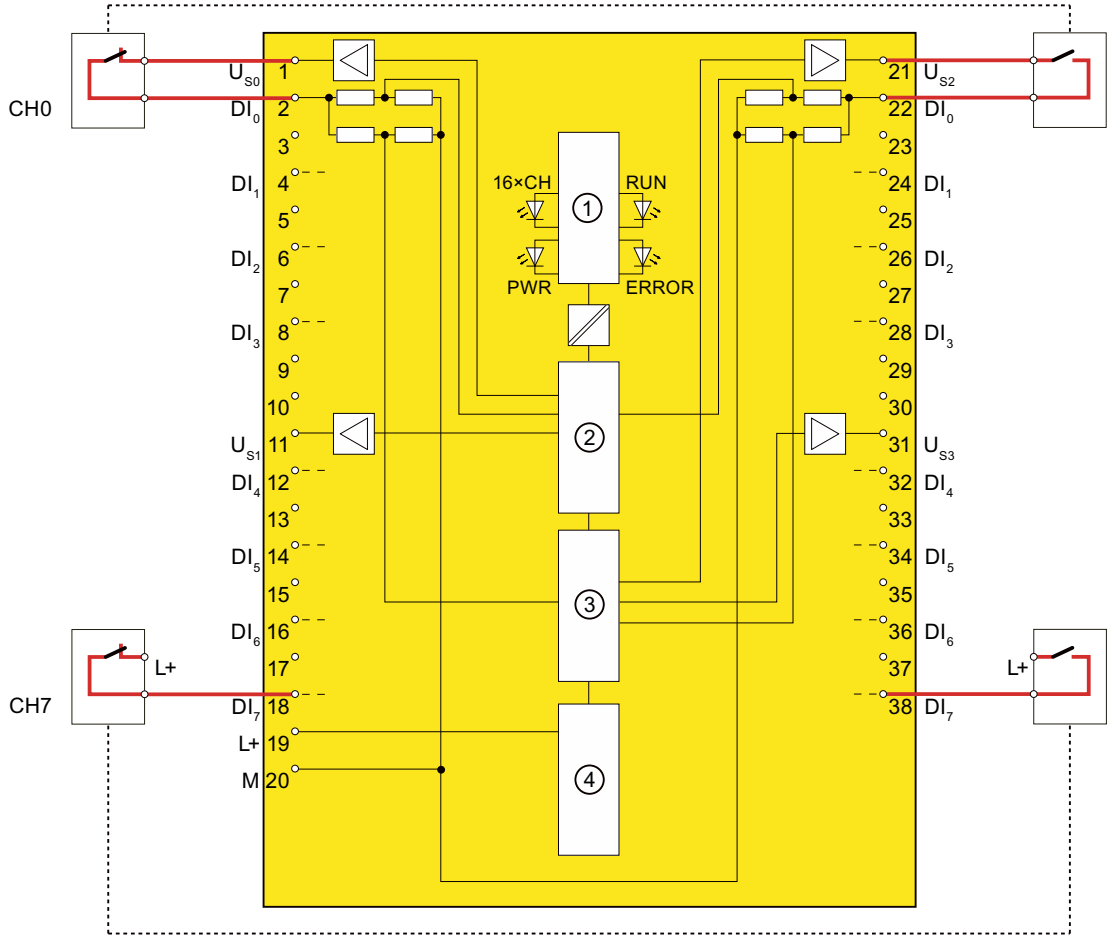
To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram – connecting two single-channel sensors non-equivalent

Two single-channel sensors are connected non-equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply one or both sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe digital input module F-DI 16x24VDC with non-equivalent connection of two single-channel sensors.



① Backplane bus interface
② Microcontroller 1
③ Microcontroller 2
④ Reverse polarity protection

Figure 1-613 Two single-channel sensors connected non-equivalently, internal sensor supply (top) or external sensor supply (bottom)

⚠ WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 1-883 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, non-equivalent	
Supplied channels	Channels [x...y]	None
Short-circuit test activated	• Disable • Enable*	Disable

*) optional. The selection of an internal sensor supply, however, is required for using the short-circuit test.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-884 Fault detection

Fault	Fault detection
Short-circuit within the channel pair, with other channels or other sensor supplies	Yes
Short-circuit with L+ to DI_n	yes* / yes (for channel whose short-circuit test is activated)
Short-circuit with M to DI_n	Yes*
Discrepancy error	Yes
Short-circuit with L+ to U_{Sn}	Yes, if internal sensor supply is used and short-circuit test activated
Short-circuit with M to U_{Sn} or defective	Yes, if internal sensor supply is activated

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Interrupts/diagnostic messages

6

6.1 Status and error displays

LED displays

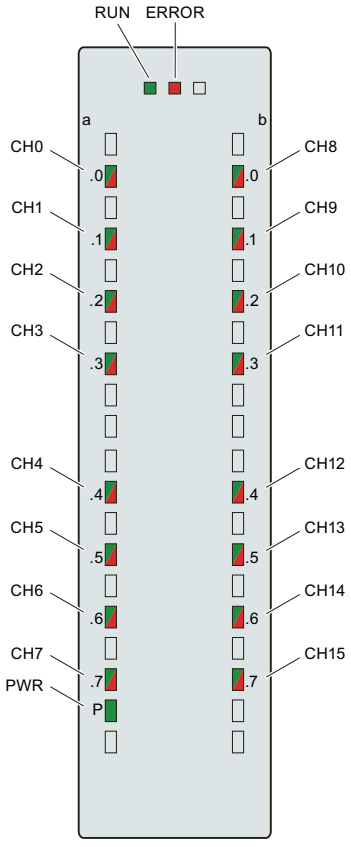


Figure 1-614 LED displays of the F-DI 16x24VDC module

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic alarms can be found in section Diagnostic alarms (Page 49).

WARNING

The RUN, ERROR LEDs and channel status/channel diagnostics LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

RUN and ERROR LEDs

Table 1-885 RUN and ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Missing or insufficient voltage on the backplane bus	• Switch on the CPU and/or the system power supply modules. • Check whether the module is correctly plugged into the U-connector. • Check whether too many modules are plugged in.
Flashing	Off	Module starts up and flashes up to the valid parameter assignment.	---
On	Off	Module parameters are assigned and module addressed.	
Off	Flashing	Firmware is being updated.	
On	Flashing	Indicates diagnostic interrupts: • Module fault (for example, supply voltage too high) • Channel fault (for example, frequency too high). • PROFIsafe communication error Operation in S7-1500 F-CPUs: At least one channel is waiting for user acknowledgment.	Evaluate the diagnostics and eliminate or acknowledge the error. It may be necessary to remove and re-insert the module.
Flashing	Flashing	Hardware defective.	Replace the module.
Alternately flashing		• Operation in S7-1500 F-CPUs: The F-module expects user acknowledgment after a module error. • Operation in S7-300/400 F-CPUs: At least one channel is waiting for user acknowledgment.	Acknowledge the error (see manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)).

PWR LED

Table 1-886 PWR status display

PWR LED	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

CHx LED

Table 1-887 Display channel status/channel diagnostics

Status CHx	Diagnostics CHx	Meaning
Off	Off	Process signal = 0 and no channel diagnostics*
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

* Operation in S7-300/400 F-CPUs only: If necessary, wait for user acknowledgment, if an additional channel is also waiting for user acknowledgment due to an error that occurred later.

CHx/Error LED with PROFIsafe address assignment

Table 1-888 Channel status/channel diagnostics/Error display with PROFIsafe address assignment

Status CHx	Diagnostics CHx	ERROR	Meaning
Off	All on	Flashing	The PROFIsafe address does not match the configured PROFIsafe address
All are flashing	Off	Flashing	Identification of the F-module when assigning the PROFIsafe address

CHx/RUN/ERROR LED if supply voltage error occurs

Table 1-889 Channel status/channel diagnostics/RUN/ERROR display if supply voltage error occurs

CHx status	Diagnostics CHx	RUN	ERROR	Meaning
Off	On	On	Flashing	Supply voltage too high or too low. • Operation in S7-1500 F-CPUs: Module is waiting for user acknowledgment. • Operation in S7-300/400 F-CPUs: Module is automatically reintegrated after the correction of the error.

6.2 Interrupts

Introduction

The F-DI 16x24VDC fail-safe digital input module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic alarm described in section Diagnostic alarms (Page 49).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

Table 1-890 Diagnostic interrupts of the F-DI 16x24VDC

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	1, 2, 3	F-module	No
Parameter error	16_D			
Supply voltage missing	17_D			
Mismatch of safety destination address (F_Dest_Add)	64_D			
Safety destination address not valid (F_Dest_Add)	65_D			
Safety source address not valid (F_Source_Add)	66_D			
Safety watchdog time value is 0 ms (F_WD_Time)	67_D			
Parameter F_SIL exceeds SIL from specific device application	68_D			
Parameter F_CRC_Length does not match the generated values	69_D			
Version of F-parameter set incorrectly	70_D			
CRC1 fault	71_D			
Save iParameter watchdog time exceeded	73_D			
Restore iParameter watchdog time exceeded	74_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Transmission error: Inconsistent data (CRC error)	77_D			
Transmission error: Timeout (watchdog time 1 or 2 expired)	78_D			
Module is defective	256_D			
Watchdog tripped	259_D			
Invalid/inconsistent firmware present	283_D			
Discrepancy failure, channel state 0/0	768_D	2, 3	Channel	
Discrepancy failure, channel state 0/1	769_D			
Discrepancy failure, channel state 1/0	770_D			
Discrepancy failure, channel state 1/1	771_D			
Input signal not recorded unique	773_D	1, 2, 3		
Internal sensor supply short-circuit to P	774_D			Yes
Overload or internal sensor supply short-circuit to ground	775_D			
Channel failure acknowledgment	779_D			
F-address memory not accessible	781_D		F-module	No
Sensor signal flutters	784_D	1	Channel	Yes

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Frequency too high	785_D		Channel	No
Undertemperature	786_D		F-module	
Input shorted to P	796_D		Channel	Yes
Supply voltage too high	801_D		F-module	No
Supply voltage too low	802_D			

6.3 Diagnostic alarms

Diagnostic alarms

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 1-891 Diagnostic alarms of the F-DI 16x24VDC

Diagnostic alarm	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 54)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Parameter error	16_D	Parameter errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the front connector • Check the front connector

Diagnostic alarm	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	64_D	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	65_D	The firmware of the F-module has detected an illegal different F-destination address.	
Safety source address not valid (F_Source_Add)	66_D	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	67_D	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	68_D	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	69_D	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	70_D	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	71_D	The firmware of the F-module has detected inconsistent F-parameters.	
Save iParameter watchdog time exceeded	73_D	iPar server does not respond to "save IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Restore iParameter watchdog time exceeded	74_D	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	75_D	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The firmware of the F-module has detected an incorrect F_block_ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	77_D	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	78_D	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.

Diagnostic alarm	Fault code	Meaning	Remedy
Watchdog tripped	259_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Invalid/inconsistent firmware present	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Discrepancy failure, channel state 0/0	768_D	Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short-circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring.
Discrepancy failure, channel state 0/1	769_D		
Discrepancy failure, channel state 1/0	770_D		
Discrepancy failure, channel state 1/1	771_D		
Input signal not recorded unique	773_D	An error occurred during the plausibility check of the input signal between the processors. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Internal sensor supply short-circuit to P	774_D	Possible causes: • There is a short-circuit of the internal sensor supply with L+. • There is a short-circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short-circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.
Overload or internal sensor supply short-circuit to ground	775_D	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short-circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.

Diagnostic alarm	Fault code	Meaning	Remedy
Channel failure acknowledgment	779_D	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	781_D	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Sensor signal flutters	784_D	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor/switch is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Frequency too high	785_D	The switching frequency of the encoder is too high.	Reduce the switching frequency of the sensor.
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 54))
Input shorted to P	796_D	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	801_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	802_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the ERROR LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute, see Technical specifications (Page 54)), the ERROR LED stops flashing. The module remains passivated and waits for user acknowledgment.

Behavior in case of cross circuit/short-circuit to the sensor supply

When internal sensor supply is configured and short-circuit test is deactivated, short-circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is configured and short-circuit test is enabled, short-circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short-circuit test and the sensor power supply. For this reason, tables on fault detection for the applications are presented under Applications of the F-I/O module (Page 27).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all F-modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-DI 16x24VDC

	6ES7526-1BH00-0AB0
General information	
Product type designation	F-DI 16x24VDC
Firmware version	
FW update possible	Yes
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 with HSP0086
Operating mode	
DI	Yes
Supply voltage	
Rated value (DC)	24 V
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	50 mA
Sensor supply	
Number of outputs	4
Short-circuit protection	Yes; electronic (response threshold 0.7 A to 1.8 A)
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short-circuit protection	Yes
Output current, max.	300 mA; max. 100 mA with vertical mounting position
Power	
Power consumption from the backplane bus	0.9 W
Power loss	
Power loss, typ.	4.6 W
Address range	
Address space per module	
Address space per module, max.	9 bytes
Digital inputs	
Number of inputs	16
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes

	6ES7526-1BH00-0AB0
Input voltage	
Rated value (DC)	24 V
For "0" signal	-30 ... +5 V
For "1" signal	+15 ... +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
Configurable	Yes
For "0" to "1", min.	0.4 ms
For "0" to "1", max.	20 ms
For "1" to "0", min.	0.4 ms
For "1" to "0", max.	20 ms
Cable length	
shielded, max.	1000 m
unshielded, max.	500 m
Interrupts/diagnostics/status information	
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	No
Short-circuit	Yes
Group error	Yes
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation, channels	
Between channels and backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC/60 V AC (basic insulation)
Insulation	
Insulation test voltage	707 VDC (type test)
Standards, approvals, certificates	
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
SIL according to IEC 61508	SIL 3
Low demand mode: PFDavg according to SIL3	< 5.00E-05
High demand/continuous mode: PFH according to SIL3	< 1.00E-09 1/h

	6ES7526-1BH00-0AB0
Environmental conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	40 °C
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	280 g

Dimension drawing

See system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Response times

A

Introduction

The next section shows the response times of the digital input module F-DI 16x24VDC. The response times of the digital input module F-DI 16x24VDC are included in the calculation of the F-system response time.

Definition of cycle time for fail-safe digital inputs

The cycle time indicates the time between the occurrence of an event and the transfer to the backplane bus.

Times required for the calculation

- Max. cycle time: T_{cycle} = 5 ms
- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 10 ms

The maximum response time in the case of fault (One Fault Delay Time, OFDT) is equivalent to the maximum response time with no faults (Worst Case Delay Time, WCDT).

Maximum response time with no faults (Worst Case Delay Time, WCDT) during 1oo1 evaluation

The following formula applies to a sensor supply without short-circuit test:

t <= 2 * cycle time + input delay

The following formula applies to a sensor supply with short-circuit test:

t <= 2 * cycle time + input delay + T1 + T2

T1	Time for short-circuit test
T2	Startup time of sensors after the short-circuit test

Maximum response time with no faults (Worst Case Delay Time, WCDT) during 1oo2 evaluation

The following formula applies to a sensor supply without short-circuit test:

t <= 2 * cycle time + input delay+ discrepancy time*

* Obsolete with discrepancy behavior "Supply value 0"

The following formula applies to a sensor supply with short-circuit test:

t <= 2 * cycle time + input delay+ max (T1p + T2p, T1s + T2s) + discrepancy time*

* Obsolete with discrepancy behavior "Supply value 0"

T1p Test time for the sensor supply of sensor 1
T2p Startup time of sensor after the short-circuit test (sensor 1)
T1s Test time for the sensor supply of sensor 2
T2s Startup time of sensor after the short-circuit test (sensor 2)

Maximum response time to external short-circuits

t <= max (120 ms, 2 * (n × cycle time) + sum [x=0...3](T1x + T2x)) + cycle time

T1x Time for the sensor test
T2x Startup time of sensors after the short-circuit test
n Number of sensor supplies with activated short-circuit test
x Sensor supply

Maximum response time to discrepancy errors during 1oo2 evaluation

t <= 2 * cycle time + input delay + discrepancy time + 2 * max (T1p + T2p, T1s + T2s)

n Number of sensor supplies with activated short-circuit test
T1x Time for the sensor test
T2x Startup time of sensors after the short-circuit test
T1p Test time for the sensor supply of sensor 1
T2p Startup time of sensor after the short-circuit test (sensor 1)
T1s Test time for the sensor supply of sensor 2
T2s Startup time of sensor after the short-circuit test (sensor 2)
x Sensor supply

Open Source Software

B

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(2011-08-01)

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1.9 The SW may be or contain licensed software other than OSS, i.e. software which has not been developed by us itself but which has been licensed to us by a third party (hereinafter referred to as the "Licensor"), e.g. Microsoft Licensing Inc. If the Licensee receives the terms and conditions stipulated by the relevant Licensor together with the SW in the Readme_OSS file in this case, such terms and conditions shall apply with respect to the Licensor's liability vis-à-vis the Licensee. Our own liability vis-à-vis the Licensee shall be governed in any case by these General License Conditions.

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The Licensee shall be granted the non-exclusive right, transferable in accordance with Clause 5.3 and valid for an unlimited period of time, to install the SW on any desired number of the Licensee's hardware devices. The number of objects (for example, users or devices) permitted to utilize the SW at the same time can be derived from the Order Data or CoL (see "Type of Use).

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2.5 Demo License
The Licensee shall be granted the non-exclusive right, transferable in accordance with Clause 5.3 and limited in time as stipulated in the Order Data or the CoL (s. " Type of use"), to install the SW in one (1) Instance and to use it for validation purposes. If the period of usage is specified in days, weeks or months, the specified period, which commences in conjunction with the first SW start-up, shall apply independently of the actual time of usage. If the period of use is specified with a date, the right of use ends on this date – regardless of the actual period of use.

2.6 Demo Floating License
The Licensee shall be granted the non-exclusive right, transferable in accordance with Clause 5.3 and limited in time as stipulated in the Order Data or the CoL (s. " Type of use"), to install the SW on any desired number of the Licensee's hardware devices. The number of objects (for example, users or devices) permitted to utilize the SW at the same time can be derived from the Order Data or CoL (see "Type of Use) as well. If the period of usage is specified in days, weeks or months, the specified period, which commences in conjunction with the first SW start-up, shall apply independently of the actual time of usage. If the period of use is specified with a date, the right of use ends on this date – regardless of the actual period of use.

2.7 Trial License
The Licensee shall be granted the non-exclusive and non-transferable right to install the SW in one (1) Instance and to use it for validation purposes in the manner specified in the Order Data or CoL (see "Type of Use"). The period of usage is limited to 14 days and commences with the SW start-up, unless a different period of usage is specified in the Order Data or CoL.

3. Software Type
If the Software Type is not specified in the Order Data or CoL, the rights specified in Clause 3.2 (Runtime Software) shall apply to the SW.

3.1 Engineering Software (hereinafter referred to as "E-SW")
In the event that the Licensee uses E-SW to generate its own programs or data containing parts of the E-SW, the Licensee shall have the right, without having to pay any license fee, to copy and to use these parts of the E-SW as a part of its own programs or data, or to supply them to third parties for use. In the event that such parts are supplied to third parties for use, these parties shall be bound in writing to comply with stipulations corresponding to those in Clauses 5.1 and 5.2 with respect to the above parts of the E-SW.

3.2 Runtime Software (hereinafter referred to as "R-SW")
If the Licensee incorporates R-SW or any parts thereof into its own programs or data, it shall purchase a license with respect to the R-SW each time it installs or copies - depending on what is done first - its own programs or data containing R-SW or parts thereof, in accordance with the relevant intended Type of Use and on the basis of the Siemens catalog valid at that time. In the event that the Licensee supplies the specified programs or data to third parties for their use, these parties shall be bound in writing to adhere to stipulations corresponding to those in Section 5, with respect to the R-SW parts contained therein. The aforesaid shall not affect the Licensee's obligation to purchase a license for the R-SW if the R-SW original is copied. If the R-SW contains tools for parameterization/configuration and extended rights have been granted in this regard, this will be detailed in the readme file of the R-SW.

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SIMATIC
S7-1500/ET 200MP
Product information for documentation of the digital input module F-DI 16x24VDC (6ES7526-1BH00-0AB0)

Product Information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

General amendments to the documentation

Content
This Product Information contains additional information and corrections relating to the documentation on the digital input module F-DI 16x24VDC (6ES7526-1BH00-0AB0).
The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Technical specifications

The information on "Permitted potential difference between different circuits" is no longer part of the technical specifications.

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Response times

Definition of response time for fail-safe digital inputs
The response time of the considered channel represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Maximum response time with external short-circuits
Max. response time = Input delay + T1 + 158 ms + 2 * Sum[x=0..3](T1x + T2x * corr)

T1 = Short-circuit test time for the considered channel
x = activated sensor supply
T1x = Time for the short-circuit test
T2x = Startup time of the sensor after the short-circuit test
corr = correction factor = 1.03
Sum term = sum [x=0..3](T1x + T2x * corr): Sum of all short-circuit tests and startup times of the active sensor supplies

Examples
Below you will find an example for the calculation of the maximum response time of the F-DI 16x24VDC with default parameter assignment.

Channel	Input delay [ms]	Short-circuit test	T1 [ms]	T2 [ms]	Sensor supply	Sum term [ms]	max. response time [ms]
0 to 3	3.2	enabled	4.2	4.2	0	34.1	233.6
4 to 7	3.2	enabled	4.2	4.2	1		233.6
8 to 11	3.2	enabled	4.2	4.2	2		233.6
12 to 15	3.2	enabled	4.2	4.2	3		233.6

Sample calculation: Sum term = (4.2 ms + 4.2 ms * 1.03) + (4.2 ms + 4.2 ms * 1.03) + (4.2 ms + 4.2 ms * 1.03) + (4.2 ms + 4.2 ms * 1.03) = 34.1 ms

Below you will find an example for the calculation of the maximum response time of the F-DI 16x24VDC depending on the parameter assignment.

Channel	Input delay [ms]	Short-circuit test	T1 [ms]	T2 [ms]	Sensor supply	Sum term [ms]	max. response time [ms]
0	0.4	enable	3.7	3.7	0	4188.1	8538.3
1	0.4						8538.3
2	3.2						8541.1
3	3.2						8541.1
4	6.4	enable	100	20	1		8640.6
5	10						8644.2
6	12.8						8647.0
7	12.8						8647.0
8	20	enable	2000	2000	2		10554.2
9	20						10554.2
10	20						10554.2
11	20						10554.2
12	0.4	disable	-	-	3		- *)

*) With short-circuit test deactivated, external short-circuits are not detected.

13	1.6	disable	-	-	3	4188.1	- *)
14	10						- *)
15	20						- *)

*) With short-circuit test deactivated, external short-circuits are not detected.

Sample calculation: Sum term = (3.7 ms + 3.7 ms * 1.03) + (100 ms + 20 ms * 1.03) + (2000 ms + 2000 ms * 1.03) = 4188.1 ms

Chan-nel	**Input delay [ms]**	**Short-circuit test**	**T1 [ms]**	**T2 [ms]**	**Sensor supply**	**Sum term [ms]**	**max. response time [ms]**
0	0.4	enable	20	20	0	1055.6	2289.6
1	0.4						2289.6
2	3.2						2292.4
3	3.2						2292.4
4	6.4						2295.6
5	10						2299.2
6	12.8						2302.0
7	12.8						2302.0
8	20	enable	500	500	2		2789.2
9	20						2789.2
10	20						2789.2
11	20						2789.2
12	0.4						2769.6
13	1.6						2770.8
14	10						2779.2
15	20						2789.2

Sample calculation: Sum term = (20 ms + 20 ms * 1.03) + (500 ms + 500 ms * 1.03) = 1055.6 ms

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SIMATIC

S7-1500/ET 200MP Analog Input Module F-AI 8xI 0(4)..20mA (6ES7536-1MF00-0AB0)

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09/2024
A5E51970360-AC

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Introduction

1

Purpose of the documentation

This manual supplements the system manual S7-1500 Automation System. You can find information on the functions that apply generally to the S7-1500 automation system and the ET 200MP distributed I/O system in the system manual S7-1500 Automation System (https://support.industry.siemens.com/cs/ww/en/view/59191792).

The information provided in this manual and the system manual enables you to commission the S7-1500 automation system and ET 200MP distributed I/O system.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the "STEP 7 (TIA Portal)" configuration and programming software.

Please also observe the notes identified as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which particular attention should be paid.

Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators by means of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/24471)

Open source software

Open source software is used in the firmware of the product described. The open source software is provided free of charge. We are liable for the product described, including the open source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

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SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1 S7-1500/ET 200MP Documentation Guide

1.1.1 S7-1500/ET 200MP documentation guide



The documentation for the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require. Changes and supplements to the manuals are documented in a Product Information.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

Basic information



The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- S7-1500/ET 200MP System Manual
- Online help TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules
- Equipment Manuals Power Supply Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC S7-1500 and ET 200MPsystems.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manual Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the S7-1500 and ET 200MP systems on the Internet (https://support.industry.siemens.com/cs/de/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/86140384)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:



Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:



Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)



YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)
     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:
     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7536-1MF00-0AB0

View of the module

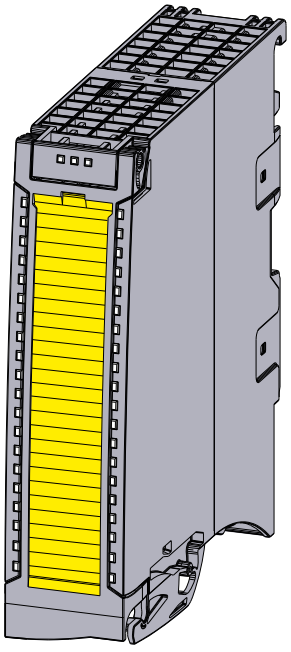


Figure 1-615 View of the F-AI 8xI 0(4)..20mA module

Properties

The module has the following technical properties:

- Fail-safe analog module for use in the S7-1500 automation system and in the ET 200MP distributed I/O system.
- PROFIsafe profile V2.6.1
- PROFIsafe address type 2
- Supports the profile RIOforFA-Safety (on F-CPUs S7-1200 and S7-1500)
- Measurement type current adjustable per channel
  - 0 to 20 mA
  - 4 to 20 mA
- Interference frequency suppression: 50/60 Hz
- 8 analog inputs (SIL3/Cat.3/PLd) or 4 inputs (SIL3/Cat.4/PLe)
- Use of various interconnection types are possible (1oo1 & 1oo2)
- External sensor supply possible
- Internal short-circuit-proof sensor supplies for each channel
- Electrical isolation
  - From backplane bus
  - In groups of 4 channels (AI_0 ... AI_3, AI_4 ... AI_7)
- Status display RUN (green LED)
- Status display module diagnostics (red LED)
- Status display channel status (green LED)
- Status display power supply (green LED)
- Channel diagnostics per input (red LED)
- Resolution 16 bits including sign
- Channel-specific or module-wide passivation

Supported functions:

- Firmware update
- I&M identification data
- Service data
- Value status
- HART communication (Rev. 5 to Rev. 7; is supported as of firmware V2.0)
- Up to 3 additional submodules can be configured as module-internal shared input (MSI) or as HART variables (supported as of firmware V2.0)

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, switch off the power supply of the affected module before 100 hours expires.
Follow the repair procedure described in section Diagnostic alarms (Page 72).

Accessories

The following accessories are supplied with the module and can also be ordered as spare part:

- Labeling strips
- U-connector
- Universal front cover
- Electronic coding element
- Shielding bracket
- Shield terminal
- Power supply element

Additional components

The following component must be ordered separately:

- Front connector and cable tie

You can find more information on accessories in the S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792) system manual.

3.2 F-CPU and Engineering

Requirement

- F-CPU 15xxF as of firmware V2.0
- F-CPU 12xxF as of firmware V4.2
- Safety system version as of V2.5
- PROFIsafe driver profile V2.6.1
- As of TIA Portal V18 SP1 with HSP0394 (firmware V1.0)
- As of TIA Portal V19 with HSP0451 (firmware V2.0)

Connecting

4

4.1 Block diagram

This section includes the block diagram with the general pin assignment of the F-module.

You can find more information on the parameter assignment of the F-module in the section Parameters/address space (Page 34).

You can find more information on the various connection options in the section Applications of the F-I/O module (Page 59).

You can find information on wiring the front connectors and providing the cable shielding, etc., in the Wiring section of the Automation System S7-1500 (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual.

Abbreviations used

In the following images, the abbreviations used mean:

I_n+/I_n-	Analog input channel n (current only)
L+	Connection to power supply
M	Connection to ground
U_{Sn}	Sensor supply

Pin assignment for the power supply element

The power supply element is plugged onto the front connector and serves as the shield connection. For this, you must connect the power supply to terminal 41 (L+) and terminal 44 (M).

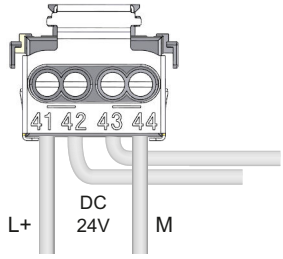
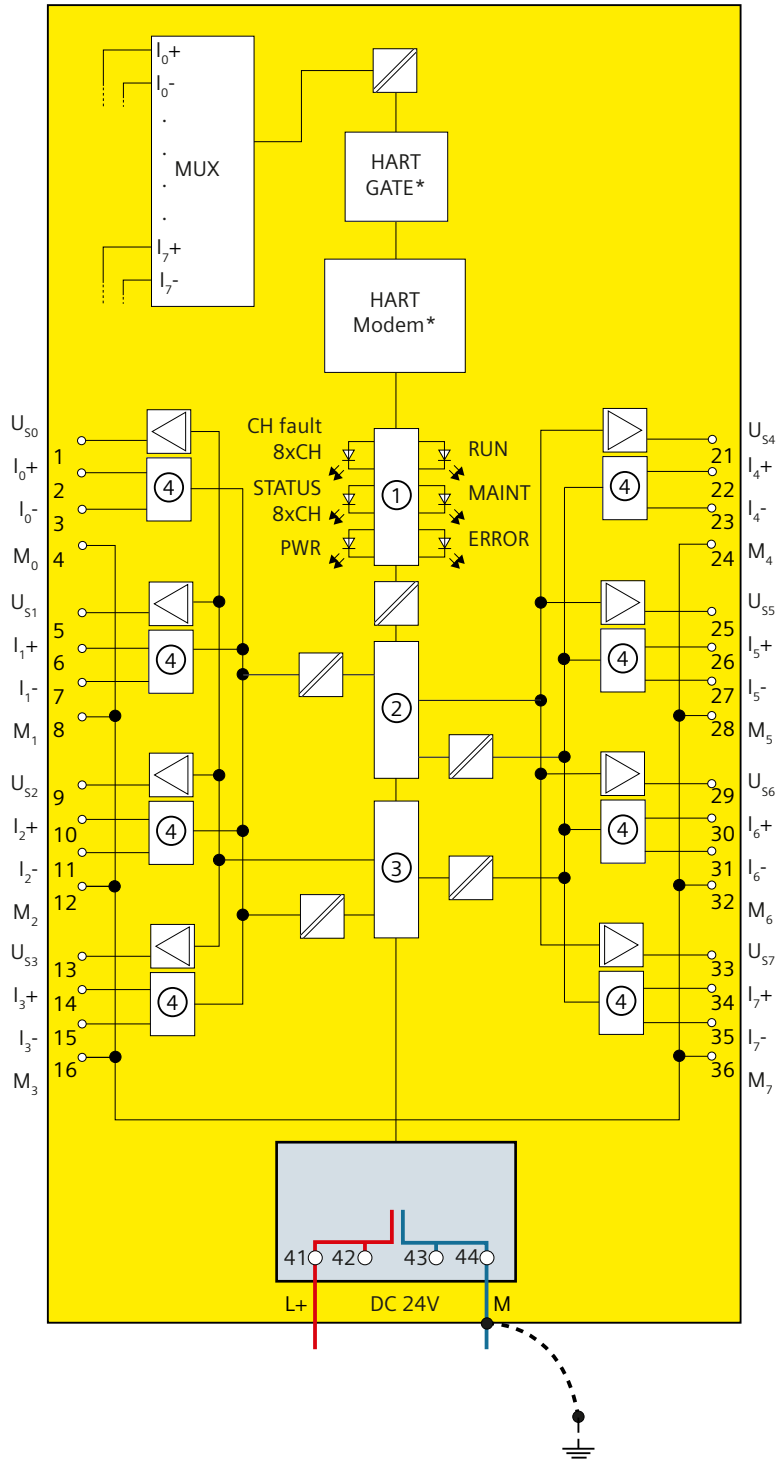


Figure 1-616 Connection of power supply element

Block diagram

The following figure shows the assignment of channels to addresses (input word).



①	Backplane bus interface	RUN	LED status display (green)
②	Microcontroller 1	ERROR	LED for fault display (red)

③	Microcontroller 2	PWR	LED for power supply (green)
④	Signal evaluation	MAINT	LED for MAINT ALARM (yellow)
		CH fault	LED for channel fault (red)
		STATUS	LED for channel status (green)
		*	The function is supported as of firmware V2.0.

Figure 1-617 Block diagram

Sensor supply

⚠ WARNING

Voltage dips and voltage fluctuations of the power supply are not buffered by the F-module and therefore affect the sensor supply.
This can cause the measured value to be falsified and must be taken into account when determining the safety function.
To ensure that the sensor functions without problems, we recommend one of the following options:

- You can avoid voltage dips by using a voltage supply according to the NAMUR recommendation NE 21.

or

- Use a transmitter with an appropriate battery backup or diagnostics.

Recommendation: Internal sensor supply

You are strongly advised to use the short-circuit-proof internal sensor supply of the F-module. This internal sensor supply is monitored and its status is indicated by the Fn LED. The input is also protected in the event of short-circuits in the wiring or at the sensor.

NOTE

The internal sensor supply is switched off in case of a short-circuit to ground or during power-up in the event of short-circuit to L+.
The sensor supply is also switched off at input currents > 35 mA.
A check is made approximately 1 minute later to determine if the error has gone.

NOTE

Behavior of process values and diagnostics evaluation

Sensor startup during module startup:

After the internal sensor supply is activated, the evaluation of wire break and underflow diagnostics is suppressed for 3 seconds. During this time, the module makes the secure process value 0 available at all channels. This suppresses a possible wire break or underflow diagnostics caused by the sensor startup. If the sensor startup is not yet complete after the 3 seconds have elapsed, it is possible that the module might detect wire break or underflow and passivate the affected channel. In this case, the channel fault must be acknowledged during startup.

Sensor startup during operation:

If a sensor startup takes place during operation, e.g. the sensor supply is reactivated after a short-circuit, all analog values are invalid and wire break or underflow diagnostics can occur on the sensors connected to the internal sensor supply.

External/internal sensor supply

The figures in section Applications of the F-I/O module (Page 59) show how you can supply power to the sensors via an external sensor supply (for example, from another module).

⚠ WARNING

A short-circuit from L+ to I_n+ might destroy the input resistors, depending on the selected interconnection type.

You can avoid this problem through proper wiring and use of the internal sensor supply. When an external sensor supply is used, other suitable measures are necessary to protect the input resistors (e.g. external quick-response 50 mA fuse in the input circuit of the F-module).

⚠ WARNING

External sensor supply

If you use an external sensor supply, you need to take into consideration the voltage dips and voltage fluctuations when determining the safety function.

To ensure that the sensor functions without problems, we recommend one of the following options:

- Use a transmitter with an appropriate battery backup or diagnostics.
  or
- Use a **redundant** external sensor supply
  or
- **Monitor** the external sensor supply for undervoltage/overvoltage, including shutdown of the sensor supply in the event of a fault (1-channel for SIL2; 2-channel for SIL3).

HART function

5

5.1 Usage of HART

Definition

"HART" stands for "Highway Addressable Remote Transducer" = Remote-controlled field devices (sensors or transmitters) that can be addressed via communication.

Using the HART functionality, you can also use the analog input module F-AI 8xI 0(4)..20mA to exchange data with the connected field devices. The HART protocol is generally accepted as a standard protocol for communication with intelligent field devices: HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol. You can find detailed information about HART in the HART specification.

NOTE

HART communication (Rev. 5 to Rev. 7) is supported as of firmware V2.0.

Advantages of HART

Using the analog input module F-AI 8xI 0(4)..20mA offers the following advantages:

- Additional digital communication using the HART protocol
- Numerous field devices with HART functions are in use
- Analog input module F-AI 8xI 0(4)..20mA is used to integrate HART into the S7 system.

Use in the system

Analog input module F-AI 8xI 0(4)..20mA is used in the central I/O as well as in the distributed structure, which is connected to PROFIBUS DP or PROFINET IO.

You can connect a field device to any channel: The analog input module F-AI 8xI 0(4)..20mA operates as a HART master, monodrop; field devices as HART devices.

Typical applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Field device parameters can be changed online
- Information, maintenance, and diagnostics displays for the field devices
- Integration of configuration tools for field devices via the HART interface

⚠ WARNING

The HART protocol is not a safety-related protocol.

Use of HART communication with marine applications

NOTE

Power supply requirements with marine applications

To meet the requirements of the marine approvals specified in the S7-1500 automation system (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual, you must install the F-AI 8xI 0(4)..20mA analog input module and the associated power supply unit in the same control cabinet if HART communication is enabled. Only F-AI 8xI 0(4)..20mA analog input modules may be supplied with the power supply unit.
If HART communication is disabled, these restrictions do not apply.

5.2 HART operating principle

Introduction

The HART protocol describes the physical form of the transfer: transfer procedures, message structure, data formats and commands.

HART signal

The figure below shows the analog signal with the modulated HART signal (FSK method), which consists of sine waves of 1200 Hz and 2200 Hz and has a mean value of 0. It can be filtered out using an input filter so that the original analog signal is available again.

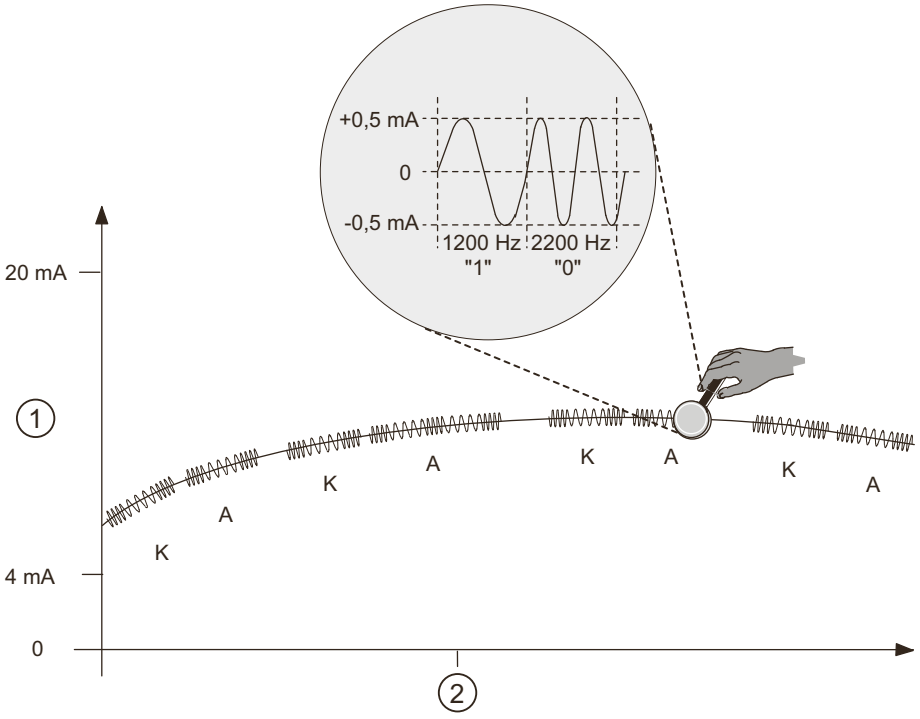


Figure 1-618 The HART signal

①	Analog signal
②	Time (seconds)
K	Command
A	Response

HART communication

The analog input module F-AI 8xI 0(4)..20mA processes the HART communication sequentially in multiplex mode, i.e. channel-by-channel one after the other. HART commands of the individual channels therefore influence the speed of HART processing of the other channels.

When HART mode is enabled, the analog module independently sends HART commands to the connected field devices. This always takes place on a channel-specific basis, alternating with any pending external HART commands that arrive via the module's command interface, see HART command interface (Page 29).

Commissioning a HART field device

Only HART field devices that are set to the short frame address 0 can be operated. If a HART field device with a different short frame address is connected or a connected field device is reconfigured to a short frame address other than 0 during operation, the module starts a scan of all possible short frame addresses at the next re-establishment of HART communication (command 0 with short frame addresses 1...63). As soon as the connected field device responds, it is converted to the short frame address 0 (HART command 6) by the module. During the scan, the module reports a HART communication error.

HART commands

The assignable properties of the HART field devices (HART parameters) can be set with HART commands and read by means of HART replies. The HART commands and their parameters are divided into 3 groups with the following properties:

- Universal
- Common practice
- Device-specific

Universal commands must be supported by all manufacturers of HART field devices and common practice commands should be supported. There are also device-specific commands that apply only to the particular field device.

Examples of HART commands

The following two tables show examples of HART commands:

Table 1-892 Examples of universal commands

Command	Function
0	Read manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Read manufacturer and device type
1	Read primary variable and unit
2	Read current output and percent of range, digitally as floating-point number (IEEE 754)
3	Read up to four pre-defined dynamic variables (primary variables, secondary variables, etc.)
13, 18	Read or write tag, descriptor and date (data included in transmission)

Table 1-893 Examples of common practice commands

Command	Function
36	Set upper range value
37	Set lower range value
41	Perform self-test
43	Set the primary variable to zero
109	Switch burst mode on or off

Structure of the HART protocol

Each HART frame (request frame) sent from the analog module to the connected field device and each HART frame (response frame) received by the field device has the following basic structure.

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE: Bytes (0xFF) for synchronization.
5 to 20 bytes depending on parameter assignment

STRT: Start character (start delimiter)

ADDR: Address of the field device (1 byte; short address or 5 bytes; long address)

COM: HART command number

BCNT: Byte count, number of bytes to follow without checksum

STATUS: HART device status (1st and 2nd status byte). Only present for a response frame. For structure of HART device status, see below.

DATA: Transferred user data / parameters, quantity depending on command (0...230 bytes)

CHK: Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface. See section HART request and response data records (DS 80 to DS 95) (Page 90).

HART replies always contain data. Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response. You should evaluate these to make sure the response is correct.

Structure of HART device status (1st and 2nd status bytes).

Table 1-894 1st status byte

When Bit 7 = 1: "Communication error"	
Bit 6 = 1	Parity error
Bit 5 = 1	Overflow
Bit 4 = 1	Framing error
Bit 3 = 1	Checksum error
Bit 2 = 0	Reserved
Bit 1 = 1	Overflow in the receive buffer
Bit 0 = 0	Reserved

When bit 7 = 0: "Specific in line with response frame"

Table 1-895 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Non primary variable outside the limits
Bit 0 = 1	Primary variable outside the range

HART Fast Mode

The analog input module F-AI 8xI 0(4)..20mA supports processing of HART commands as SHC sequence ("Successive HART Command").
When a HART command with a set SHC bit for a channel is detected by the analog module, the complete HART command processing is reserved on the analog module for that channel for about 2 seconds. For all other channels of the analog module, no HART frame processing occurs during this time, see section HART command interface (Page 29)

NOTE

- While a HART channel of the HART module of the analog input module F-AI 8xI 0(4)..20mA processes an SHC sequence, i.e. the HART processing for this channel is reserved, the HART variables of all HART channels are no longer updated. They remain unchanged in the value and quality code.
- HART requests for other channels of the HART module are not processed and acknowledged accordingly.

Burst mode

Analog input module F-AI 8xI 0(4)..20mA does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

5.3 Using HART

System environment for the use of HART

To use an intelligent field device with HART functionality, you require the following system environment:

- Current loop 4 to 20 mA
  Connection of the transmitters to the analog input module F-AI 8xI 0(4)..20mA

- HART configuration tool "Client":
  You can assign the HART parameters using an external hand-held operating device (HART handheld) or a HART configuration tool (PDM). Both assume the function of a "client":
  The configuration tool accesses through the analog input module F-AI 8xI 0(4)..20mA while the HART handheld is connected directly in parallel to the field device.
  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.
- HART system integration:
  The analog input module F-AI 8xI 0(4)..20mA assumes the function of a "master" by receiving the commands from the HART configuration tool or programmed from an S7 user program, passing them on to the intelligent field device and then returning the replies. The interface of the analog input module F-AI 8xI 0(4)..20mA is represented by data records that are transferred via the S7-1500 I/O bus. The data records must be created and interpreted by the client.

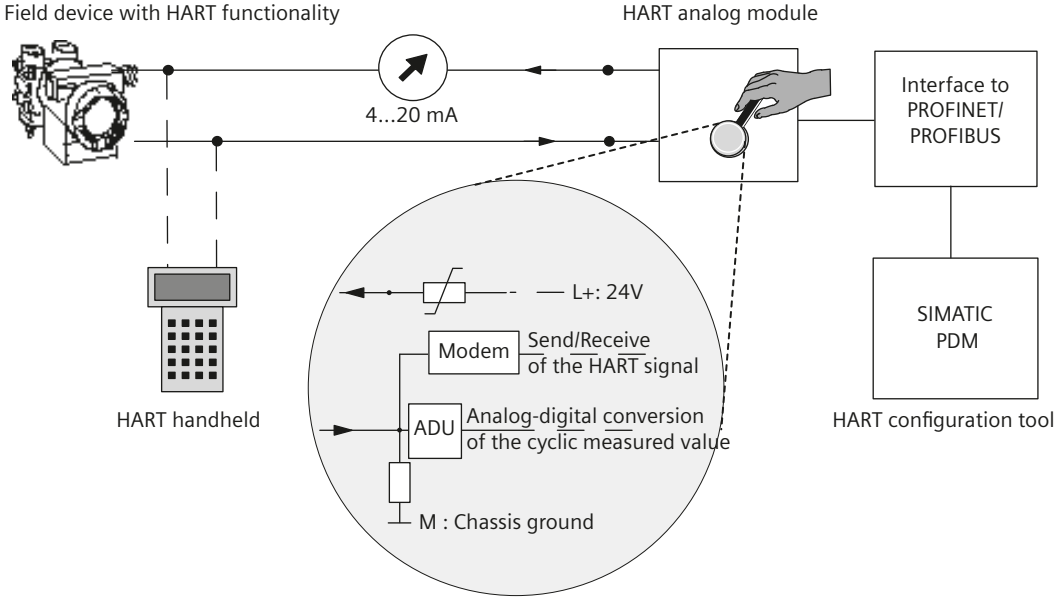


Figure 1-619 System environment for the use of HART

Error management

The two HART status bytes (HART device status), which are transmitted with each response from the field device, contain error messages about the HART communication, HART command and device status.

Among other things, these are evaluated by the analog input module F-AI 8xI 0(4)..20mA and made available in the system via the S7 diagnostic alarms.

Configuration/commissioning

You configure the analog input module F-AI 8xI 0(4)..20mA in the SIMATIC system with STEP 7 or the TIA Portal. You configure the individual channels with respect to the actual analog value acquisition and the use of the HART variables in the input address space of the additional submodules of the module.

You can configure one field device per channel. By means of this configured field device, the configuration/parameter assignment of the connected field device is then carried out using PDM or the EDD for the S7-1500/ET 200MP. You will find the current EDD for download in Siemens Industry Online Support under entry ID 109822354 (https://support.industry.siemens.com/cs/ww/en/view/109822354).

With PROFINET IO, analog input module F-AI 8xI 0(4)..20mA can be configured via a GSD file. However, in this case, direct configuration / parameter assignment of the connected field devices is not possible.

Parameter reassignment of the field devices

The analog input module F-AI 8xI 0(4)..20mA generally accepts triggered parameter reassignment for field devices. Access rights can only be allocated in the configuration tool.

For parameter reassignment of the field devices connected to analog input module F-AI 8xI 0(4)..20mA, proceed as follows:

1. You trigger parameter reassignment of a field device with a HART command entered using the SIMATIC PDM configuration tool or programmed via the STEP 7 user program.
2. The corresponding bit is set in the HART device status of the connected field device (in the 2nd status byte) after you have reassigned the parameters of a HART field device.
3. The parameter reassignment of the field device causes the analog input module F-AI 8xI 0(4)..20mA to trigger a "HART configuration changed" diagnostic interrupt, if this is enabled. See Diagnostic alarms (Page 72). This diagnostic interrupt is to be regarded as information and not as an error and is automatically deleted again by the analog module after approximately 1 minute.

A diagnostic interrupt can also be triggered, if enabled, when parameters are reassigned with the handheld.

⚠ WARNING

An external operating device (e.g. HART handheld or HART modem) may only be used if one of the following requirements is met:

- The input signals (i.e. process values or user data in the input range in section Address space (Page 53)) are checked for plausibility. For example, by comparison in the fail-safe user program with the equivalent value of another F-I/O module.
- Your system is in a state in which parameter reassignment of a HART field device is possible without risk.

See also

Block diagram (Page 16)

5.4 HART for safety-related applications

Overview

- "HART gate" parameter
  You use the "HART gate" parameter to switch on the HART function (HART communication) for the I/O module. The "HART gate" parameter acts as a fail-safe "main switch" for the complete module.
- "HART function" parameter
  You use the "HART function" parameter to enable or disable HART communication with the HART field device for the relevant channel of the I/O module.
  The parameter is not safety-related. In other words, this parameter cannot be used for fail-safe shutdown of HART communication.

⚠ WARNING

Write protection of the connected HART field devices should always be enabled as soon as the "HART gate" is switched on.
This measure guarantees both protection from unauthorized access or manipulation of the HART sensors and compliance with the requirements for using HART field devices in safety-related applications.
If write protection is not enabled and the "HART gate" is switched on, one of the following conditions must be met:

- The input signals (i.e. input values or user data in the input range in the section Address space (Page 53)) are checked for plausibility. For example, by comparison in the fail-safe user program with the equivalent value of another F-I/O module.
- Your system is in a state in which parameter reassignment of a HART field device is possible without risk.

⚠ WARNING

If the "HART gate" is switched on, the additional error of the input signal (i.e. input values or user data in the input range in section Address space (Page 53)) specified in the Technical specifications (Page 78) of the F-I/O module must be taken into account by the HART signal modulated on the input signal depending on the configured interference frequency suppression.

⚠ WARNING

An external operating device (e.g. HART handheld or HART modem) may only be used if one of the following requirements is met:

- The input signals (i.e. input values or user data in the input range in the section Address space (Page 53)) are checked for plausibility. For example, by comparison in the fail-safe user program with the equivalent value of another F-I/O module.
- Your system is in a state in which parameter reassignment of a HART field device is possible without risk.

5.5 HART command interface

Data records

The HART commands are sent as "external" HART requests from the client (e.g. PDM or the STEP 7 user program) via data records to the connected field device. The response from the field device is then made available in the system via data records.

HART communication may be controlled by only one client (e.g. PDM) per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. Analog input module F-AI 8xI 0(4)..20mA does not support client management.

Fixed data records are assigned to each client/channel:

Table 1-896 Structure of the data records

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87
4	88	89
5	90	91
6	92	93
7	94	95

The corresponding data records are transferred to the module with the "WRREC" instruction and read by the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS.

Errors during interpretation of the request data record are signaled in the corresponding response data record. The faulty request can be read back again using the request data record.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error displays.
- The response data record must always be read completely because the analog module may modify the data record after the initial reading with "successful" or "error" status. If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.
- The client may only write a request data record to the module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is disabled. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command is sent to the module with the SHC bit set, this channel is reserved for external HART commands for 2 seconds.

For each additional HART command with the SHC bit set, the module reserves this channel again for a further 2 seconds for HART commands. If a HART command without a set SHC bit is detected for this channel or if no further command is received for this channel within 2 seconds of the previous HART command, command 3 or 9 is sent cyclically again for this channel to read the HART variables to the field device.

5.6 HART variables

Introduction

Numerous HART field devices provide additional measured quantities (e.g. sensor temperature).

For each channel with activated HART functionality, a maximum of 4 HART variables supported by the connected field device are read cyclically. The HART variables are read automatically via HART command 3 (for field devices with HART Rev. 5 and 6) or via command 9 (for field devices from HART Rev. 7).

These 4 HART variables per channel are always stored in the HART variable data record 121 and can be read at any time. See section HART variable data record (DS 121) (Page 88).

In addition, a maximum of 8 HART variables can be configured directly in the input address space of the additional submodules of the analog input module F-AI 8xI 0(4)..20mA. See section Additional submodules (Page 49). You assign the respective HART variables to a channel in the "HART variables configuration" properties dialog of the module. Parameter

assignment is performed via parameter data record 140. See section Parameter assignment and structure of the HART mapping parameters (DS 140) (Page 97). This enables you to easily process measured values directly from the field device as input data in the automation device.

Evaluating the multiHART area

You can select the multiHART area via the parameter assignment dialog.

The multiHART area occupies 1 byte in the output range (command) and 6 bytes in the input range (1 byte acknowledgment + 5 bytes HART variable).

You can read all HART variables available in the module using the multiHART area. To do this, you must request a HART variable from the module using the command byte in the output range.

The command byte identifies the requested HART variable (HART variable reference):

HART variable reference	
Bit 4 ... 7: Channel number 0 ... 7	Bit 0 ... 3: Variable identification 1 = PV (Primary Variable) 2 = SV (Secondary Variable) 3 = TV (Tertiary Variable) 4 = QV (Quaternary Variable)

The command is confirmed via the acknowledgment byte in the input range. As soon as the HART variable reference requested using the command can be read, the requested HART variable can be evaluated.

If an invalid HART variable reference is requested, this is also acknowledged accordingly. The value of the corresponding HART variable is then zero, and the quality code is signaled with $0x37_H$ (initialization value from analog module).

Example:
The primary variable of channel 6 is to be read.

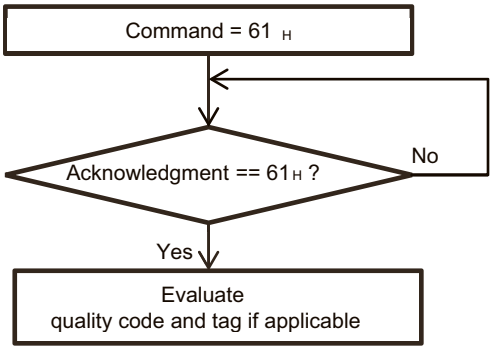


Figure 1-620 Command = 0x61

Address assignment

You can configure up to three additional submodules and access the HART variables in the input address space of these additional submodules (see section Additional submodules (Page 49)).

You can find the address assignment in section Address space of additional submodules (Page 55).

Configuration of HART variables

You can configure up to 4 HART variables for each channel:

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary Variable)

When HART mode is activated, the analog input module F-AI 8xI 0(4)..20mA automatically reads the variables supplied by the connected field devices cyclically and makes them available in the input address space of the module's additional submodules in accordance with the configuration.

Each HART variable consists of a 4-byte value and a 1-byte quality code.

Quality code

The quality code describes the process status of the corresponding HART variable.

Basic structure of the quality code

Bit	7 ... 6	5 ... 2	1 ... 0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the analog input module F-AI 8xI 0(4)..20mA depend on the HART revision of the field device used.

For field devices with HART Revision 5 and 6

The quality code is formed exclusively from the 1st and 2nd Status byte (HART device status) of the response frames (HART command 3).

Quality code	Meaning (process status)	
80_H	Value is okay	Also applies if the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting
78_H	Value is uncertain	Also applies if the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Non primary variable outside the limits • Primary variable outside the range

Quality code	Meaning (process status)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	• After module startup • After incorrect operation of the multiHART interface
00_H	Initialization value from S7 system	

For field devices from HART Revision 7

The quality code is formed from the 1st status byte (HART device status) and from the "Device variable status" (DVS) of the response frames (HART command 9).

Quality code	Meaning (process status)	
80_H	Value is okay	
28_H ... $2B_H$	"Bad"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above)
68_H ... $6B_H$	"Poor accuracy"	
78_H ... $7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
88_H	"More device variable state available" (additional status information available)	
89_H	"Good" with "Low limit"	
$8A_H$	"Good" with "High limit"	
$8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	• After module startup • After incorrect operation of the multiHART interface
40_H	Alternatively read via command 3	
00_H	Initialization value from S7 system	

Parameters/address space

6

6.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 1-897 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Current	0 to 20 mA (2- and 3-/4-wire transducer) 4 to 20 mA (2- and 3-/4-wire transducer)	16 bits including sign 16 bits including sign

You can find the tables of the measuring ranges as well as overflow, overrange, etc. in the Appendix Representation of analog values (Page 84).

6.2 Parameters

Parameters for F-AI 8xI 0(4)..20mA

WARNING

Diagnostic functions must be activated or deactivated in accordance with the application; see section Applications of the F-I/O module (Page 59).

The following parameters are possible:

Table 1-898 Configurable parameters

Parameter	Value range	Default	Configuration in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Dependent on parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Suggested by F-system	No	Module
F-parameter signature (without addresses)	0 to 65535	Calculated by F-system	No	Module
Behavior after channel fault	• Passivate the entire module • Passivate channel	Passivate channel	No	Module

*) See formula in the section "Parameter assignment of discrepancy analysis for 1oo2 evaluation"

Parameter	Value range	Default	Configuration in RUN	Scope
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB-number	Value range depending on parameter assignment of the F-CPU	Suggested by F-system	No	Module
F-I/O DB-name	—	Suggested by F-system	No	Module
AI parameters:				
HART gate	• On • Off • Switchable	Off	No	Module
Interference frequency suppression	• 50 Hz • 60 Hz	50 Hz	No	Module
Channel parameters				
Channel n, n+4				
Sensor evaluation	• 1oo1 evaluation (max. SIL3/Cat.3/PLd) • 1oo2 evaluation (max. SIL3/Cat.4/PLe)	1oo2 evaluation (max. SIL3/Cat.4/PLe)	No	Channel
Unit value	• MIN • MAX	MIN	No	Channel
Discrepancy time *	100 to 30000 ms	100 ms	No	Channel
Tolerance window abs.	0.3 to 20.0%	2.5%	No	Channel
Tolerance window rel.	0.3 to 20.0%	2.5%	No	Channel
Channel n				
Activated	• Disable • Enable	Enable	No	Channel
Channel fault acknowledge	• Manual • Automatic	Manual	No	Channel
Measuring range	• 0...20 mA • 4...20 mA	4...20 mA	No	Channel
Diagnosis: Wire break **	• Disable • Enable	Enable	No	Channel
Smoothing	• 1 • 2 • 4 • 8 • 16 • 32 • 64	1	No	Channel

*) See formula in the section "Parameter assignment of discrepancy analysis for 1oo2 evaluation"

Table 1-899 HART/MSI/HART variables parameter

Parameter	Value range	Default	Configuration in RUN	Scope
Module parameters:				
AI configuration				
Number of additional submodules (for MSI / HART variables)				
Additional submodules	• None • 1 • 2 • 3	None	No	Module
HART:				
Channel n				
HART function	• Disable • Enable	Disable	Yes	Channel
HART preamble bytes	5 to 20	5	Yes	Channel
HART repetitions	1 to 10	5	Yes	Channel
HART diagnostics	• Disable • Enable	Disable	Yes	Channel
HART variables configuration				
HART variables	• None • 4 HART • 8 HART • 1 multiHART	None	No	Module
Submodule_n: *				
Submodule type				
Submodule type	• MSI • HART variables	MSI	No	Module

*) Only present if the "Additional submodules" parameter is configured with 1, 2 or 3

6.3 Explanation of parameters

6.3.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Basis for PROFIsafe addresses" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

6.3.1.1 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

6.3.1.2 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

6.3.1.3 HART gate

Definition

This parameter is used to enable the HART communication for the I/O module.

The "HART gate" parameter acts as a fail-safe "main switch" for the complete module.

The following parameter assignments are possible:

- "On": HART communication is enabled.
- "Off": HART communication is disabled.
- "Switchable": If the module is in RUN, HART communication can be switched on and off from the safety program via the process output byte QB x + 0. This means that the HART communication with HART field devices can be activated and deactivated during operation of the F-CPU (e.g. for maintenance purposes). You can find more information about the address assignment in the section Address space (Page 53).

HART communication is then activated on a channel-specific basis with the "HART function" parameter.

You can find more information on this parameter in the section "HART for safety-related applications (Page 28)".

6.3.1.4 Interference frequency suppression

Here you set the interference frequency suppression for the line frequency:

- 50 Hz
- 60 Hz

You can find more information on this in the Analog value processing function manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

6.3.2 Parameters of the channels

6.3.2.1 Evaluation of the sensors

Overview

Here you select the type of sensor evaluation:

- "1oo1 evaluation (max. SIL3/Cat.3/PLd)"
- "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

If you do not want to measure with a channel or channel pair, disable the channel or the channel pair.

1oo1 evaluation (max. SIL3/Cat.3/PLd)

With the 1oo1 evaluation, there is one sensor, and it is connected to the F-module via a single channel.

1oo2 evaluation (max. SIL3/Cat.4/PLe)

With the 1oo2 evaluation, two input channels are occupied by:

- Two single-channel sensors
- One two-channel sensor

Note that in 1oo2 evaluation, two channels are combined into a channel pair.

Achievable safety class

Depending on the selected sensor evaluation, you achieve the following safety classes with a sensor that is qualified accordingly:

- SIL3/Cat.3/PLd for "1oo1 evaluation" or
- SIL3/Cat.4/PLe for "1oo2 evaluation"

6.3.2.2 Unit value

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can choose for each input channel pair which of the two F-CPU values is provided.

- "MIN": the lesser of the two values.
- "MAX": the greater of the two values.

During a discrepancy between the two input channels, the last valid unit value prior to the occurrence of the discrepancy is made available to the F-CPU.

6.3.2.3 Discrepancy time

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the discrepancy time for each channel pair here in milliseconds.

The discrepancy time does not start until the unit value is outside the assigned tolerance window (relative or absolute). If the two redundant input channels of the channel pair differ by more than the specified tolerance and for longer than the specified discrepancy time but no longer than the duration of the maximum response time, the F-module detects a discrepancy error and triggers a diagnostic interrupt. If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.

For more information regarding configuring the discrepancy analysis refer to Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 40).

A discrepancy error is handled by the safety program in the same way as a channel fault. More information is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.3.2.4 Tolerance window abs.

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for the channel pair. You specify the tolerance window as a percentage of the full-scale value. The reference value is the full-scale value, i.e. 20 mA. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

You can find more information on setting the tolerance window under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 40).

Example

You have assigned the following:

- "Tolerance window abs." at 10%
- The measuring range of 0...20 mA
- A discrepancy time of 100 ms

The input channels may differ from the configured discrepancy time (100 ms) up to the max. reaction time for a time window with a difference of more than 2 mA.

See also

Discrepancy time (Page 39)

6.3.2.5 Tolerance window rel.

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for each channel pair. You specify the tolerance window as a percentage of the assigned unit value. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

The two parameters "Tolerance window abs." and "Tolerance window rel." are combined. The "Tolerance window abs." parameter is decisive in the case of low process values.

You can find more information on setting the tolerance window under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 40).

Example

You have assigned the following:

- "Tolerance window rel." at 10%
- The measuring range of 0...20 mA
- A discrepancy time of 200 ms
- The unit value to MIN

With a measured value of 20 mA a difference of more than 2 mA from the configured discrepancy time (200 ms) up to the max. response time may occur.

See also

Discrepancy time (Page 39)

6.3.2.6 Parameter assignment of discrepancy analysis for 1oo2 evaluation

Operating principle of discrepancy analysis

A discrepancy analysis is performed with a configured 1oo2 evaluation. **Smoothed** process values are used for the discrepancy analysis.

An assignable tolerance window is formed around the process value that represents the instantaneous unit value (value that is signaled to the F-CPU).

The tolerance window is formed relative to the process value or as an absolute value relative to the measuring range end value. Relative and absolute tolerance windows are combined.

If the process value does not represent the unit value at an instant and is within the tolerance window, **no** discrepancy exists.

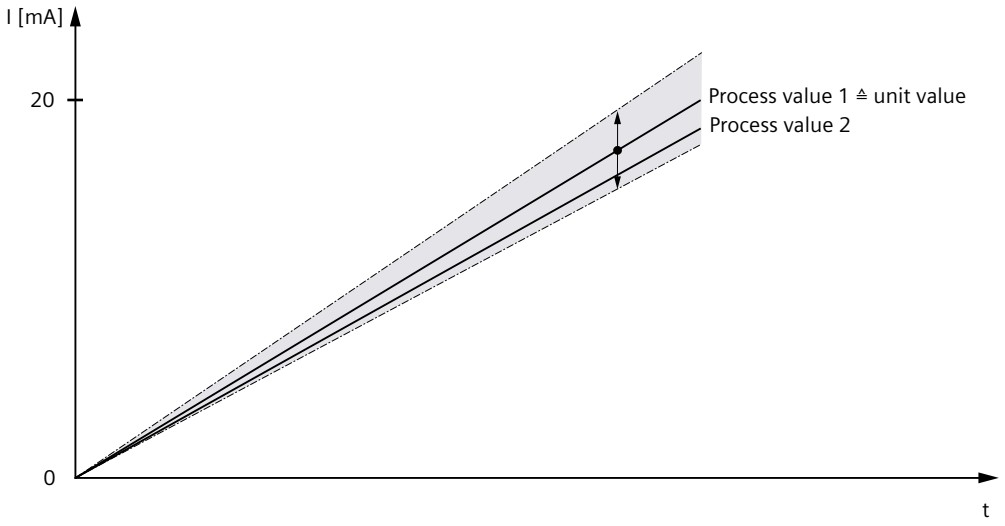


Figure 1-621 Example of a relative tolerance window *without* discrepancy (parameter assignment: unit value = MAX)

If the process value does not represent the unit value at an instant but is outside the tolerance window, a discrepancy exists.

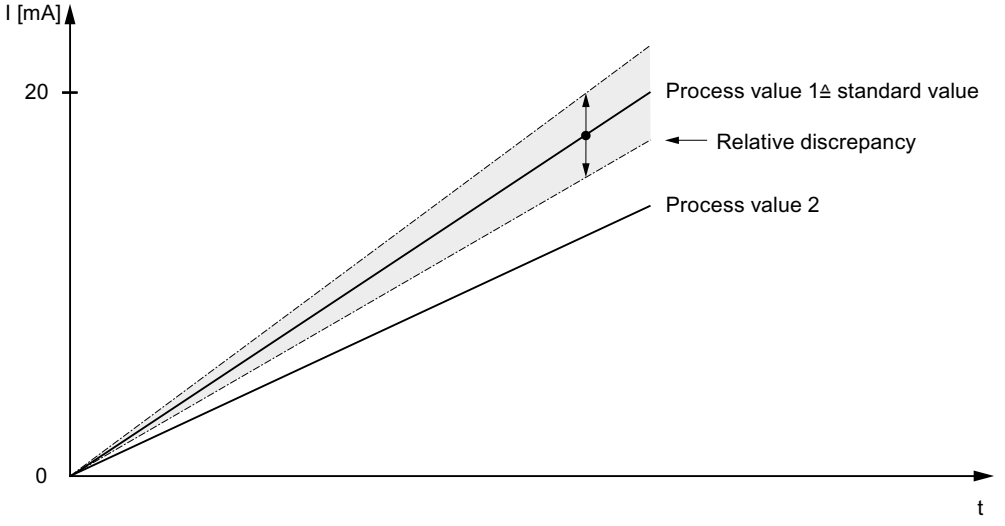


Figure 1-622 Example of a relative tolerance window *with* discrepancy (parameter assignment: unit value = MAX)

The assigned discrepancy time starts as soon as a discrepancy is detected. The discrepancy time runs as long as the discrepancy exists.

- During a discrepancy between the two input channels, the last valid unit value prior to occurrence of the discrepancy is signaled to the F-CPU.

  If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.
- There is no valid old value after startup. If the discrepancy is detected during this time, 0 is output and the discrepancy time is started.

  If there is no longer a discrepancy between the input channels when the discrepancy time expires, the unit value is output.

If the discrepancy time expires, an error is signaled and the process value is set to 0. In the PII, the substitute value 0 is set for the safety program.

A discrepancy error is handled by the safety program in the same way as a channel fault. More information is available in the STEP 7 Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Configuring the discrepancy analysis parameters

The following four parameters for the discrepancy analysis are assigned for each channel pair:

- Discrepancy time
- Unit value
- Tolerance window abs.
- Tolerance window rel.

"Discrepancy time" parameter

If the following is true, the F-module detects a discrepancy error:

- The process value that does not represent the unit value is outside the configured tolerance window.
- Lasts longer than the configured discrepancy time.
- Lasts at maximum the duration of the maximum response time.

In the case of a discrepancy error, the F-module triggers a diagnostic interrupt and sets the process value to 0. The discrepancy time is reset if the unit value lies within the tolerance window again.

In the PII, the substitute value 0 is set for the safety program.

You calculate the maximum discrepancy time that is permitted in the respective application using the following formula:

Discrepancy time = Maximum response time (in case of discrepancy error) – 2 × Conversion cycle time × Smoothing – 2 × Conversion cycle time

NOTE

You calculate the discrepancy time by using the values from the appendix Response times (Page 82) in the above equation.

You can assign the discrepancy time for each channel pair.

"Unit value" parameter

You can select which of the two values is to be signaled to the F-CPU for each input channel pair. During a discrepancy between the two input channels, the last valid unit value prior to occurrence of the discrepancy is signaled to the F-CPU.

- "MIN": The lower of the two values is signaled to the F-CPU as the unit value.
- "MAX": The higher of the two values is signaled to the F-CPU as the unit value.

"Tolerance window abs." parameter

You can calculate the absolute tolerance window using the following formula:

$$T_{abs} = \frac{|\Delta I_{abs}|}{I_{ME} - I_{MA}} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta I_{abs} = \pm \frac{(I_{ME} - I_{MA}) \times T_{abs}}{100} \ [\text{mA}]$$

With

- I_{ME} = 20 mA (full-scale value)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA (start-of-scale value)
- I_{MA} = 4 mA for measuring range 4 ... 20 mA (start-of-scale value)
- T_{abs} = Tolerance in %
- ΔI_{abs} = Maximum deviation of current (+/-)

You can assign a value of 0.3 to 20.0% for the "Tolerance window abs." parameter for each channel pair.

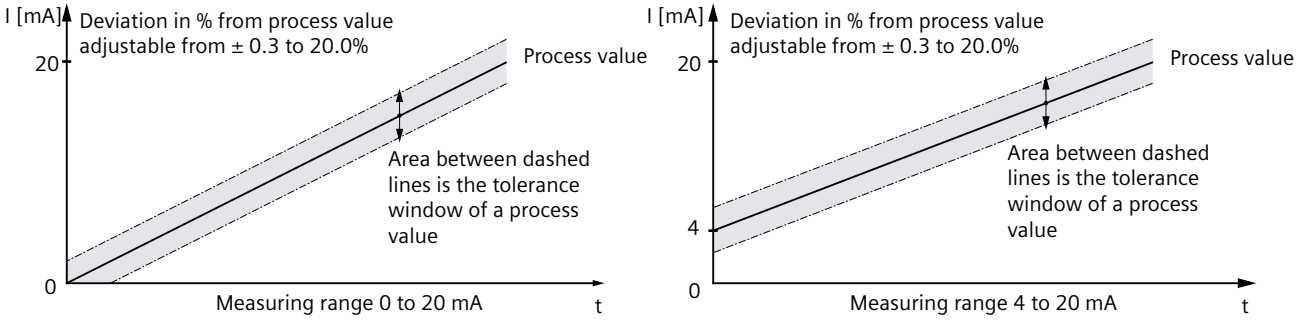


Figure 1-623 Absolute deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

"Tolerance window rel." parameter

The tolerance window is calculated as a percentage of the **smoothed** process value that represents the MIN or MAX value (depending on the parameter assignment of the unit value) in this instant.

You can calculate the relative tolerance window using the following formula:

$$\mathbf{T}_{rel} = \frac{|\Delta \mathbf{I}_{rel}|}{|\mathbf{I}_{EW} - \mathbf{I}_{MA}|} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta \mathbf{I}_{rel} = \pm \frac{|\mathbf{I}_{EW} - \mathbf{I}_{MA}| \times \mathbf{T}_{rel}}{100} \ [\text{mA}]$$

With

- I_{EW} = Process unit value (min./max.)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA
- I_{MA} = 4 mA for measuring range 4 ... 20 mA
- T_{rel} = Tolerance in %
- ΔI_{rel} = Maximum deviation of current (+/-)

You can assign a value of 0.3 to 20.0% for the "Tolerance window rel." parameter for each channel pair.

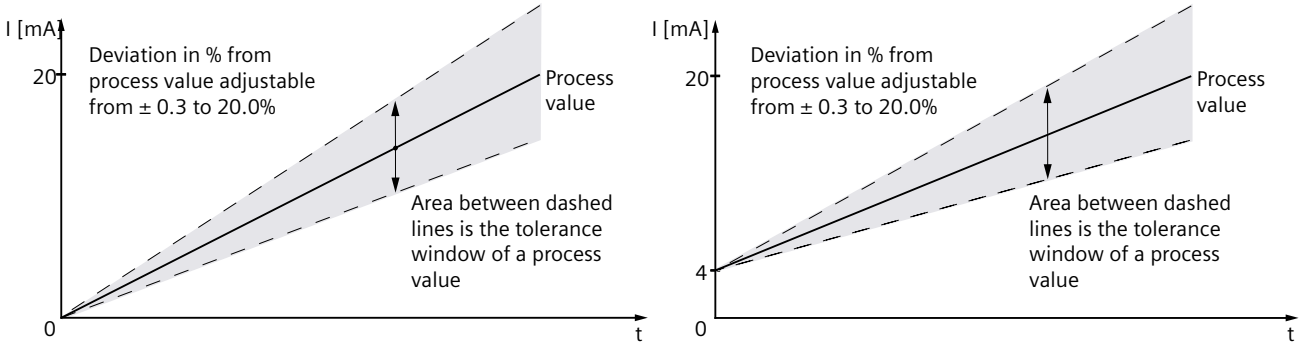


Figure 1-624 Relative deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

Combination of the "Tolerance window abs." and "Tolerance window rel." parameters

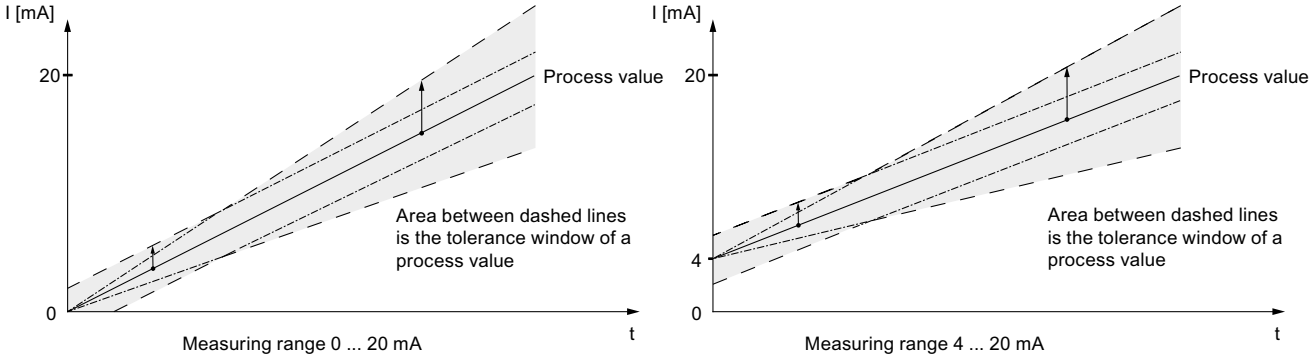
You can combine the "Tolerance window abs." and "Tolerance window rel." parameters as needed. The combined tolerance window (shown in gray in the figure below) is the maximum of T_{rel} and T_{abs}.

$T = MAX \{ T_{rel}, T_{abs} \}$

$\Delta I = MAX \{ \Delta I_{rel}, \Delta I_{abs} \}$

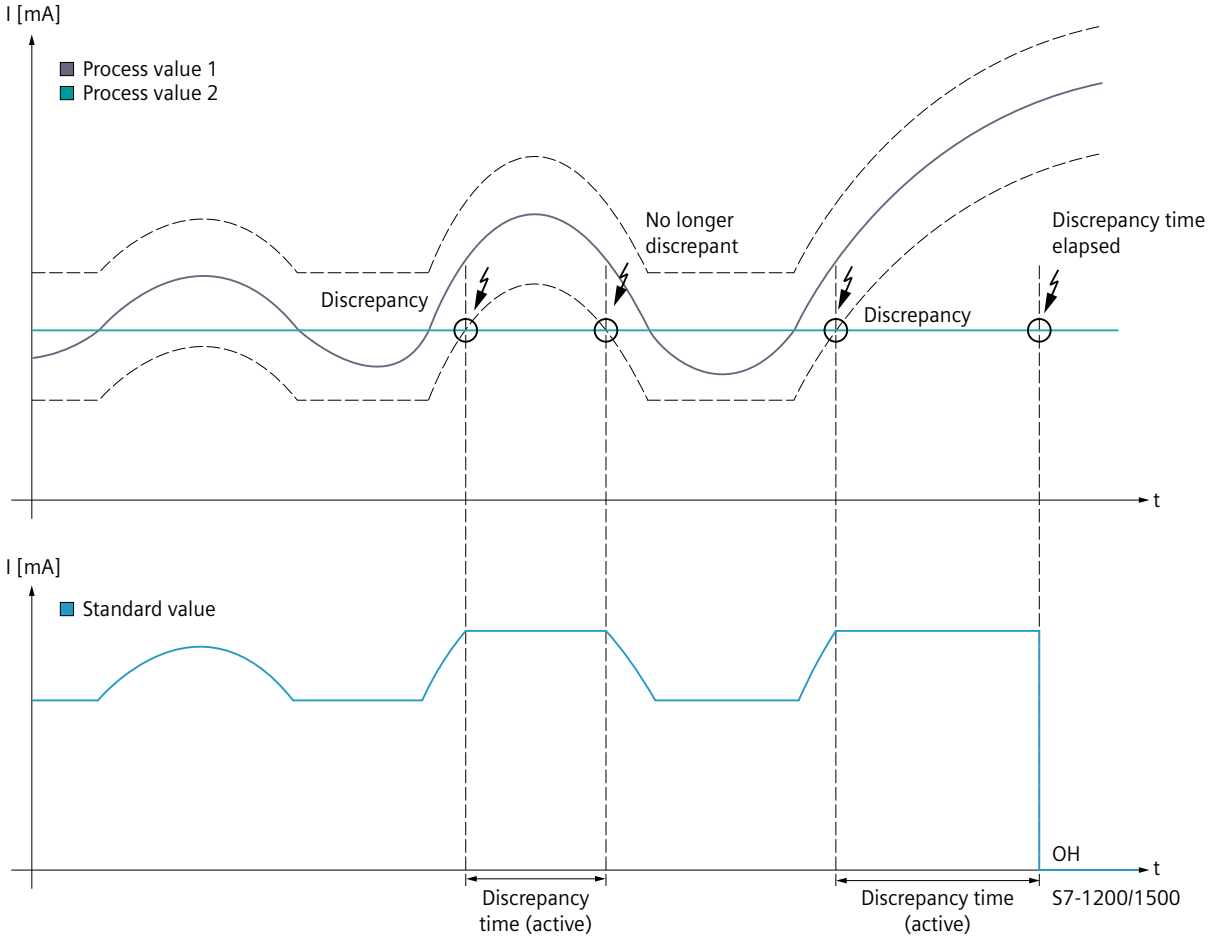
With

- T = Tolerance, in %
- ΔI = Maximum deviation of current (+/-)



Example

The following diagrams show you the behavior of the discrepancy evaluation when unit value = MAX.



The upper of the two diagrams shows you the characteristic curve of the two process values. The dashed line represents the absolute tolerance range configured in this example.

The lower of the two diagrams shows you the unit value signaled to the F-CPU.

In this example, on the first occurrence of a discrepancy, process value 1 is **within** the tolerance range again **before** expiration of the discrepancy time. This means the discrepancy error is not signaled.

In this example, on the second occurrence of a discrepancy, process value 1 is **outside** the tolerance range when the discrepancy time expires. As a result, a discrepancy error is signaled after expiration of the discrepancy time. In the PII, the substitute value 0 is set for the safety program.

6.3.2.7 Activated

If you select this check box, the corresponding channel is enabled for signal processing.

You can deactivate an unused channel with this parameter.

If you deactivate unused channels, the response time of the F-module is reduced.

You can find more information on the response times of the F-module in the appendix Response times (Page 82).

6.3.2.8 Channel failure acknowledge

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

See also

SIMATIC Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/54110126)

6.3.2.9 Measuring range

You select the measuring range for the channel with this parameter:

- 0...20 mA
- 4...20 mA

6.3.2.10 Diagnosis: Wire break

Function

Here you activate wire break detection for a configured measuring range of 4 to 20 mA.

With an assigned measuring range of 4 to 20 mA:

- With assigned wire break diagnostics and currents < 3.6 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without configured wire break and currents diagnostics < 0.4444 mA detects "underflow" and triggers a diagnostic interrupt in the F-CPU.

With an assigned measuring range of 0 to 20 mA, the wire break diagnostics is permanently set by default. With currents < 0.4442 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.

If you do not need a channel, deactivate the channel. Then, a wire break is not detected.

6.3.2.11 Smoothing

Using smoothing

Smoothing of analog values provides a stabilized analog signal for further processing. Smoothed values are always used for discrepancy analysis.

⚠ WARNING

The smoothing takes place as a result of averaging over the selected number of most recently converted analog values of a channel, e.g. 64.
The mean value generation causes a discrepancy to be delayed with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)". You can find an example below.

Smoothing principle

The measured values are smoothed by a digital filter. Smoothing is achieved by the F-module forming the mean of a number of converted (digitized) analog values determined by the "Smoothing" parameter.

You assign smoothing in 7 levels (1, 2, 4, 8, 16, 32, 64 conversion cycles). The level determines the number of analog signals that are averaged. If smoothing = 1 is configured, the smoothing is deactivated.

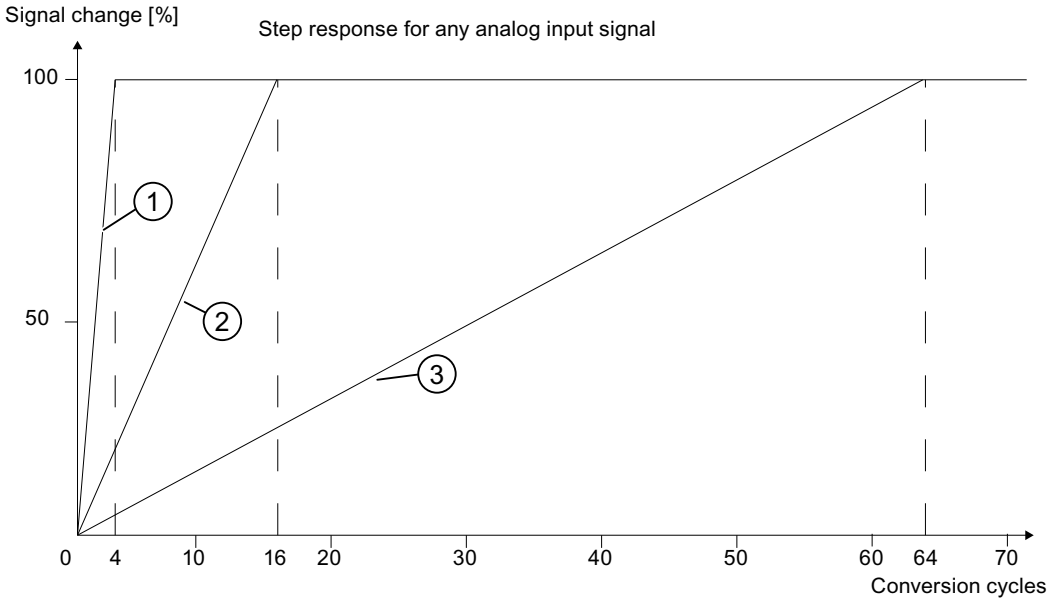
A higher smoothing provides a more stable analog value, and prolongs the time it takes to apply a smoothed analog signal following a unit step. You can find an example below.

NOTE

Smoothing is reset after startup, short-circuit, wire break or another channel fault. If, for example, smoothing with 16 conversion cycles is assigned and all channels are active, it takes up to 1600 ms until the process value is signaled with a configured interference frequency suppression of 50 Hz.
Until the first valid process value, the F-module reports the process value 0 for the channel.
If a discrepancy occurs, measuring and smoothing continues and is not restarted.

Example

The figure below shows the number of conversion cycles, depending on the smoothing setting, after which the analog value is completely smoothed and available in the case of a unit step. The figure applies to all signal changes at the analog input.



① Smoothing - 4 conversion cycles
② Smoothing - 16 conversion cycles
③ Smoothing - 64 conversion cycles

Example: Effect of smoothing on the maximum response time for a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)" in case of error

If an error (One Fault Delay Time, OFDT) occurred with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you calculate the maximum response time according to the following formula:

Maximum response time (in case of discrepancy error) = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

For example, one channel pair connected and configured (activated), interference frequency 50 Hz, smoothing = 16 conversion cycles, discrepancy time = 2000 ms, conversion cycle time calculated with the formula from the appendix Response times (Page 82):

Max. response time (in case of discrepancy error) = 2 × 31 ms × 16 + 2000 ms + 2 × 31 ms = 3054 ms

If a discrepancy exists between the two input channels, it can take 4380 ms until the F-module signals a discrepancy error to the F-CPU.

If the discrepancy time expires, an error is signaled and the process value is set to 0. In the PII, the substitute value 0 is set for the safety program.

6.3.3 AI configuration

6.3.3.1 Additional submodules

In addition to the basic submodule, you can create up to 3 additional submodules. You can find more information about the address assignment in the section Address space of the additional submodules (Page 55).

Use this parameter to specify the number of additional submodules:

- None
- 1
- 2
- 3

The additional submodules are only available when the module is used in a distributed setup that is connected to PROFINET.

When using the module in a Shared Device, you can assign the additional submodules to up to 3 IO controllers (fail-safe or non-fail-safe). Each IO controller has read access to the same data. The number of IO controllers depends on the interface module used. Follow the instructions in the respective manual for the interface module.

The additional submodules are preset to module-internal shared input (MSI). Channels 0 to 7 are copied to the additional submodules. Channels 0 to 7 are then available with identical input values in all submodules configured as MSI. Alternatively, you can copy the HART variables (8 HART, 4 HART or 1 multiHART) into the additional submodules; see section HART variables (Page 30). The change from MSI (default setting) to the HART variables is possible in TIA Portal within the additional submodules.

You can use MSI and HART variables simultaneously in up to three additional submodules. For example, MSI in the 1st additional submodule and HART variables in the 2nd and 3rd additional submodule. The HART variables used in the up to 3 additional submodules are defined once and are therefore identical in all additional submodules (i.e. 8 HART, 4 HART or 1 multiHART).

You can find the assignment of the address space of the additional submodules in the section Address space of the additional submodules (Page 55).

⚠ WARNING

All values in the additional submodules are not safety-related and must therefore not be used for safety-related activities.

NOTE

Procedure when assigning the PROFIsafe address

Assignment of the PROFIsafe address in TIA Portal is only possible when the value "None" is set for the "Additional submodules" parameter.

If you want to use 1, 2 or 3 additional submodules, we recommend that you proceed as follows:

1. Set "Additional submodules" to "None" initially.
2. Assign the PROFIsafe address.
3. Set the desired number of additional submodules (1, 2 or 3).
4. Configure the set additional submodules.

NOTE

Displaying diagnostics alarms

If you have set the "Additional submodules" parameter to 1, 2 or 3 in the settings, diagnostics with the F-module scope are not displayed correctly in the TIA Portal (see sections Interrupts (Page 70) and Diagnostics alarms (Page 72)). Instead, only a PROFIsafe communication error (channel diagnostics) is shown. You can refer to the diagnostics buffer of the F-CPU for the correct diagnostics alarm in this case.

6.3.4 HART

6.3.4.1 HART function

Use this parameter to enable HART communication for the relevant channel.

This parameter can only be configured if the "HART gate" parameter is configured as "On" or "Switchable" and measuring range "4...20 mA" is set.

This parameter is not safety-related, i.e. it cannot be used for fail-safe shutdown of HART communication.

6.3.4.2 HART preamble bytes

Use this parameter to specify the number of preamble bytes sent.

6.3.4.3 HART repetitions

Use this parameter to specify the number of HART frame repetitions. If the analog input module F-AI 8xI 0(4)..20mA receives no response or a response with errors to a HART frame sent to the field device, the frame is repeated. It is therefore sent again to the field device.

Because HART communication of the individual channels uses multiplex mode, HART frames with errors affect the other channels when the number of HART repetitions is high. In other words, the other channels are processed less frequently.

6.3.4.4 HART diagnostics

Enabling the diagnostics of the HART frame specific monitoring and the status information supplied by the connected field device in the HART frame (HART device status).

The parameter is only relevant if the "HART function" parameter is activated.

The HART diagnostics are reported as maintenance events.

6.3.4.5 HART variables

Use this parameter to specify which HART variables can be copied to the additional submodules:

- None
- 8 HART
- 4 HART
- 1 multiHART

This parameter is only relevant if at least one additional submodule with "HART variables" is configured with the "Submodule type" parameter.

You can find information on the additional submodules in the section Additional submodules (Page 49).

⚠ WARNING

The HART variables are not safety-related and must therefore not be used for safety-related activities.

Use of "1 multiHART"

If you have configured the value "HART variables" as the "Submodule type" for more than one additional submodule and set the "HART variables" parameter to "1 multiHART", all these additional submodules read and write to the same multiHART area in the module.

By evaluating the acknowledgment byte in the input range of the submodule, you can determine if the HART variable requested by the respective submodule is available in the input range. See example under "Evaluating the multiHART area" in the section HART variables (Page 30). To ensure data consistency, read the acknowledgment byte and the HART variable from the input range of the submodule at the same time.

6.3.4.6 HART mapping

A maximum of 8 HART variables can be configured (mapped) in the address space of the additional submodules via the HART mapping parameters.

Each HART variable occupies 5 bytes of input data. Depending on the configuration, the addresses are assigned for 4 variables (20 bytes) or 8 variables (40 bytes).

You can find the assignment of the address space in section Address space of additional submodules (Page 55).

If required, this can be changed via data record 140; see section Parameter assignment and structure of the HART mapping parameters (DS 140) (Page 97).

Parameters

Table 1-900 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN
Variable 1	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 2	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 3	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 4	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
The following variables only apply to a configuration with 8 HART variables:				
Variable 5	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 6	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 7	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes
Variable 8	Channel	0 ... 7	0	Yes
	Type	• None • PV (Primary Variable) • SV (Secondary Variable) • TV (Tertiary Variable) • QV (Quaternary Variable)	None	Yes

See also

Address space (Page 53)

6.3.5 Submodule type

Use this parameter to specify whether module-internal shared input (MSI) is available in the additional Submodule_n or the HART variables are copied into the additional Submodule_n.

The parameter is only present if the "Additional submodules" parameter is configured with 1, 2 or 3.

6.4 Address space

Address assignment of the analog input module F-AI 8xI 0(4)..20mA

The analog input module F-AI 8xI 0(4)..20mA occupies the following address ranges in the F-CPU:

Table 1-901 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
F-CPUs S7-1200 and S7-1500	IB x + 0 to x + 22	QB x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of the analog input module F-AI 8xI 0(4)..20mA

The user data and the value status occupy the following addresses in the F-CPU out of all the assigned addresses of the analog input module F-AI 8xI 0(4)..20mA:

Table 1-902 Address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/4)							
IB x + 1								
IB x + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/5)							
IB x + 3								
IB x + 4	Input value at channel 2 (Result of the 1oo2 evaluation channel 2/6)							
IB x + 5								
IB x + 6	Input value at channel 3 (Result of the 1oo2 evaluation channel 3/7)							
IB x + 7								
IB x + 8	Input value at channel 4							
IB x + 9								
IB x + 10	Input value at channel 5							
IB x + 11								
IB x + 12	Input value at channel 6							
IB x + 13								

x = Module start address

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 14	Input value at channel 7							
IB x + 15								
IB x + 16	Value status for AI_7	Value status for AI_6	Value status for AI_5	Value status for AI_4	Value status for AI_3	Value status for AI_2	Value status for AI_1	Value status for AI_0
IB x + 17	-	-	-	-	-	-	-	Value status for HART gate

x = Module start address

NOTE

You only have read access to the addresses occupied by user data and value status.
The other address ranges occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.
With 1oo2 evaluation of the sensors, two channels are combined, e.g. channel 0 (input word AI_0) with channel 4 (input word AI_4). In this example, you may only access the input bit AI_0 in the safety program with 1oo2 evaluation of the sensors.

Table 1-903 Address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB x + 0								HART gate*

* The function is supported as of firmware V2.0. Only evaluated if HART gate is configured as "Switchable".

x = Module start address

More information

For detailed information about F-I/O access and for evaluation and processing of the value status, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.5 Address space of additional submodules

⚠ WARNING

All values in the additional submodules are not safety-related and must therefore not be used for safety-related activities.

Address assignment of the additional submodule for configuration MSI

The following table shows the allocation of the address space:

Table 1-904 Address assignment in the input range of the additional submodule

Byte	Assigned bits per F-module							
	7	6	5	4	3	2	1	0
IB a + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/4)							
IB a + 1								
IB a + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/5)							
IB a + 3								
IB a + 4	Input value at channel 2 (Result of the 1oo2 evaluation channel 2/6)							
IB a + 5								
IB a + 6	Input value at channel 3 (Result of the 1oo2 evaluation channel 3/7)							
IB a + 7								
IB a + 8	Input value at channel 4							
IB a + 9								
IB a + 10	Input value at channel 5							
IB a + 11								
IB a + 12	Input value at channel 6							
IB a + 13								
IB a + 14	Input value at channel 7							
IB a + 15								
IB a + 16	Value status for AI_7	Value status for AI_6	Value status for AI_5	Value status for AI_4	Value status for AI_3	Value status for AI_2	Value status for AI_1	Value status for AI_0
IB a + 17	-	-	-	-	-	-	-	Value status for HART gate

a = Start address of the additional submodule

Reference

You can find information on the Shared Input/Output (MSI/MSO) functionality in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) Function Manual in the Module-internal shared input/shared output (MSI/MSO) section.

NOTE

If the module is in the reintegration state (ACK_REQ = true), the following scenario can occur: The input values and value status of the channels can have the value 0 in the basic submodule (see section Address space (Page 53)). At the same time, the input values and value status of the channels in the additional submodule configured with MSI can have a value not equal to 0.
In this case, the substitute values are output instead of the input values in the basic submodule. By contrast, the valid input values are already present in the additional submodule configured with MSI.

Address assignment of the additional submodule for HART configuration with 8 variables

The following table shows the allocation of the address space:

Table 1-905 Address assignment in the input range of the additional submodule

Byte	Assigned bits per F-module							
	7	6	5	4	3	2	1	0
IB a + 0	HART variable 1							
IB a + 1								
IB a + 2								
IB a + 3								
IB a + 4	Quality code HART variable 1							
IB a + 5	HART variable 2							
IB a + 6								
IB a + 7								
IB a + 8								
IB a + 9	Quality code HART variable 2							
IB a + 10	HART variable 3							
IB a + 11								
IB a + 12								
IB a + 13								
IB a + 14	Quality code HART variable 3							
IB a + 15	HART variable 4							
IB a + 16								
IB a + 17								
IB a + 18								
IB a + 19	Quality code HART variable 4							
IB a + 20	HART variable 5							
IB a + 21								

a = Start address of the additional submodule

IB a + 22	HART variable 5
IB a + 23	
IB a + 24	Quality code HART variable 5
IB a + 25	HART variable 6
IB a + 26	
IB a + 27	
IB a + 28	
IB a + 29	Quality code HART variable 6
IB a + 30	HART variable 7
IB a + 31	
IB a + 32	
IB a + 33	
IB a + 34	Quality code HART variable 7
IB a + 35	HART variable 8
IB a + 36	
IB a + 37	
IB a + 38	
IB a + 39	Quality code HART variable 8

a = Start address of the additional submodule

Address assignment of the additional submodule for HART configuration with 4 variables

The following table shows the allocation of the address space:

Table 1-906 Address assignment in the input range of the additional submodule

Byte	Assigned bits per F-module							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB a + 0	HART variable 1							
IB a + 1								
IB a + 2								
IB a + 3								
IB a + 4	Quality code HART variable 1							
IB a + 5	HART variable 2							
IB a + 6								
IB a + 7								
IB a + 8								
IB a + 9	Quality code HART variable 2							
IB a + 10	HART variable 3							
IB a + 11								
IB a + 12								
IB a + 13								
IB a + 14	Quality code HART variable 3							
IB a + 15	HART variable 4							
IB a + 16								

a = Start address of the additional submodule

IB a + 17	HART variable 4
IB a + 18	
IB a + 19	Quality code HART variable 4

a = Start address of the additional submodule

Address assignment of the additional submodule for configuration with multiHART

The following table shows the allocation of the address space:

Table 1-907 Address assignment in the input range of the additional submodule

Byte	**Assigned bits per F-module**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB a + 0	Channel number 0 ... 7				Variable identification			
IB a + 1	HART variable							
IB a + 2								
IB a + 3								
IB a + 4								
IB a + 5	Quality code HART variable							

a = Start address of the additional submodule (input range)

Table 1-908 Address assignment in the output range of the additional submodule

Byte	**Assigned bits per F-module**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB b + 0	Channel number 0 ... 7				Variable identification			

b = Start address of the additional submodule (output range)

Applications of the F-I/O module

7

7.1 Application cases of the F-AI 8xI 0(4)..20mA

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

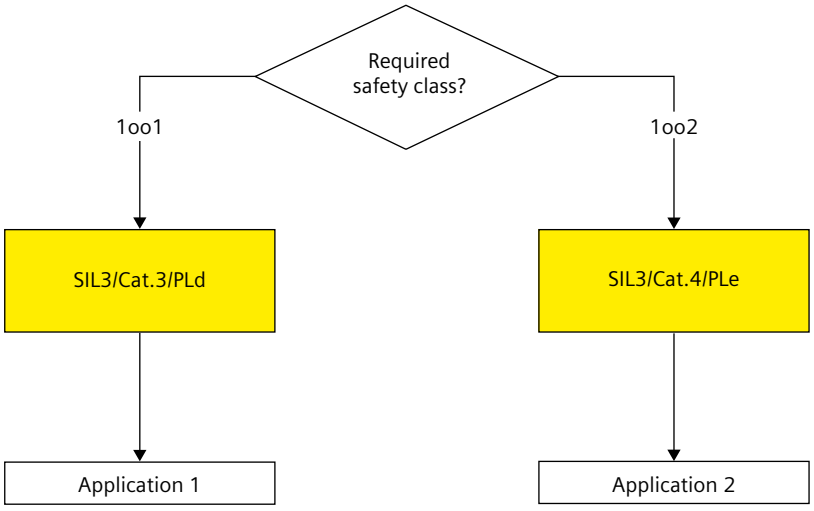


Figure 1-625 Select application case - Analog input module F-AI 8xI 0(4)..20mA

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the mission time in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 1-909 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Achievable SIL/Cat./PL
1	1oo1	3/3/d
2	1oo2	3/4/e

NOTE
You can operate the various inputs of an F-AI module simultaneously in SIL3/Cat.3/PLd **and** in SIL3/Cat.4/PLe. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules of the system manual S7-1500 Automation System (https://support.industry.siemens.com/cs/ww/en/view/59191792).

7.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (https://support.industry.siemens.com/cs/ww/en/view/59191792) system manual.

Sensor supply

The sensor supply can be powered internally or externally.

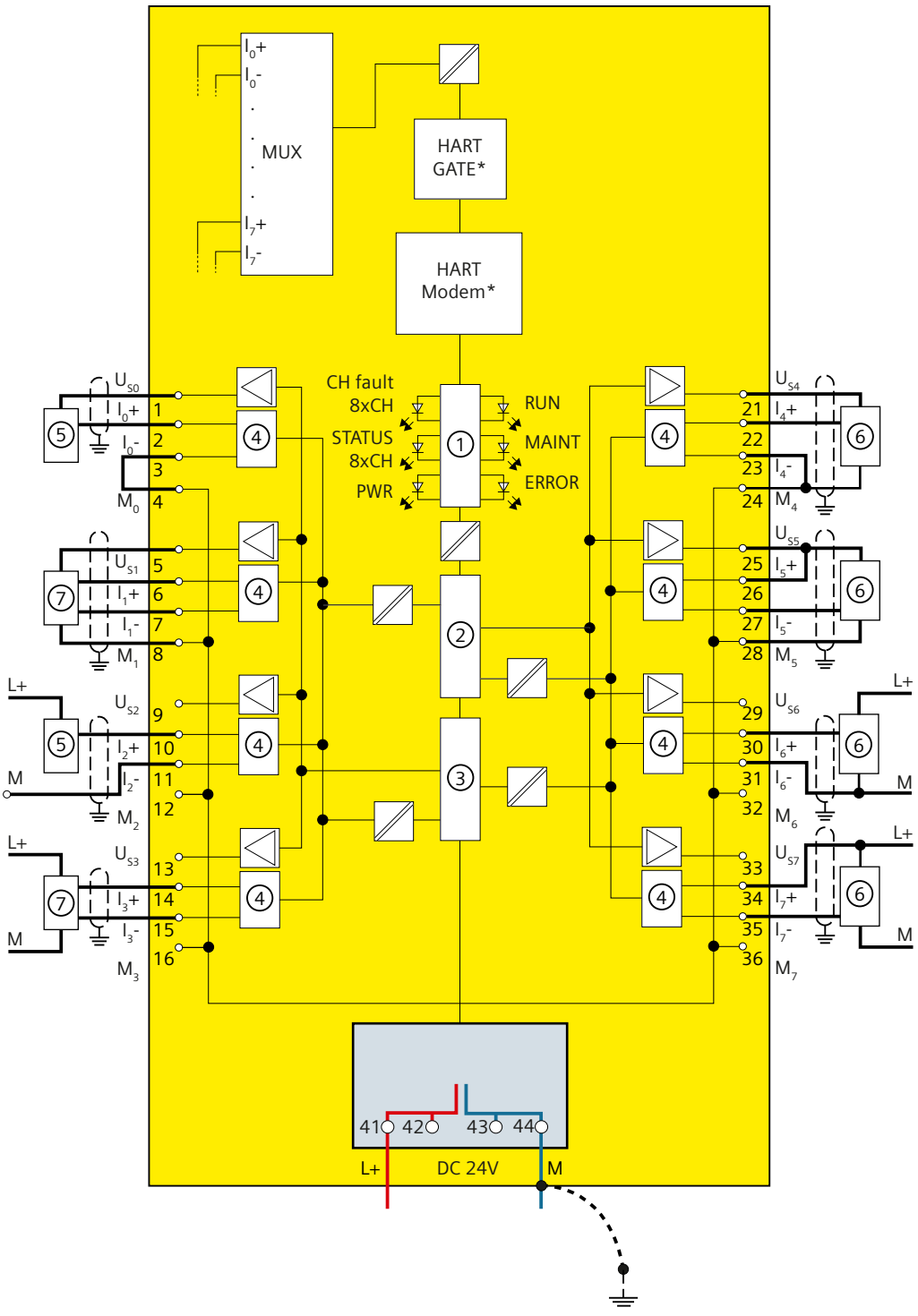
Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal.

The assignment of the sensor supply is defined by the terminals. There is one fused sensor supply per channel.

You can also supply the sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe analog input module F-AI 8xI 0(4)..20mA for connecting 1-channel sensors.



①	Backplane bus interface	RUN	LED status display (green)
②	Microcontroller 1	ERROR	LED for fault display (red)
③	Microcontroller 2	PWR	LED for power supply (green)
④	Signal evaluation	MAINT	LED for MAINT ALARM (yellow)

⑤	2-wire transducer	CH fault	LED for channel fault (red)
⑥	3-wire transducer	STATUS	LED for channel status (green)
⑦	4-wire transducer	*	The function is supported as of firmware V2.0.

Figure 1-626 One sensor connected via one channel

⚠ WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

⚠ WARNING

With 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Assignable parameters for application 1

Table 1-910 Parameters for application case 1 of F-AI 8xI 0(4)..20mA

Parameter	Value range in safety mode
Behavior after channel faults	• Passivate the entire module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0...20 mA • 4...20 mA
Diagnosis: Wire break	(in measuring range 4...20 mA) • Disable • Enable
Smoothing	1/2/4/8/16/32/64 conversion cycles

7.3 Application 2: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The analog input module F-AI 8xI 0(4)..20mA has 8 fail-safe inputs AI_0 to AI_7 (SIL3). You can combine two of these inputs each to one input.

You can combine the following inputs:

- AI_0 and AI_4
- AI_1 and AI_5
- AI_2 and AI_6
- AI_3 and AI_7

The process signals are provided by channels AI_0, AI_1, AI_2 and AI_3.

NOTE

You can mix 1oo1 evaluation and 1oo2 evaluation in an F-AI module. You must interconnect and configure the inputs according to the fail-safe requirements (SIL3/Cat.3/PLd and SIL3/Cat.4/PLe).

Wiring

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (https://support.industry.siemens.com/cs/ww/en/view/59191792) system manual.

Sensor supply

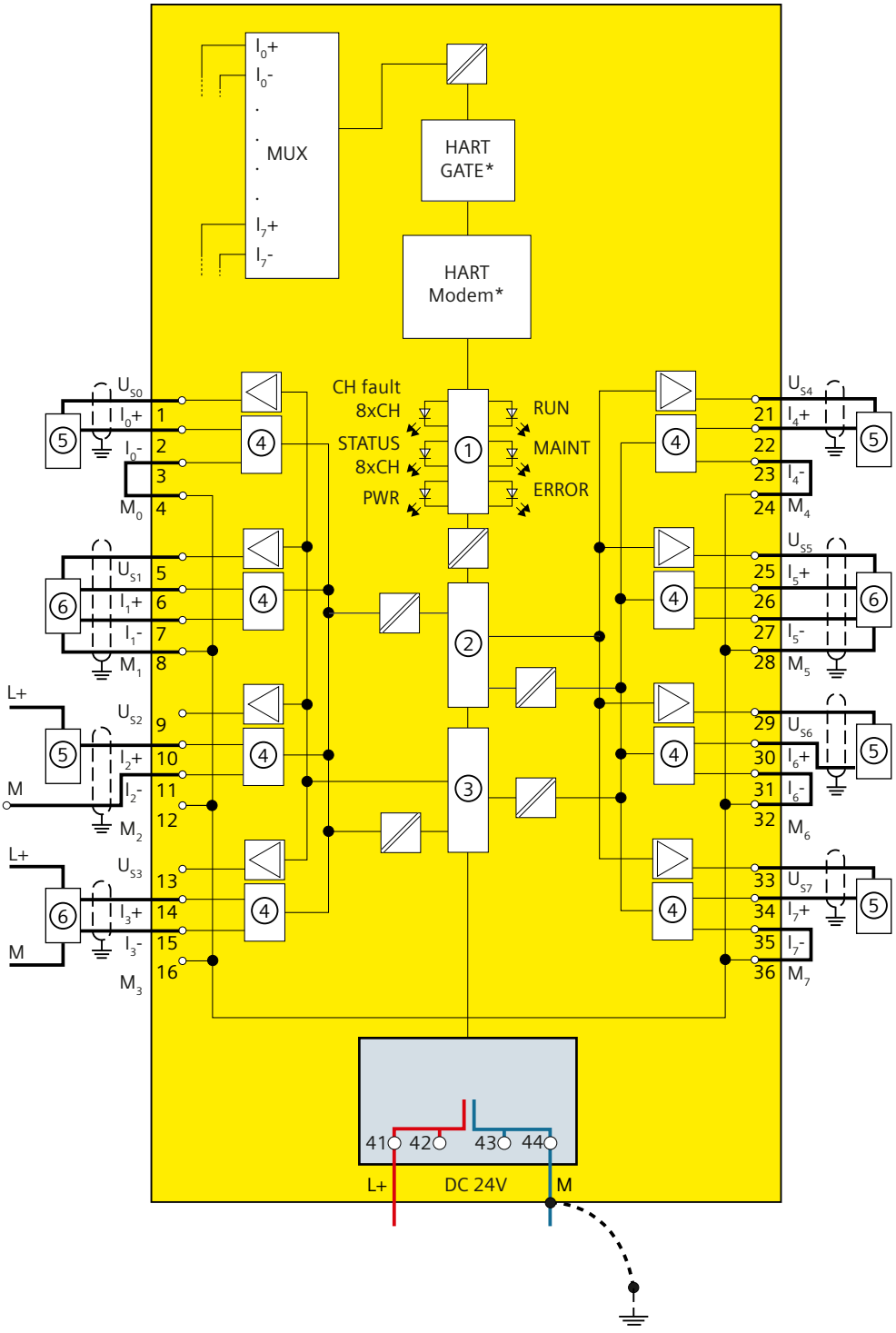
The sensor supply can be powered internally or externally.

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

You can also supply the sensors by means of an external sensor supply.

The figure below shows an example of the pin assignment of the fail-safe analog input module F-AI 8xI 0(4)..20mA for connecting 2-channel sensors.



①	Backplane bus interface	RUN	LED status display (green)
②	Microcontroller 1	ERROR	LED for fault display (red)
③	Microcontroller 2	PWR	LED for power supply (green)
④	Signal evaluation	MAINT	LED for MAINT ALARM (yellow)
⑤	2-wire transducer	CH fault	LED for channel fault (red)
⑥	4-wire transducer	STATUS	LED for channel status (green)
		*	The function is supported as of firmware V2.0.

Figure 1-627 Two single-channel sensors connected via 2 channels

⚠ WARNING

To achieve SIL3/Cat.4/PLe with this wiring, you must use suitably qualified sensors.

⚠ WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 2

Table 1-911 Parameters for application case 2 of F-AI 8xI 0(4)..20mA

Parameter	Value range in safety mode
Unit value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window abs.	0.3 to 20.0%
Tolerance window rel.	0.3 to 20.0%
Behavior after channel faults	• Passivate the entire module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	• 0...20 mA • 4...20 mA
Diagnosis: Wire break	(in measuring range 4...20 mA) • Disable • Enable
Smoothing	1/2/4/8/16/32/64 conversion cycles

Interrupts/diagnostic messages

8

8.1 Status and error displays

LED displays

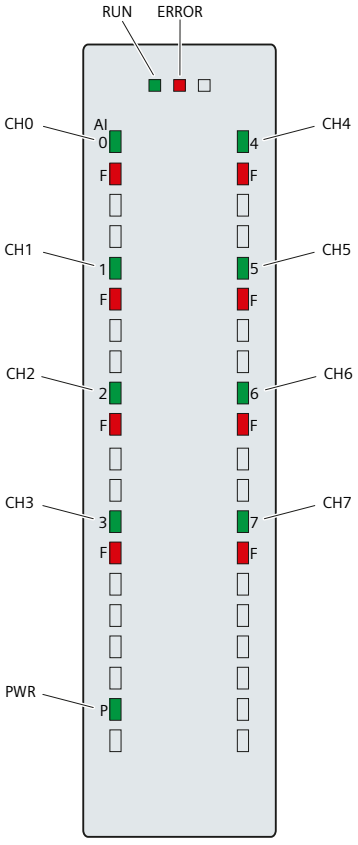


Figure 1-628 **LED displays of the F-AI 8xI 0(4)..20mA** module

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic alarms can be found in section Diagnostic alarms (Page 72).

WARNING

The RUN, ERROR LEDs and channel status/channel diagnostics LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

RUN and ERROR LEDs

Table 1-912 RUN and ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Missing or insufficient voltage on the backplane bus	• Switch on the CPU and/or the system power supply modules. • Check whether the module is correctly plugged into the U-connector. • Check whether too many modules are plugged in.
Flashing	Off	Module starts up and flashes up to the valid parameter assignment.	---
On	Off	Module parameters are assigned and module addressed.	
Off	Flashing	Firmware is being updated.	
On	Flashing	Indicates diagnostic interrupts: • Module fault (for example, supply voltage too high) • Channel fault (e.g. wire break) • PROFIsafe communication fault • At least one channel is waiting for user acknowledgment.	Evaluate the diagnostics and eliminate or acknowledge the error. It may be necessary to remove and re-insert the module.
Flashing	Flashing	Hardware defective.	Replace the module.
Alternately flashing		The F-module expects user acknowledgment after a module fault.	Acknowledge the error (see manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)).

PWR LED

Table 1-913 PWR status display

PWR LED	Meaning
Off	Power supply L+ missing
On	Power supply L+ available

CHx LED

Table 1-914 Display channel status/channel diagnostics

Status CHx	Diagnostics CHx	Meaning
Off	Off	Channel deactivated or power supply L+ missing.
On	Off	Channel activated and no channel diagnostics

Status CHx	Diagnostics CHx	Meaning
Off	On	Channel activated and channel diagnostics
On	On	Channel activated and diagnostics with HART protocol
Alternately flashing		Channel waiting for user acknowledgment

CHx/Error LED with PROFIsafe address assignment

Table 1-915 Channel status/channel diagnostics/Error display with PROFIsafe address assignment

Status CHx	Diagnostics CHx	ERROR	Meaning
Off	All on	Flashing	The PROFIsafe address does not match the configured PROFIsafe address
All are flashing	Off	Flashing	Identification of the F-module when assigning the PROFIsafe address

CHx/RUN/ERROR LED if power supply error occurs

Table 1-916 Channel status/channel diagnostics/RUN/ERROR display if power supply error occurs

CHx status	Diagnostics CHx	RUN	ERROR	Meaning
Off	On	On	Flashing	• Supply voltage too high or too low. • Module is waiting for user acknowledgment.

8.2 Interrupts

Introduction

The fail-safe analog input module F-AI 8xI 0(4)..20mA supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic alarm described in section Diagnostic alarms (Page 72).

The table below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Diagnostics Short-circuit
Before acknowledging the short-circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the troubleshooting procedure described in section Diagnostic alarms (Page 72)

Table 1-917 Diagnostic interrupts of the F-AI 8xI 0(4)..20mA

Diagnostic interrupt	Fault code	Signaled in application case	Scope of diagnostic interrupt	Configurable
Overtemperature	5_H	1, 2	F-module	No
Wire break	6_H		Channel	Yes
High limit exceeded	7_H			No
Low limit violated	8_H			
Parameter error	10_H		F-module	
Supply voltage missing	11_H			
Communication fault	13_H			
Channel/component temporarily not available	$1F_H$			
Mismatch of safety destination address (F_Dest_Add)	40_H			
Safety destination address not valid (F_Dest_Add)	41_H			
Safety source address not valid (F_Source_Add)	42_H			
Safety watchdog time value is 0 ms (F_WD_Time)	43_H			
Parameter F_SIL exceeds SIL from specific device application	44_H			
Parameter F_CRC_Length does not match the generated values	45_H			
Version of F parameter set incorrect	46_H			
CRC1 fault	47_H			
Device-specific diagnostics information, see manual	48_H			
Save iParameter watchdog time exceeded	49_H			
Restore iParameter watchdog time exceeded	$4A_H$			
Inconsistent iParameters (iParCRC error)	$4B_H$			
F_Block_ID not supported	$4C_H$			
Transmission error: Inconsistent data (CRC error)	$4D_H$			
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$			

Diagnostic interrupt	Fault code	Signaled in application case	Scope of diagnostic interrupt	Configurable
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	$4F_H$	1, 2	F-module	No
Watchdog tripped	103_H			
Internal supply voltage fault	104_H			
Invalid/inconsistent firmware present	$11B_H$			
Diagnostics queue overflow	$13E_H$			
HART parameter error	140_H		Channel	Yes
HART communication error	141_H			
HART primary variable out of range	142_H			
HART analog output current saturated	143_H			
HART output current of the field device fixed	144_H			
HART - more status available	145_H			
HART configuration changed	146_H			
HART field device malfunction	147_H			
HART - non primary variable out of limits	149_H			
Analog input signal not recorded unique	304_H		Channel	No
Internal sensor supply short-circuit to P	306_H		Channel	No
Overload or internal sensor supply short-circuit to ground	307_H		Channel	No
Channel failure acknowledgment	$30B_H$		Channel	No
F-address memory not accessible	$30D_H$		F-module	No
No valid F-address available	$30E_H$			
Undertemperature	312_H			
Discrepancy failure	314_H		Channel	No
Supply voltage too high	321_H		F-module	No
Supply voltage too low	322_H			
Safety related HART shutoff defective	$32A_H$			
F module error (0x032F)	$32F_H$			
ADC failure	331_H		Channel	No
Failure in the test circuit	332_H			

8.3 Diagnostic alarms

Diagnostic alarms

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For more information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Table 1-918 Diagnostic alarms of the F-AI 8xI 0(4)..20mA

Diagnostic alarm	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 78)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_H	Possible causes: • A cable to the sensor is broken. • Fault at the external circuit • Defective sensor • Wrong sensor type set in the parameters • Input channel not used • Measurement resistance too high	Check the possible causes and eliminate the fault.
High limit exceeded	7_H	The measured value exceeds the measuring range.	Check the interaction between the module and the sensor.
Low limit violated	8_H	The measured input value is below a measuring range.	Check the interaction between the module and the sensor.
Parameter error	10_H	Parameter errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient power supply L+	• Check power supply L+ at the front connector • Check the front connector
Communication fault	13_H	The module is defective.	Replace the module.
Channel/component temporarily not available	$1F_H$	Possible causes: • Internal fault in the F-module • Firmware update error	• Replace the F-module. • Repeat the firmware update.

Diagnostic alarm	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The firmware of the F-module has detected an illegal different F-destination address.	
Safety source address not valid (F_Source_Add)	42_H	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The firmware of the F-module has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	Check the parameter assignment of the PROFIsafe driver.
Save iParameter watchdog time exceeded	49_H	iPar server does not respond to "save IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Restore iParameter watchdog time exceeded	$4A_H$	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	$4B_H$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The firmware of the F-module has detected an incorrect F_block_ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	$4F_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.

Diagnostic alarm	Fault code	Meaning	Remedy
Watchdog tripped	103_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Internal supply voltage fault	104_H	Internal voltage is too low.	Replace the F-module.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostics queue overflow	$13E_H$	Overflow of the diagnostics memory. It was not possible to send all pending diagnostics. This error can lead to deactivation of the F-module and even to switch off/on of the power supply.	Remedy the cause of the diagnostics surge.
HART parameter error	140_H	The module has detected an error in a HART parameter data record.	Check and correct the HART-specific parameters.
HART communication error	141_H	• HART field device does not reply • Timing error • HART field device did not understand the command that was sent (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set output current ≥4 mA • Increase number of configured repetitions
HART primary variable out of range	142_H	• Incorrect parameters in the HART field device • HART field device is set to "Primary variable out of limits" in simulation mode • Incorrect measuring point • Assigned primary variable is outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct measuring transducer is connected
HART analog output current saturated	143_H	The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART output current of the field device fixed	144_H	The output current of the HART field device is permanently set: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART - more status available	145_H	The HART field device identifier for "Additional status information available" has been set in the HART device status (in the 2nd status byte).	Read out status with HART command 48 and clear error/cause if necessary

Diagnostic alarm	Fault code	Meaning	Remedy
HART configuration changed	146_H	The identifier for "re-parameterization" of the HART field device has been set in the HART device status (in the 2nd status byte).	If a diagnostic interrupt is not to be triggered for the re-parameterization, the diagnostic interrupt must not be enabled.
HART field device malfunction	147_H	In the HART device status (in the 2nd status byte), the field device reports a malfunction.	• Read out status with HART command 48 and clear error/cause if necessary • Replace field device
HART - non primary variable out of limits	149_H	• Incorrect parameters in the HART field device • HART field device is set to "Non primary variable out of limits" in simulation mode • Incorrect measuring point • Assigned non primary variable is outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct measuring transducer is connected
Analog input signal not recorded unique	304_H	Measured values from the sensor are not plausible. Possible causes: • Increased EMC • F-module defective	Check the interaction between the F-module and the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • There is a short-circuit of the internal sensor supply with L+. • There is a short-circuit of two sensor supplies. • The sensor is defective.	• Eliminate the short-circuit in the process wiring. • Replace the sensor.
Overload or internal sensor supply short-circuit to ground	307_H	• The internal sensor supply is overloaded. • Missing or insufficient power supply L+.	• Eliminate the short-circuit in the process wiring.
Channel failure acknowledgment	$30B_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	$30D_H$	The F-source address and F-destination address stored in the electronic coding element cannot be accessed.	Verify that the coding element is present. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is saved in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between target and actual configuration of the plant.	• In the case of initial commissioning or deliberate parameter change, assign the PROFIsafe address. • Check the consistency of the target and actual configuration.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 78))
Discrepancy failure	314_H	The discrepancy time set for 1oo2 operation has been exceeded. Possible causes of the discrepancy failure: • Incorrect parameter assignment • Wire break in the sensor's supply cable	Check the discrepancy time, the sensors and the cabling.
Supply voltage too high	321_H	The power supply is too high.	Check the power supply.
Supply voltage too low	322_H	The power supply is too low.	Check the power supply.

Diagnostic alarm	Fault code	Meaning	Remedy
Safety related HART shutoff defective	$32A_H$	The signal module has a malfunction in the safety-related HART shutoff. Cause: Fault in the F-module	Replace the F-module.
F module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. The module must be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
ADC failure	331_H	Internal error during analog-digital conversion. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Failure in the test circuit	332_H	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

NOTE

HART diagnostics for PROFIBUS IM with GSD file

For PROFIBUS IM with GSD file, the HART diagnostics are represented by "External error".

NOTE

HART diagnostics

HART diagnostics are generated in parallel and additionally in the event of wire break and over/underflow.

Power supply outside the nominal range

If the power supply L+ is outside the specified value range, the ERROR LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute, see Technical specifications (Page 78)), the ERROR LED stops flashing. The module remains passivated and waits for user acknowledgment.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all F-modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

Applications of the F-I/O module (Page 59)

8.4 Value status

Properties

In addition to the diagnostic messages and the status and fault display, the F-module provides information about the validity of each analog input signal – the value status. The value status is entered in the process image along with the input signal.

Value status for analog input and output modules

The value status is the binary additional information of an analog input signal. The value status is entered in the process image of the inputs at the same time as the process value. It provides information about the validity of the analog input signal.

The value status is affected by all faults.

- 1_B: A valid process value is output for the channel.
- 0_B: A substitute value is output for the channel, or the channel is deactivated.

NOTE

You may only access the addresses occupied by user data and value status.
The other address ranges occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.
1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors, you can only access the low order channel in the safety program, e.g. channel 0.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image inputs. You can find the assignment in section Address space (Page 53).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

9

Technical specifications of F-AI 8xI 0(4)..20mA

The table below shows the technical specifications as of 06/2024. A data sheet with technical specifications updated on a daily basis can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7536-1MF00-0AB0/td?dl=en).

Article number	6ES7536-1MF00-0AB0
General information	
Product type designation	F-AI 8xI 0(4) ... 20 mA
Firmware version	
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V18 with HSP0394 (FW V1.0) / V19 with HSP0451 (FW V2.0)
• PROFINET from GSD version/GSD revision	V2.42 / -
Operating mode	
• MSI	Yes; firmware V2.0 or higher
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA
Current consumption, max.	2.5 A; All channels are supplied from the encoder supply
Encoder supply	
Number of outputs	8
Short-circuit protection	Yes
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes
• Output current per channel, max.	300 mA
Power	
Power available from the backplane bus	0.5 W
Power loss	
Power loss, typ.	2.5 W

Article number	6ES7536-1MF00-0AB0
Address area	
Address space per module	
• Inputs	23 byte
• Outputs	6 byte
Hardware configuration	
Automatic encoding	Yes
Analog inputs	
Number of analog inputs	8
permissible input current for current input (destruction limit), max.	35 mA
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
– Input resistance (0 to 20 mA)	150 Ω
• 4 mA to 20 mA	Yes
– Input resistance (4 mA to 20 mA)	150 Ω
Cable length	
• shielded, max.	1 000 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	20 / 16,667
• Interference voltage suppression for interference frequency f1 in Hz	50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	7
• parameterizable	Yes
• Step: None	Yes; 1x conversion time
• Step: low	Yes; 2x / 4x conversion cycle time
• Step: Medium	Yes; 8x / 16x conversion cycle time
• Step: High	Yes; 32x / 64x conversion cycle time
Encoder	
Connection of signal encoders	
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.05 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, max.	-70 dB

Article number	6ES7536-1MF00-0AB0
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.3 %; without HART communication
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.05 %; without HART communication
Influence of a HART signal modulated on the input signal in relation to input range	
• error occurred at interference frequency suppression: 60 Hz	0.12 %
• error occurred at interference frequency suppression: 50 Hz	0.12 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
• Common mode voltage, max.	60 V DC/30 V AC
• Common mode interference, min.	70 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
Potential separation	
Potential separation analog inputs	
• between the channels	No
• between the channels, in groups of	4
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	60 V DC/30 V AC

Article number	6ES7536-1MF00-0AB0
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 4.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	40 °C
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	290 g

Operational error limit in overall temperature range

⚠ WARNING

When designing the safety function, you must take into account the "Operational error limit in overall temperature range" information for the entire mission time.

Dimension drawing

See S7-1500 Automation System (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual.

Response times

A

Introduction

The next section shows the response times of the analog input module F-AI 8xI 0(4)..20mA. The response times of F-AI 8xI 0(4)..20mA analog input module are included in the calculation of the F-system response time.

Definition of cycle time for fail-safe analog inputs

The response time results from the number of channels/channel pairs, the response time per channel/channel pair, the basic response time and the configured smoothing.

Times required for the calculation

- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 25 ms
- Basic response time: 8 ms
- Response time per channel pair
  - At 50 Hz: 23 ms
  - At 60 Hz: 20 ms

Conversion cycle time = Basic response time + (N × Response time per channel pair)

(N = Number of active channel pairs)

The conversion cycle time is the time in which all activated channels are processed/converted once.

Channel pairs are: 0-4, 1-5, 2-6, 3-7

If you use only one channel of the channel pair, the channel pair is considered used.

Example:

Activated channels: 0, 4, 1, 5 => N = 2

Activated channels: 0, 4, 1, 2 => N = 3

Typical response time

You can calculate the typical response time of F-AI 8xI 0(4)..20mA using the following formula:

Typical response time = Conversion cycle time × Smoothing

Maximum response time with no faults (Worst Case Delay Time, WCDT)

You can calculate the maximum response time of F-AI 8xI 0(4)..20mA (Worst Case Delay Time, WCDT) using the following formula:

Max. response time = 2 × Conversion cycle time × Smoothing

Response time in the case of a fault (one fault delay time, OFDT)

You calculate the response time of the F-AI 8xI 0(4)..20mA (One Fault Delay Time, OFDT):

- According to the following formula if a discrepancy error is present:

  Typical response time = Conversion cycle time × Smoothing + Discrepancy time + Conversion cycle time

  Maximum response time = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time
- According to the following formula if a channel fault is present:

  Typical response time = Conversion cycle time

  Max. response time = 2 × Conversion cycle time

This means that, for OFDT, the time on occurrence of a discrepancy error should be taken with parameter assignment "1oo2 evaluation (max. SIL3/Cat.4/PLe)" and the time on occurrence of a channel fault should be taken with parameter assignment "1oo1 evaluation (max. SIL3/Cat.3/PLd)".

Representation of analog values

B

This section shows the analog values for all measuring ranges that you can use with the F-AI 8xI 0(4)..20mA analog input module.

Measured value resolution

The analog values are shown as fixed-point number in two's complement.

The resolutions shown here are 16 bits including sign.

Table 1-919 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of analog values

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 1-920 Current measuring range 0 to 20 mA

Values		Current measuring range	Range
Dec.	Hex.	0 to 20 mA	
32512	$7F00_H$	> 23.518 mA	Overflow
32511 . . 27649	$7EFF_H$ . . $6C01_H$	23.518 mA . . 20.0007 mA	Overrange
27648 . . 614	$6C00_H$ . . 266_H	20 mA . . 0.4442 mA	Nominal range
613 . . 1 0	265_H . . 1_H 0_H	< 0.4442 mA . . 723.4 nA 0 mA	Wire break

Table 1-921 Current measuring range 4 to 20 mA

Values		Current measuring range	Range	
Dec.	Hex.	4 to 20 mA	Diagnostics wire break: No	Diagnostics wire break: Yes
32512	$7F00_H$	> 22.814 mA	Overflow	Overflow
32511 . . 27649	$7EFF_H$ . . $6C01_H$	22.814 mA . . 20.0006 mA	Overrange	Overrange

Values		**Current measuring range**	**Range**	
27648 . . 1 0	$6C00_H$ . . 1_H 0_H	20 mA . . 4 mA + 578.7 nA 4 mA	Nominal range	Nominal range
-1 . . -691	$FFFF_H$ . . $FD4D_H$	3.9994 mA . . 3.6 mA	Underrange	Underrange
-692 . . -6144	$FD4C_H$ . . $E800_H$	< 3.6 mA . . 0.4444 mA		Wire break
-6145	$E7FF_H$	< 0.4444 mA	Underflow	

HART operating data records

C

C.1 HART operating data records

Read/write data in RUN

HART operating data records are transferred to the module with the "WRREC" instruction and read from the module with the "RDREC" instruction.

Errors during transmission are indicated at the output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART request Channel 0	240	Yes	Yes
81	HART response Channel 0	240	No	Yes
82	HART request Channel 1	240	Yes	Yes
83	HART response Channel 1	240	No	Yes
84	HART request Channel 2	240	Yes	Yes
85	HART response Channel 2	240	No	Yes
86	HART request Channel 3	240	Yes	Yes
87	HART response Channel 3	240	No	Yes
88	HART request Channel 4	240	Yes	Yes
89	HART response Channel 4	240	No	Yes
90	HART request Channel 5	240	Yes	Yes
91	HART response Channel 5	240	No	Yes
92	HART request Channel 6	240	Yes	Yes
93	HART response Channel 6	240	No	Yes
94	HART request Channel 7	240	Yes	Yes
95	HART response Channel 7	240	No	Yes
121	HART variables	160	No	Yes
131	HART parameters Channel 0	8	Yes	Yes
132	HART parameters Channel 1	8	Yes	Yes
133	HART parameters Channel 2	8	Yes	Yes
134	HART parameters Channel 3	8	Yes	Yes
135	HART parameters Channel 4	8	Yes	Yes
136	HART parameters Channel 5	8	Yes	Yes
137	HART parameters Channel 6	8	Yes	Yes
138	HART parameters Channel 7	8	Yes	Yes
140	HART mapping parameters	12 or 20	Yes	Yes
148	HART directory	25	No	Yes
149	HART feature data	3	No	Yes

C.2 HART directory (DS 148)

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 8
5	Write Read Index Offset	= 1 (The response to a request data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records are not configurable. Data records starting from data record number 80 (80, 82, 84, 86, 88, 90, 92, 94) are always used.

C.3 HART feature data (DS 149)

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit 1 = 1: "Parameter check result is given with a read response" Bit5 = 1: “compact format is supported”
1	Byte 1	= 0
2	Max Length Data Unit	= 230 (maximum length of the HART request data)

C.4 HART variable data record (DS 121)

The analog module F-AI 8xI 0(4)..20mA supports a maximum of 4 HART variables per channel. Provided they are supported by the connected field device, these variables are read cyclically.

These 32 HART variables are made available as readable variables in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a 1-byte quality code.

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0 ... 3	Value	PV (Primary Variable)
4	Quality code	
5 ... 8	Value	SV (Secondary Variable)
9	Quality code	
10 ... 13	Value	TV (Tertiary Variable)
14	Quality code	
15 ... 18	Value	QV (Quaternary Variable)
19	Quality code	
Channel 1		
20 ... 39	HART variables same as for channel 0	
Channel 2		
40 ... 59	HART variables same as for channel 0	
Channel 3		
60 ... 79	HART variables same as for channel 0	
Channel 4		
80 ... 99	HART variables same as for channel 0	
Channel 5		
100 ... 119	HART variables same as for channel 0	
Channel 6		
120 ... 139	HART variables same as for channel 0	
Channel 7		
140 ... 159	HART variables same as for channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

C.5 HART-specific settings (DS 131 to DS 138)

HART communication is available via the standard configuration (see Parameters (Page 34)).

Additional HART-specific settings can be specified channel-specifically via data records 131 to 138.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Channel	Data record number
0	131
1	132
2	133
3	134
4	135
5	136
6	137
7	138

Structure of the HART-specific settings

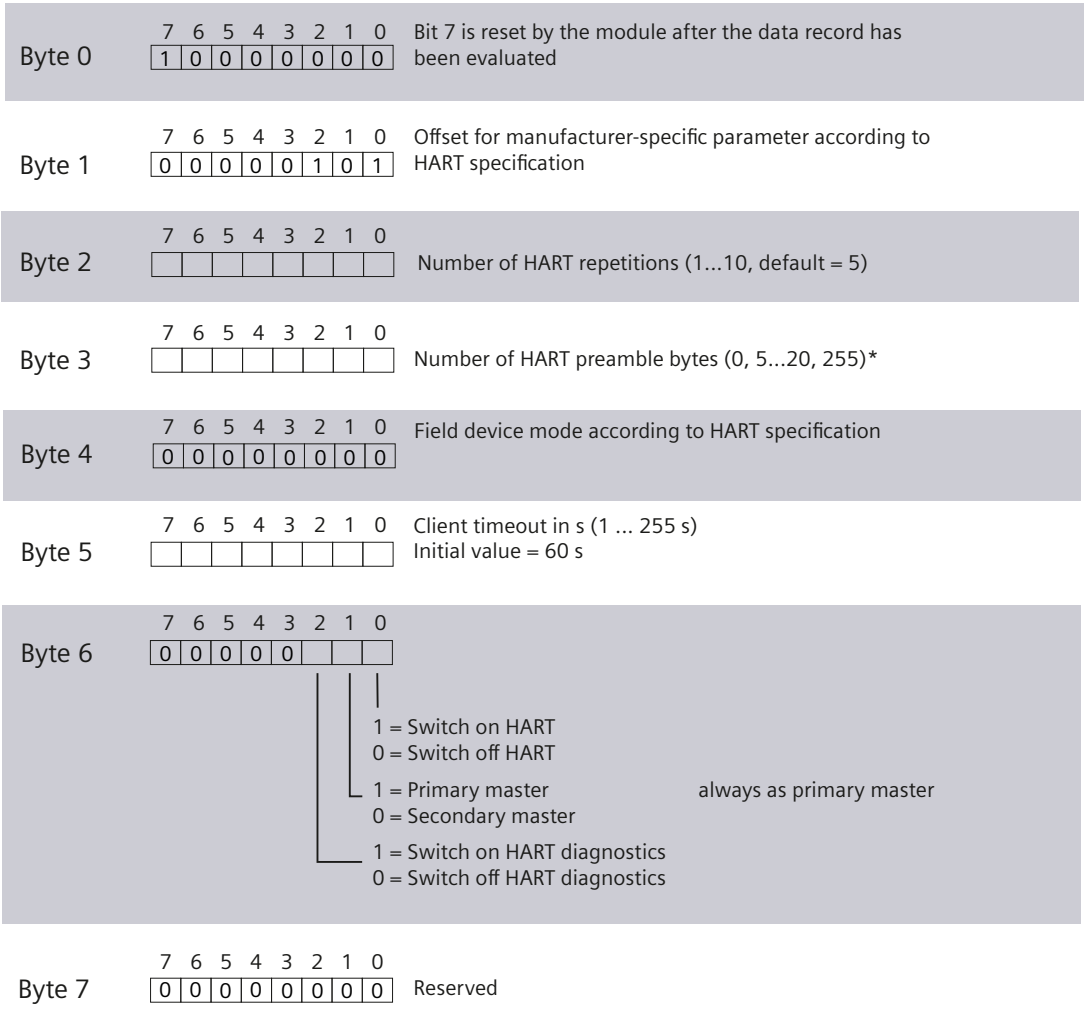


Figure 1-629 Settings

* If the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device is used, but at least 5.

If the number of HART preamble bytes = 255, 20 preamble bytes are used.

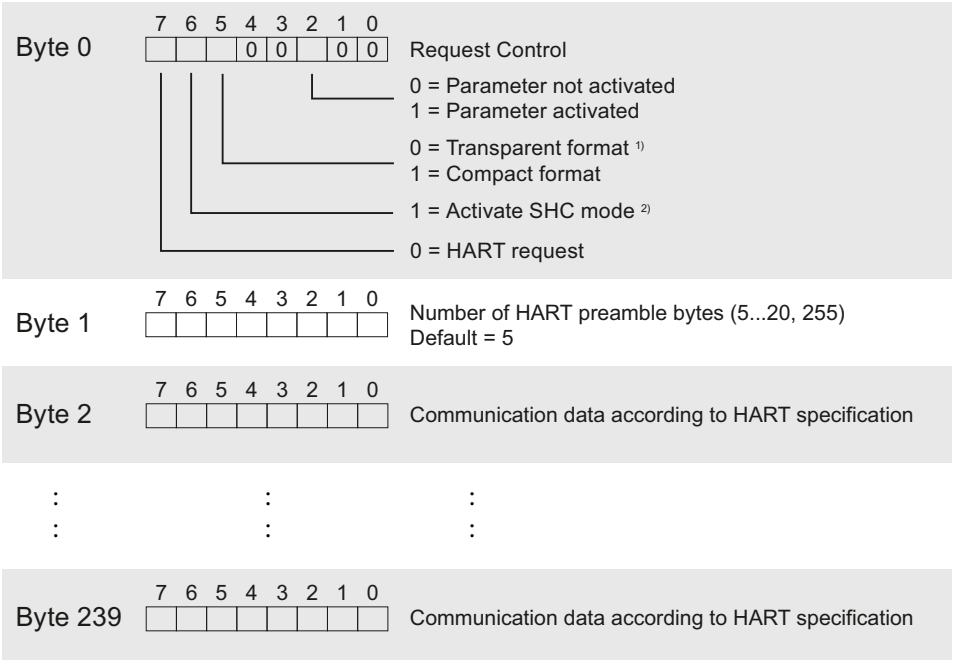
C.6 HART request and response data records (DS 80 to DS 95)

HART commands are processed channel-specifically via a separate command interface, each with a request data record and a response data record.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

Channel	Data record number	
	Request to the field device	Response from the field device
4	88	89
5	90	91
6	92	93
7	94	95

Structure of the request data records 80, 82, 84, 86, 88, 90, 92, 94



1) HART commands are processed by the analog module in transparent message format and in compact message format. However, the response data from the module is always made available in transparent message format.

2) When a sequence of HART commands in the form of an SHC sequence is processed, this affects all other channels with activated HART. See HART command interface (Page 29) SHC sequence.

Figure 1-630 Request data record

NOTE

If "Number of HART preamble bytes" = 255, the number of preambles set via the parameters is used. 5 are set by default. You can change the configured number of preamble bytes via the parameters as well as via the HART-specific settings (see HART-specific settings (DS 131 to DS 138) (Page 89)).

Structure of the response data records 81, 83, 85, 87, 89, 91, 93, 95

In case of successful response

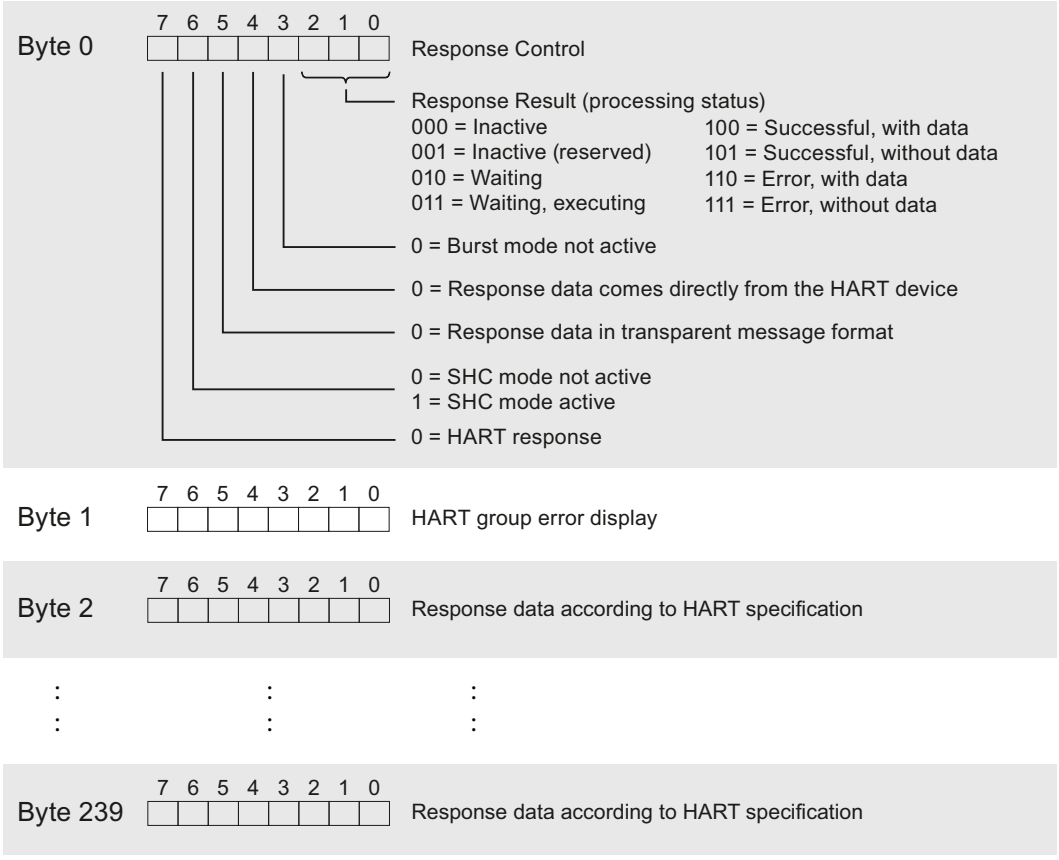
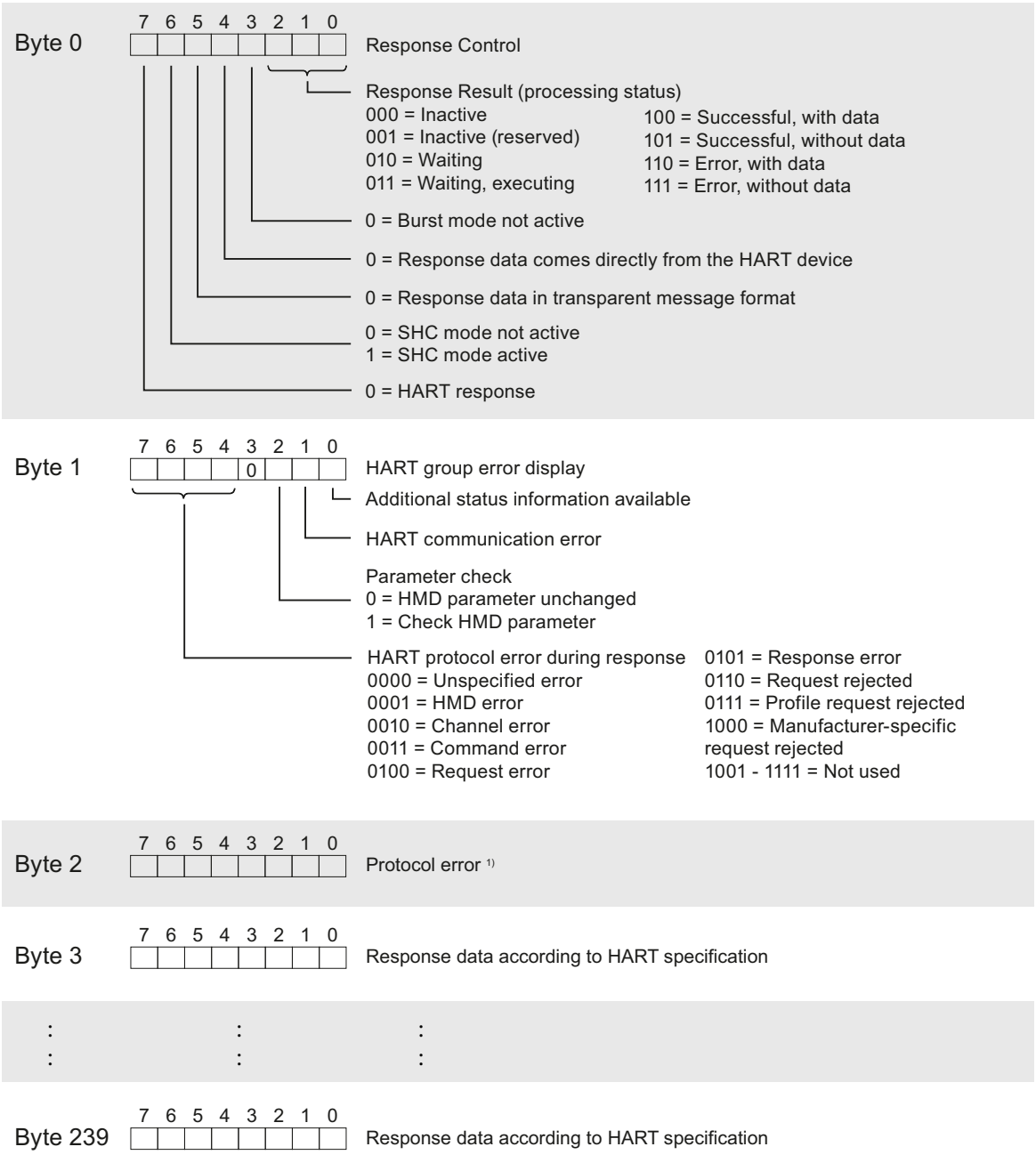


Figure 1-631 Response data record in case of successful response

In case of response error



1) See table: "HART protocol error during response" coding

Figure 1-632 Response data record in case of response error

Table 1-922 "HART protocol error during response" coding

HART protocol error with response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6 ... 127: Reserved 128 ... 255: Manufacturer-specific
2	Channel error	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6 ... 127: Reserved 128 ... 255: Manufacturer-specific
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 5 ... 127: Reserved 128 ... 255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

Example of HART programming (HART command interface)

For HART channel 0, command 01 is to be sent in Transparent Message Format to the HART field device with the address "2A 2F 00 59 D3".

A positive edge at input 4.0 of a digital input module causes the HART command to be written.

The following assumptions are made:

- The identification number of the hardware component of the analog module F-AI 8xI 0(4)..20mA is 266 ($10A_H$).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

Symbol	Address	Data type	Comment
T_DS80	I 4.0	Bool	Button of DS80
M_PF_WR	M 104.0	Bool	Positive edges auxiliary flag WRREC
M_WR_Done	M 51.0	Bool	Flag =1 : Data record was transferred
M_WR_Busy	M 51.1	Bool	Flag =1 : Writing has not yet finished
M_WR_Error	M 51.2	Bool	Flag =1 : An error occurred when writing.
MD_WR_Sta-tus	MD 93	DWord	WRREC block status or error information
DB80	DB80	DB80	The data record is stored in DB80

```
SCL                                 Explanation
"R_TRIG_DB"(CLK:="T_DS80",
  Q=>"M_PF_WR");
WHILE "M_PF_WR" DO
  "WRREC_DB"(REQ := TRUE,
    ID := 266,                      Identification number of the hardware component
    INDEX := 80,                    Data record number 80
    LEN := 11,                      Data record length 11 bytes
    DONE => "M_WR_Done",            Done= True: Data record was transferred
    BUSY => "M_WR_Busy",            BUSY= True: Writing has not yet finished
    ERROR => "M_WR_Error",          ERROR = True: An error occurred when writing.
    STATUS => "MD_WR_Status",       Block status or error information
    RECORD := P#DB80.DBX0.0 BYTE    Data record with length of 11 bytes (must corres-
11                                  pond to the exact length that is to be transferred)
  );
  IF ("M_WR_Done"                   Exit loop immediately if data record was trans-
OR "M_WR_Error") THEN               ferred or an error occurred.
    EXIT;
    ;
  END_IF;
  ;
END_WHILE;
```

Table 1-923 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	2A	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	2F	
5	00	
6	59	
7	D3	
8	01	Command (CMD)
9	00	Length in bytes
10	0D	Checksum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

A HART command can also be sent in Compact Message Format. In this case, the data transmitted via DB 80 is reduced to 4 bytes.

Table 1-924 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format. 60 = Compact message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Symbol	Address	Data type	Comment
T_DS81	I 4.1	Bool	Button of DS81
M_PF_RD	M 104.1	Bool	Positive edges auxiliary flag RDREC
M_RD_Done	M 49.0	Bool	Flag = True : New data record was received and is valid
M_RD_Busy	M 49.1	Bool	Flag = True : Reading has not yet finished.
M_RD_Error	M 49.2	Bool	Flag = True : An error occurred when reading
MD_RD_Status	MD 100	DWord	RDREC block status or error information
MW_RD_Len	MW104	Word	The read length of the data record
DB81	DB81	DB81	The read data record is stored in DB81

```
SCL                                    Explanation
"R_TRIG_DB_1"(CLK:="T_DS81",
  Q=>"M_PF_RD");
```

```
WHILE "M_PF_RD" DO
  "RDREC_DB"(REQ:=TRUE,
    ID:=266,                        Identification number of the hardware component
    INDEX:=81,                      Data record number 81
    MLEN:=255,                      Maximum length in bytes of the data record informa-
                                    tion to be read
    VALID=>"M_RD_Done",             New data record was received and is valid
    BUSY=>"M_RD_Busy",              BUSY = True: Reading has not yet finished.
    ERROR=>"M_RD_Error",            ERROR = True: An error occurred when reading
    STATUS=>"MD_RD_Status",         Block status or error information
    LEN=>"MW_RD_Len",               Read length of the data record
    RECORD:=P#DB81.DBX0.0 BYTE      Data record
255
  IF ("M_RD_Done"                   Exit loop immediately if data record was trans-
OR "M_RD_Error") THEN               ferred or an error occurred.
    EXIT;
    ;
  END_IF;
  ;
END_WHILE;
```

As long as "0x03" is in byte 0 of DB81, the response has not been received from the field device. As soon as bit 2 = 1 in byte 0, there is positive response data from the field device that you can evaluate.
In the event of incorrect response data, see the tables "HART group error display" in byte 1 or "HART protocol error on response" in byte 2 of the response from the field device.

C.7 Parameter assignment and structure of the HART mapping parameters (DS 140)

Structure of data record 140

Data record 140 has a length of 20 bytes.

You can use the parameters of data record 140 to configure/map up to 8 HART variables in the additional submodules of the module, provided the corresponding configuration is selected, see "HART mapping (Page 51)".

Data record 140 is then only evaluated by the module if 4 HART or 8 HART variables are configured.

Header information

The figure below shows the structure of the header information.

	7 6 5 4 3 2 1 0	
Byte 0		Version = 0
Byte 1		Block length = 19 bytes
Byte 2		Block type = 75
Byte 3		Reserved = 0

Figure 1-633 Header information

Parameters

The following figure shows the configuration of the 8 HART variables 1 ... 8.

	7 6 5 4 3 2 1 0	
Byte x*		Channel: 0...7
Byte x+1		Variable identifier: 0 = None 1 = PV (Primary variable) 2 = SV (Secondary variable) 3 = TV (Tertiary variable) 4 = QV (Quaternary variable)

* x = 4 + (HART variable - 1) * 2; with HART variable 1 ... 8

Figure 1-634 Parameters

SIEMENS

SIMATIC

ET 200MP
Digital output module F-DQ 8x24VDC/2A PPM (6ES7526-2BF00-0AB0)

Equipment Manual

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Applications of the F-I/O module 5

Interrupts/diagnostic messages 6

Technical specifications 7

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Switching of loads B

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Preface

Purpose of the documentation

This manual supplements the system manual S7-1500 Automation System. You can find information on the functions that apply generally to the S7-1500 automation system and the ET 200MP distributed I/O system in the system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

The information provided in this manual and the system manual enables you to commission the S7-1500 automation system and ET 200MP distributed I/O system.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes identified as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which particular attention should be paid.

Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators by means of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

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For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this in the appendix.

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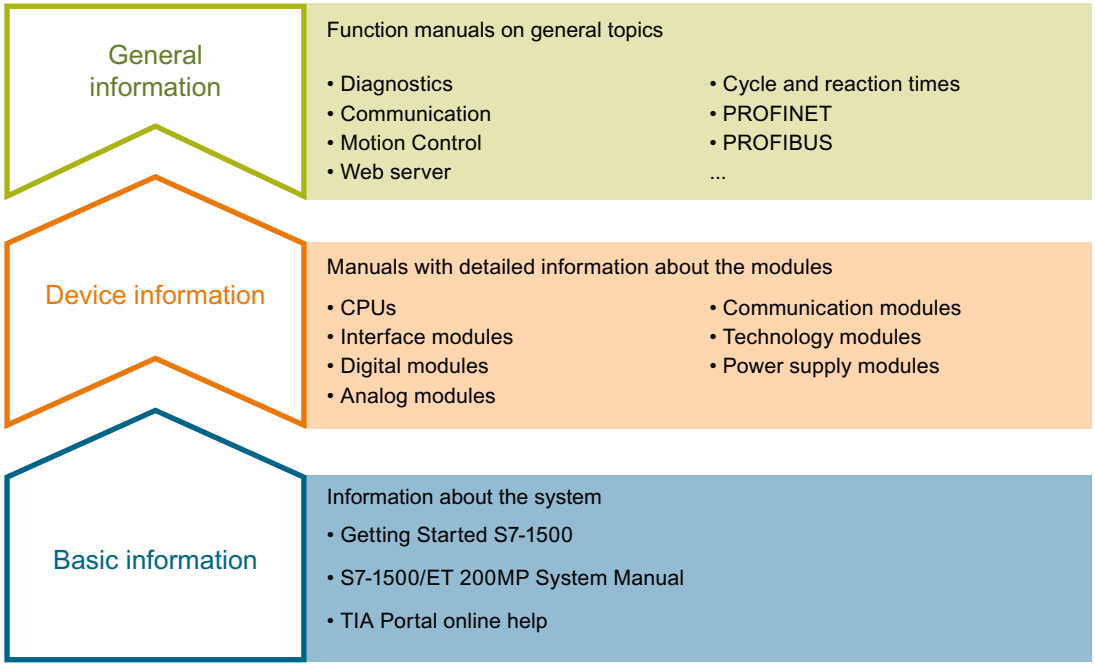
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Documentation guide

1

1.1 Guide to documentation S7-1500 / ET 200MP

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information
The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information
Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information
The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (http://www.automation.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-controllers/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet.

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/86140384).

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"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Order number

6ES7526-2BF00-0AB0

View of the module

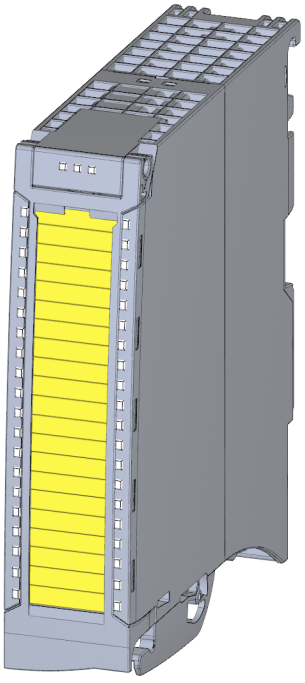


Figure 1-635 View of the F-DQ 8x24VDC/2A PPM module

Properties

- Technical properties
  - Fail-safe digital module for use in the S7-1500 automation system and in the ET 200MP distributed I/O system.
  - PROFIsafe
  - PROFIsafe address type 2
  - Supports the RIOforFA-Safety profile (on S7-1500 F-CPUs)
  - 8 output PM-switching or PP-switching in 2 channel groups (SIL3/Cat.4/PLe)
  - Supply voltage L+

  - Output current per output 2 A
  - Source output (PM/PP-switching)
  - Suitable for solenoid valves, DC contactors and signal lamps
  - Status display RUN (green LED)
  - Status display module diagnostics (red LED)
  - Status display channel status/channel diagnostics per output (green/red LED)
  - Status display supply voltage (green LED)
  - Diagnostics, e.g., short-circuit/wire break/load voltage missing, channel-specific
  - Channel-specific or module-wide passivation
- Supported functions
  - Firmware update
  - I&M identification data

⚠ WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, switch off the supply voltage of the affected module before 100 hours expires. The module switches off independently after the 100 hours have expired.
Follow the repair procedure described in section Diagnostic alarms (Page 43).

Accessories

The following accessories are supplied with the module and can also be ordered as spare part:

- Labeling strips
- U-connector
- Universal front cover
- Electronic coding element

Additional components

The following component is to be ordered separately:

- Front connector incl. potential bridges and cable ties

You can find additional information on accessories in the S7-1500/ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

Passivation of fail-safe outputs over a long period of time

⚠ WARNING

Unintentional activation of F-I/O with fail-safe outputs
If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.
Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.
One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.
The required measures are standardized for plants with product standards.
For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Connecting

3

3.1 Block diagram

This section includes:

- The block diagram with the general pin assignment of the F-module.
- An example for switching of loads with ground.

For information on parameter assignment of the F-module, refer to "Parameters/address space (Page 16)".

Information on different connection options is available in the section Applications of the F-I/O module (Page 28).

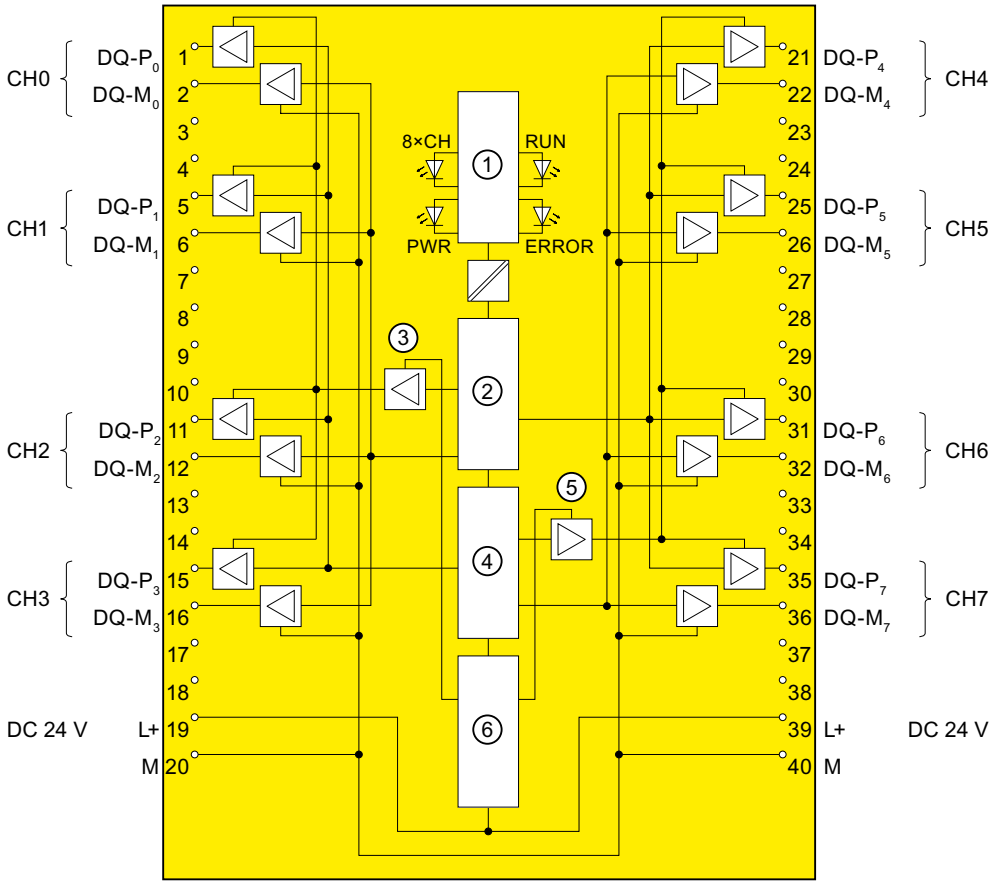
You can find information on wiring the front connectors and creating the cable shielding, etc., in the Wiring section of the system manual Automation System S7-1500 (http://support.automation.siemens.com/WW/view/en/59191792).

WARNING

To protect the F-module, always install an external fuse with the following properties for the load circuit: Circuit-breaker 24 V DC/16 A, tripping characteristic type B.

Block diagram

The following figure shows the assignment of channels to addresses.



①	Backplane bus interface	$DQ\text{-}M_n$	Ground for output bit n, channel n, M-switching
②	Microcontroller 1	L+	Supply voltage 24 V DC
③	P1 switch for channel groups 0 to 3	M	Chassis ground
④	Microcontroller 2	CH	Channel or LED channel status, channel diagnostics (green, red)
⑤	P1 switch for channel groups 4 to 7	PWR	LED supply voltage (green)
⑥	Reverse polarity protection	RUN	RUN LED (green)
$DQ\text{-}P_n$	Output bit n, channel n, P-switching	ERROR	LED module diagnostics (red)

Note:
- In PP operation, the DQ M channels are not used.
- Terminal 19 and 39 (L+) bridged internally
- Terminal 20 and 40 (M) bridged internally
  Note the maximum permissible cable cross-sections and use both terminals, if necessary.

Figure 1-636 Block diagram of the F-DQ 8x24VDC/2A PPM

Switching of loads with ground if the F-module is configured PM-switching

If the following two conditions are met, F-DQ 8x24VDC/2A PPM detects a short-circuit:

- If loads that have a connection between chassis and ground are switched by the F-DQ 8x24VDC/2A PPM (for example, to improve the EMC properties).
- If chassis and ground are connected at the power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below for an example).

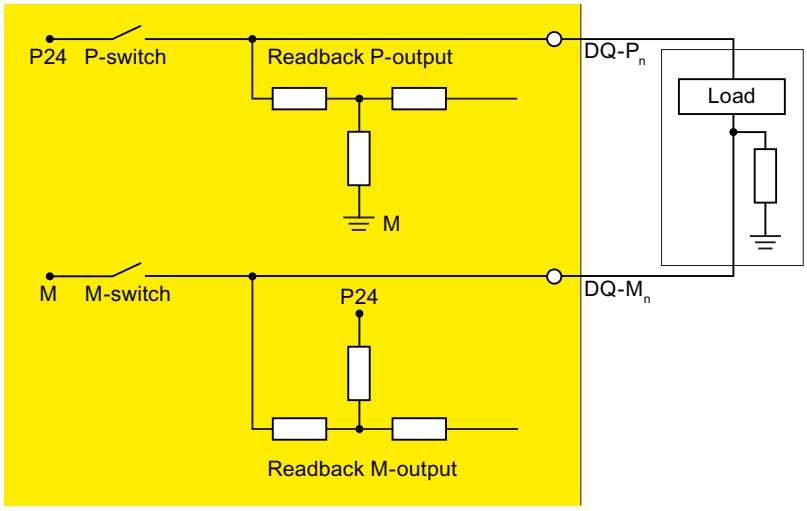


Figure 1-637 Switching of grounded loads (resistance between chassis and ground)

Remedy:

- Increase the parameters "Max. readback time dark test" and "Max. readback time switch-on test".
- Increase the value of the resistance between chassis and ground at the load end to more than 100 kΩ.

Or:

- Use the F-DQ 8x24VDC/2A PPM configured as a PP-switching module.

Parameters/address space

4

4.1 Parameters

Parameters

WARNING

Diagnostic functions must be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 28).

Table 1-925 Parameters for F-DQ 8x24VDC/2A PPM

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of F-monitoring time	• Disable • Enable	No	Module
F-monitoring time	1 to 65535 ms	No	Module
F-source address	1 to 65534	No	Module
F-destination address	1 to 65534	No	Module
F-parameter signature (without address)	0 to 65535	No	Module
Behavior after channel fault	• Passivate channel • Passivate the entire module	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	No	Module
F-I/O DB-number	—	No	Module
F-I/O DB name	—	No	Module
DQ parameters:			
Maximum test period	• 100 s • 1000 s	No	Module
Operating mode of the output	• PM-switching mode • PP switching	No	Module
Channel parameters in operating mode PM-switching:			
Channel n			
Diagnostics: Wire break	• Disable • Enable	No	Channel
Channel activated	• Disable • Enable	No	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	No	Channel
Max. readback time dark test	0.8 to 400.0 ms	No	Channel
Disable dark test for 48 hours	• Disable • Enable	No	Channel
Max. readback time switch on test	0.8 to 5.0 ms	No	Channel
Activated light test	• Disable • Enable	No	Channel
Channel parameters in operating mode PP-switching:			
Channel n			
Diagnostics: Wire break	• Disable • Enable	No	Channel
Channel activated	• Disable • Enable	No	Channel 1…7 (Channel 0 always enabled)
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	No	Channel
Max. readback time dark test	0.8 to 400.0 ms	No	Module (Channel 0)
Disable dark test for 48 hours	Disable	No	Module
Max. readback time switch on test	0.8 to 5.0 ms	No	Module (Channel 0)
Activated light test	Enable	No	Module

4.2 Explanation of parameters

4.2.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Basis for PROFIsafe addresses" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

4.2.1.1 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

4.2.1.2 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use in S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use in S7-1500 F-CPUs
When using the fail-safe module in S7-1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.2 DQ parameters

4.2.2.1 Maximum test period

With this parameter, you specify the time within which the light, dark and switch on tests should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test time is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

The "Maximum test period" parameter is a module parameter, which means the test cycle for the entire fail-safe output module is performed within the configured maximum test time. If the bit pattern test is not performed within the configured time (or the shortened test time of 60 seconds in case of an error), the module goes into the error state.

4.2.2.2 Operating mode of the output

Chooses between PM and PP switching mode for the outputs.

After re-parameterization of the operating mode, the power supply of the F-module must be switched OFF and ON.

4.2.3 Parameters of the channels

4.2.3.1 Diagnostics: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

You also have to activate the light test to detect a wire break with an output signal "0".

⚠ WARNING

The diagnostics for wire break of the outputs is not designed for safety-related functions and can therefore not be evaluated for safety-related activities.

4.2.3.2 Channel activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

4.2.3.3 Channel failure acknowledge

Use in S7-1500 F-CPUs

This parameter is only relevant if the fail-safe module is operated on an S7-1500 F-CPU, and can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel should react to a channel fault:

- Manual: A channel is not reintegrated until after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. There you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

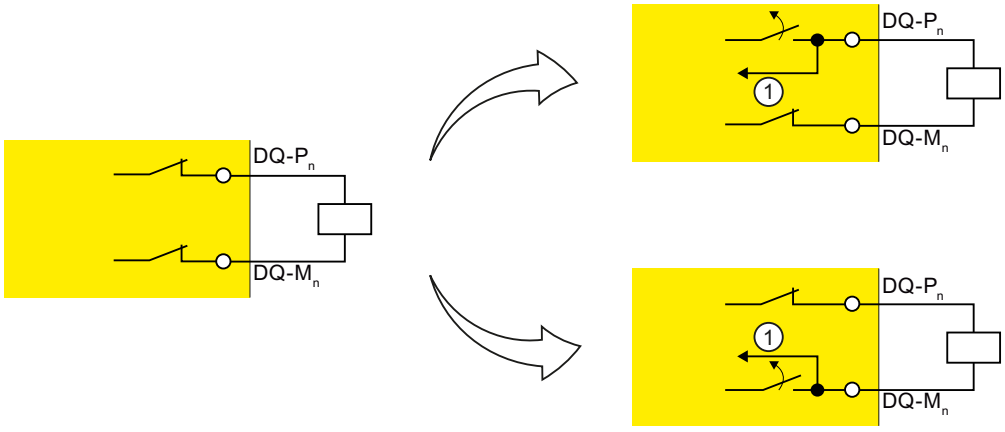
For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.3.4 Max. readback time dark test

Function

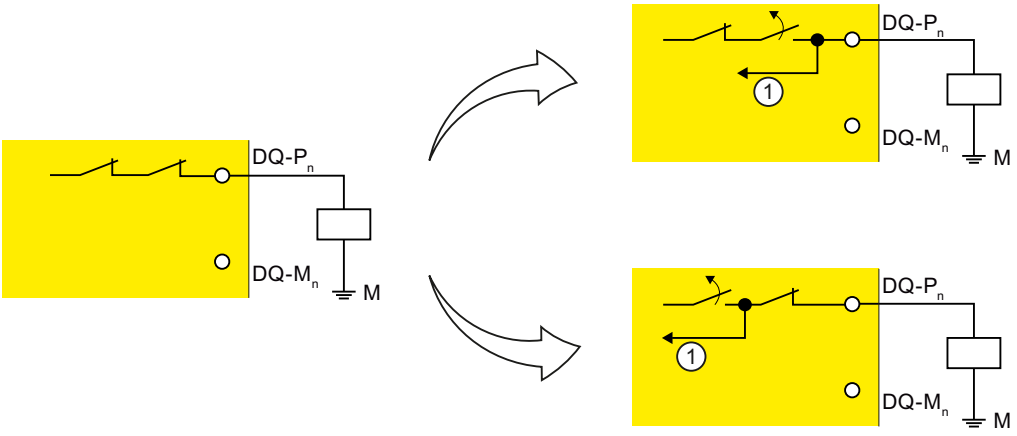
Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). The output channel is then switched off briefly (= "dark period") and read back (for **PM operation**, P- and M-readback, for **PP operation** only PP-readback). A sufficiently slow actuator does not respond to this and remains switched on.



① Readback (P-switch and M-switch do not switch simultaneously.)

Figure 1-638 Functional principle of the dark test (PM switching)



① Readback (The two P-switches do not switch simultaneously.)

Figure 1-639 Functional principle of the dark test (PP switching)

This parameter allows you to set the time for the readback.

If the expected signals could not be read back correctly after expiration of the readback time, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

⚠ WARNING

Through the configured readback time dark test, short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).
Short-circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short-circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test as low as possible, but high enough that the output channel is not passivated.

In case of the "Connecting a load per digital output, PP switching" (Page 34) application, see the warnings and notes in the section describing the application.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 52).

Setting readback time dark test with unknown actuator capacity

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time dark test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

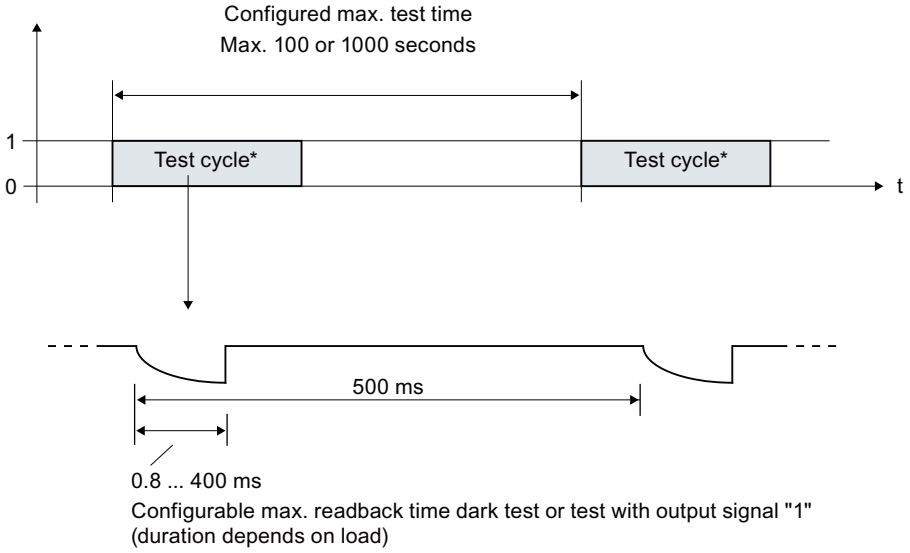
Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "1" with a minimum duration that corresponds to the "maximum test time" parameter.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

Test pulses of the dark test



* Output of test pulses only during test cycle.

Figure 1-640 Test pulses of the dark test

The interval between two test pulses is 500 ms.

4.2.3.5 Disable dark test for 48 hours

NOTE

Can only be configured for **PM operation**.

This option allows you to suppress the dark test.

If the channel is permanently active (1) for 48 hours, one dark test pulse is applied at the channel once this time has expired.

You must ensure the signal change from 1 to 0 at the channel yourself within 48 hours to prevent the dark test pulse. This also applies to the operating time if the operating time is < 48 hours. The dark test is suspended for another 48 hours after the signal change from 0 to 1.

The dark test is permanently suppressed if the following condition is met:

- A signal change from 1 to 0 takes place before the 48 hours have expired.

⚠ WARNING

When you use the function "Disable dark test for 48 hours", cross-circuits and other errors are not detected.

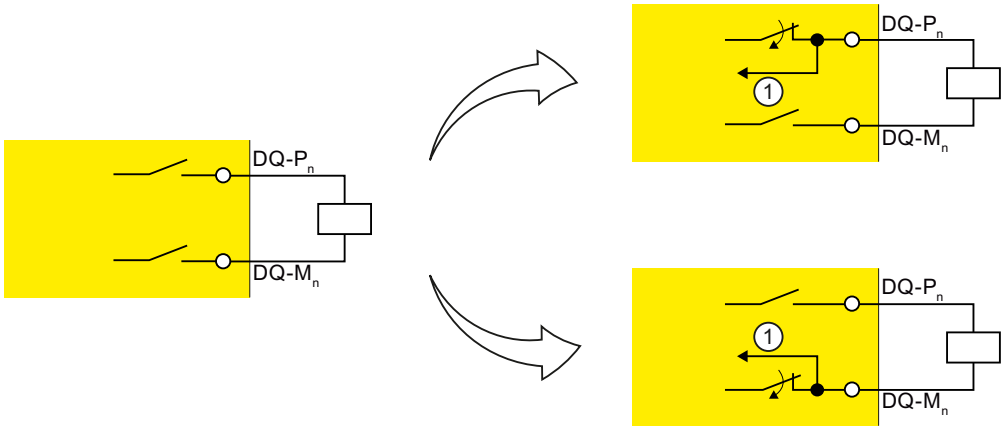
Also take into consideration the respective requirements of your product standards regarding error detection time.

4.2.3.6 Max. readback time switch-on test

Function

The switch on test is part of the bit pattern test.

PM operation
During the switch-on test in PM operation, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.



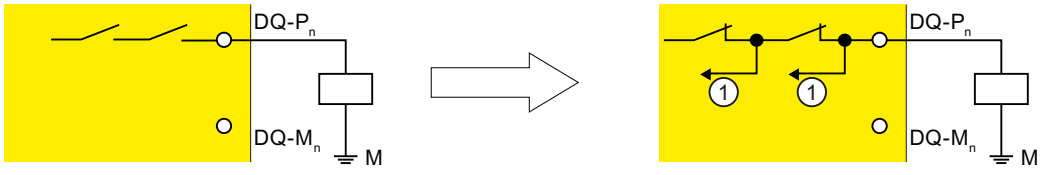
① Readback

Figure 1-641 Functional principle of the switch on test (PM switching)

WARNING

In case of an error, the bit pattern test can apply voltage to the load up to a duration that was configured with the "Maximum readback time switch on test" parameter.
For capacitive loads, it can happen that these are not actively discharged in the event of an error.
Therefore, always configure a maximum readback time that cannot activate the load under any circumstances.

PP operation
The M-switch is meaningless during the switch-on test in PP operation. The switch-on test corresponds to the light test and current flows through the load. The light test is always activated in PP operation.



① Readback

Figure 1-642 Functional principle of the switch on test (PP switching)

This parameter allows you to set the time for the readback.

If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short-circuit to L+ with output signal "0"
- Short-circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short-circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).
Short-circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time switch on test

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time as low as possible, but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 52).

Setting readback time switch on test with unknown actuator capacity

If the capacitance of the actuator is not known, you may have to determine the required value for the readback time switch-on test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "0" with a minimum duration that corresponds to the "maximum test time" parameter. If you have not configured a light test, continue by changing the process value to "1" after the verification.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time is too small for a connected capacitive load. The charge of the capacitive load cannot take place during the configured readback time. Increase the readback time.

If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

4.2.3.7 Activated light test

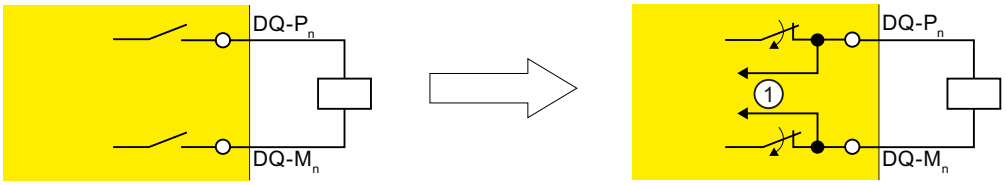
Function

Overload and wire break are detected with a 0 signal at the output.

For a light test, a test signal is switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.

PM operation

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

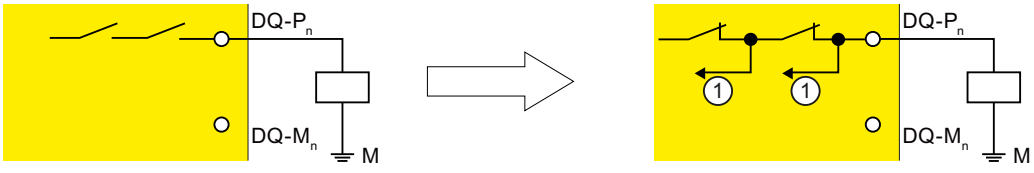


① Readback

Figure 1-643 Functional principle of the light test (PM switching)

PP operation

The M-switch is meaningless during the light test in PP operation. The light test corresponds to the switch-on test and current flows through the load. The light test is always activated in PP operation.



① Readback

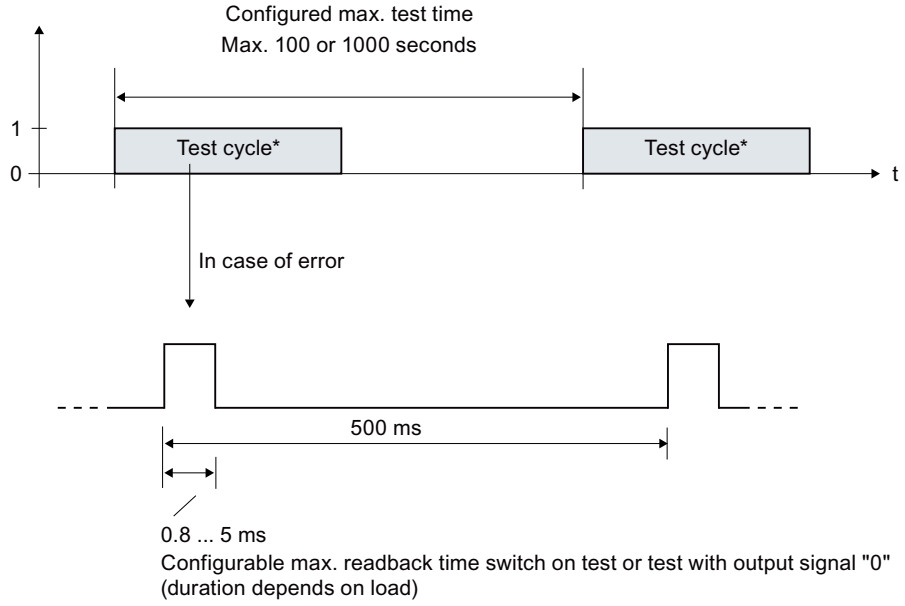
Figure 1-644 Functional principle of the light test (PP switching)

If the readback signals are incorrect, the signal is present for the configured readback time at the output channel before the fault causes passivation of the output channel.

If the signal was not read back correctly once the maximum readback time switch on test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test



* Output of test pulses only during test cycle. The module cycle is 5 ms.

Figure 1-645 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test time per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 500 ms. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.3 Address space

Address assignment of the digital output module F-DQ 8x24VDC/2A PPM

The digital output module F-DQ 8x24VDC/2A PPM occupies the following address areas in the F-CPU:

Table 1-926 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	x + 0 to x + 4	x + 0 to x + 4
S7-1500 F-CPUs	x + 0 to x + 5	x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 8x24VDC/2A PPM

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 8x24VDC/2A PPM:

Table 1-927 Address assignment of user data **in the input range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Value status DQ_7 (CH7)	Value status DQ_6 (CH6)	Value status DQ_5 (CH5)	Value status DQ_4 (CH4)	Value status DQ_3 (CH3)	Value status DQ_2 (CH2)	Value status DQ_1 (CH1)	Value status DQ_0 (CH0)

x = Module start address

Table 1-928 Address assignment of user data **in the output range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
QB x + 0	DQ_7 (CH7)	DQ_6 (CH6)	DQ_5 (CH5)	DQ_4 (CH4)	DQ_3 (CH3)	DQ_2 (CH2)	DQ_1 (CH1)	DQ_0 (CH0)

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.
The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access and for evaluation and processing of the value status, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications for the F-DQ 8x24VDC/2A PPM

You achieve SIL3/Cat.4/PLe with the following applications.

The wiring is carried out on the front connector of the module. Refer to the "Wiring" section in the S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual.

See also

Connecting (Page 13)

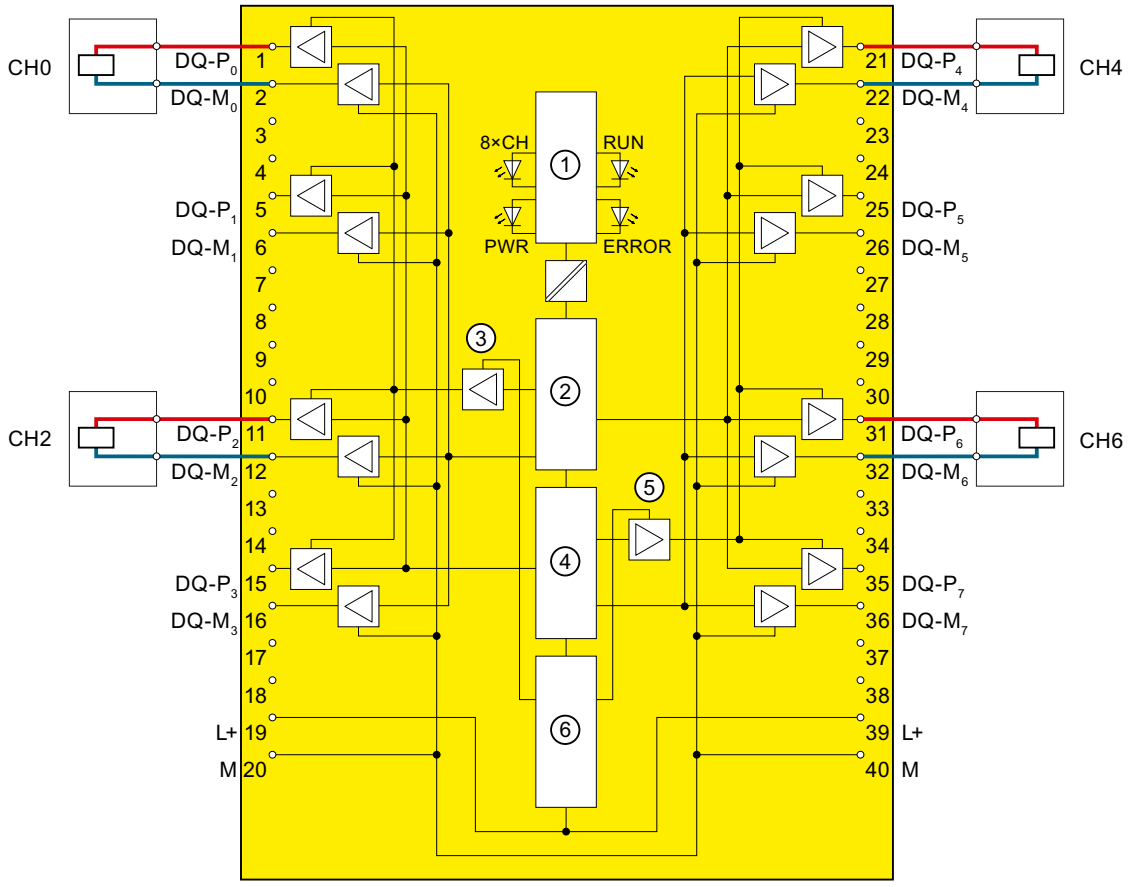
5.2 Application: Connecting a load per digital output, PM switching

Each of the 8 fail-safe digital outputs consists of a P-switch DQ-P_n and an M-switch DQ-M_n. You connect the load between the P-switch and the M-switch. The two switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

The figure below shows an example of the pin assignment of the fail-safe digital output module F-DQ 8x24VDC/2A PPM with connection of one load per digital output, PM switching.

WARNING

To protect the F-module, always install an external fuse with the following properties for the load circuit: Circuit-breaker 24 V DC/16 A, tripping characteristic type B.



① Backplane bus interface
② Microcontroller 1
③ P1 switch for channel groups 0 to 3
④ Microcontroller 2
⑤ P1 switch for channel groups 4 to 7
⑥ Reverse polarity protection

Figure 1-646 Wiring diagram for 1 relay to 1 F-DQ of the digital output module F-DQ 8x24VDC/2A PPM, PM-switching mode

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel group:

Table 1-929 Parameter

Parameter	
Operating mode of the output	PM-switching mode

5.3 Application: Connection of loads per digital output to L+ and M, PM-switching mode

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

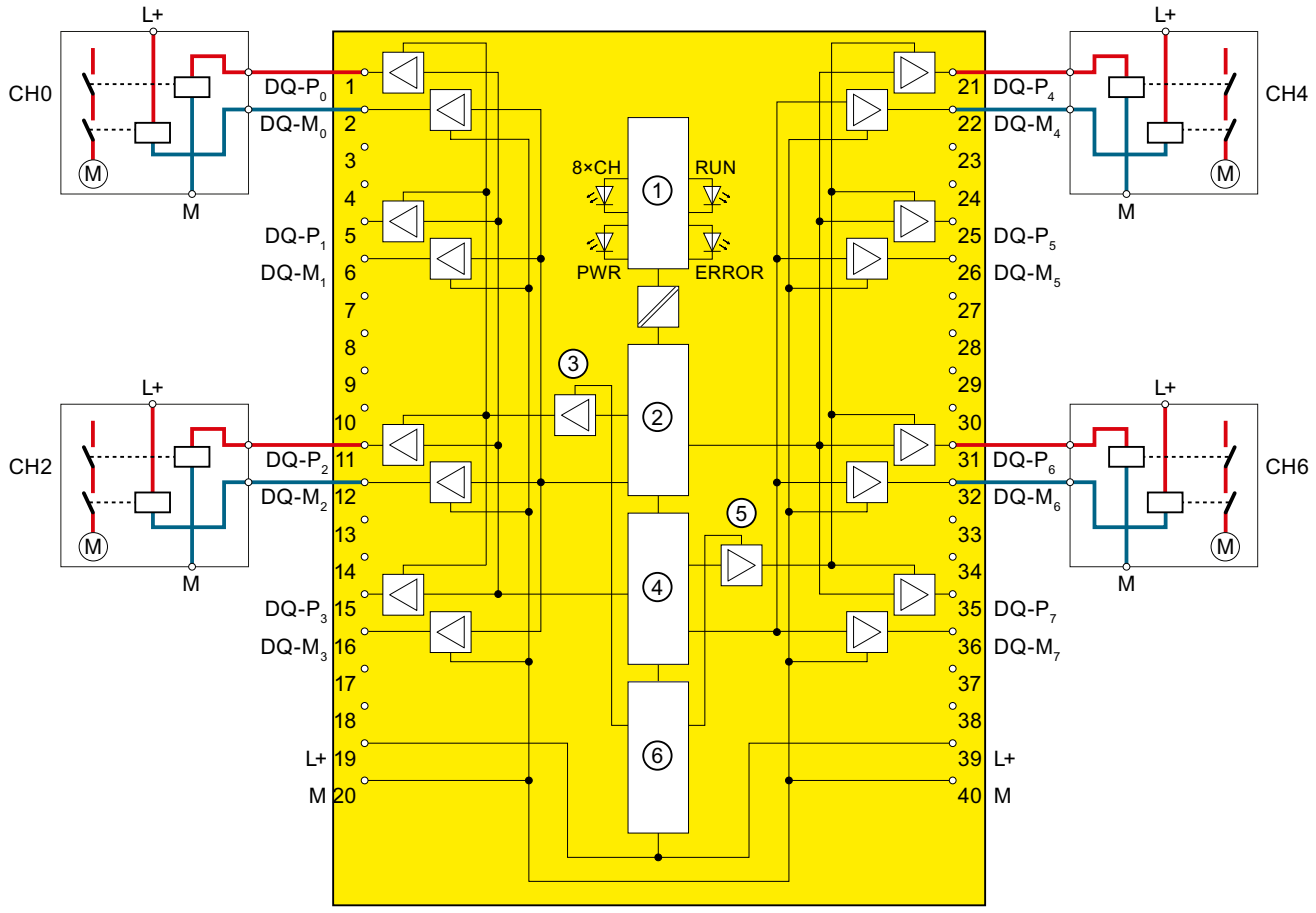
- Same reference potential
- The normally open contacts of the two relays must be connected in series.

This configuration achieves SIL3/Cat.4/PLe (process status readback required).

The figure below shows an example of the pin assignment of the fail-safe digital output module F-DQ 8x24VDC/2A PPM with connection of loads per digital output to L+ and M, PM-switching mode.

⚠ WARNING

To protect the F-module, always install an external fuse with the following properties for the load circuit: Circuit-breaker 24 V DC/16 A, tripping characteristic type B.



① Backplane bus interface
② Microcontroller 1
③ P1 switch for channel groups 0 to 3
④ Microcontroller 2
⑤ P1 switch for channel groups 4 to 7
⑥ Reverse polarity protection

Figure 1-647 Wiring diagram for 2 relay to 1 F-DQ of the digital output module F-DQ 8x24VDC/2A PPM, PM-switching mode

WARNING

When two relays are connected to one digital output, as shown in the figure above, the "wire break" and "overload" faults are detected only at the P-switch of the output (not at the M-switch).

WARNING

With a cross circuit between P-switch and M-switch of the output, the module detects the fault and switches off the output. But the actuator is still supplied with power due to the external fault.
To avoid cross circuits between the P and M-switches of a fail-safe digital output, you should always wire the relay connection to the P and M-switches separately, in order to prevent any cross circuits. For example, as separately sheathed cables or in separate cable ducts.

NOTE

The digital output module F-DQ 8x24VDC/2A PPM performs a bit pattern test depending on the parameter assignment. For this, the module outputs up to 5 ms pulses depending on the parameter assignment. This test (switch-on test) is run with a time offset between the P-switch and M-switch to prevent the actuator from being activated. This pulse may cause the corresponding relay to operated, which may reduce its mission time.

We therefore recommend adhering to the wiring scheme described below. See section Application: Connecting 2 loads in parallel per digital output, PM-switching mode (Page 32).

Parameter assignment

Assign the following parameter for the corresponding channel group:

Table 1-930 Parameter

Parameter	
Operating mode of the output	PM-switching mode

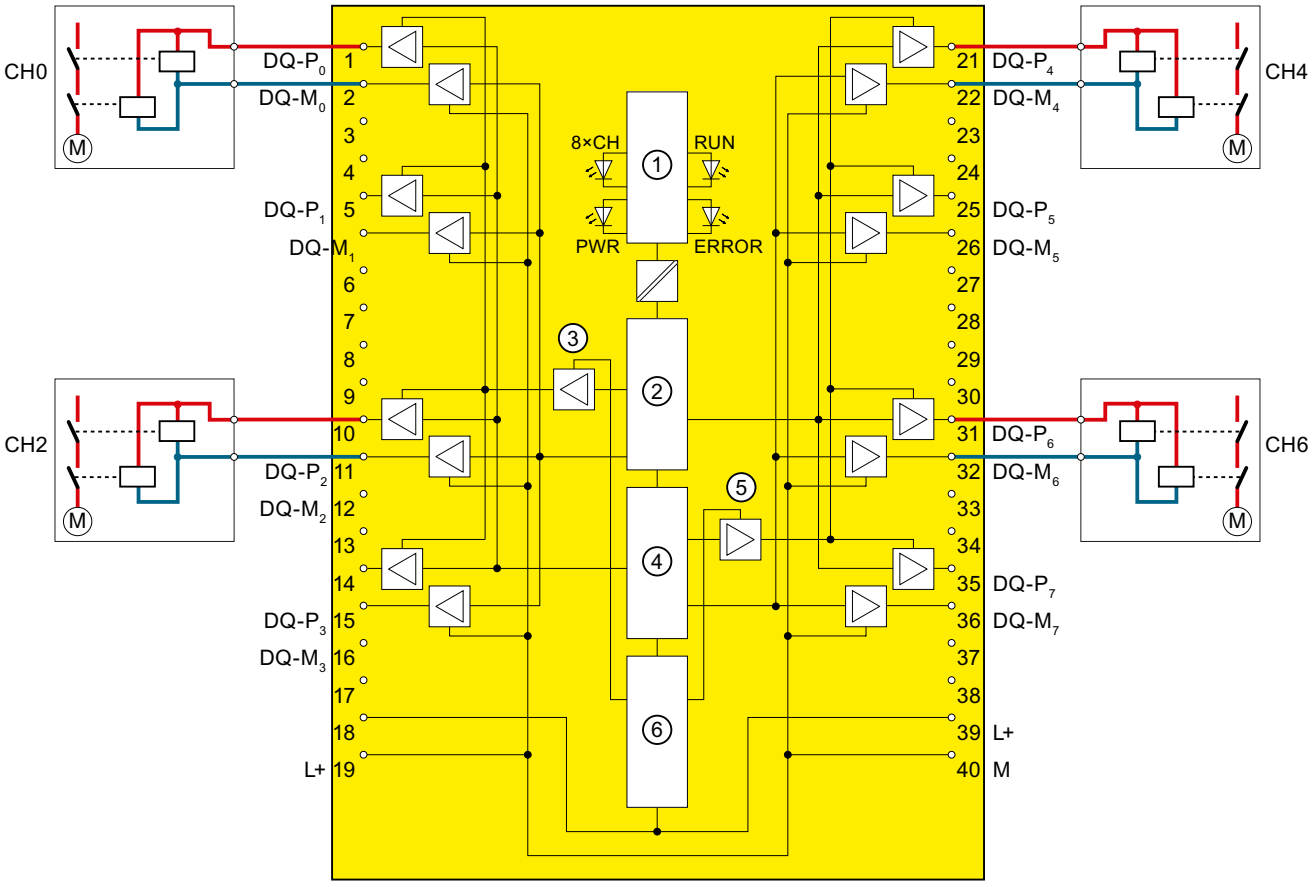
5.4 Application: Connecting 2 loads in parallel per digital output, PM-switching mode

To protect against cross-circuits between P-switch and M-switch in fail-safe digital outputs, we recommend the following wiring scheme. This circuit achieves SIL3/Cat.4/PLe.

The figure below shows an example of the pin assignment of the fail-safe digital output module F-DQ 8x24VDC/2A PPM with connection of two parallel loads per digital output, PM-switching mode.

⚠ WARNING

To protect the F-module, always install an external fuse with the following properties for the load circuit: Circuit-breaker 24 V DC/16 A, tripping characteristic type B.



① Backplane bus interface
② Microcontroller 1
③ P1 switch for channel groups 0 to 3
④ Microcontroller 2
⑤ P1 switch for channel groups 4 to 7
⑥ Reverse polarity protection

Figure 1-648 Wiring diagram for 2 relays in parallel to 1 F-DQ of the digital output module F-DQ 8x24VDC/2A PPM, PM-switching mode

NOTE

With a parallel connection of two relays on one digital output (as shown above) the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnostics is not safety-related.

NOTE

You can connect several actuators per output.

If several actuators are connected to an output, the diagnostics of each actuator affects the other ones.

This means:

- A wire break is only signaled when several actuators are affected.
- A single short-circuit affects multiple actuators.

Parameter assignment

Assign the following parameter for the corresponding channel group:

Table 1-931 Parameter

Parameter	
Operating mode of the output	PM-switching mode

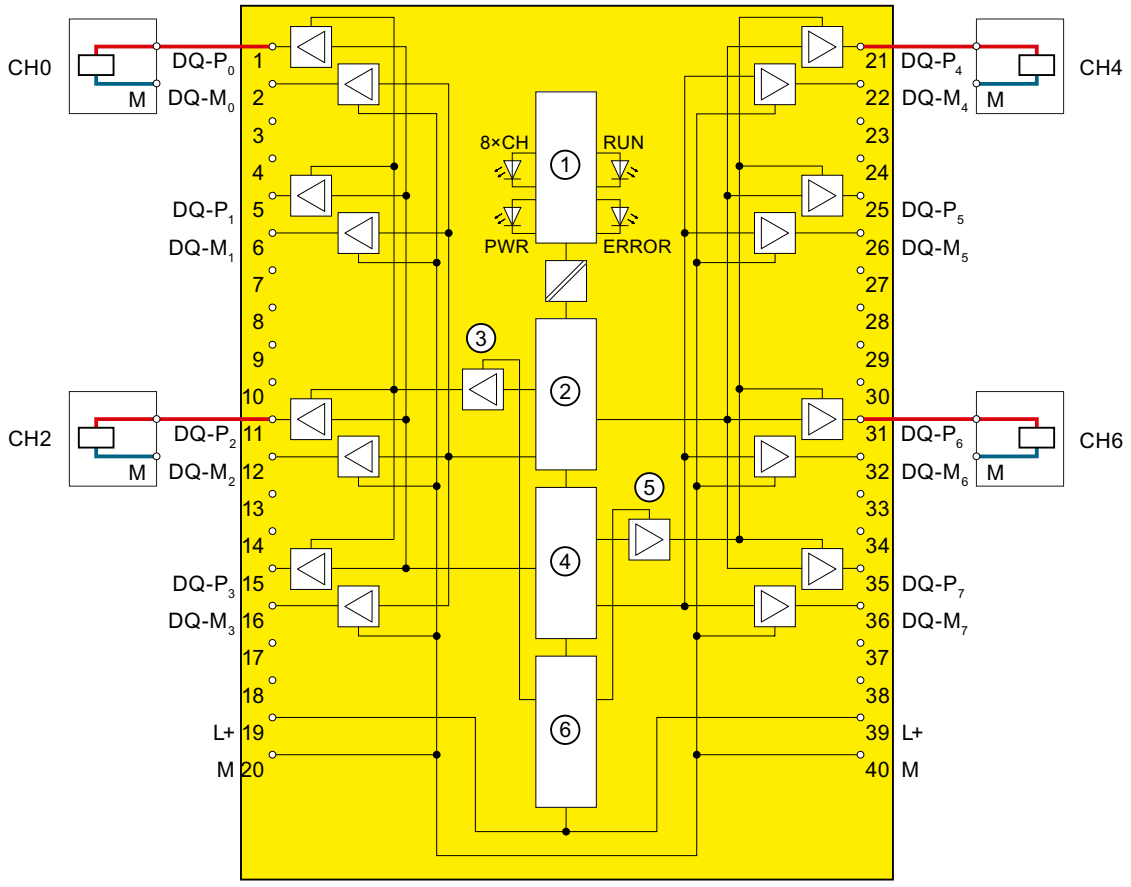
5.5 Application: Connecting a load per digital output, PP switching

You connect the load between the P-switch DQ-P_n and chassis ground in this application. This circuit achieves SIL3/Cat.4/PLe.

The figure below shows an example of the pin assignment of the fail-safe digital output module F-DQ 8x24VDC/2A PPM with connection of one load per digital output, PP switching.

⚠ WARNING

To protect the F-module, always install an external fuse with the following properties for the load circuit: Circuit-breaker 24 V DC/16 A, tripping characteristic type B.



①	Backplane bus interface	④	Microcontroller 2
②	Microcontroller 1	⑤	P1 switch for channel groups 4 to 7
③	P1 switch for channel groups 0 to 3	⑥	Reverse polarity protection

Figure 1-649 Wiring diagram for 1 relay to 1 F-DQ of the digital output module F-DQ 8x24VDC/2A PPM, PP switching

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

⚠ WARNING

In PP operation, the actuator can no longer be shut down if a cross circuit has developed between a positive potential (e.g. L+) and DQ. To prevent cross circuits between a positive potential (e.g. L+) and DQ, you must route the cables used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

⚠ WARNING

In this application, you have to connect two ground terminals for safety reasons. Otherwise, the maximum residual current at signal "0" (specified in the technical specifications) cannot be maintained if a single ground line is interrupted.

⚠ WARNING

PP operation
In the event of an error at a non-passivated, non-activated output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + max. readback time dark test (Trb).

Parameter assignment

Assign the following parameter for the corresponding channel group:

Table 1-932 Parameter

Parameter	
Operating mode of the output	PP switching

6 Interrupts/diagnostic messages

6.1 Status and error displays

LED displays

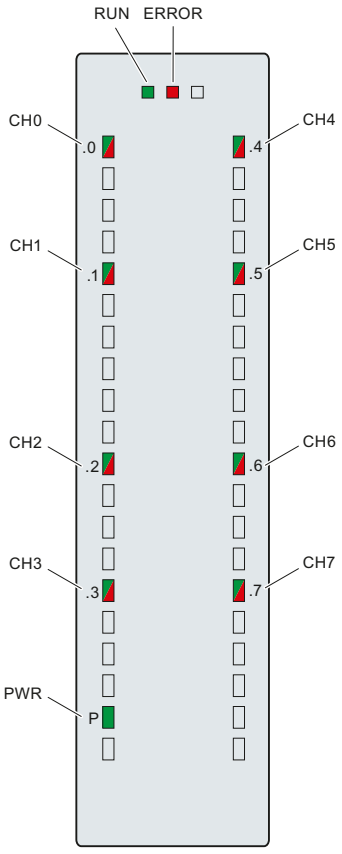


Figure 1-650 LED displays of the F-DQ 8x24VDC/2A PPM

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic alarms can be found in section Diagnostic alarms (Page 43).

WARNING

The RUN, ERROR LEDs and channel status/channel diagnostics LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

RUN and ERROR LEDs

Table 1-933 RUN/ERROR status and error displays

LED		Meaning	Remedy
RUN	ERROR		
Off	Off	Missing or insufficient voltage on the backplane bus	• Switch on the CPU and/or the system power supply modules. • Check whether the module is correctly plugged into the U-connector. • Check whether too many modules are plugged in.
Flashing	Off	Module starts up and flashes up to the valid parameter assignment.	---
On	Off	Module parameters are assigned and module addressed.	
Off	Flashing	Firmware is being updated.	
On	Flashing	Indicates diagnostic interrupts: • Module fault (for example, supply voltage too high) • Channel fault (for example, frequency too high). • PROFIsafe communication error Operation in S7-1500 F-CPUs: At least one channel is waiting for user acknowledgment.	Evaluate the diagnostics and eliminate or acknowledge the error. It may be necessary to remove and re-insert the module.
Flashing	Flashing	Hardware defective.	Replace the module.
Alternately flashing		• Operation in S7-1500 F-CPUs: The F-module expects user acknowledgment after a module error. • Operation in S7-300/400 F-CPUs: At least one channel is waiting for user acknowledgment.	Acknowledge the error (see manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)).

PWR LED

Table 1-934 PWR status display

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

CHx LED

Table 1-935 Display channel status/channel diagnostics

Status CHx	Diagnostics CHx	Meaning
Off	Off	Process signal = 0 and no channel diagnostics*
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
Alternately flashing		Channel waiting for user acknowledgment

* Operation in S7-300/400 F-CPUs only: If necessary, wait for user acknowledgment, if an additional channel is also waiting for user acknowledgment due to an error that occurred later.

CHx/ERROR LED with PROFIsafe address assignment

Table 1-936 Channel status/channel diagnostics/ERROR display with PROFIsafe address assignment

Status CHx	Diagnostics CHx	ERROR	Meaning
Off	All on	Flashing	The PROFIsafe address does not match the configured PROFIsafe address
All are flashing	Off	Flashing	Identification of the F-module when assigning the PROFIsafe address

LED CHx/RUN/ERROR if supply voltage error occurs

Table 1-937 Channel status/channel diagnostics/RUN/ERROR display if supply voltage error occurs

CHx status	Diagnostics CHx	RUN	ERROR	Meaning
Off	On	On	Flashing	Supply voltage too high or too low. • Operation in S7-1500 F-CPUs: Module is waiting for user acknowledgment. • Operation in S7-300/400 F-CPUs: Module is automatically reintegrated after the correction of the error.

6.2 Interrupts

Introduction

The F-DQ 8x24VDC/2A PPM fail-safe digital output module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic alarm described in section Diagnostic alarms (Page 43).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short-circuit diagnostic alarm, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic alarms (Page 43).

Table 1-938 Diagnostic interrupts of the F-DQ 8x24VDC/2A PPM

Diagnostic interrupt	Fault code	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	F-module	No
Wire break	6_D		
Parameter error	16_D		
Supply voltage missing	17_D		
Safety event	25_D		
Mismatch of safety destination address (F_Dest_Add)	64_D		
Safety destination address not valid (F_Dest_Add)	65_D		
Safety source address not valid (F_Source_Add)	66_D		
Safety watchdog time value is 0 ms (F_WD_Time)	67_D		
Parameter F_SIL exceeds SIL from specific device application	68_D		
Parameter F_CRC_Length does not match the generated values	69_D		
Version of F-parameter set incorrectly	70_D		
CRC1 fault	71_D		
Save iParameter watchdog time exceeded	73_D		
Restore iParameter watchdog time exceeded	74_D		
Inconsistent iParameters (iParCRC error)	75_D		
F_Block_ID not supported	76_D		
Transmission error: Inconsistent data (CRC error)	77_D		
Transmission error: Timeout (watchdog time 1 or 2 expired)	78_D		
Module is defective	256_D		
Watchdog tripped	259_D		
Short-circuit to L+	261_D	Channel	Yes
Short-circuit to ground	262_D		

Diagnostic interrupt	Fault code	Scope of diagnostic interrupt	Configurable
Invalid/inconsistent firmware present	283_D	F-module	No
Channel failure acknowledgment	779_D	Channel	
F-address memory not accessible	781_D	F-module	
Frequency too high	785_D	Channel	
Undertemperature	786_D	F-module	
Output defective	797_D	Channel	No
Read back failure	798_D	Channel	
Overload	800_D	Channel	
Supply voltage too high	801_D	F-module	
Supply voltage too low	802_D	F-module	

6.3 Diagnostic alarms

Diagnostic alarms

Module faults are indicated as diagnostics (module status).

NOTE

You can connect several actuators per output.
If several actuators are connected to an output, the diagnostics of each actuator affects the other ones.
This means:

- A wire break is only signaled when several actuators are affected.
- A single short-circuit affects multiple actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 1-939 Diagnostic alarms of the F-DQ 8x24VDC/2A PPM

Diagnostic alarm	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 47)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_D	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open). • A short-circuit exists.	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short-circuit.
Parameter error	16_D	Parameter errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the front connector • Check the front connector
Safety event	25_D	For safety purposes, channel was switched off due to an error on another channel. Possible causes: • A short-circuit exists. • The capacitive load is too high (PP-switching operation).	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).

Diagnostic alarm	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	64_D	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	65_D	The firmware of the F-module has detected an illegal different F-destination address.	
Safety source address not valid (F_Source_Add)	66_D	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	67_D	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	68_D	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	69_D	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	70_D	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	71_D	The firmware of the F-module has detected inconsistent F-parameters.	
Save iParameter watchdog time exceeded	73_D	iPar server does not respond to "save IPar" within 4.4 minutes.	Check the configuration/parameter assignment of the iPar server.
Restore iParameter watchdog time exceeded	74_D	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the configuration/parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	75_D	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The firmware of the F-module has detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	77_D	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	78_D	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.

Diagnostic alarm	Fault code	Meaning	Remedy
Watchdog tripped	259_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Short-circuit to L+	261_D	Short-circuit to L+ can mean: • The output cable is short-circuited to L+. • The capacitive load between the channels is too high (for example, due to cable length) You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Short-circuit to ground	262_D	Short-circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • There is a short-circuit between two output channels. • The capacitive load is too high. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Invalid/inconsistent firmware present	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Channel failure acknowledgment	779_D	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	781_D	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Frequency too high	785_D	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency (see Technical specifications (Page 47))
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 47))

Diagnostic alarm	Fault code	Meaning	Remedy
Output defective	797_D	The F-module has detected an internal error. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible. Possible causes: • The capacitive load is too high. • Short-circuit to L+ or M • The F-module has detected an internal error and has reacted in a safety-related manner.	• Increase the test times (dark, light, switch-on tests). • Check the wiring. • Consider replacing the F-module.
Read back failure	798_D	The F-module has detected an internal error. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible. Possible causes: • Impermissibly high electromagnetic interference is present. • The capacitive load is too high. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Increase the test times (dark, light, switch-on tests). • If the error continues, consider replacing the F-module.
Overload	800_D	The maximum permissible output current has been exceeded. The output stage has been switched off. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible. Possible causes: • A short-circuit exists. • The connected load is too high.	• Check the process wiring. • Reduce the load or the load current.
Supply voltage too high	801_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	802_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the ERROR LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute, see Technical specifications (Page 47)), the ERROR LED stops flashing. The module remains passivated and waits for user acknowledgment.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications

7

Technical specifications of F-DQ 8x24VDC/2A PPM

	6ES7526-2BF00-0AB0
General information	
Product type designation	F-DQ 8x24VDC/2A PPM
Firmware version	
FW update possible	Yes
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1 with HSP0086
Operating mode	
DQ	Yes
Supply voltage	
Rated value (DC)	24 V
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	110 mA; without load
Output voltage	
Rated value (DC)	24 V
Power	
Power consumption from the backplane bus	0.8 W
Power loss	
Power loss, typ.	11 W
Address range	
Address space per module	
Address space per module, max.	6 byte
Digital outputs	
Number of outputs	8
M switching	Yes
P switching	Yes
Short-circuit protection	Yes
Wire break detection	Yes
Response threshold, typ.	8 mA
Overload protection	Yes
Response threshold, typ.	2.9 A
Voltage induced on current interruption limited to	PM switching: -24 V + (-47 V), PP switching: -24 V
Switching capacity of outputs	

	6ES7526-2BF00-0AB0
With resistive load, max.	2 A
With lamp load, max.	10 W
Load resistance range	
Low limit	12 Ω
High limit	2000 Ω
Output voltage	
For "1" signal, min.	24 V; L+ (-0.5 V)
Output current	
For "1" signal, rated value	2 A
For "0" signal, residual current, max.	0.5 mA; PP switching or separate P and M-switch, PM-switching: max. 1 mA
Switching frequency	
With resistive load, max.	30 Hz
With inductive load, max.	0.1 Hz
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per channel	2 A
Total current of the outputs (per module)	
Horizontal mounting position	
Up to 40 ℃, max.	16 A
Up to 60 ℃, max.	8 A
Vertical mounting position	
Up to 40 ℃, max.	8 A
Cable length	
shielded, max.	1000 m
unshielded, max.	500 m
Interrupts/diagnostics/status information	
Fail-safe values can be switched to	No
Interrupts	
Diagnostic interrupt	Yes
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes
Group error	Yes
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of the supply voltage (PWR-LED)	Yes
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; red LED
Electrical isolation	
Electrical isolation, channels	
Between channels	No

	6ES7526-2BF00-0AB0
Between channels and backplane bus	Yes
Insulation	
Insulation test voltage	707 VDC (type test)
Standards, approvals, certificates	
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
SIL according to IEC 61508	SIL 3
Low demand mode: PFDavg according to SIL3	< 6.00E-05
High demand/continuous mode: PFH according to SIL3	< 2.00E-09 1/h
Environmental conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	40 °C
Dimensions	
Width	35 mm
Height	147 mm
Depth	129 mm
Weights	
Weight, approx.	300 g

NOTE

To reach the maximum cable length, it may be necessary to increase the settings for maximum readback time switch on test or maximum read-back time dark test.
We also recommend a more detailed consideration of the boundary conditions, such as EMC, cables used, cable guide, etc.

Dimension drawing

See system manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792).

Response times

A

Introduction

The next section shows the response times of the digital output module F-DQ 8×24VDC/2A PPM. The response times of digital output module F-DQ 8×24VDC/2A PPM are included in the calculation of the F-system response time.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

- Max. cycle time: T_{cycle} = 5 ms
- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 10 ms

The maximum response time in the case of fault (One Fault Delay Time, OFDT) is equivalent to the maximum response time with no faults (Worst Case Delay Time, WCDT).

Assign the parameters for maximum readback time dark test (Maximum Readback Time, T_{rb}) and a maximum readback time switch-on test (Maximum Readback Time Switch-On Test, T_{rb_swon}) in STEP 7.

Maximum response time with no faults (Worst Case Delay Time, WCDT)

t <= 3 * cycle time + max (T_{rb}, T_{rb_swon})

Maximum response time with detection of a channel fault by readback

t <= 4 * cycle time + 2 * max (T_{rb}, T_{rb_swon})

Maximum response time with detection of a channel fault by bit pattern test

t <= 2 * cycle time + maximum test time

Maximum response time with detection of a wire break at "1" signal

t <= 3 * cycle time + 1000 ms (wire break detection) + max (T_{rb}, T_{rb_swon})

Maximum response time with detection of an overload at "1" signal

t <= 4 * cycle time + max (T_{rb}, T_{rb_swon})

Maximum response time with detection of an overload or wire break at "0" signal and light test activated.

t <= 2 * cycle time + maximum test time

Switching of loads

B

B.1 Connecting capacitive loads

If an F-DQ 8x24VDC/2A PPM digital output module is interconnected with loads that require little current and have capacitance, this can lead to detection of a short-circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trends shown in the two figures below represent the correlation between load impedance and maximum switched load capacitance at a supply voltage of 24 V DC.

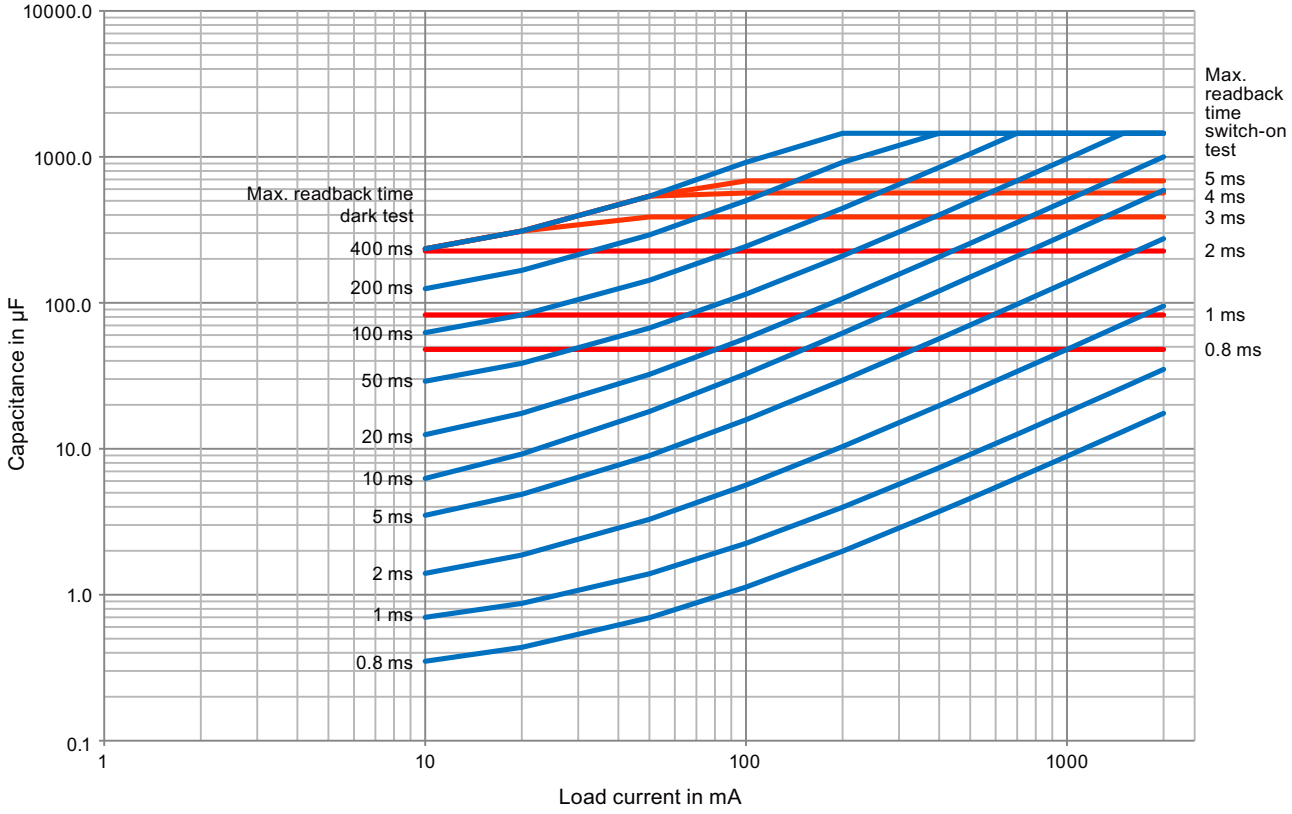


Figure 1-651 Switching of capacitive loads for the F-DQ 8x24VDC/2A PPM digital output module in PM-switching mode depending on the configured dark and light test times

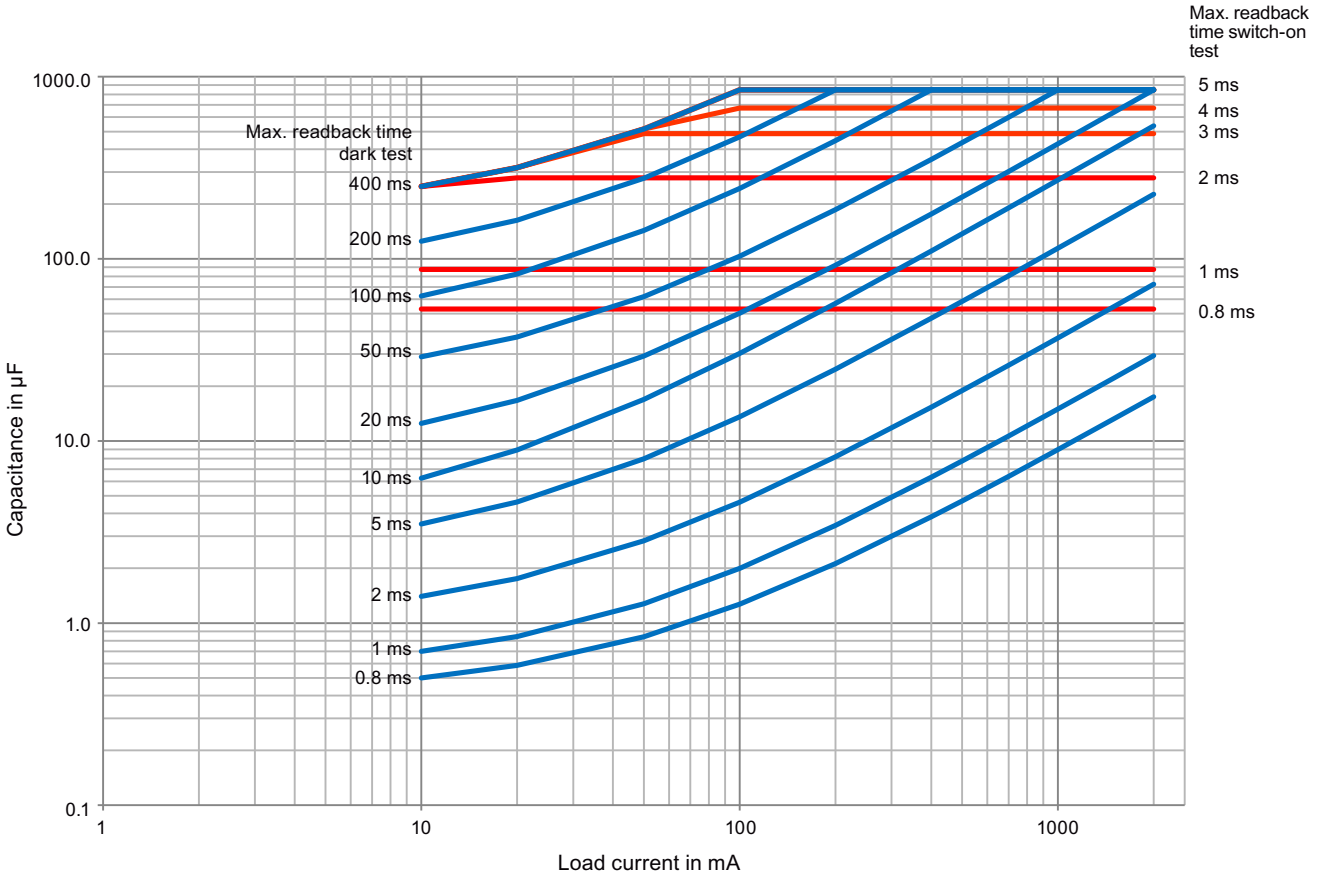


Figure 1-652 Switching of capacitive loads for the F-DQ 8x24VDC/2A PPM digital output module in PP-switching mode depending on the configured dark and light test times

The trends shown were plotted using a SIMATIC PS 307 10A power supply unit with a cable length of 25 m (cable cross-section of 1.5 mm^2) between the output of the F-DQ 8x24VDC/2A PPM output module and the load.

NOTE

The maximum readback time switch on test is only relevant if the light test is activated.

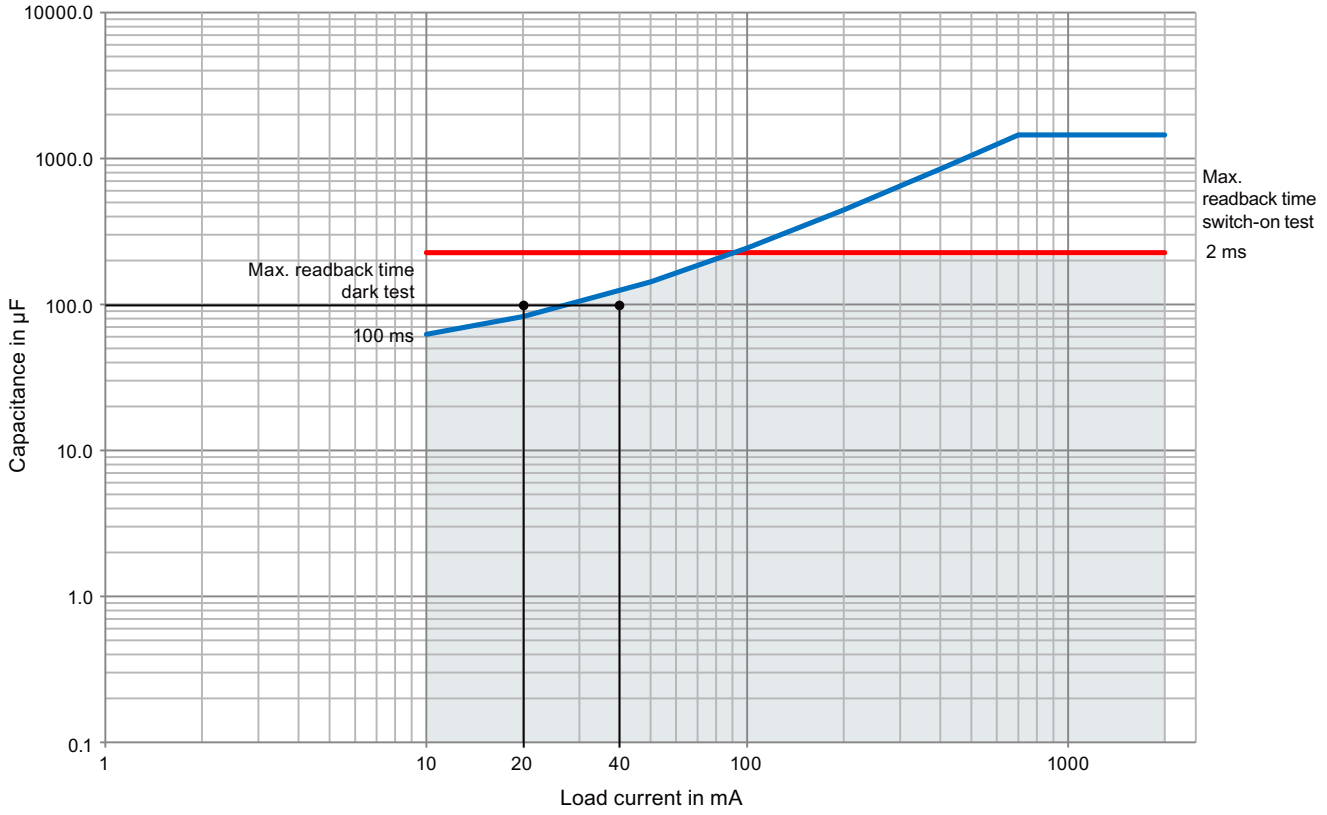
Remedy for detecting a short-circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the trend, select an actuator with higher current consumption so that the new operating point is below the curve.

Example

You have set a dark test time of 100 ms, a light test time of 2 ms and the PM-switching mode. You have set the load current to 20 mA and the capacity to 100 µF. The operating point is thus outside the range defined by the two trends (gray background).

Solution: Select an actuator with higher current consumption. In this example, 40 mA. Alternatively, you can configure the parameter "Max. readback time dark test" with 200 ms.



B.2 Switching of inductive loads

Switching of inductive loads

Use the switchgear for control and auxiliary circuits according to the utilization category DC-13 in accordance with IEC 60947-5-1:2014.

Open Source Software

C

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(2011-08-01)

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2. License Type

Depending on the License Type, the Licensee shall be granted the following rights to the SW:

2.1 Single License (One Off License, Copy License)
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SIMATIC
S7-1500/ET 200MP
Product information for the digital output module F-DQ 8x24VDC/2A PPM (6ES7526-2BF00-0AB0)

Product Information

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.
Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.
Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Content

This product information contains **important information on the digital output module F-DQ 8x24VDC/2A PPM (6ES7526-2BF00-0AB0)**. The product information is part of the product supplied. The information in this Product Information should be considered more up-to-date than other documentation if uncertainties arise.

Addition to the section "Max. readback time dark test"

⚠ WARNING
You can configure the parameter "Max. readback time dark test" with a maximum of 100 ms for F-modules with firmware version 1.0.0.

Addition to the section "Operating mode of the output"

⚠ WARNING
If the F-module with firmware version 1.0.0 has been configured with PP-switching mode, you need to change the "Behavior after channel fault" parameter from "Passivate channel" to "Passivate the entire module".

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Correction in the section "Application: Connection of one load per digital output, PP-switching"

WARNING

In PP operation, a cross-circuit between a positive potential (e.g. L+ or other signal lines) and DQ is detected by the module and it switches the output off. However, the connected actuator is still supplied with power due to the external fault.
To prevent cross-circuits between a positive potential (e.g. L+ or other signal lines) and DQ, you must route the lines used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

Correction in the section "Connecting capacitive loads"

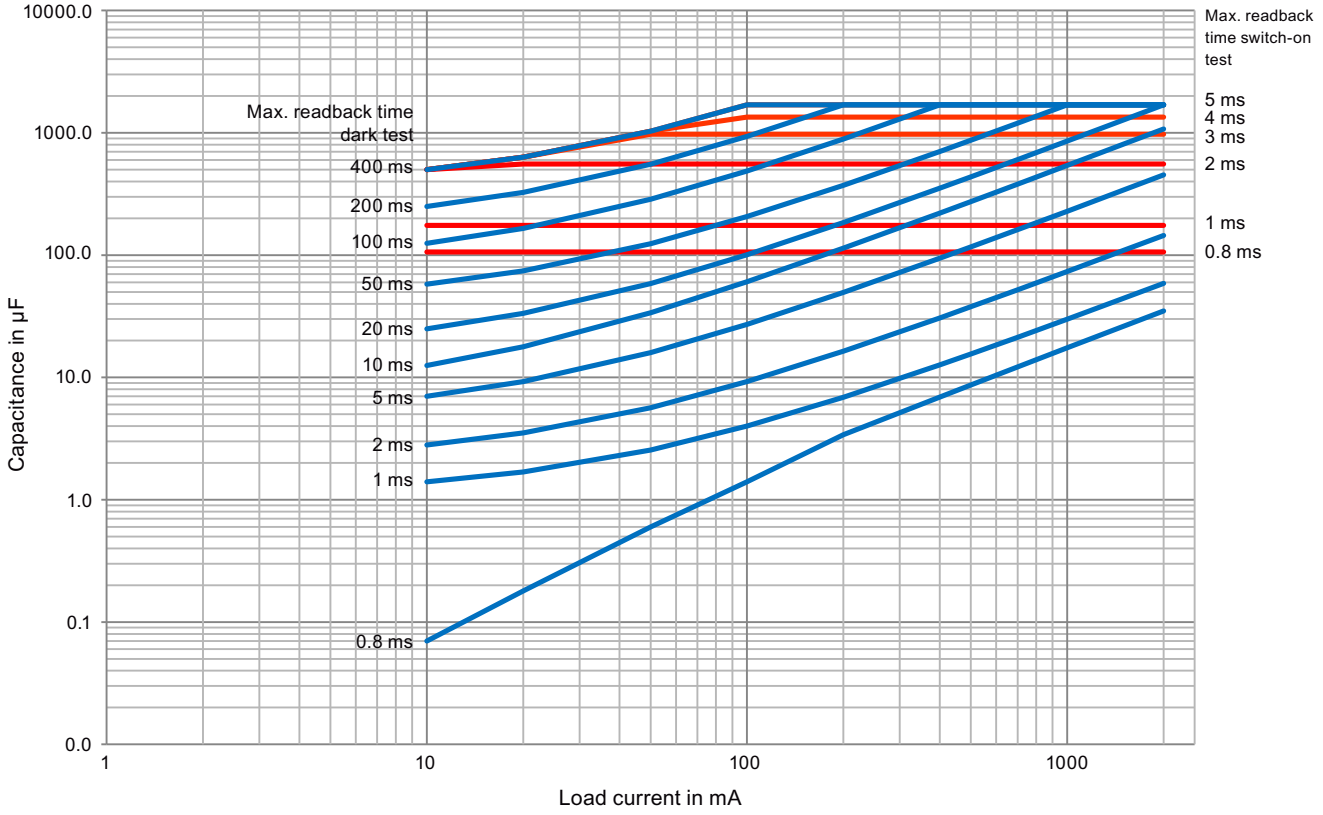


Figure 1 Switching of capacitive loads for the F-DQ 8x24VDC/2A PPM digital output module in PP-switching mode depending on the configured dark and light test times

SIEMENS

SIMATIC

ET 200AL
Distributed I/O system

System Manual

08/2025
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ET 200AL
Distributed I/O system

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Introduction

1

Purpose of the documentation

This documentation provides you with important information on how to configure, install, wire and commission the SIMATIC ET 200AL distributed I/O system.

Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Scope of the documentation

This documentation is valid for the SIMATIC ET 200AL distributed I/O system.

Conventions

Observe the notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation and on the handling of the product to which particular attention should be paid.

Standards

You can find a dated reference to the respective standards or the EC Declaration of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14245/cert?ct=444&ci=526).

Special information

NOTE

Important note for maintaining the operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log into SiePortal. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

NOTE

When using F-CPUs in safety mode and fail-safe modules, note the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/de/view/54110126/en).

ID Link for the digital nameplate



Figure 1-654 ID Link example DI 16x24VDC 8xM12

The ID Link is a globally unique identifier according to IEC 61406, which you will find in the future as a QR code on your product.

The figure shows an example of an ID Link for the I/O device digital inputs DI 16x24VDC 8xM12.

You can recognize the ID Link by the frame with a black corner at the bottom right. The ID Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner or reader app. Call the ID Link.

In the digital nameplate, you will find product data, manuals, Declarations of Conformity, certificates, and other useful information about your product.

1.1 SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**
  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).
- **Product support**
  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**
  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**
  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**
  For answers and solutions concerning automation technology.
- **mySiePortal**
  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

1.2 ET 200AL Documentation Guide



The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet. (https://support.industry.siemens.com/cs/ww/en/view/109742667)

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200AL System Manual
- STEP 7 Professional
- Product information

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Communications Modules

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200AL distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- Function Manual IO-Link system

Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/95242965)

1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.

- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.4 S7 Port Configuration Tool (S7-PCT)

SIMATIC S7-PCT

The Port Configuration Tool (PCT) is a PC-based software for the parameter assignment of Siemens IO-Link Master modules and IO-Link devices from any manufacturer.

You integrate IO-Link-devices using the standardized device description "IODD", which you get from the respective device manufacturer. S7-PCT supports version 1.0 and V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link Master from STEP 7. When STEP 7 is not used or the IO-Link Master is not operated on a SIMATIC controller, "standalone"-operation is also possible.

You can find additional information on IO-Link on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html).

1.5 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.6 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)
     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:
     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions

2

2.1 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

2.2 Safety-related symbols for IP65/IP67 modules

The following table contains an explanation of the symbols located on your IP65/IP67 modules, their packaging or in the accompanying documentation.

Symbol	Meaning
	General warning sign **Caution/Notice** You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
	The assigned safety symbols apply to devices **with Ex approval**. You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by an electrically skilled person. IEC 60417 No. 6182
	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
	Note that the device must be constructed and connected in accordance with EMC regulations.

Symbol	Meaning
 230V MODULES	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2
 24V MODULES	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-DB Symbol 5180 "Class III equipment"
 INDOOR USE ONLY INDUSTRIAL USE ONLY	Be aware that the device is only approved for the industrial field and only for indoor use.

2.3 Intended use

The system is used to control machines and plants.

Intended use also includes observance of this documentation, in particular the safety instructions and conditions of use. See section Technical specifications (Page 116).

2.4 Changes to the device and spare parts

Modifications to the module may affect the safety and the function of the module:

- Do not make any changes or attachments to the module.
- Do not remove or paste over safety instructions on the module.
- Only use original spare parts and accessories.

2.5 Target group and personnel qualifications

All persons working with this module require the following knowledge:

- Contents of this document as well as contents of the enclosed documents.
- Handling the module (after instruction)
- Relevant standards and regulations
- Accident prevention regulations

The following activities are reserved for specially qualified personnel:

Working on electrical parts
Work on electrical parts may only be performed by the following persons:

- Qualified electricians
- Persons trained in electrical engineering under the direction and supervision of qualified personnel.

Commissioning and configuration
Commissioning and configuration requires general knowledge in the field of automation technology.

2.6 Personal protective equipment

The personal protective equipment depends on the activity and is determined by the operator. To avoid material damage during packing, unpacking and installation activities we recommend:

- ESD wrist strap
- ESD shoes

2.7 Working on electrical parts

Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 17)).

- Always observe the country-specific safety rules.
- Notify all those who will be affected by the procedure.
- Follow the 5 safety rules according to DIN EN 50110-1 (VDE 0105-1):

1. Disconnect
2. Secure to prevent reconnection
3. Verify safe isolation from the supply (all poles)
4. Ground and short-circuit
5. Erect barriers around or cover adjacent live parts

After completing work:

- Restore operational readiness in reverse order.

2.8 Residual risks

Despite all the technical and procedural risk reductions that have been carried out, not all dangers can be avoided. The following sections describe these residual risks and measures to avoid them.

2.8.1 Live parts

Electrocution on contact with live parts leads to life-threatening injuries (death).

Operation

- Do not open the module.
- Do not use damaged modules.
- Pull the plug and not the cable.

Installation and connection

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 17)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 18))
- Fuse the connection cables according to the current-carrying capacity of the cable used, taking into account the applicable standards.
- Ground the module according to regulations.
- For the 24 V DC supply (SELV/PELV), only use power supply units that provide safe electrical extra-low voltage in accordance with IEC 61131-2 or IEC 61010-2-201.

Maintenance

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 17)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 18)).

2.8.2 Conductive pollution

Electrocution during transmission of electrical energy via conductive contamination to the body leads to life-threatening injuries (death).

- Seal unused connections with a suitable and approved sealing cap.
- Keep the module free from conductive pollution.

2.8.3 Overheating

Smoke development and fire due to overheating of module and cables result in burns and life-threatening injuries (death).

To avoid overheating:

- Ensure the correct installation position.
- Ensure sufficient air supply (e.g. maintain mounting clearances).
- Only use undamaged cables.

Installation and connection

- Follow the instructions for the mounting position.
- Adhere to the specified ventilation clearances.
- Fuse the connecting cables according to the cable cross-section.

Maintenance

- Check plug-in connections and cables regularly for damage.

2.8.4 Uncontrolled movements

Uncontrolled movements of driven machine or system parts during commissioning, operation, maintenance and repair.

- Follow the safety instructions described in the function manuals.

2.8.5 Unsafe operating states

Unsafe operating states may result in personal injury of unknown extent.
The following factors can be triggers:

- Manipulation of the software, e.g. viruses, trojans or worms.

Manipulation of the software, e.g. viruses, trojans or worms.

- Adhere to the protective measures against tampering with the software (see section Industrial cybersecurity (Page 128)).
- Perform available updates in a timely manner.
- Protect files stored on removable media from malware with appropriate protective measures, e.g. virus scanner.
- Set up access protection for the CPU.

2.9 Behavior in case of emergency

- Force EMERGENCY OFF

When the safe operating state has been restored:

- Unlock the EMERGENCY OFF mechanism.
- The person responsible for the system ensures that the system starts up in a controlled and defined manner.

2.10 Material damage

2.10.1 Transport and storage

- Only pack, store, transport and ship electronic components, modules or devices in the original product packaging or in other suitable materials, e.g. conductive foam rubber or aluminum foil.
- Observe the limits during transport and storage. See Technical specifications (Page 116) section.

2.10.2 Installation and connection

- We recommend touching components, modules and devices only if they are grounded by one of the following measures:
  - With an ESD wrist strap.
  - With ESD shoes or ESD grounding strips in ESD areas with conductive flooring.
- Place electronic components, modules and devices only on conductive surfaces (e.g. tables with ESD coating, conductive ESD plastic foam, ESD packing bags, ESD transport containers).
- Ensure that there is sufficient overvoltage protection.

Installation/disassembly with voltage switched on

- Refer to section Mounting (Page 36)
- Refer to section Replacing modules (Page 108)

New properties/functions

3

What's new in the ET 200AL System Manual, Edition 08/2025 compared to Edition 03/2025?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	ID Link	Here you will find a description of the ID Link	Section Introduction (Page 8)
	The module "Communications module CM 4xIO-Link 4xM12" has been added	In various sections contents on the module "Communications module CM 4xIO-Link 4xM12" have been added.	Section Marks and approvals (Page 116) Section Safety-related shutdown of ET200AL standard modules (Page 145)
	The module "Communications module CM 8xIO-Link + DIQ 6x24VDC/-0.5A 8xM12" has been added	In various sections contents on the module "Communications module CM 8xIO-Link + DIQ 6x24VDC/0.5A 8xM12" have been added.	
	The module "Voltage distributor PD 24VDC" has been added	In various sections, content has been added to the module "Voltage distributor PD 24VDC".	Section Components (Page 28) Section Connecting (Page 41) Section Marks and approvals (Page 116) Section Safety-related shutdown of ET200AL standard modules (Page 145)
	Accessories for power supply M12-L	M12-L cables for voltage supply are now also included in the section	Section Accessories/spare parts (Page 150)
	Importer addresses	You can find the importer addresses for specific countries here.	Standards and requirements (Page 119) section
	SIMATIC ET 200AL data	This section provides an overview of the data that is generated by the SIMATIC ET 200AL automation system and accessible to you.	SIMATIC ET 200AL Data (Page 166) section
Changed contents	Technical specifications	Various specifications have been adapted in the "Technical specifications" section	Section Technical specifications (Page 116)
	"Industrial Cybersecurity" section	The content of the "Industrial Cybersecurity" section has been updated	Section Industrial cybersecurity (Page 128)
	Ambient conditions	The operating conditions and storage conditions have been adapted.	Section Transport and storage conditions (Page 123) Section Mechanical and climatic ambient conditions (Page 124)

What's new in the ET 200AL System Manual, Edition 03/2025 compared to Edition 10/2024?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	The "Digital input/digital output module DIQ 8x24VDC/0.5A 8xM8" has been added.	In various sections, content has been added to the module "Digital input/digital output module DIQ 8x24VDC/0.5A 8xM8".	Section Marks and approvals (Page 116) Section Mechanical and climatic ambient conditions (Page 124)
Changed contents	"Industrial Cybersecurity" section	The content of the "Industrial Cybersecurity" section has been updated	Section Industrial cybersecurity (Page 128)

What's new in the ET 200AL System Manual, Edition 10/2024 compared to Edition 12/2023?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	"Industrial Cybersecurity" section	These sections have been added to the "Industrial Cybersecurity" section: • Secure Boot • Secure operation of I/O modules	Section Secure Boot (Page 142) Section Safe operation of I/O modules (Page 143)
	Use above 2000 m is possible.	Information and this table have been added to the section "Mechanical and climatic environmental conditions": Derating factor of installation altitude and ambient temperature for use above 2000 m above sea level.	Section Mechanical and climatic ambient conditions (Page 124)
Changed contents	"Introduction" section	The contents have been updated in the "Introduction" section	Section Introduction (Page 8)
	"Configuring" section	The "Configuring" section has been newly structured	Section Configuring (Page 69)
	Update of the section	Various values have been added and updated in the "Technical specifications" section	Section Technical specifications (Page 116)

What's new in Edition 12/2023 of the ET 200AL System Manual compared with Edition 12/2022?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	General security instructions	The section contains a compilation of general security instructions for the ET 200AL distributed I/O system.	Section Safety instructions (Page 16)
	"Industrial Cybersecurity" section	Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities. The section contains the following information: • Basic information on the subject of industrial cybersecurity • Measures to protect individual components and the entire system against manipulation and unwanted access.	Section Industrial cybersecurity (Page 128)
	Supplement IM 157-1 MF module	The MultiFieldbus interface module IM 157-1 MF	Starting with section System overview (Page 24)

What's new in Edition 12/2022 of the ET 200AL System Manual compared with Edition 08/2021?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Technical specifications of the plug	The technical specifications of the plug-in connections are listed in the section.	Starting with section Connectors (Page 162)
Changed contents	Update of the section	The UKCA approval has been added.	Section Marks and approvals (Page 116)
	Update of the section	The table "Pulse-shaped disturbance variables" has been revised.	Section Electromagnetic compatibility (Page 121)

System overview

4

4.1 What is the SIMATIC ET 200AL distributed I/O system?

SIMATIC ET 200AL

The SIMATIC ET 200AL distributed I/O system is a scalable and highly flexible, distributed I/O system for connecting process signals to a higher-level control system with a field bus.

Customer benefits of the system

Compact design

- High IO configuration limits for module widths of 30 mm or 45 mm and up to 32 modules for each ET 200AL
- High degree of protection IP65/IP67
- Adequate for temperatures from -30 °C/-25 °C to +55 °C and accelera-tions up to 10g

Easy to use

- Easy wiring thanks to color-coded connectors
- CAx compliant labeling of all interfaces
- Fast, convenient configuration and commissioning with STEP 7 (TIA Portal)
- Configuration customizing for future extension through integrated configurationcontrol

Flexible mounting

- Easy mounting in all mounting positions - even in small spaces
- Spatially separated mounting of the modules by means of a backplane bus designed as a cable(= ET Connection)
- Flexible connection to MultiFieldbus, PROFIBUS or integration in SIMATIC ET 200SP
- Integration of sensors and actuators through M8 and M12 connection technology



Energy efficiency

- PROFIenergy as integrated function

Communication standards

- PROFINET IO
- EtherNet/IP
- Modbus TCP
- PROFIBUS DP
- IO-Link
- PROFIsafe

Powerful technology

- Module with counting function
- Fail-safe modules

Figure 1-655 ET 200AL benefits

Area of application

The SIMATIC ET 200AL distributed I/O system is especially well suited for use in tight spaces, moving applications and for assembly and handling technology. Thanks to its scalable construction, you have the option to precisely customize its configuration to your on site needs.

The SIMATIC ET 200AL distributed I/O system features degree of protection IP65/IP67. The I/O modules are suitable for distributed use indoors on a machine or assembly line.

Setup

The SIMATIC ET 200AL distributed I/O system is made up of the following components:

- Interface modules (MultiFieldbus/PROFINET/PROFIBUS)
- Digital and analog I/O modules
- Communications modules
- Fail-safe modules

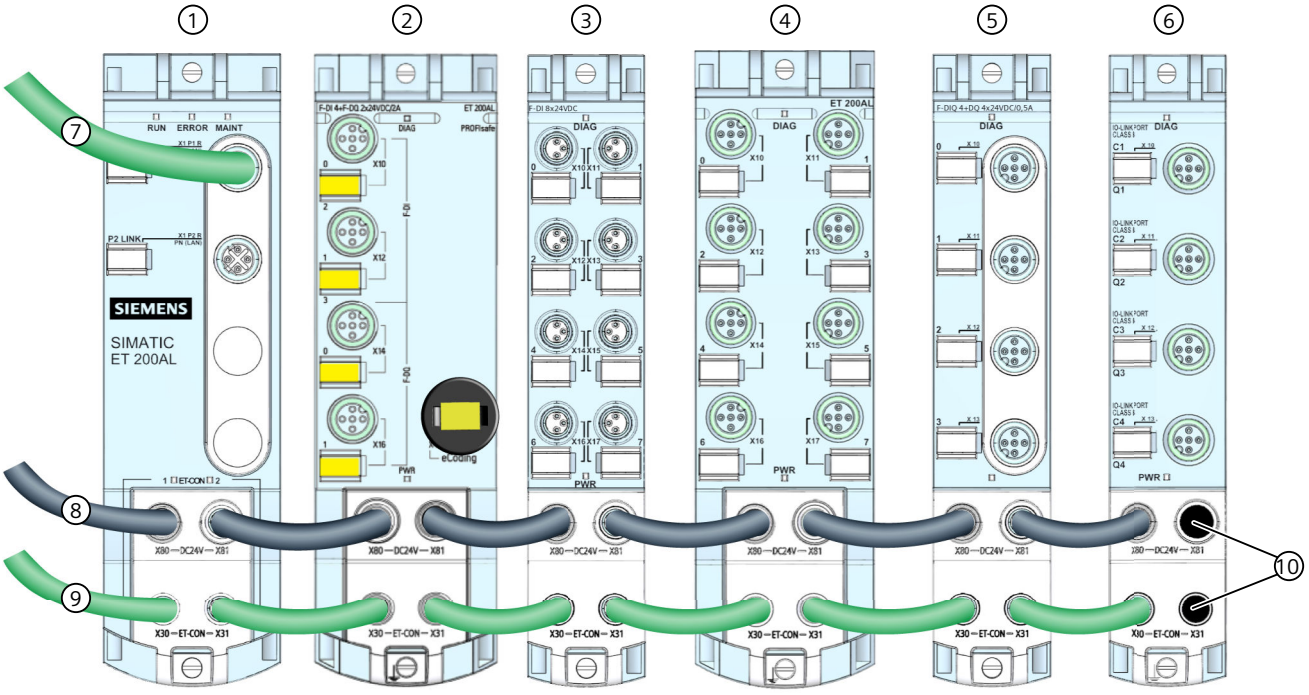
After an interface module you can configure 2 lines (ET-Connection), each with 16 modules.

Alternatively, you can configure a line with 16 I/O modules on the SIMATIC ET 200SP distributed I/O system with BaseUnit BU-Send and the BusAdapter BA-Send 1xFC.

The ET-Connection backplane bus is designed as a cable. This allows you to create spatial distances of up to 15 m between the modules.

Configuration example

The figure below shows a configuration example of the SIMATIC ET 200AL distributed I/O system with a PROFINET interface module.



① Interface module (PROFINET)
② Fail-safe digital input / digital output module
③ Digital input/output module
④ Digital output module
⑤ Analog input module
⑥ Communication module
⑦ PROFINET cable
⑧ Power supply cable
⑨ ET-Connection cable
⑩ Sealing caps

Figure 1-656 Configuration example of the ET 200AL

4.2 What are fail-safe automation systems and fail-safe modules?

Fail-safe automation systems

Fail-safe automation systems are mainly used in applications where failure could have consequences for the safety of people and/or the environment. Fail-safe systems are therefore intended to reduce hazards or failures that could cause physical damage. Their purpose is to ensure a tolerable level of risk.

F-systems are used to control processes and provide a safe operating state when faults are detected. Fault detection is ensured by a very high level of diagnostic coverage. When a fault is detected, appropriate actions are initiated to bring the affected application to a safe state.

F-systems offer improved fault detection and fault localization through detailed diagnostics and diagnostic messages. This is the most important difference between fail-safe systems and standard systems. The use of fail-safe systems should be considered for applications where hazards are inherent and can cause physical damage.

Safety Integrated

Safety Integrated is the integrated safety concept for automation and drive technology from Siemens.

Proven technologies and systems from automation technology are used for safety systems. Safety Integrated includes the complete safety sequence, ranging from sensor, actuator and fail-safe modules right through to the controller, including safety-related communication via standard fieldbuses. Drives and controllers handle safety tasks in addition to their actual functions.

Fail-safe modules

The key difference between fail-safe modules (F-modules) and standard modules is that they have an internal two-channel design. This means the two integrated processors monitor each other, automatically test the input and output circuits, and switch the fail-safe module to a safe state in the event of a fault.

The F-CPU communicates with a fail-safe module via the safety-related PROFIsafe bus profile.

Possible uses of ET 200AL with fail-safe modules

The use of ET 200AL with fail-safe modules makes it possible to replace conventional mounting technology in safety technology with PLC components. This also includes the replacement of switchgear for EMERGENCY STOP, safety door monitoring, ambidextrous operation, etc.

Fail-safe modules for ET 200AL are supported together with the STEP 7 Safety Advanced V17 or higher option package.

F-modules for ET 200AL can be used either with an ET 200AL PROFINET interface module (IM), a direct ET connection to an ET 200SP F-CPU or a direct ET connection to an ET 200SP IM (mixed configuration).

Use in SIMATIC Safety F-systems

The fail-safe ET 200AL modules can be used with STEP 7 Safety Advanced from V17 with PROFINET and direct ET connection configurations together with an F-CPU.

The fail-safe modules can only be used in safety mode. Fault safe and non-fault safe modules can be combined within one ET 200AL ET connection.

Achievable safety classes

The fail-safe modules are equipped with integrated safety functions for safety mode.
You can achieve the safety classes of the table below:

- With the appropriate parameter assignment of the safety functions in STEP 7
- With a specific combination of fail-safe and non-fail-safe I/O modules
- With a special arrangement and wiring of the sensors and actuators

Table 1-940 Safety classes that can be achieved with ET 200AL in safety mode

Safety class in safety mode		
According to IEC 61508	**According to ISO 13849-1**	
SIL2	Category 3	(PL) Performance Level d
SIL3	Category 3	(PL) Performance Level e
SIL3	Category 4	(PL) Performance Level e

⚠ WARNING

The safety performance of your installation depends on the design and ongoing maintenance of the individual complete safety function.
SIMATIC fail-safe CPUs and ET 200AL fail-safe modules have logic processing components with certified safety integrity levels, provided they are operated in accordance with classifications, specifications, and instructions.
Failure to adhere to this may cause damage or unpredictable operation, resulting in fatal or serious injury and/or property damage.
To achieve the level of safety you require, you need to select all components of your plant and construct and maintain them in accordance with accepted safety standards and practices.

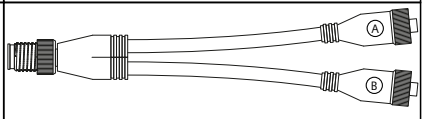
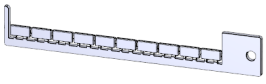
4.3 Components

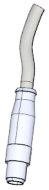
Components of the ET 200AL distributed I/O system

The following table shows and explains the function of the most important components of the ET 200AL distributed I/O system.

Table 1-941 Components of the ET 200AL distributed I/O system

Components	Function	View
Interface module for MultiFieldbus	• The interface module connects the distributed I/O system ET 200AL with one or more I/O controllers, scanners, Modbus clients • Exchanges data with the I/O modules via ET-Connection	

Components	Function	View
Interface module for PROFINET IO	• The interface module connects the ET 200AL distributed I/O system with the IO controller • Exchanges data with the I/O modules via ET-Connection	
Interface module for PROFIBUS DP	• The interface module connects the ET 200AL distributed I/O system with the DP master • Exchanges data with the I/O modules via ET-Connection	
I/O modules	• The I/O modules form the interface to the process • Recording and controlling the current process status via the connected sensors and actuators	
Voltage distributor	• The voltage distributor distributes the voltage 24 V DC to the I/O modules • 1 input M12-L connector • 4 outputs M8 socket with electronic fusing of 4 A per output for 1L+ and 2L+	
eCoding plug connector	Electronic coding element with an overwritable electronic memory for module-specific fail-safe address data (for example, the F-destination address)	
Y-cable	Y-cable connects multiple actuators or sensors to inputs or outputs. There are two types: • Y-cable: Connects inputs or outputs of the module to several actuators or sensors. • Inverted Y-cable: Connects several fail-safe inputs or outputs of the F-module with one or more sensors and actuators	
Identification labels	• The identification labels come with the module and can be machine printed • Can be ordered separately in white or yellow for fail-safe modules	

Components	Function	View
Bus cable and M8 connector for ET-Connection	The bus cable creates the bus connection between the modules	
Power cable and M8 connector for power supply	The power cable provides power to the modules	
Stripping tool ET-Connection	The stripping tool is used to strip the ET-Connection bus cable	

Application planning

5

5.1 Hardware configuration

Mechanical maximum configuration

The following tables show the rules of the mechanical configuration. As soon as one of the following rules applies, the maximum configuration has been reached.

Table 1-942 Maximum mechanical configuration - on ET 200AL interface module

Properties	Rule (max.)	
	Interface modules as of firmware version V1.0.0	Interface modules as of firmware version V1.0.1
Number of ET 200AL I/O modules in the configuration	32	
Number of ET-Connection outlets	2	
Number of I/O modules per ET-Connection outlet	16	
Spatial extension per ET-Connection line	160 m	240 m
Cable length between the modules	10 m	15 m

Table 1-943 Maximum mechanical configuration - on ET 200SP with interface module

Properties	Rule (max.)	
	Interface modules as of firmware version V3.0.0	Interface modules as of firmware version V3.3.0
Number of ET 200AL I/O modules in the configuration	16	
Number of ET-Connection outlets	1	
Spatial extension ET-Connection line	160 m	240 m
Cable length between the modules	10 m	15 m

Table 1-944 Maximum mechanical configuration - on ET 200SP with CPU

Properties	Rule (max.)
	CPUs with firmware version as of V2.0.0
Number of ET 200AL I/O modules in the configuration	16
Number of ET-Connection outlets	1
Spatial extension ET-Connection line	240 m
Cable length between the modules	15 m

Electrical maximum configuration

The number of usable I/O modules of a potential group is limited by the following points:

- Power requirements of the I/O modules
- Power requirements of the components supplied via these I/O modules

The maximum infeed current of the I/O modules is 4 A with 1L+ supply voltage (non-switched) and 2L+ load voltage (switched). When the maximum infeed current has been reached, you must open a new potential group.

Reference

You will find more information in the section Wiring rules for the interface module and I/O modules (Page 60).

5.2 Configuration variants with ET-Connection

5.2.1 ET 200AL with ET-Connection

Every ET 200AL interface module has 2 ET-Connection I/Os.

From every ET-Connection, you have the option to set up a line with a maximum of 16 ET 200AL I/O modules.

ET-Connection1

The figure below shows a configuration in the IP65/IP67 environment with one ET-Connection line.

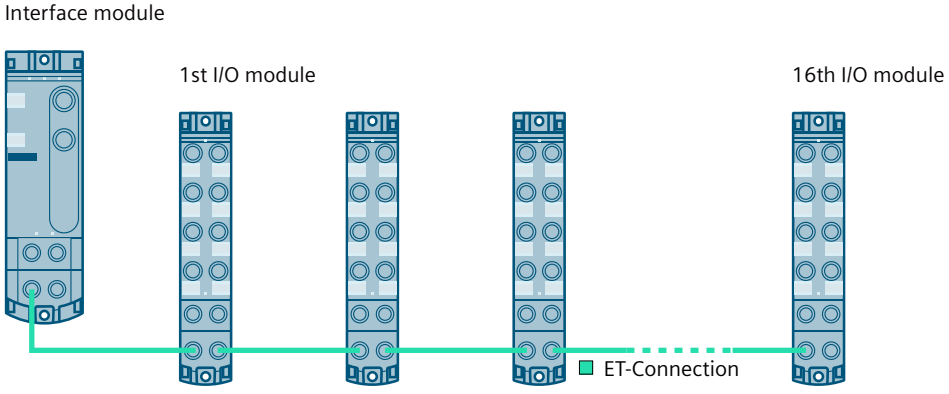


Figure 1-657 ET 200AL with ET-Connection1

ET-Connection1 and ET-Connection2

The figure below shows a configuration in the IP65/IP67 environment with two ET-Connection lines

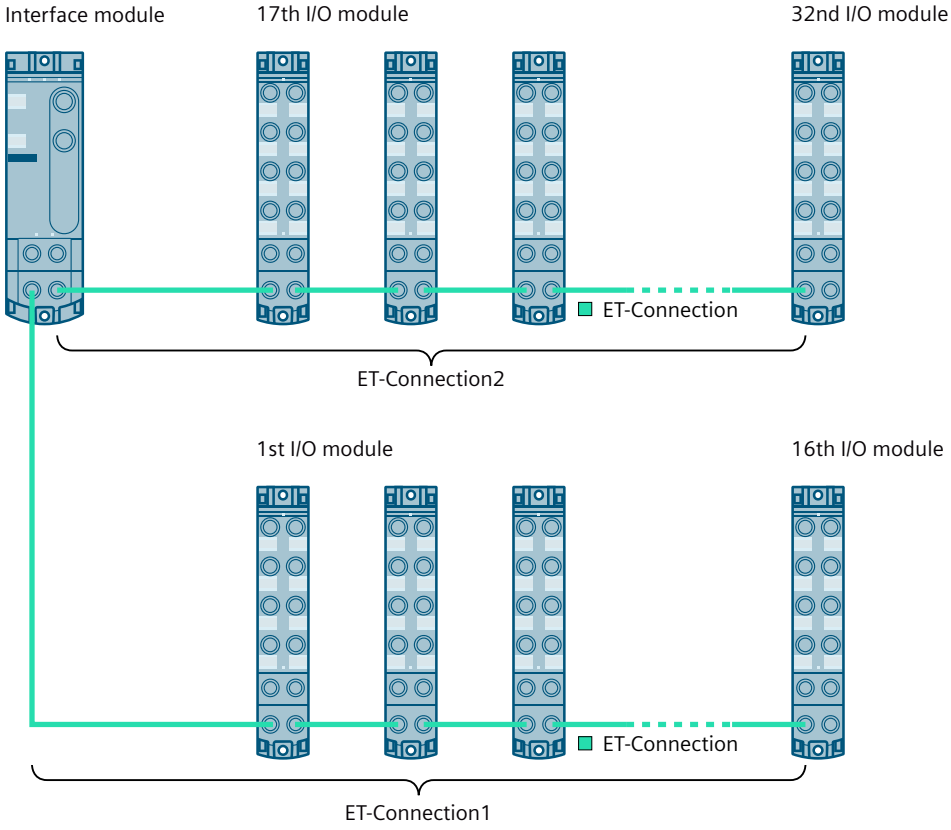


Figure 1-658 ET 200AL with ET-Connection1 and ET-Connection2

5.2.2 Hybrid configuration ET 200AL/ET 200SP with ET-Connection

Hybrid configuration ET 200AL and ET 200SP

You have the possibility to integrate standard and fail-safe I/O modules of the distributed I/O systems ET 200AL (IP65/IP67) into a configuration of the distributed I/O system ET 200SP (IP20). Fail-safe and non-fail-safe modules may be combined at will in the ET 200AL distributed I/O system.

The figure below shows a combination of the modules of the ET 200AL and ET 200SP distributed I/O systems.

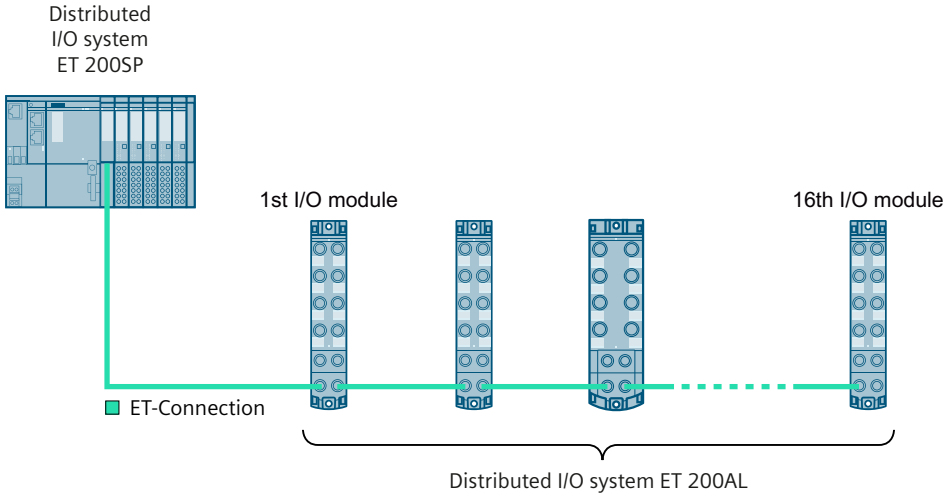


Figure 1-659 Hybrid configuration ET 200SP and ET 200AL with ET-Connection

Requirement

For a hybrid configuration, you need at least the following components:

- Interface module or CPU

NOTE

Use of a F-CPU with F-modules

A fail-safe CPU must also be used when using a fail-safe module in the ET 200AL.

- BaseUnit BU-Send with BusAdapter BA-Send 1xFC
- ET-Connection cable pre-assembled on one side
- Power cable pre-assembled on one side

Rules

When putting together a hybrid configuration, you must observe the following rules:

- The bus length of the ET 200SP distributed I/O system is a maximum of 1 m (excluding interface module/CPU, including BU-Send, BA-Send 1×FC and server module).
- A maximum of 16 ET 200AL I/O modules can be connected to ET-Connection.
- The maximum length of the bus cable for ET-Connection between two modules is 15 m.

Rules

The following table shows a rough overview of the functions of the ET 200AL I/O modules in combination with the ET 200SP.

Function	Hybrid configuration		
	ET 200SP		ET 200AL I/O modules on ET connection
	IM	CPU	
Isochronous mode	●	--	--
Configuration control	●	●	●
Shared device	●	●	●
PROFIenergy	●[1]	--	●[1]
System redundancy S2	●[2]	--	●[2]

1) PROFIenergy is not supported by fail-safe I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12

2) With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF as of V4.2

Details on the hybrid configuration are available here (https://support.industry.siemens.com/cs/de/en/view/100300517).

Procedure

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/95886672)

Proceed as follows to put together a multi-tier configuration:

1. Mount the BaseUnit BU-Send directly to the right of the ET 200SP interface module or the ET 200SP CPU.
2. Then install the other BaseUnits/I/O modules for the ET 200SP distributed I/O system and the server module.
3. Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1×FC and install it on the BaseUnit BU-Send.
4. Fasten the BusAdapter BA-Send 1×FC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). Use a screwdriver with a 3 to 3.5 mm blade to do this.
5. Connect the other end of the bus cable for ET-Connection (with M8 plug) to the first ET 200AL I/O module (socket X30 ET-Connection IN).
6. Connect the supply voltage (24 V DC) to the ET 200AL I/O modules (X80 plug).

Mounting

6

6.1 Basics

Introduction

All the modules of the ET 200AL distributed I/O system are designed for the degree of protection IP65/IP67. This means that you can directly mount this system in your plant.

Installation position

You can mount the ET 200AL distributed I/O system in any position.

Minimum clearances

At ambient temperatures of >50 °C or higher, ensure that the module is mounted at a distance of least 1 cm from an adjacent module or other device.

With the voltage distributor PD 24VDC (6ES7194-2CA00-0AA0), maintain a minimum clearance of 1 cm from adjacent modules or other devices when mounting.

Mounting rules

When mounting the modules, you do not need to following any special rules.

NOTE

Mounting of the modules
Mount the ET 200AL distributed I/O system only with disconnected supply voltages.

NOTICE
Mounting of the interface modules When mounting the interface modules of the ET 200AL, ensure that the rear of the module is protected against mechanical damage.

6.2 Mounting modules

Introduction

The modules of the ET 200AL distributed I/O system are designed for installation on a level, firm surface.

Thanks to the axisymmetrical drill holes in the modules, you have the option to fasten the modules on an aluminum profile using tee nuts.

The following images shows the aluminum profile on which you can mount the modules.

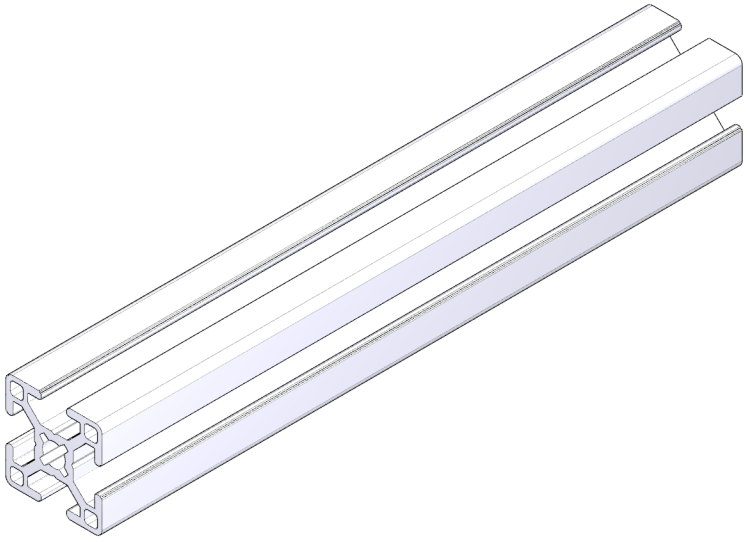


Figure 1-660 Aluminum profile

Required tools

For installation, you need a screwdriver or an Allen wrench.

Required screws

The following table shows and explains the screw types required to mount the modules.

Table 1-945 Recommended screws

Screw type	Explanation
Socket head cap screw M4 according to DIN EN ISO 1207 / DIN EN ISO 1580	The screw length must be at least 30 mm. If you need washers, use DIN EN ISO 7089/DIN EN ISO 7090 washers.
Hexagon socket head cap screw M4 according to DIN EN ISO 4762	

Drill holes of the modules

All modules of the ET 200AL distributed I/O system feature a uniform drill pattern.

- All module housings are axisymmetrical.
- The distance between the top and bottom drill hole is identical for all modules.

Mounting interface module and 45 mm I/O modules (front)

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/95886672)

The interface modules and the 45 mm I/O modules have an attachment point on top and on the bottom.

To mount an interface module or 45 mm I/O module, follow these steps:

1. Drill 2 fastening holes with 4.5 mm diameter at a distance of 149.6 mm.
2. Fasten the interface module or the 45 mm I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening the IM 157-1 PN interface module and the DQ 8x24VDC/2A 8xM12 45 mm I/O module.

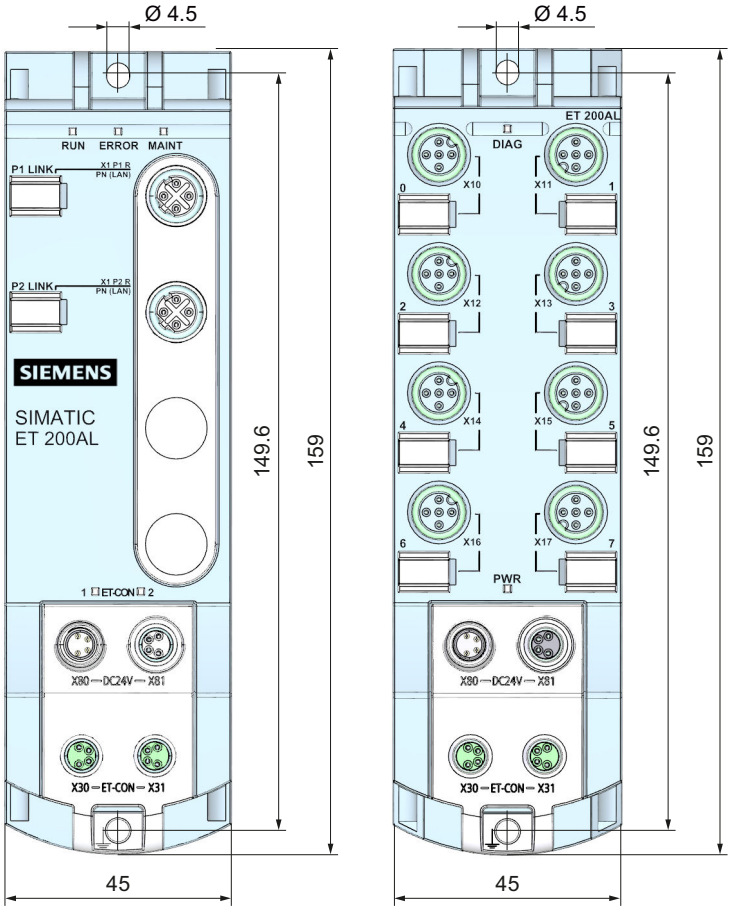


Figure 1-661 Dimensions for mounting interface modules and 45 mm I/O modules

Mounting 30 mm I/O modules (front or side)

Watch video sequence (https://support.industry.siemens.com/cs/ww/en/view/95886672)

The 30 mm I/O modules have an attachment point on top and on the bottom. You also have the option of fastening the 30 mm I/O modules at the side. When fastening them at the side, you must use the supplied spacers.

To mount a 30 mm I/O module, follow these steps:

1. Drill 2 fastening holes with 4.5 mm diameter at a distance of 149.6 mm.
2. Use the supplied spacers for side fastening of the I/O module on the top and bottom (on one side adjacent to the fastening surface).
3. Fasten the I/O module with the screws to both fastening points (tightening torque 1.2 Nm).

The figure below shows the dimensions for fastening the 30 mm I/O modules using the example of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 I/O module.

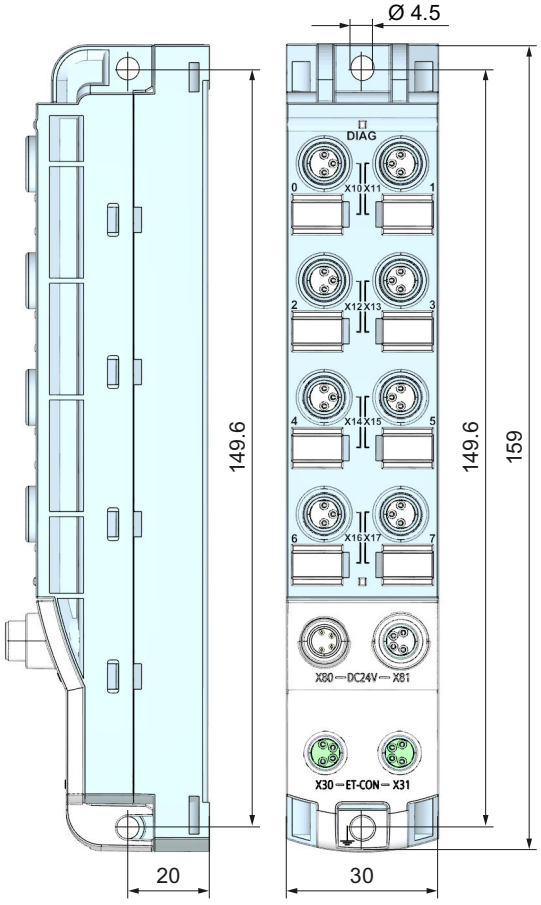


Figure 1-662 Dimensions for mounting 30 mm I/O modules

Fastening for cable ties

All module of the ET 200AL distributed I/O system have an integrated attachment point for cable ties. The attachment points are found on all four corners of the modules.

The figure below shows the top left attachment point for 2.5 mm wide cable ties for fastening the cables.

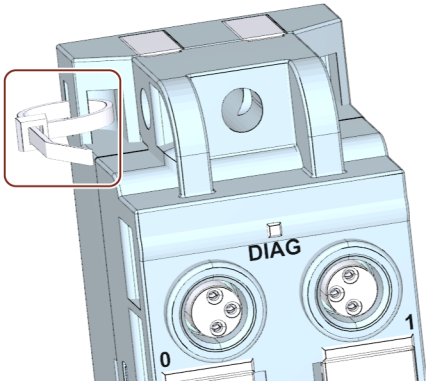


Figure 1-663 Top left attachment point for cable ties

Connecting 7

7.1 Rules and regulations for operation

Introduction

Depending on the area of application, the ET 200AL distributed I/O system, as a component of plants and systems, requires that special rules and specifications be observed.

This section gives an overview of the most important rules to be followed for integration of the ET 200AL distributed I/O system in a plant or in a system.

Specific application

Follow the safety and accident prevention regulations applicable to specific applications, e.g. the machinery directive.

EMERGENCY-STOP device

EMERGENCY-STOP devices according to IEC 60204 (corresponds to DIN VDE 113) must remain in effect in all operating modes of the plant or system.

Excluding hazardous system conditions

Hazardous plant states must not occur.

Ensure that dangerous system conditions are excluded, even in the following situations:

- In the event of a voltage dip or power outage
- When the plant restarts after a voltage dip or power outage
- When the ET 200AL distributed I/O system restarts after interruption of PROFINET communication

If necessary, force the EMERGENCY OFF.

An uncontrolled or undefined startup is not permitted after the "EMERGENCY STOP" is unlocked.

Cables and wires

The cables and lines used including the connector must fulfill the following requirements:

- Designed for at least the supply voltage used
- Designed for continuous cable temperature of at least 20 K above the ambient air temperature of the ET 200AL modules.
- Conductor cross-section suitable for the application and fusing.

An example for the line voltage drop at the used cables and lines is available in the section "Connecting cables for ET 200AL (Page 60)".

External fuses/switches

External fuses and switches must be installed so that they meet the standards for cable and device protection applicable to your application.

Line voltage of the SELV/PELV power supply

The following section describes what you need to pay attention to with respect to the line voltage (you will find additional information in the section Information on insulation, protection class, degree of protection, and rated voltage (Page 126)):

- For stationary plants or systems without an all-pole line disconnector, there must be a disconnector unit (all-pole) fitted in the building installation.
- For load current supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200AL distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 V DC supply

Below there is a description of what you need to pay attention to with 24 V DC supply:

- For buildings:
  If there is a danger due to overvoltages, you must take lightning protection measures for external lightning protection (e.g. lighting protection elements).
- With 24 V DC supply lines and signal lines:
  If there is a danger due to overvoltages, you must take lightning protection measures for internal lightning protection (e.g. lightning protection elements. You will find additional information in the Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566) function manual).

- For 24 V DC supply:
  Ensure that there is safe (electrical) separation of low voltage (SELV/PELV) according to IEC 61010-2-201 or IEC 60950-1.
  Use a UL/IEC-approved fuse for the infeed supply voltages.
  - For interface modules and I/O modules: 28.8 V DC/4 A fuse (type B or type C tripping characteristic). Ensure that the fuse used blows within 120 s at a current of 8.33 A.

    NOTE

    The 4 A fuse is not required if you use the voltage distributor PD 24VDC for the voltage supply.

  - For voltage distributor PD 24VDC:

    For UL approval usage: 28.8 V DC/10 A or 28.8 V DC/15 A (tripping characteristic type T according to UL 248-15), depending on the cable cross-section used.

    For IEC usage: 28.8 V DC/10 A or 28.8 V DC/16 A (tripping characteristic type B or type C), depending on the cable cross-section used.
- Continuous operation of fail-safe modules with more than 28.8 V DC can result in personal injury and equipment damage.

⚠ WARNING

Continuous operation of fail-safe modules with more than 28.8 V DC can result in personal injury and equipment damage.
Certain transients from certain source impedances (for example according to EN 61000-4-2, 61000- 4-4 and 61000-4- 5), as specified in the "Electromagnetic compatibility" section, can act on this voltage without interrupting operation or causing damage.
Operate the fail-safe module within the voltage parameters specified in the technical specifications. This will avoid unacceptable temperature increases and heat damage that will cause the module to lose its functionality.

Requirements for power supplies in the event of a power interruption

To ensure compliance with IEC 61131-2, use only power supply units/power supplies with a power failure bridging time of at least 20 ms. Observe the relevant requirement in your product standards (e.g. 30 ms for "burners" according to EN 298) with regard to possible voltage interruptions. You can find the latest information on power supply components on the Internet.

Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- For all plants or systems in which the ET 200AL distributed I/O system is integrated, you must ensure that the equipment or system is functionally grounded to discharge electromagnetic interference.
- For supply, signal and bus cables, you must ensure that the cable routing and installation is correct.
- For signal and bus cables, you must ensure that a wire/cable breakage or a cross-wire does not lead to undefined states of the plant or system.

Reference

Additional information can be found in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

7.2 Additional rules and regulations for the operation of the ET 200AL with fail-safe modules

7.2.1 Safety extra-low-voltage (SELV, PELV) for fail-safe modules

⚠ WARNING

The fail-safe modules must be operated with a safe extra-low voltage (SELV, PELV).
You can find additional information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.
The fail-safe modules operate at a rated voltage of 24 V DC. The tolerance range is 20.4 V DC to 28.8 V DC.
Within the overvoltage range from 28.8 V DC to 35 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages higher than 35 V DC, the F-modules are permanently de-energized.
Use a power supply unit that does not exceed U_m = 35 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.
All system components that can supply electrical energy in any form whatsoever must fulfill this condition.
Each additional circuit (24 V DC) used in the system must have a safety extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.
Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module must not exceed a fault voltage U_m in the event of a fault.

⚠ WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.
An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage U_m to be exceeded.

Immunity to surge voltages

To meet the product standard for burner controls (EN 298), the wiring must be equipped with external protection against coupled surge voltages caused by lightning. Further information on this can be found in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

7.2.2 Requirements for sensors and actuators for fail-safe modules

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

⚠ WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Remember, too, that sensors and actuators do not generally withstand proof-test intervals of 20 years as defined in IEC 61508 without considerable loss of safety.
The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".
To achieve the required safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PLe, a single-channel sensor is adequate. However, to achieve SIL3/Cat. 3/PLe with a single-channel sensor, the sensor itself must be SIL3/Cat. 3/PLe-capable; otherwise the sensor must be connected by two channels to achieve this safety level.

To achieve SIL3/Cat. 4/PLe, sensors must be connected by two channels.

⚠ WARNING

In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.
Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Duration requirements for sensor signals

⚠ WARNING

Observe the following requirements for sensor signals:

- To ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in the section "Response times" of the relevant F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

⚠ WARNING

If the actuators switch voltages greater than 24 V DC (e.g. 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).
This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

7.2.3 Crosstalk of digital input/output signals

Readback errors may occur on the F-DQ channels if the fail-safe digital output signals and fail-safe digital input signals are routed through a single cable.

Cause: capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. A cross circuit/short-circuit is detected, which leads to safety-related tripping.

Remedy:

- Separate cables for fail-safe DQ modules and non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it.

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

Remedy:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

7.3 Operation of the ET 200AL on grounded/non-grounded infeed

Introduction

Information is provided below on the overall configuration of an ET 200AL distributed I/O system on a grounded incoming supply (TN-S network). The specific subjects discussed are:

- Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113)
- Load current supplies and load circuits
- Supply voltages of the ET 200AL distributed I/O system

Grounded infeed

In grounded incoming supplies, the neutral conductor of the supply system is grounded. A simple ground fault between a live conductor and ground or a grounded section of the plant causes the protective devices to trip.

Supply voltages

Provide the ET 200AL distributed I/O devices with a SELV/PELV supply voltage for 1L+.
The supplied SELV/PELV load voltage for 2L+ can be switched, depending on the application.

- 1L+: Supply voltage (non-switched)
- 2L+: Load voltage (switched)

Safe electrical separation (SELV/PELV)

For operating the ET 200AL distributed I/O system, mains devices/power supply modules with safe electrical separation SELV/PELV are required. These power supplies/power supply modules must comply with IEC 61010-2-201.

The wiring of SELV/PELV circuits must be separated from the wiring of non-SELV/PELV circuits. Alternatively, the insulation of all conductors must be dimensioned for the higher voltage.

NOTICE
Operation in damp/wet environments When operating in a damp/wet environment, other voltage limits apply for SELV/PELV according to IEC 61010-2-201.

Configuring ET 200AL with grounded reference potential

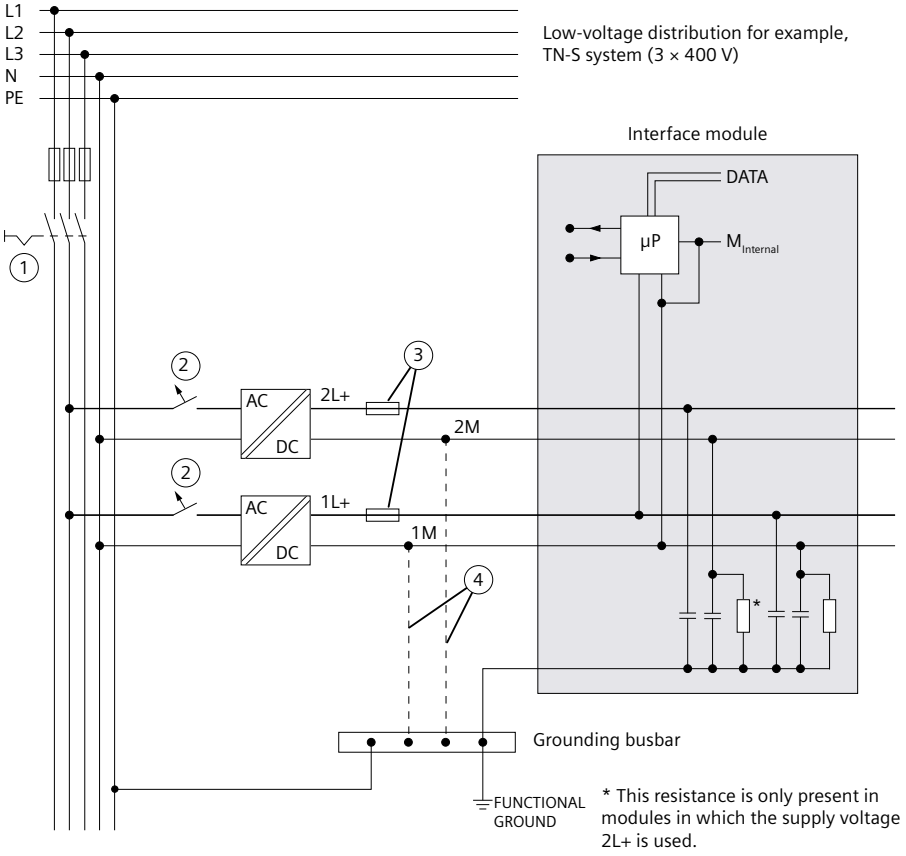
When configuring the ET 200AL distributed I/O system with grounded reference potential, occurring interference currents are discharged into functional ground. The connections must be externally connected (connection between 1M and functional ground).

Configuring ET 200AL with ungrounded reference potential

When configuring the ET 200AL distributed I/O system with non-grounded reference potential, occurring interference currents are discharged via an internal RC network to functional ground (no external connection between 1M and functional ground).

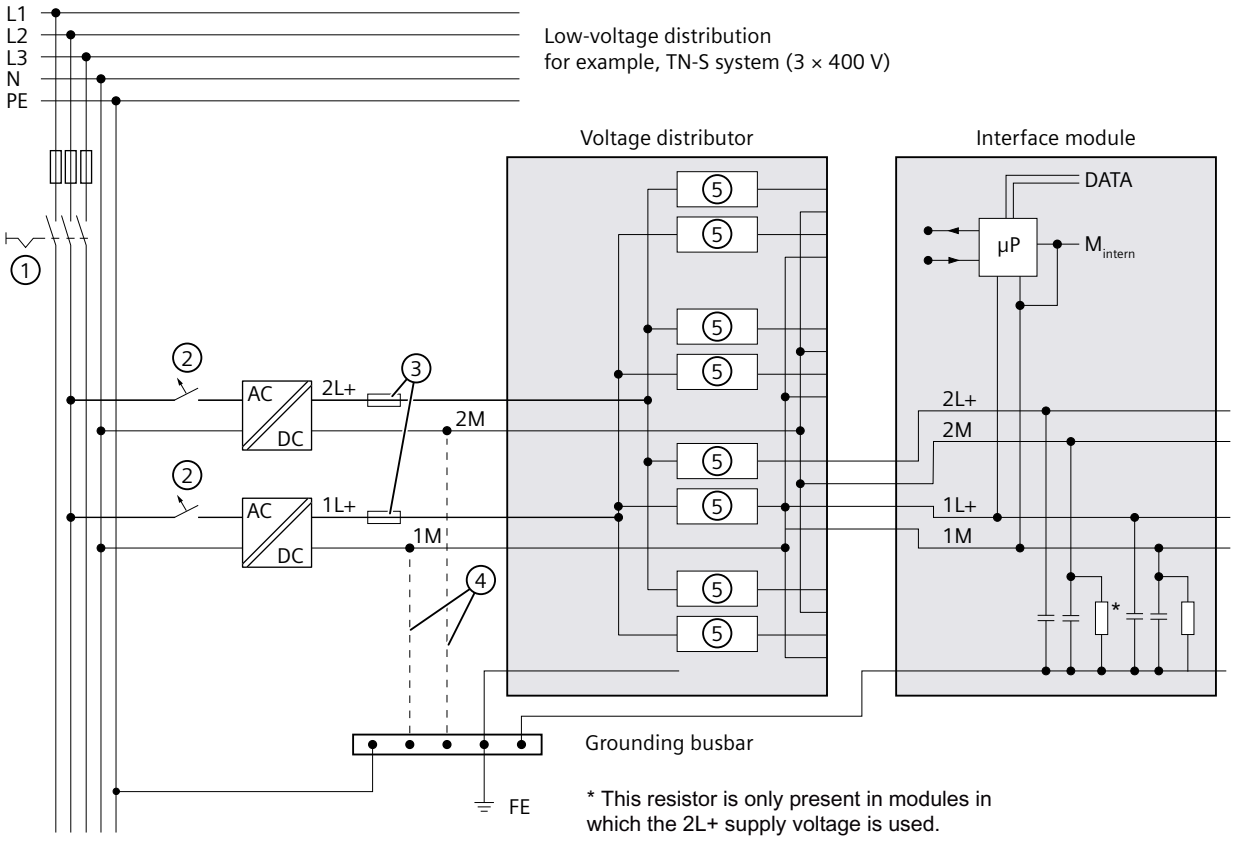
ET 200AL in the overall configuration

The figures below show the ET 200AL distributed I/O system in the complete electrical configuration using an interface module with and without voltage distributor as the example.



① Main switch
② Short-circuit and overvoltage protection
③ Fuses for cable protection (fuse for 4 A)
④ When configuring the ET 200AL distributed I/O system with non-grounded reference potential, no connection is made between 1M, 2M and functional ground

Figure 1-664 Electrical configuration



① Main switch
② Short-circuit and overvoltage protection
③ Fuses for cable protection (see Rules and regulations for operation (Page 41))
④ When configuring the ET 200AL distributed I/O system with non-grounded reference potential, no connection is made between 1M, 2M and functional ground
⑤ Integrated short-circuit protection electronic 4 A

Figure 1-665 Electrical configuration with voltage distributor

Components and protective measures

Various components and protective measures are stipulated for setting up a complete plant. The types of components and the degree to which the protective measures are mandatory depend on the IEC regulation that applies to your plant setup.

The following table shows the components of the electrical configuration with reference to the previous figure and compares the IEC regulations.

Table 1-946 Components of electrical configuration

	Reference to illustration	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Disconnection element for controller, sensors, and actuators	①	Main switch	Disconnector
Short-circuit / overload protection	②	Single-pole protection of circuits Secure all incoming supply cables with a circuit breaker. (See Rules and regulations for operation (Page 41))	Secure single pole for a grounded secondary circuit
Cable protection	③	Protection of cables and wires against overcurrent	-

Insulation monitoring

In the following situations, you must provide insulation monitoring:

- When configuring the ET 200AL distributed I/O system with non-grounded reference potential
- When hazardous system conditions may occur due to errors

7.4 Electrical configuration of the ET 200AL distributed I/O system

Electrical isolation

When electrically configuring the ET 200AL distributed I/O system, there is electrical isolation between:

- Load voltage 2L+ and all other switching parts
- Communication interfaces (PROFINET/PROFIBUS) of the interface modules and all other switching parts
- ET-Connection and all other switching parts

The following images show the potential conditions of the modules of the ET 200AL distributed I/O system.

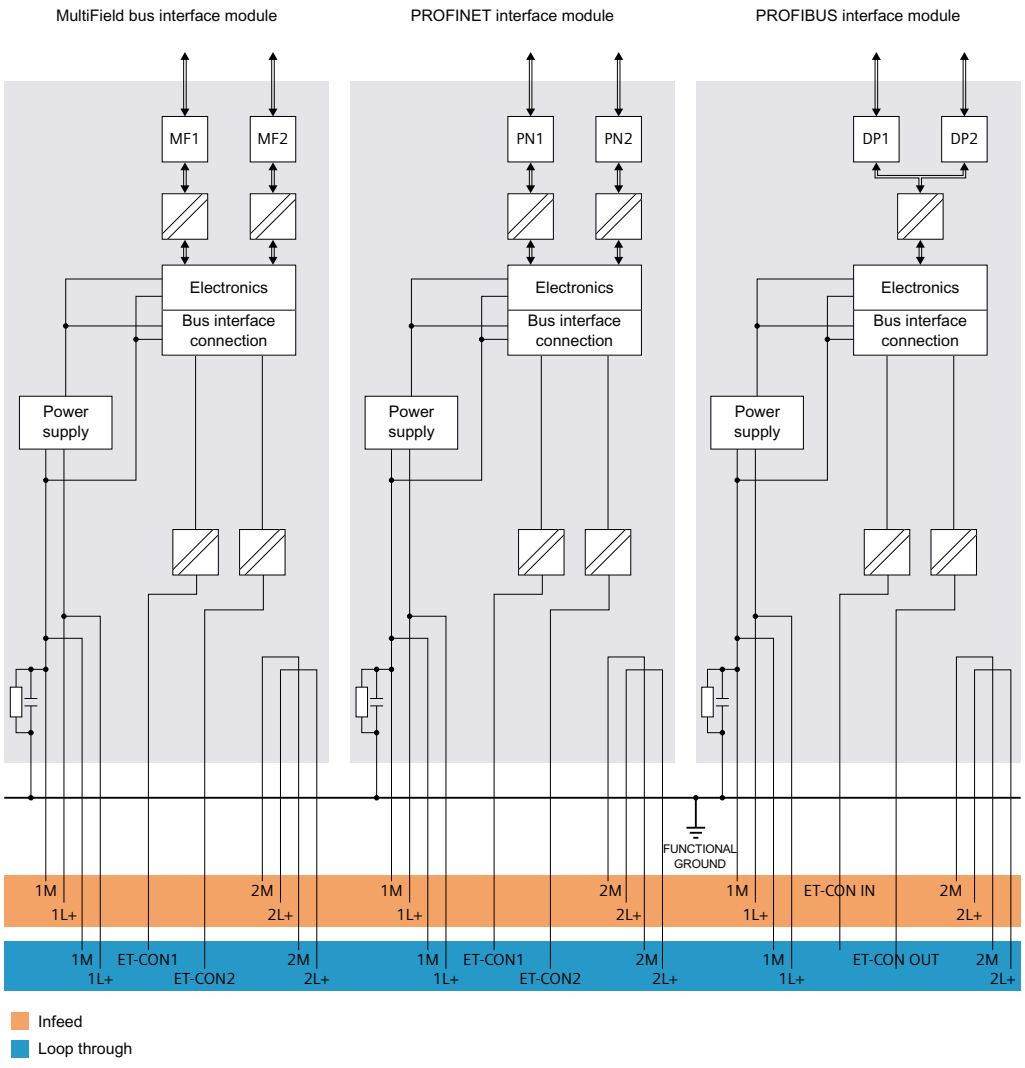


Figure 1-666 Potential conditions of the ET 200AL distributed I/O system (Part 1)

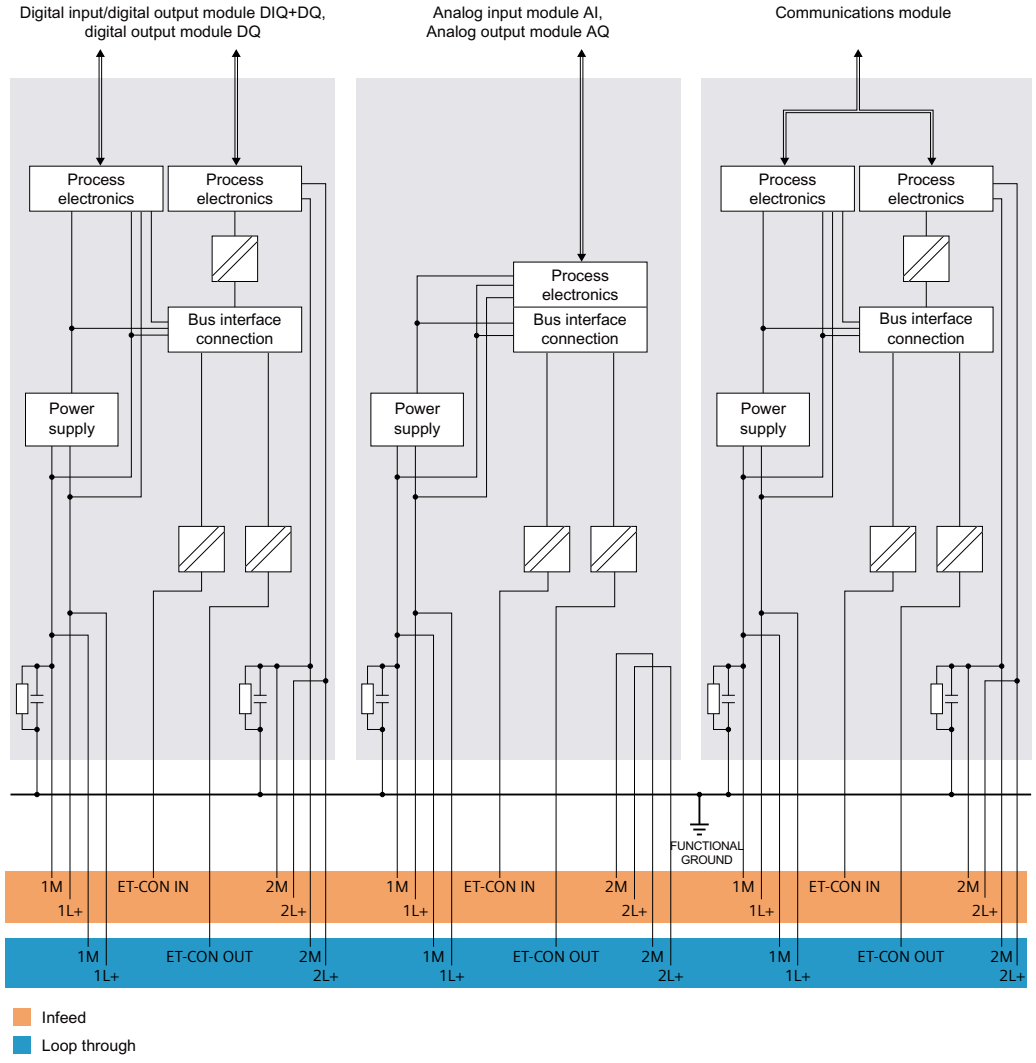


Figure 1-667 Potential conditions of the ET 200AL distributed I/O system (Part 2)

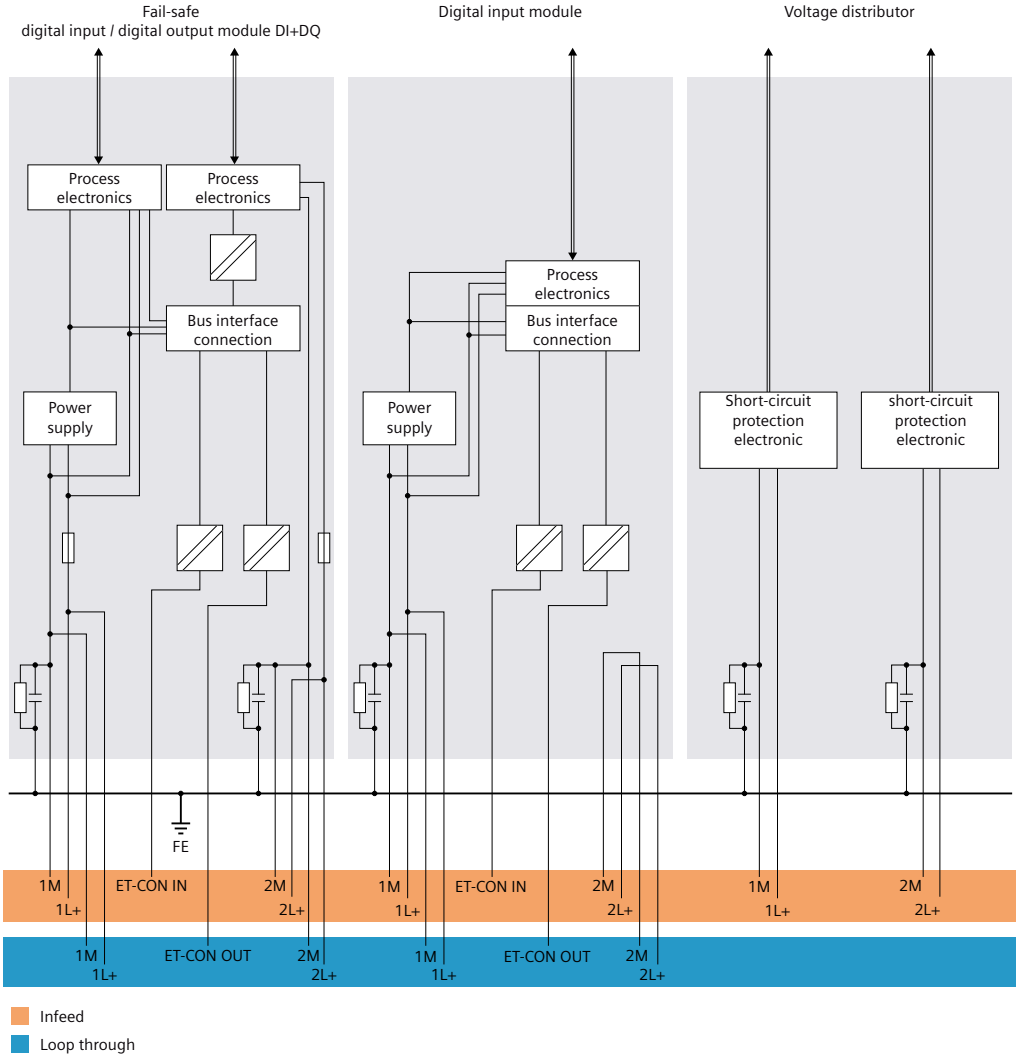


Figure 1-668 Potential conditions of the ET 200AL distributed I/O system (Part 3)

Connection of a digital output with a digital input

NOTICE
Pay attention to the potential group When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M may then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+. The possible compensating currents can destroy the digital module.

⚠ WARNING

Note potential groups for safety-related shutdown
When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M may then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+.
Safety-related shutdown is not permitted if electrical isolation has been eliminated.

Cable protection

According to IEC 60364, cable protection is required. Secure the supply cables externally.

Information about the fuses can be found in the section "Rules and regulations for operation (Page 41)" under "24 V DC supply".

Power supply of the configuration

Two voltage groups are available for the distributed I/O system ET 200AL: 1L+ (supply voltage) and 2L+ (load voltage).

A second infeed may be needed to supply all the modules of a configuration with the required voltage. Renewed voltage supply of 1L+ and 2L+ can be necessary to configure different potential groups or because the voltage is not sufficient for all modules due to the voltage drop. Create a power balance for the selection of the infeed point of the voltage.

NOTE

Turning 1L+ and 2L+ on and off
In contrast to the load voltage 2L+, the operational switching on and off of the supply voltage 1L+ results in a restart of the module.

The figure below shows a configuration with a new voltage infeed for the modules. The different potential groups have a gray background.

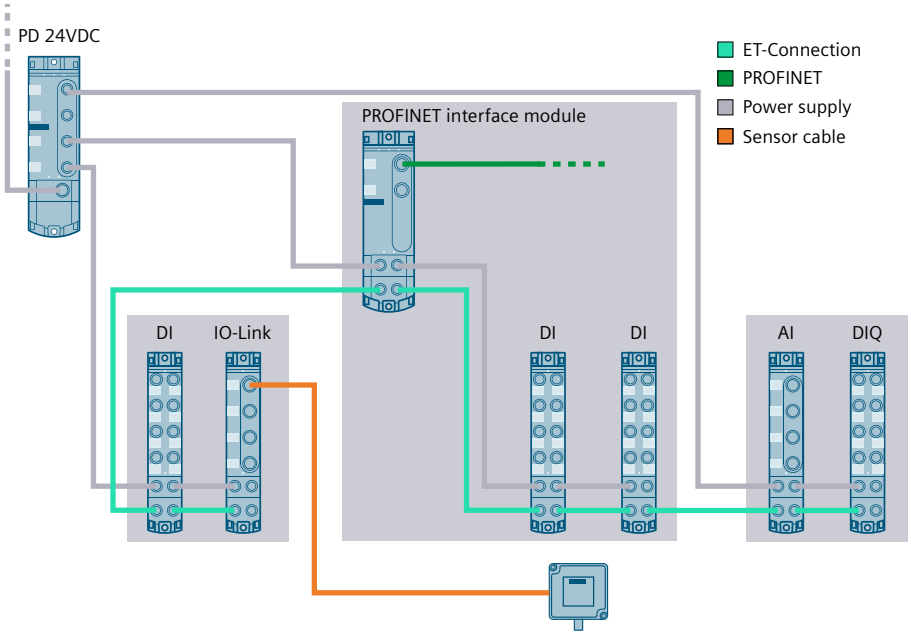


Figure 1-669 Wiring of the power supply

Reference

You will find additional information on electrical configuration and the voltage drop in the section Connecting cables for ET 200AL (Page 60).

7.5 Connecting ET 200AL to functional earth

Introduction

You must connect the distributed I/O system ET 200AL to functional earth (FE)

What is functional earth?

All ET 200AL modules feature a functional earth connection. This connection is used to suppress interference sensitivity, but not for protection purposes. With the functional earth connection, you create an electrical connection directly to a point of your system or shielding. This discharges the EMC interference directly into the earth. By discharging the EMC interference, the interference safety of the entire module is increased.

The figure below shows the symbol with which the functional earth connection is identified on the ET 200AL modules.

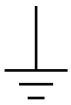


Figure 1-670 Functional earth

7.5.1 Mounting ET 200AL modules on conductive substrate

Requirement

Conductive substrate for mounting of the module

Required tools

To connect to functional earth, you need the following tools:

- Screwdriver

Required accessories:

To connect to functional earth, you need the following accessories:

- 2 x M4 fastening screws.

Mounting

To connect modules of the ET 200AL distributed I/O system to functional earth with a conductive mounting substrate, proceed as follows:

1. Drill two fastening holes.
2. Screw the module with the M4 fastening screws using a torque of 1.2 Nm.

NOTE

Earthing with conductive mounting substrate

When you fasten a module of the ET 200AL distributed I/O system on a conductive, grounded substrate, the bottom fastening screw provides a conductive connection to the ground potential.

Ensure that there is a low-impedance connection between the module and conductive underground as well as between the conductive underground and functional earth.

Reference

You will find more information on installing the modules in the section Mounting modules (Page 37).

7.5.2 Mounting ET 200AL modules on non-conductive substrate

Requirement

Conductive substrate for mounting of the module

Required tools

To connect to functional earth, you need the following tools:

- Screwdriver
- Stripping tool
- Crimp tool

Required accessories:

To connect to functional earth on a non-conductive fastening substrate, you need the following accessories:

- 2 x M4 fastening screws.
- Cable lug suitable for M4 screws
- Grounding cable (braided copper cable) with a minimum cross section of 4 mm^2

Mounting

To connect modules of the ET 200AL distributed I/O system to functional earth, proceed as follows:

1. Drill two fastening holes.
2. Strip the grounding cable.
3. Fasten the cable lug to the grounding cable.
4. Screw the module and the cable lug with the M4 fastening screws using a torque of 1.2 Nm.

The figure below shows how to connect functional earth using the example of the IM 157-1 PN interface module.

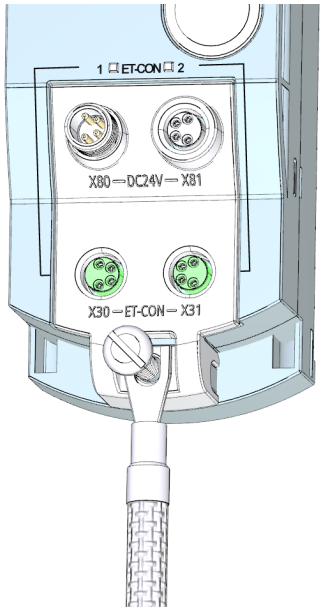


Figure 1-671 Connecting the functional earth

NOTE

Earthing with non-conductive mounting substrate

Make sure there is a low-impedance connection between the module and the functional earth.

Reference

You will find more information on installing the modules in the section Mounting modules (Page 37).

7.6 Connecting cables for ET 200AL

7.6.1 Wiring rules for the interface module and I/O modules

Impact of cable length on the supply voltage

When you wire your configuration, you must take into account the impact of the cable length on the supply voltage of the ET 200AL distributed I/O system.

CAUTION

Pay attention to maximum incoming currents
For interface modules and I/O modules, you may feed a maximum of 4 A per power supply (1L+, 2L+).
Comply with the maximum infeed currents and the required cable cross-sections. If you do not comply with the specifications, then an increased infeed current can lead to overheating of the cable insulation and the contacts. This could result in damage to the modules.

The figure below shows the voltage drop depending on the cable length for 4 current strengths, using the example of a copper cable with ∅ 0.5 mm².

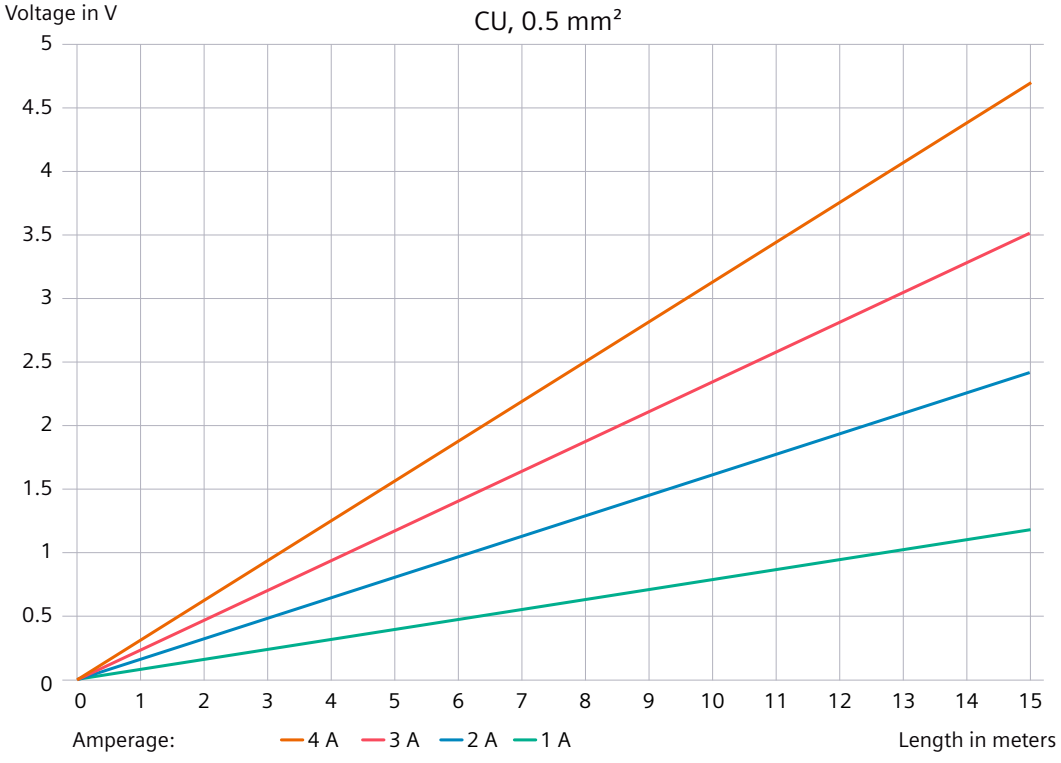


Figure 1-672 Voltage drop with a cable cross-section of 0.5 mm²

To estimate the voltage drop in your ET 200AL distributed I/O system, you must add the voltage drops of the different cables. For every module used, you must add an additional voltage drop of around 0.1 V.

Example

If you have a 7 m power supply cable with ∅ 0.5 mm², the voltage drop is around 1.5 V with a load of 3 A.

7.6.2 Connecting cables for voltage distributor PD 24VDC

Impact of cable length on the supply voltage

When you wire your configuration, you must take into account the impact of the cable length on the supply voltage of the ET 200AL distributed I/O system.

⚠ CAUTION

Pay attention to maximum incoming currents
For each power supply (1L+, 2L+), you can feed in a maximum of 15 A.
Comply with the maximum infeed currents and the required cable cross-sections. If you do not comply with the specifications, then an increased infeed current can lead to overheating of the cable insulation and the contacts. This could result in damage to the modules.

To estimate the voltage drop in your ET 200AL distributed I/O system, you must add the voltage drops of the different cables.

Voltage drop for copper cable with ∅ 2.5 mm²

The figure below shows the voltage drop depending on the cable length for 4 current strengths, using the example of a copper cable with ∅ 2.5 mm².

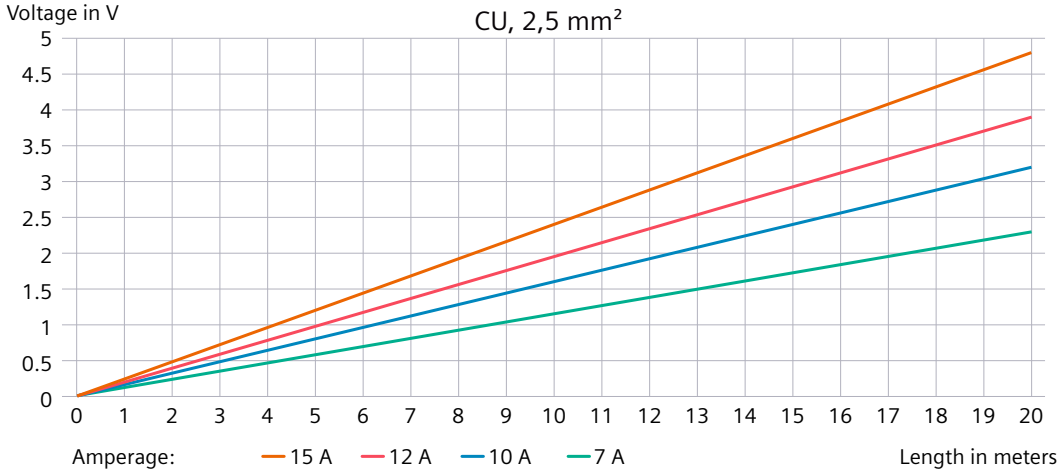


Figure 1-673 Voltage drop with a cable cross-section of 2.5 mm²

Example

If you have a 15 m power supply cable with ∅ 2.5 mm², the voltage drop is around 2.4 V with a load of 10 A.

7.7 Wiring

Connection

Connect all cables to the front side of the modules:

- Supply voltage and ET-Connection to the 4-pin M8 round sockets and M8 round connectors
- Signal lines to the 3-pin M8 or 4/5-pin M12 round sockets
- Fieldbus lines to the 4/5 pole M12 round sockets and M12 round connectors

NOTE

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

Requirement

Wire the modules with the supply voltage off.

Required tools

If you are not using pre-assembled cables, you need the following tools:

- Stripping tool
- Screwdriver to wire the connection plugs
- Stripping Tool for ET-Connection

Required accessories when connecting the supply voltage

You need the following accessories:

- Cables
  - Pre-assembled power cable, M8, 4-pin, or
  - Flexible 4-wire copper cable (wire cross section: 0.25 to 0.5 mm^2)
- 4-pin M8 connection plug

Accessories required for the connection of ET-Connection

You need the following accessories:

- ET-Connection cables
- 4-pin M8 connection plug

NOTE

ET-Connection cables
When connecting ET-Connection **use only** the offered cables.

Connecting M8 plugs

To connect M8 plugs, proceed as follows:

1. Insert the connector in the appropriate round socket on the module.
   Make sure that there is proper locking between the connector and socket.
2. Tighten the connector using the knurled screw with a torque of 0.4 Nm.

The figure below shows the connection of the M8 plugs, using the example of the DIQ 4+DQ 4x24VDC/0.5A 8xM8 digital input / digital output module.

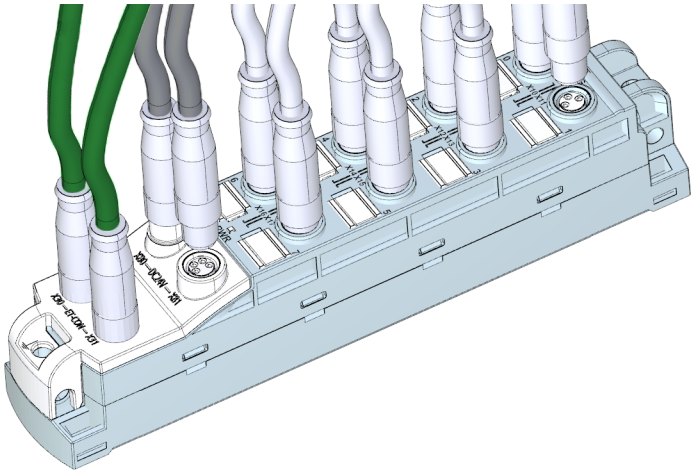


Figure 1-674 Connecting M8 plugs

Connecting M12 plugs

To connect M12 plugs, proceed as follows:

1. Insert the connector in the appropriate round socket on the module.
   Make sure that there is proper locking between the connector and socket (nut and spring).
2. Tighten the connector using the knurled screw with a torque of 1 Nm.

The figure below shows the connection of the M12 plugs, using the example of the analog input module AI 4xU/I/RTD 4xM12.

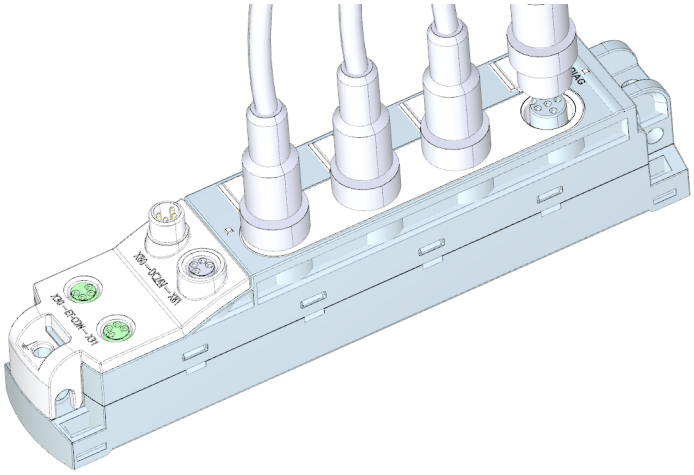


Figure 1-675 Connecting M12 plugs

Pin assignment of the sockets

The pin assignment of the sockets can be found in the manuals for the interface modules (https://support.industry.siemens.com/cs/ww/en/ps/14246/man) and I/O modules (https://support.industry.siemens.com/cs/ww/en/ps/14247/man) in the section on pin assignment and on the side surface of the module.

Y-cable

The Y-cable allows you to connect two actuators or sensors to the inputs or outputs.

The use of a Y-cable is particularly recommended when two channels are occupied for each socket of an I/O device. The Y-cable distributes the channels to two circular connectors.

- Y-cable (6ES7194-6KA00-0XA0) for connecting 2 actuators or sensors for double connection of inputs (also fail-safe inputs) or double connection of outputs with one cable
- Y-cable (6ES7194-6KB00-0XA0) for connecting 2 sensors for double connection F-DI with one cable. Only suitable for use with the F-DI module.

You can find details about connection in the respective user manual of the product.

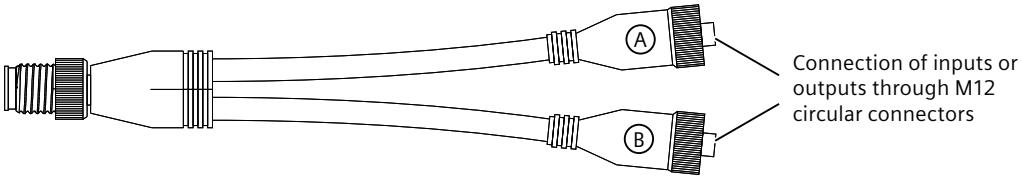
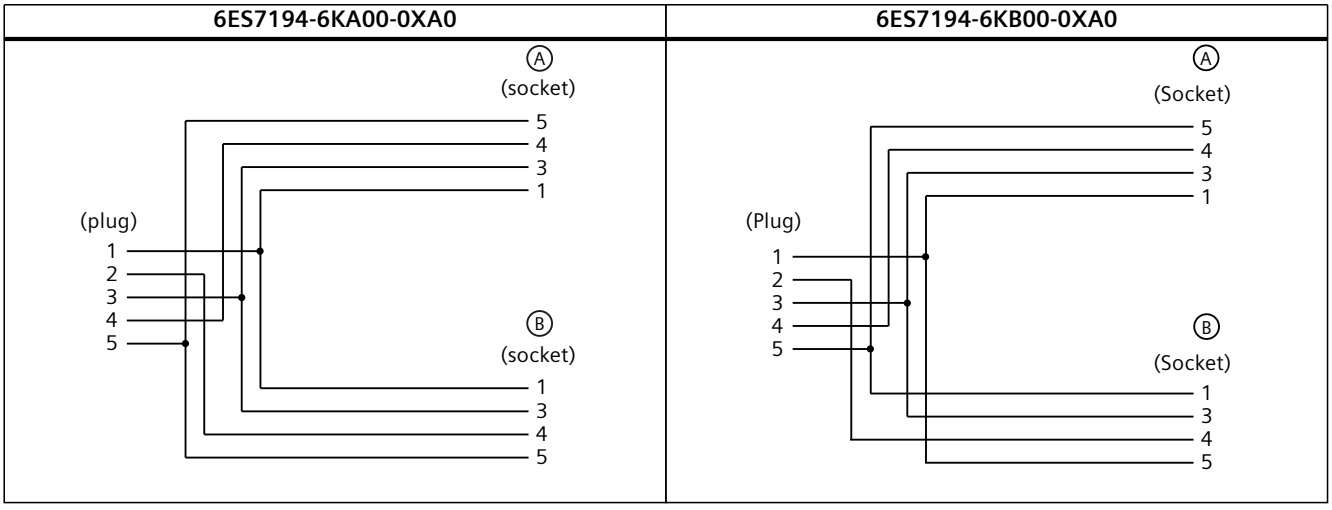


Figure 1-676 Y-cable

The following figure shows the wiring of the Y-cables.



Inverted Y-cable

The inverted Y-cable enables the connection of fail-safe inputs and a fail-safe output to an I/O device (for example a Siemens SIRIUS safety position switch with interlock) with only one cable.

You can find details about connection in the respective user manual of the product.

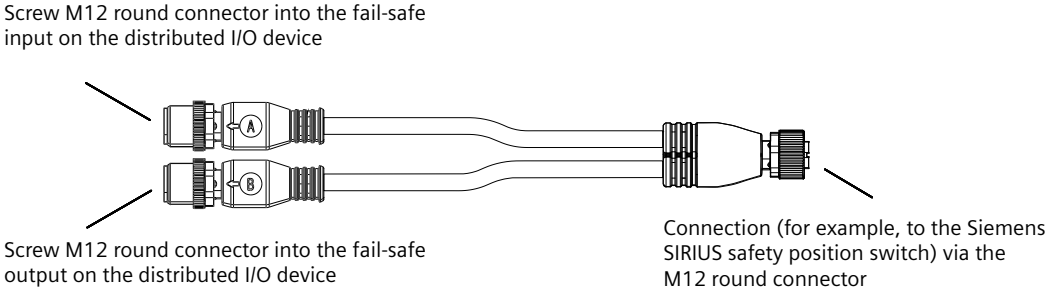


Figure 1-677 Inverted Y-cable

The following figure shows the wiring of the Y-cables.

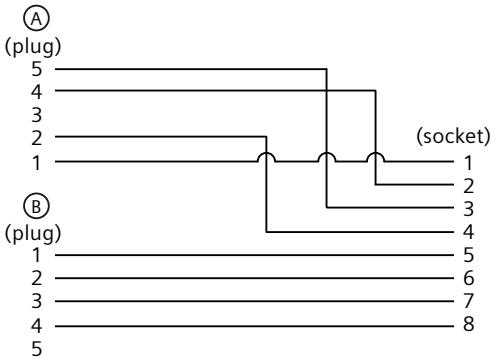


Figure 1-678 Y-cable 6ES7194-6KC00-0XA0

Sealing of unused sockets

To ensure IP65 or IP67 degree of protection, seal off all unused sockets with sealing caps.

Article numbers for accessories/spare parts.

You will find the article numbers in the Appendix in section Accessories/spare parts (Page 150).

7.8 ET 200AL marking

7.8.1 Factory markings

Introduction

For better orientation, the ET 200AL distributed I/O system is identified using various markings which will help you when configuring and connecting the modules.

Marking of the interfaces

The interfaces of the modules are factory-labeled.

The table below shows the labeling of the interfaces.

Table 1-947 Interface labeling

interface	Labeling
PROFINET IO interfaces MultiFieldbus interfaces	X1 P1R and X1 P2R
PROFIBUS DP interfaces	X1 DP1 and X1 DP2
I/O input and output interfaces	X10 to X17
ET-Connection interfaces (interface modules)	X30 (ET-CON1) and X31 (ET-CON2)
ET-Connection interfaces (I/O modules)	X30 (ET-CON IN) and X31 (ET-CON OUT)
Power supply interfaces	X80 (IN) and X81, X82, X83, X84 (OUT)

NOTE

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

NOTICE

ET-Connection/supply voltage

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage. Mixing up the ET-Connection connectors and the connectors for the supply voltage can destroy the module.

Pin assignment

The pin assignments of the various interfaces are lasered at the factory, on the side of every module.

7.8.2 Optional markings

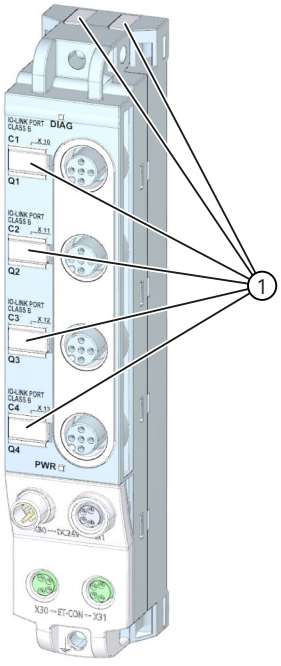
Introduction

In addition to the factory markings, there are also optional possibilities for labeling and/or identifying interfaces and modules on the ET 200AL distributed I/O system.

Identification label

The identification labels come with each module as strips and can be machine-printed. A strip has 10 identification labels measuring 10 x 5 mm in the color RAL9016. The identification labels can be inserted into every module at the points provided. The identification labels are used for channel, module and slot labeling.

The figure below shows all points where you can use the identification labels using the example of the IO-Link Master CM 4xIO-Link 4xM12 communication module.



① Identification labels

Figure 1-679 Optional marking

7.8.3 Mounting identification labels

Introduction

This section describes how to mount or remove identification labels.

Required tools

You need a screwdriver with 3 mm blade width (only to remove identification labels).

Mounting procedure

To mount an identification label, proceed as follows:

1. Print the identification label using commercially available marking systems.
2. Press the identification label out of its holder.
3. Stick the identification labels into the cutouts provided, as shown in the figure Optional marking (Page 67).

Mounting the identification labels is the same for all modules.

Removal procedure

To remove an identification label, proceed as follows:

1. Carefully use a screwdriver to pull out the identification label.

Removing identification labels is the same for all modules.

Configuring

8

8.1 Introduction

You configure and assign parameters for the ET 200AL distributed I/O system (interface modules and I/O modules) using STEP 7 or the configuration software of another manufacturer.

8.2 Requirements

Configuration software and requirements

The following table shows the configuration software that can be used and the associated requirements.

Table 1-948 Configuration software and requirements

Configuration software	Requirements	Installation information
STEP 7 (TIA Portal) as of V19 for modules: • IM 157-1 MF • CM 8xIO-Link + DIQ 6x24VDC/0.5A 8xM12 • CM 4xIO-Link 4xM12	As of Support Package HSP 0419	STEP 7 online help
STEP 7 Safety (TIA Portal) as of V17 for modules: • F-DI 4+F-DQ 2x24VDC/2A 4xM12	• PROFINET-compliant F-CPU (with CP expansion modules) • PROFIsafe-compliant F-PLC controller, 2.6.X (RIOforFA safety profile) or PROFIsafe 2.4	
STEP 7 (TIA Portal) as of V16 for modules: • AI 4xRTD/TC 4xM12	As of Support Package HSP 0313	
STEP 7 (TIA Portal) as of V14 for modules: • DIQ 16x24VDC/0.5A 8xM12 • AQ 4XU/I, 4XM12	As of Support Package HSP 0194	
STEP 7 (TIA Portal) V13 SP1 or higher for modules: • DI 8x24VDC 4xM12 • DI 16x24VDC 8xM12	As of Support Package HSP 0155	
STEP 7 (TIA Portal) V13 SP1 or higher for modules: • DIQ 4+DQ 4x24VDC/0.5A 4xM12 • DQ 8x24VDC/2A 8xM12	As of Support Package HSP 0156	
STEP 7 (TIA Portal) V13 SP1 or higher for modules: • IM 157-1 PN • IM 157-1 DP • DI 8x24VDC 8xM8 • DIQ 4+DQ 4x24VDC/0.5A 8xM8 • AI 4xU/I/RTD 4xM12 • CM 4xIO-Link 4xM12	None, integrated in STEP 7	
STEP 7 as of V5.5 SP4 for modules: • IM 157-1 PN • IM 157-1 DP	• PROFINET IO: As of Support Package HSP 0259 • PROFIBUS DP: as of Support Package HSP 0258	
STEP 7 as of V5.5 SP4 for all IO modules	As of Support Package HSP 0260	
STEP 7 (TIA Portal) as of V13 Update 3	• PROFINET IO GSD file: GSDML-Vx.y-Siemens-ET200AL-"Date in format yyyymmdd".xml (https://support.industry.siemens.com/cs/ww/en/view/92346477) for EXAMPLE: GSDML-V2.31-Siemens-ET200AL-20140507.xml • PROFIBUS DP GSD file: siem81A9.gsg (https://support.industry.siemens.com/cs/ww/en/view/92346281)	
Software of third-party manufacturer		Manufacturer documentation

Configuring the ET 200AL distributed I/O system

See the STEP 7 online help or the documentation of the configuration software manufacturer.

8.3 Configuration

8.3.1 MultiFieldbus maximum configuration

MultiFieldbus configuration

Each of the connections for ET-Connection occupies a slot in the configuration. The slots for ET-Connection1 and ET-Connection2 are pre-defined statically in the GSD file.
ET-Connection1 is always at slot 1 and ET-Connection2 at slot 18.

The fixed slot assignment of ET-Connection1 and ET-Connection2 offers you the following advantages:

- You can expand ET-Connection1 and ET-Connection2 without a high workload
- Transparency in configuration control
- Simplification of diagnostics alarms and troubleshooting

The figure below shows the maximum configuration with modules of the ET 200AL distributed I/O system.

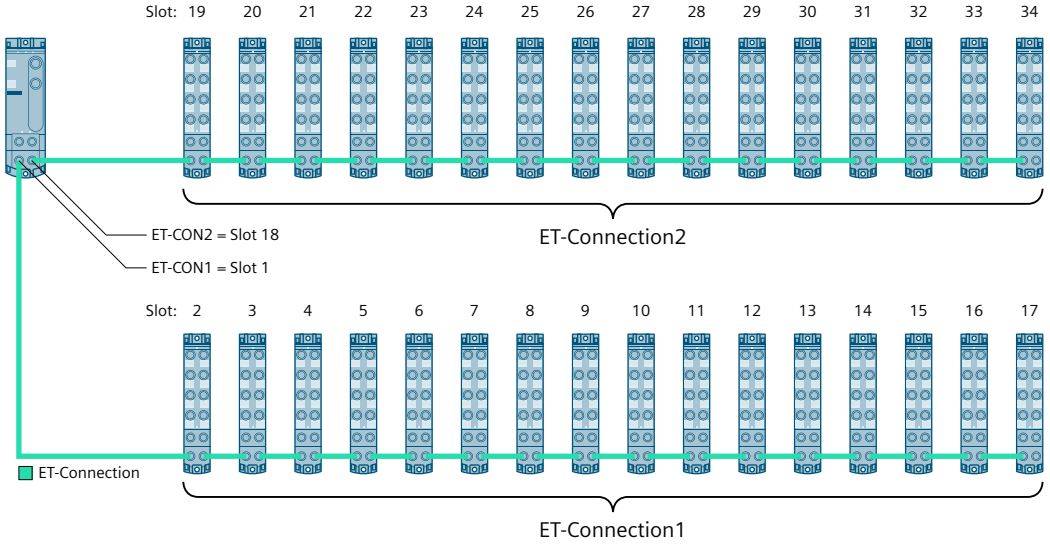


Figure 1-680 MultiFieldbus maximum configuration

Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 76).

8.3.2 PROFINET maximum configuration

PROFINET configuration

Each of the connections for ET-Connection occupies a slot in the configuration. The slots for ET-Connection1 and ET-Connection2 are specified statically in the PROFINET GSD file. ET-Connection1 is permanently on slot 1 and ET-Connection2 on slot 18.

The fixed slot assignment of ET-Connection1 and ET-Connection2 offers you the following advantages:

- You can expand ET-Connection1 and ET-Connection2 without a high workload
- Transparency in configuration control
- Simplification of diagnostics alarms and troubleshooting

The figure below shows the maximum configuration with modules of the ET 200AL distributed I/O system.

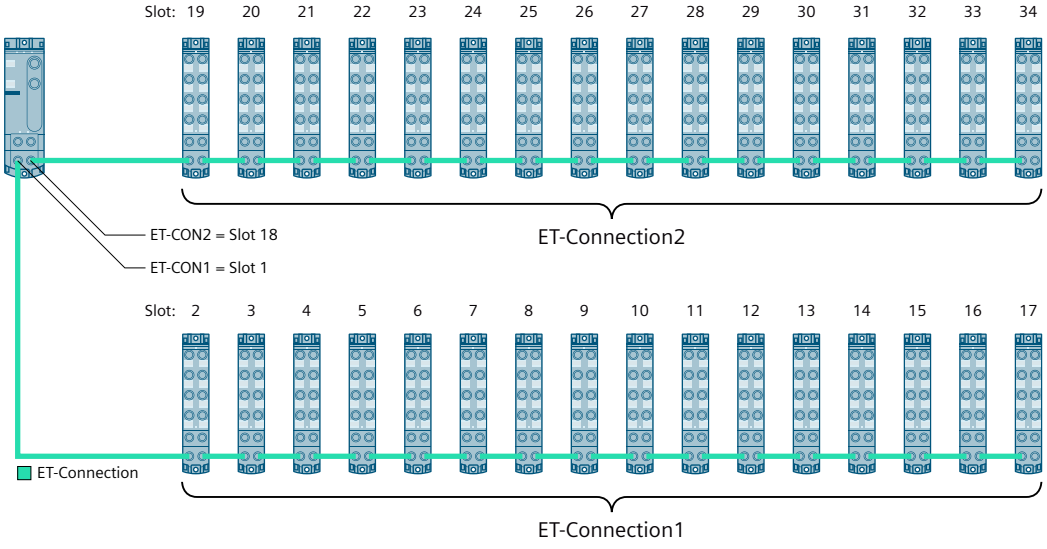


Figure 1-681 PROFINET maximum configuration

Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 76).

8.3.3 PROFIBUS maximum configuration

PROFIBUS configuration

Each of the connections for ET-Connection occupies a slot in the configuration. The slot for ET-Connection1 is statically defined in the PROFIBUS GSD file. ET-Connection1 is always permanently installed in slot 1. Always place the topology module for ET-Connection2 on slot 18. You do not need to fill slots in the configuration for ET-Connection1 with dummy modules.

The fixed slot assignment of ET-Connection1 and ET-Connetion2 offers you the following advantages:

- You can expand ET-Connection1 and ET-Connection2 without a high workload; for ET-Connection1 you need to remove the placeholder, the I/O module is placeable (no placeholders are needed for ET-Connection2)
- You cannot configure more modules on ET-Connection1 or ET-Connection2 than are allowed.
- Transparency in configuration control
- Simplification of diagnostics alarms and troubleshooting

The figure below shows the maximum configuration with modules of the ET 200AL distributed I/O system.

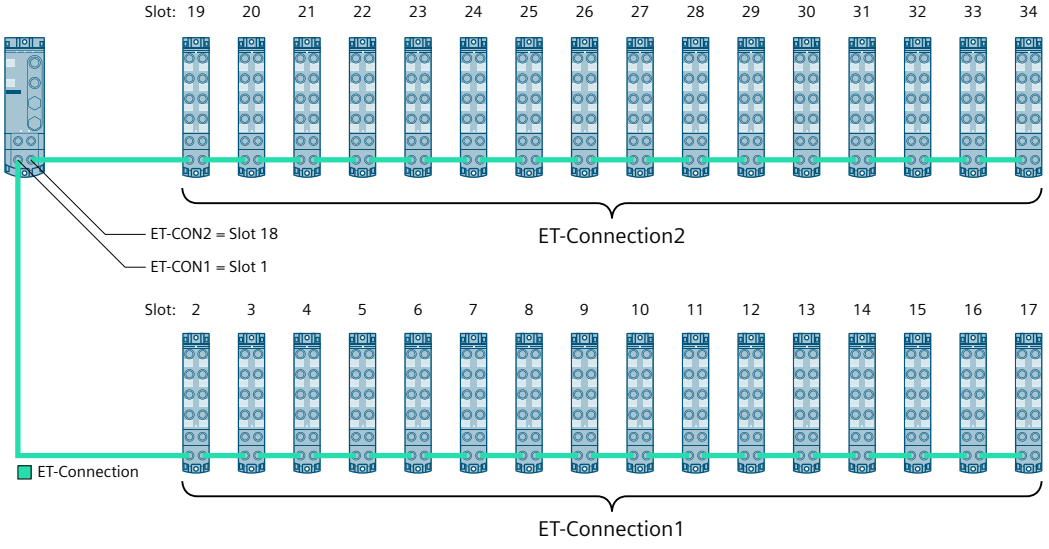


Figure 1-682 PROFIBUS maximum configuration

Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 76).

8.4 Assigning the PROFIsafe addresses

The F-destination address is permanently stored in the eCoding plug connector of the fail-safe ET 200AL I/O modules.

NOTE

When assigning the PROFIsafe addresses, the F-modules must be supplied with voltage 1L+.

NOTE

Follow these points in conjunction with the configuration control:
Before you can use the configuration control together with F-modules, the PROFIsafe addresses must be assigned to the F-modules in the designated slots.
For this, each F-module must be plugged into the slot configured for it. The actual configuration may differ from the set configuration.

You can find additional information about the assignment of the PROFIsafe addresses in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Reference

You can find additional information on this topic in section Configuration control (option handling) (Page 76).

Configuration control (option handling) 9

9.1 Configuration control

Introduction

With configuration control (option handling), you handle various standard machine configuration levels in one project without having to change the hardware configuration or user program.

Operating principle of configuration control

You can use configuration control to operate different standard machine configurations with a single configuration of the ET 200AL distributed I/O system.

- A station master (maximum configuration) is configured in a project. The station master comprises all modules needed for all possible equipment components of a modular standard machine.
- Provision is made in the user program of the project for various station options for the different configuration levels of the standard machine and for selection of a station option. A station option uses, for example, only some of the modules of the station master and these modules are not inserted in the configured order.
- Manufacturers of standard machines select a station option for a configuration level of the standard machine. They do not have change the project or download the modified configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. If a module with the configuration control is moved to another slot, it retains its parameter assignment.

The configuration control allows you to flexibly vary the centralized/distributed configuration. As a precondition for this, the station option must be able to be derived from the station master.

The following figure shows 3 configurations of a standard machine with the corresponding station options of the ET 200AL distributed I/O system.

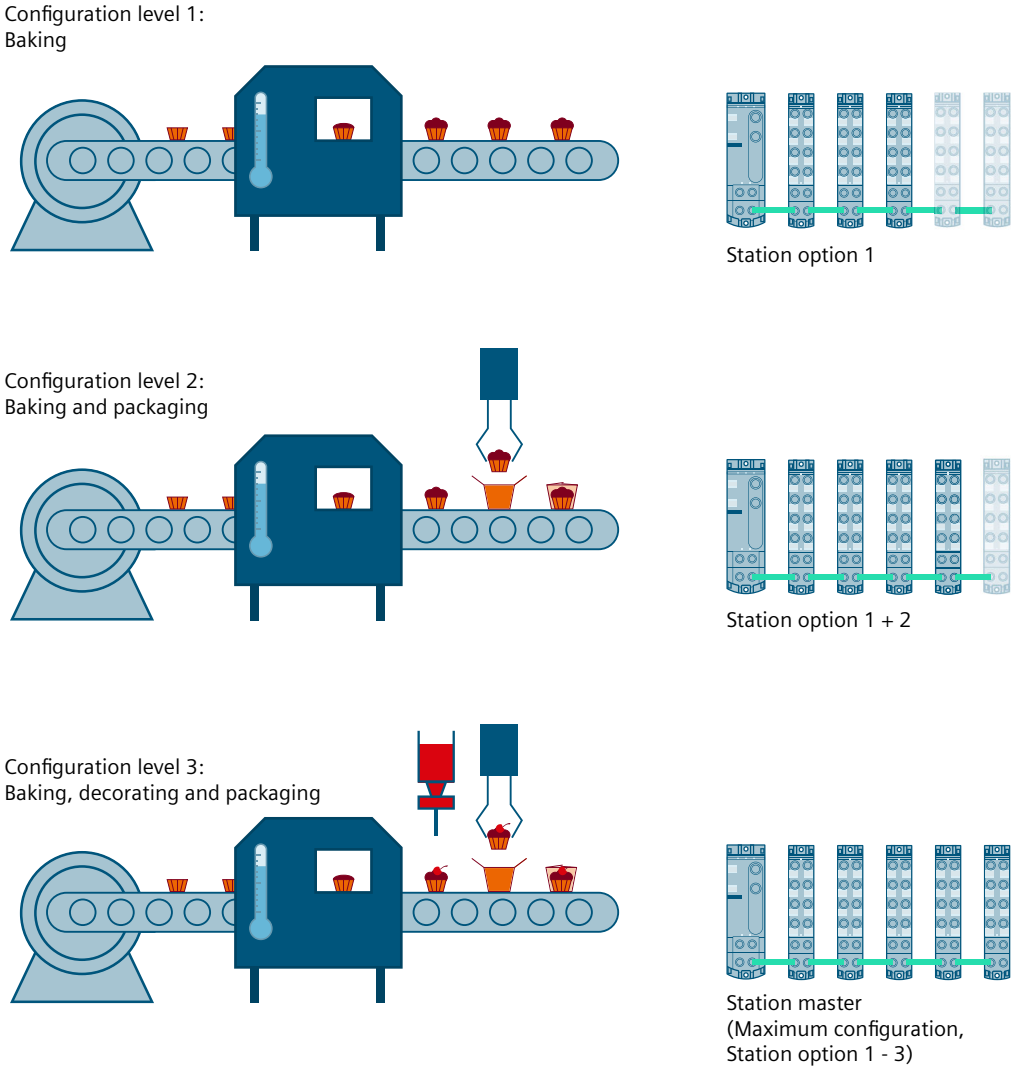


Figure 1-683 Various configuration levels of a standard machine with the corresponding station options of the ET 200AL distributed I/O system.

Benefits

- Easy project handling and commissioning through use of a single STEP 7 project for all station options.
- Easy handling during maintenance, versioning and upgrades.
- Hardware savings: Only the I/O modules needed for the current station option of the machine are installed.
- Potential savings when building, commissioning and creating documentation for standard machines.

Procedure

To set up the configuration control, follow these steps in the order given:

Step	Procedure	See...
1	Enable configuration control in STEP 7	Section Configuring (Page 78)
2	Create control data record	Section Creating the control data record (Page 80)
3	Transfer control data record	Section Transferring the control data record in the user program of the CPU (Page 88)

Library for configuration control

A library for configuration control is available for download (https://support.industry.siemens.com/cs/ww/en/view/29430270) on the internet. The library contains data types with the structure of the control data records for the ET 200AL distributed I/O system. You can implement your flexible automation solution economically with the help of these data types.

9.2 Configuring

Requirements

Via PROFINET IO:

- Configuration software, for example STEP 7 Professional as of V13
- IM 157-1 PN or IM 157-1 MF
- You have assigned the interface module to an IO controller in STEP 7

Via PROFIBUS DP:

- Configuration software, for example STEP 7 Professional as of V13
- IM 157-1 DP
- You have assigned the interface module to a DP master in STEP 7

- The parameter "Operation if preset configuration does not match actual configuration" is activated.
  The parameter "Operation if preset configuration does not match actual configuration" is located in STEP 7 in the properties of the interface module under "Module parameters" > "Start-up".

NOTE

Disabled parameter "Startup if preset configuration does not match actual configuration"
If an I/O module is missing or an incorrect or additional I/O module is plugged in and the "Startup if preset configuration does not match actual configuration" parameter is disabled, the ET 200AL distributed I/O system does not start up.
The diagnostic "Slot x no module" or "Slot x wrong module" is generated.
If the IM 157-1 DP interface module does not start up in this status, the RUN and ERROR LEDs on the interface module flash red. The DIAG LEDs flash green on all I/O modules as well.

NOTE

Follow these points in conjunction with the configuration control:
Before you can use the configuration control together with F-modules, the PROFIsafe addresses must be assigned to the F-modules in the designated slots.
For this, each F-module must be plugged into the slot configured for it. The actual configuration may differ from the set configuration.

Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the interface module.

- The parameter "Enable reconfiguration of device via user program" is located in the properties of the interface module under "Module parameters" > "Configuration control".

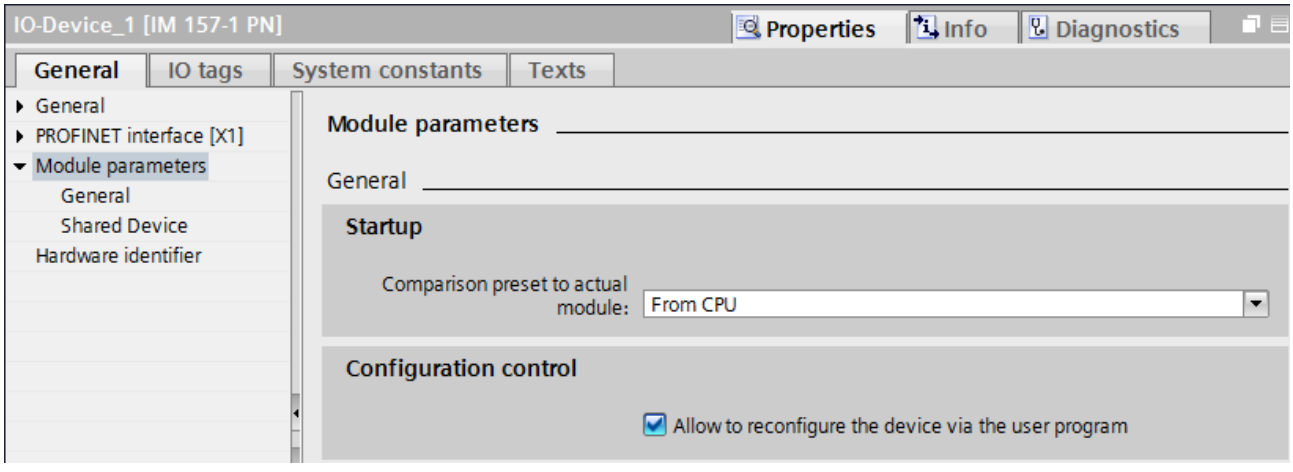


Figure 1-684 Enabling configuration control using the IM 157-1 PN as an example

9.3 Creating the control data record

9.3.1 Introduction

Required steps

The following description shows as an example how you can create a control data record for the configuration control in STEP 7 (TIA Portal).

To create a control data record for the configuration control, follow these steps:

1. Create a PLC data type that contains the structure of the control data record for an ET 200AL interface module.

   You can find the structure of the control data record in section Control data record for the ET 200AL distributed I/O system (Page 82)

CTR_REC

	Name	Data type	Default value	A...	W...	V..	S...	Comment
1	Block_Lenght	USInt	76	☑	☑	☑	☐	
2	Block_ID	USInt	196	☑	☑	☑	☐	
3	Version	USInt	2	☑	☑	☑	☐	
4	Subversion	USInt	1	☑	☑	☑	☐	
5	ET-Connection1	Struct		☑	☑	☑	☐	ET-Connection1 slots 2-17
6	Topology module	USInt	1	☑	☑	☑	☐	ET-Connection1 topology module
7	Reserved 1	USInt	0	☑	☑	☑	☐	
8	Slot 2	USInt	2	☑	☑	☑	☐	assigned "real" slot
9	Reserved 2	USInt	0	☑	☑	☑	☐	
10	Slot 3	USInt	3	☑	☑	☑	☐	assigned "real" slot
11	Reserved 3	USInt	0	☑	☑	☑	☐	
12	Slot 4	USInt	4	☑	☑	☑	☐	assigned "real" slot
13	Reserved 4	USInt	0	☑	☑	☑	☐	
14	Slot 5	USInt	5	☑	☑	☑	☐	assigned "real" slot
15	Reserved 5	USInt	0	☑	☑	☑	☐	
		USInt	6	☑	☑	☑	☐	assigned "real" slot

Figure 1-685 Creating control data record 196

2. Create a global data block.
3. Create an array of the data type of the above created PLC data type in the data block.

   The following figure shows a data block containing the control data records for an ET200AL interface module. In this example the data block contains three control data records.

ConfDB

	Name	Data type	Start value	R..	A...	V..	S...	Comment
1	Static			☐	☐	☐	☐	
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..2] of "CTR_REC"		☐	☑	☑	☐	
4	ConfigControl[0]	"CTR_REC"		☐	☑	☑	☐	
5	ConfigControl[1]	"CTR_REC"		☐	☑	☑	☐	
6	Block_Lenght	USInt	36	☐	☑	☑	☐	4+number of slots

Figure 1-686 Data block for configuration control

4. In the "Start value" column of the control data records, enter which module is located at which slot.

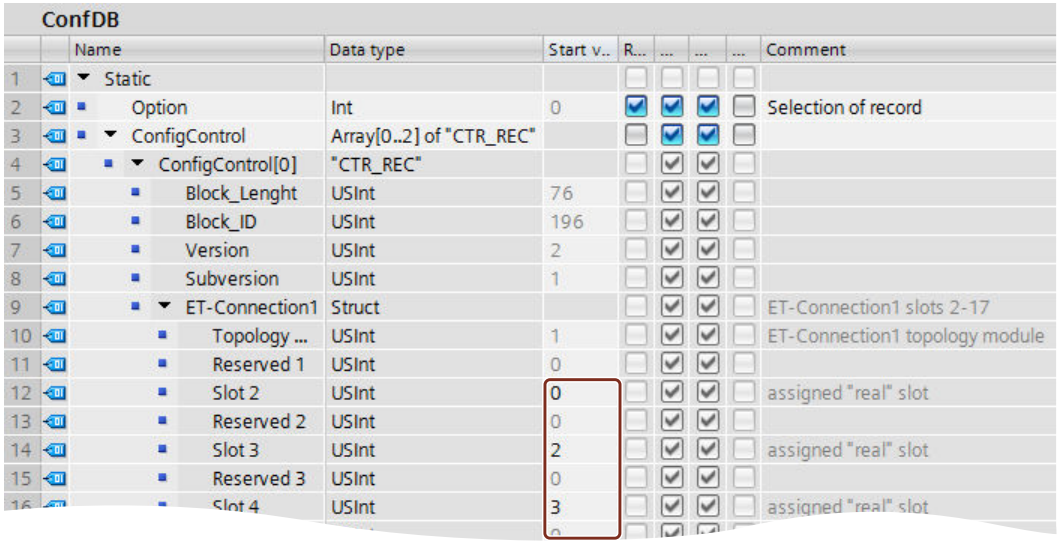


Figure 1-687 Assigning slots

Rules

Observe the following rules:

- Slot entries in the control data record outside the station master are ignored by the interface module.
- The control data record must contain the entries up to the last slot of the station option.
- Each slot of a station option may only be present once in the control data record.
- Each slot of a station option may only be assigned to one slot in the station master.
- The interface module (slot 0) is not an element of the configuration control, but instead controls this.
- The topology modules always have to exist in the data record:
  - The topology module ET-Connection 1 is always located on Slot 1.
  - The topology module ET-Connection 2 is always located on Slot 18.

9.3.2 Control data record for the ET 200AL distributed I/O system

Slot assignment

NOTE

Topology modules ET-Connetion1 and ET-Connection2
Both topology modules ET-Connection1 and ET-Connection2 should be treated like real modules during configuration control.
Restriction: ET-Connetion1 is always placed in Slot 1 and ET-Connection2 is always placed in Plot 18.

The following table shows the possible slots for the various modules for an ET 200AL interface module:

Table 1-949 Slot assignment

Modules	Possible slots	Comment
Topology ET-Connection1	1	The topology module ET-Connection 1 is always located on Slot 1.
I/O modules ET-Connection1	2-17	-
Topology module ET-Connection2	18	The topology module ET-Connection2 is always located on Slot 18.
I/O modules ET-Connection2	19-34	-

Control data record

For configuration control of the ET 200AL distributed I/O system, you define a control data record 196 V2.1, which contains a slot assignment for the modules. The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-950 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots x 2)	Header
1	Block ID	196	
2	Version	2	
3	Subversion	1	

Byte	Element	Code	Explanation
4	Slot topology module ET-Connection1	1 The topology module ET-Connection 1 is always located on Slot 1.	**Control element** Contains information on which module is inserted in which slot. The following rule determines which value you must enter in the respective byte: • If the module is included in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
5	Reserved		
6	Slot 2 of the station master	Slot assignment in the station option	
7	Reserved		
:	:	:	
38	Slot topology module ET-Connection2	18 The topology module ET-Connection2 is always located on Slot 18	
39	Reserved		
40	Slot 19 of the station master	Slot assignment in the station option	
41	Reserved		
:	:	:	
4 + ((max. slot - 1) x 2))	Maximum slot of the station master	Slot assignment in the station option	
5 + ((max. slot - 1) x 2))	Reserved		

Combination of configuration control and shared device (for PROFINET)

The configuration control function in a shared device is therefore only for the I/O modules of the IO controller to which the interface module has subscribed. I/O modules that are assigned to no controller or a different controller behave like a station without activated configuration control.

In the control data record change the slots only for those modules that are assigned to the IO-Controller.

In the control data record do not move modules to slots that are assigned to a different IO controller or no IO controller. The interface module does not check whether a control data record 196 exists for these slots. The interface module assumes a 1-to-1 assignment for these slots.

Combination of configuration control and PROFIenergy (at PROFINET)

You can use configuration control together with PROFIenergy for the ET 200AL distributed I/O system.

Ensure that you use the slots of the used station option when creating Data record 3. Do not use the slots configured in the station master.

Example: You want to set up PROFIenergy for a DQ module of an IM 157-1 PN that works with configuration control. You have configured the DQ module to Slot 5 in the station master. You have moved the DQ module to Slot 2 in the station option. In order to set up PROFIenergy for this module use Slot 2 in Data record 3.

You can find more information about PROFIenergy in the Interface module IM 157-1 PN (https://support.industry.siemens.com/cs/ww/en/view/89254863) Equipment Manual.

9.3.3 Feedback data record at the ET200AL distributed I/O system

Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0.

Feedback data record

The feedback data record exists only when configuration control is configured and always refers to the maximum configuration limits **without interface module**, i.e., 34 slots. Partial reading of the feedback data record is possible.

Table 1-951 Feedback data record

Byte	Element	Code	Explanation
0	Block length	66	Header
1	Block ID	197	
2	Version	2	
3		0	
4	Slot 1 status	0/1	Status = 1: • Module from station master is inserted in the station option • Slot is marked as not available in the control data record Status = 0: • Module pulled • Incorrect module inserted in the station option*
5	Reserved	0	
6	Status slot 2	0/1	
7	Reserved	0	
:	:	:	
70	Status Slot 34	0/1	
71	Reserved	0	

* Not possible if the slot is marked as not available.

NOTE

The data in the feedback data record is always mapped for all modules. In a Shared Device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record was sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

Error messages

In the case of an error when reading the feedback data record, the RDREC instruction returns the following error messages via the STATUS block parameter:

Table 1-952 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 197 is not correct.
$80B5_H$	Configuration control not configured

Error code	Meaning
$80B8_H$	Parameter error The following events cause a parameter error: • Incorrect block ID in the header (not equal to 197) • Invalid version identifier in the header • A reserved bit was set • Multiple slots in the station master are assigned to the same slot in the station option

9.3.4 Example of a configuration control

Introduction

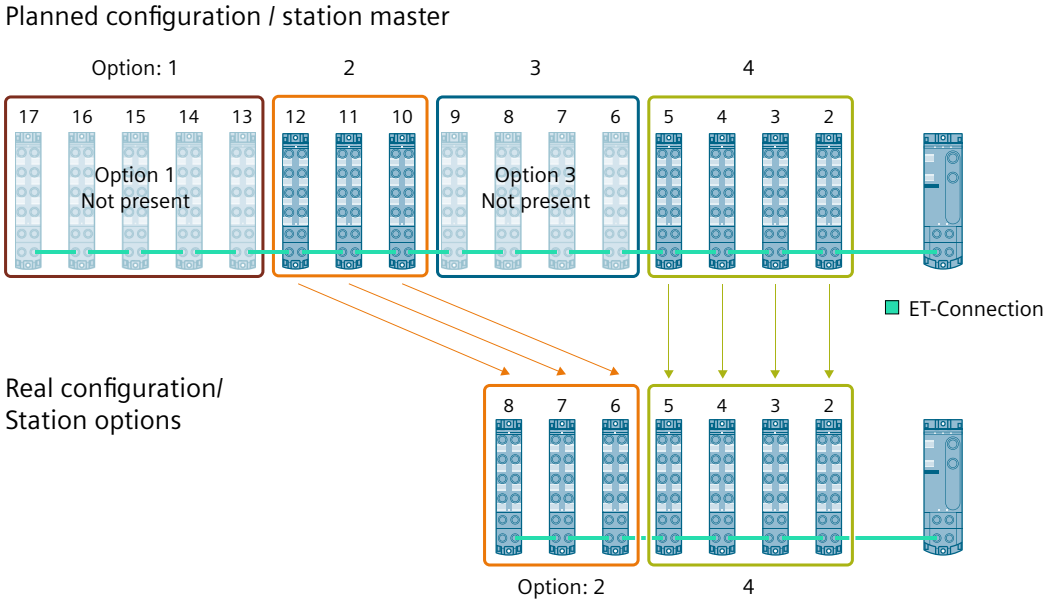
Several options/functional variations often exist for machines designed as series products. Or you have a plant that can operate in different modes.
Combine the modules that are needed for a function. With configuration control (option handling), you have the option to switch these functions on and off or expand their configuration.

The following examples show how you can form the control data record for a station option. The station master consists of an interface module IM 157-1 PN and 15 I/O modules in this case.

Station option with associated control data record

The configuration with the station options 2 and 4 differ from the station master as follows:

- The modules for options 1 and 3 do not exist.

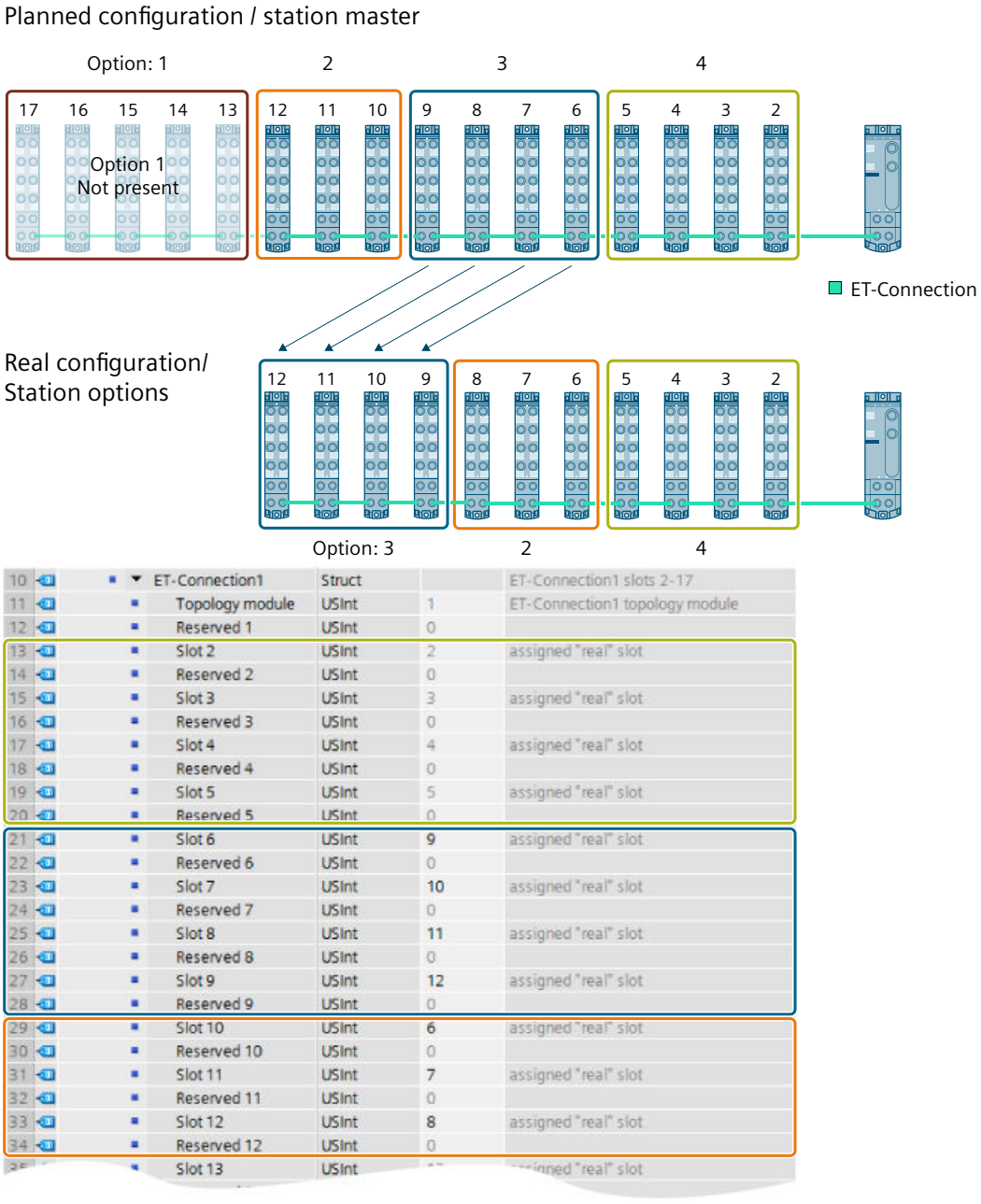


9		ET-Connection1	Struct		ET-Connection1 slots 2-17
10		Topology ...	USInt	1	ET-Connection1 topology module
11		Reserved 1	USInt	0	
12		Slot 2	USInt	2	assigned "real" slot
13		Reserved 2	USInt	0	
14		Slot 3	USInt	3	assigned "real" slot
15		Reserved 3	USInt	0	
16		Slot 4	USInt	4	assigned "real" slot
17		Reserved 4	USInt	0	
18		Slot 5	USInt	5	assigned "real" slot
19		Reserved 5	USInt	0	
20		Slot 6	USInt	0	assigned "real" slot
21		Reserved 6	USInt	0	
22		Slot 7	USInt	0	assigned "real" slot
23		Reserved 7	USInt	0	
24		Slot 8	USInt	0	assigned "real" slot
25		Reserved 8	USInt	0	
26		Slot 9	USInt	0	assigned "real" slot
27		Reserved 9	USInt	0	
28		Slot 10	USInt	6	assigned "real" slot
29		Reserved 10	USInt	0	
30		Slot 11	USInt	7	assigned "real" slot
31		Reserved 11	USInt	0	
32		Slot 12	USInt	8	assigned "real" slot
33		Reserved 12	USInt	0	
34		Slot 13	USInt	0	assigned "real" slot
35		Reserved 13	USInt	0	
36		Slot 14	USInt	0	assigned "real" slot
37		Reserved 14	USInt	0	
38		Slot 15	USInt	0	assigned "real" slot
39		Reserved 15	USInt	0	
40		Slot 16	USInt	0	assigned "real" slot
41		Reserved 16	USInt	0	
42		Slot 17	USInt	0	assigned "real" slot
43		Reserved 17	USInt	0	

Figure 1-688 Example: Hardware configuration of Station option 2 and 4 with the associated control data record in STEP 7

Extension by a station option

The following figure shows the configuration with the Station options 2 and 4 that has subsequently been extended by the Station option 3.
The modules of option 3 are added to the modules already existing.



10	ET-Connection1	Struct		ET-Connection1 slots 2-17
11	Topology module	USInt	1	ET-Connection1 topology module
12	Reserved 1	USInt	0	
13	Slot 2	USInt	2	assigned "real" slot
14	Reserved 2	USInt	0	
15	Slot 3	USInt	3	assigned "real" slot
16	Reserved 3	USInt	0	
17	Slot 4	USInt	4	assigned "real" slot
18	Reserved 4	USInt	0	
19	Slot 5	USInt	5	assigned "real" slot
20	Reserved 5	USInt	0	
21	Slot 6	USInt	9	assigned "real" slot
22	Reserved 6	USInt	0	
23	Slot 7	USInt	10	assigned "real" slot
24	Reserved 7	USInt	0	
25	Slot 8	USInt	11	assigned "real" slot
26	Reserved 8	USInt	0	
27	Slot 9	USInt	12	assigned "real" slot
28	Reserved 9	USInt	0	
29	Slot 10	USInt	6	assigned "real" slot
30	Reserved 10	USInt	0	
31	Slot 11	USInt	7	assigned "real" slot
32	Reserved 11	USInt	0	
33	Slot 12	USInt	8	assigned "real" slot
34	Reserved 12	USInt	0	
	Slot 13	USInt		assigned "real" slot

Figure 1-689 Example: Hardware configuration of station option 2 to 4 with the associated control data record in STEP 7

Detailed application example

You can find a detailed application example for the configuration control in S7-1500 in here under the keyword "Application example for ET 200SP (PROFINET) and S7-1500 based on the library" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/29430270).

9.4 Transferring the control data record in the user program of the CPU

Required steps

Transfer the created control data record 196 to the interface module using the WRREC (Write data record) instruction.

Parameters of the WRREC instruction

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

ID	HW identifier of the interface module. If you have selected the interface module in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "<Name_of_interface_module> Head".
INDEX	Data record number: 196 (decimal)
RECORD	Control data record to be transferred. You can find the structure of the control data record in section Control data record for the ET 200AL distributed I/O system (Page 82).

Selection of the station option in the user program

In order for the CPU to know which station option you want to operate, you must set up a possibility to select between the various control data records in the user program. You can implement the selection, for example, via an Int tag that references an array element. Note that the tag used to select the control data record must be stored in the retentive memory area. If the tag is not retentive, it will be initialized during startup of the CPU and will thus be unavailable for selection of the station option.

Special requirements relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200AL station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If the configuration is unchanged, you do not have to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration, this will result in a station failure in the distributed I/O system. The original data record 196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

Error messages

In case of error, the WRREC instruction returns the following error messages via the STATUS block parameter:

Table 1-953 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 196 is not correct.
$80B2_H$	Invalid slot: The configured slot is not assigned
$80B5_H$	Configuration control parameters not assigned.
$80B8_H$	Parameter error Reasons for a parameter error are: • Incorrect block ID in the header (not equal to 196) • Invalid version identifier in the header • A reserved bit was set • A station master slot was assigned an invalid slot in the station option • Multiple slots in the station master are assigned to the same slot in the station option • For shared device on submodule level: violation of defined restrictions
$80C5_H$	DP slave or module not available. Indicates that a data record has not been acknowledged due to the system.

If you receive the error code $80A2_H$, $80B2_H$ or $80C5_H$ when writing to control data record 196, check whether the required configuration was accepted despite the error code.

9.5 Behavior during operation

Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module outputs diagnostics data. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows an incorrect module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

Response to modules that are not present

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct writing access to the outputs that are not present or writing access to the process image of outputs that are not present: Remains without effect; no access error is signaled.
- Direct reading access to the inputs that are not present or reading access to the process image of inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: The output parameter STATUS of the instruction RDREC supplies the value $80A3_H$ "General CM error".

Commissioning 10

10.1 PROFINET IO

10.1.1 Commissioning ET 200AL on PROFINET IO

Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on an IO controller.

Requirements for the ET 200AL distributed I/O system on PROFINET IO

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also plan the tests to include any possible foreseeable errors. This will allow you to prevent people or plants from being placed in danger during operation.

Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 1-954 Requirements for the ET 200AL distributed I/O system on PROFINET IO

Step	Procedure	See...
1	Mounting the ET 200AL interface module	Section Mounting (Page 36)
2	Wiring the ET 200AL interface module	Section Connecting (Page 41)
3	Configuring the ET 200AL interface module	Section Configuring (Page 69)
4	Turning on the supply voltage for the ET 200AL interface module	Equipment Manual • IM 157-1 PN interface module (https://support.industry.siemens.com/cs/ww/en/view/89254863) • IM 157-1 MF interface module (https://support.industry.siemens.com/cs/ww/en/view/109824723)
5	ET 200AL interface module automatically switches to RUN mode	-

Reference

You can find additional information on assigning the PROFINET IO parameters in the PROFINET with STEP 7 V14 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

10.1.2 Startup on PROFINET IO

Principle of operation

The figure below schematically shows the startup of the ET 200AL distributed I/O system on the PROFINET IO (= IO device) as a flow chart.

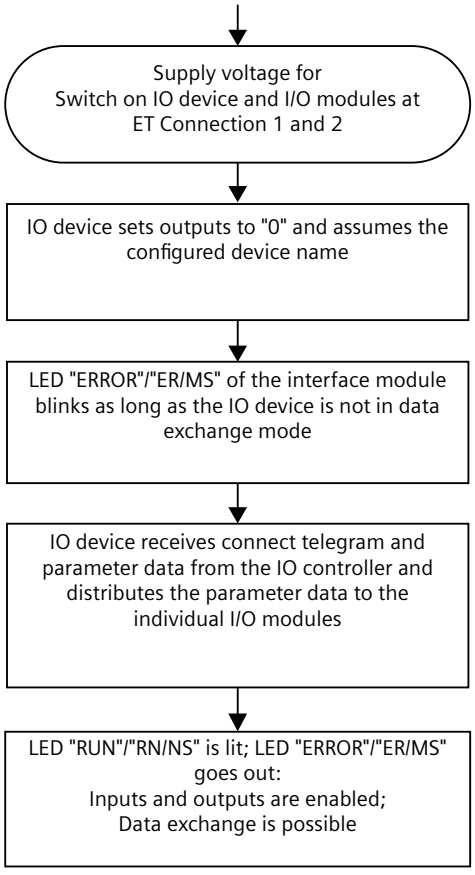


Figure 1-690 Startup of the ET 200AL distributed I/O system on the PROFINET IO

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL PROFINET interface module.

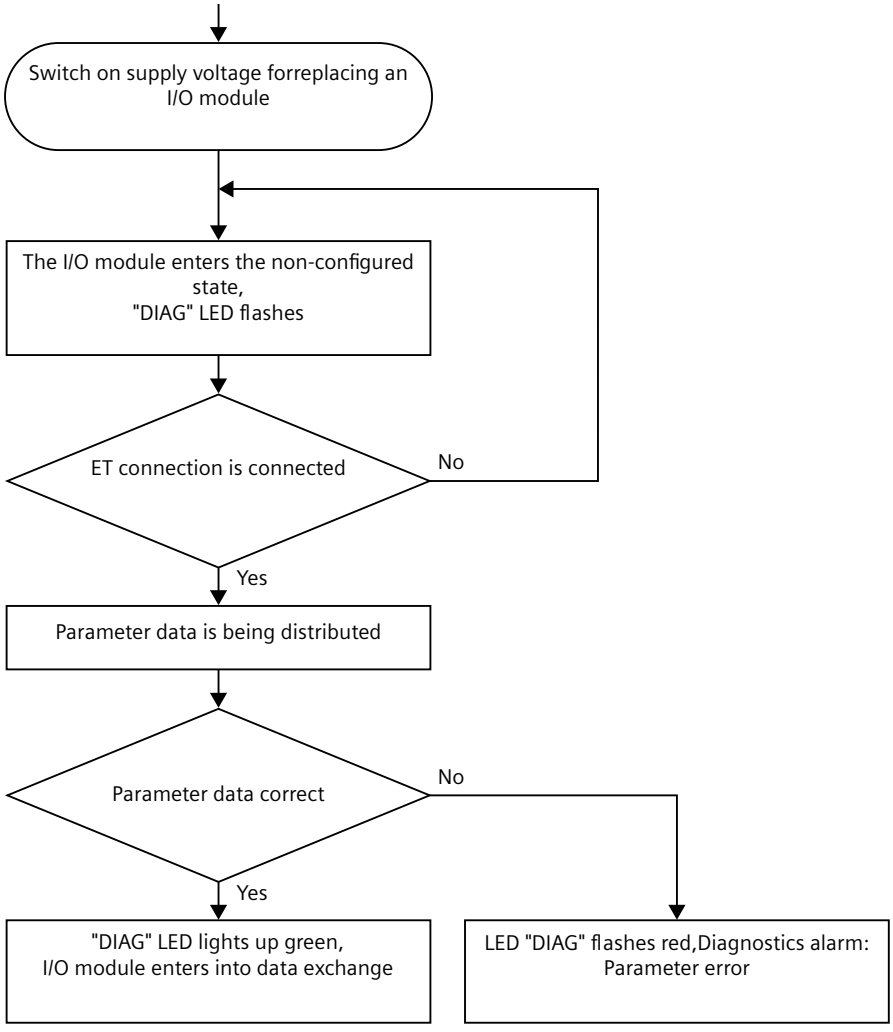


Figure 1-691 Startup of the ET 200AL I/O module

10.1.3 PROFIenergy

NOTE

PROFIenergy is not supported by fail-safe I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12.

PROFIenergy (for PROFINET) makes it possible to reduce the energy consumption of the device using the PROFIenergy command during production downtime.

Additional information

You will find more information on the Internet (https://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; as well as in the following documentation:

- IM 157-1 PN interface module (https://support.industry.siemens.com/cs/ww/en/view/89254863) manual
- I/O modules (https://support.industry.siemens.com/cs/ww/en/ps/14247/man) manuals
- PROFINET System Description (https://support.industry.siemens.com/cs/ww/en/view/19292127) system manual
- PROFINET with STEP 7 V14 (https://support.industry.siemens.com/cs/ww/en/view/49948856), function manual, Section: Saving energy with PROFIenergy
- Application guide for implementation of shutdown concepts with PROFIenergy. (https://support.industry.siemens.com/cs/ww/en/view/96837137)
- Saving energy with SIMATIC S7 (STEP 7 as of V5.5) (https://support.industry.siemens.com/cs/ww/en/view/41986454)
- Saving energy with SIMATIC S7 and SIMATIC HMI (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/view/58235225)
- SIMATIC S7 library for simple configuration of PROFIenergy. (https://support.industry.siemens.com/cs/ww/en/view/109478388)
- You can find additional information on the PROFIenergy FBs ("PE_START_END" - FB 815, "PE_CMD" - FB 816) in the online help for STEP 7 V5.5 as of SP2, Help on system functions/function blocks.

10.2 EtherNet/IP

10.2.1 Commissioning the ET 200AL on EtherNet/IP

Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on an scanner.

Requirements for the ET 200AL distributed I/O system on EtherNet/IP

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also plan the tests to include any possible foreseeable errors. This will allow you to prevent people or plants from being placed in danger during operation.

Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 1-955 Requirements for the ET 200AL distributed I/O system on EtherNet/IP

Step	Procedure	See...
1	Mounting the ET 200AL interface module	Section Mounting (Page 36)
2	Wiring the ET 200AL interface module	Section Connecting (Page 41)
3	Configuring the ET 200AL interface module	Section Configuring (Page 69)
4	Turning on the supply voltage for the ET 200AL interface module	Equipment manual IM 157-1 MF interface module (https://support.industry.siemens.com/cs/ww/en/view/109824723)
5	ET 200AL interface module automatically switches to RUN mode	-

Reference

You can find additional information about the configuration of EtherNet/IP parameters in the MultiFieldbus function manual (https://support.industry.siemens.com/cs/ww/en/view/109773209).

10.2.2 Startup on EtherNet/IP

Principle of operation

The following figure shows a schematic flow chart of the startup of the ET 200AL distributed I/O system on EtherNet/IP. The interface module is in the network of the EtherNet/IP adapter and communicates with the scanner.

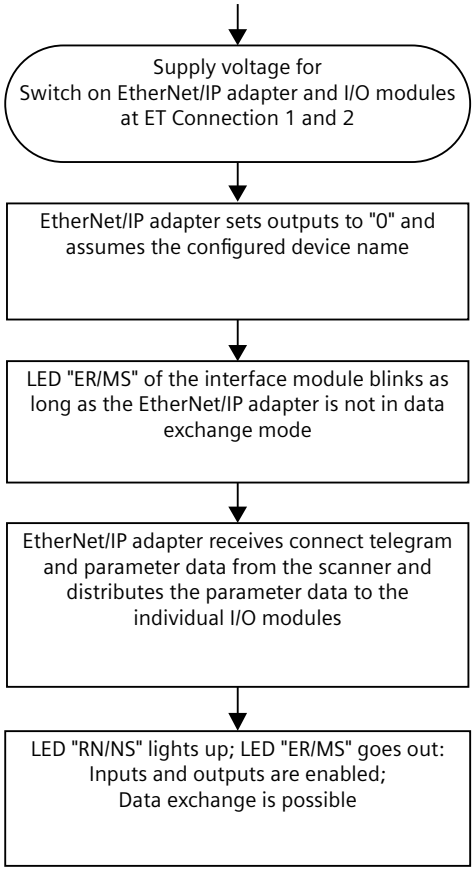


Figure 1-692 Startup of the ET 200AL distributed I/O system on EtherNet/IP

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL EtherNet/IP interface module as a flow chart.

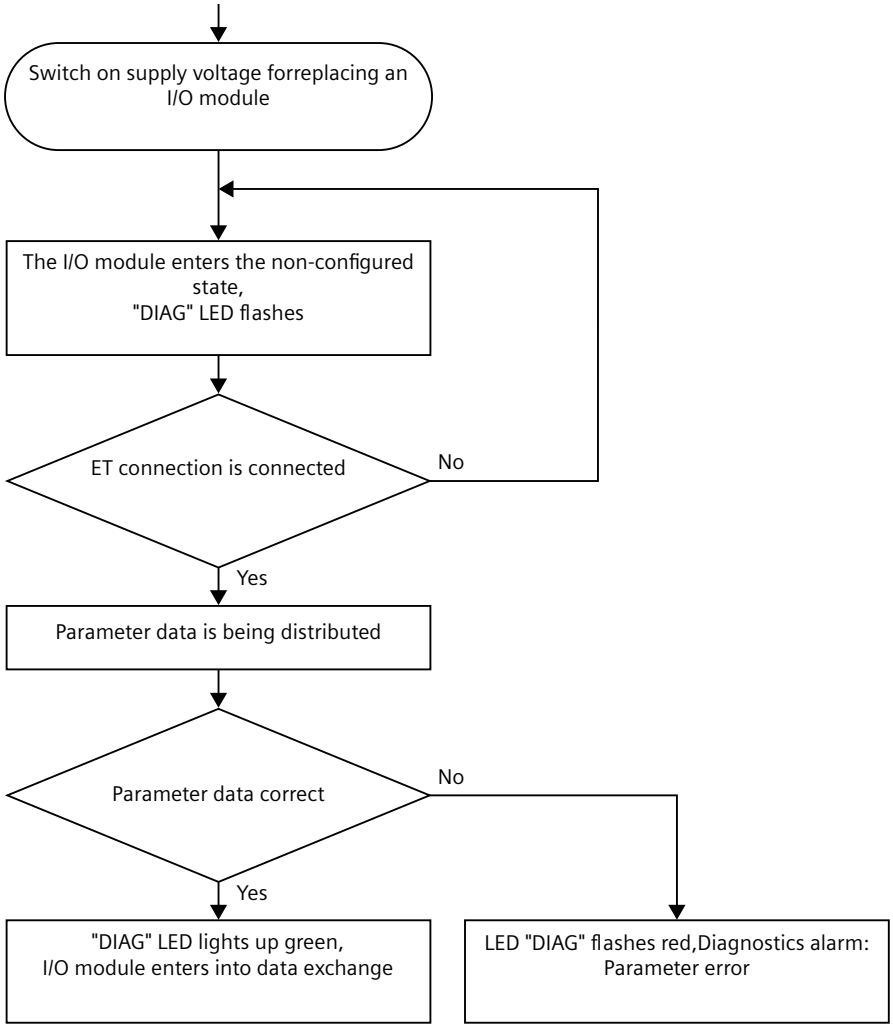


Figure 1-693 Startup of an ET 200AL I/O module

10.3 Modbus TCP

10.3.1 Commissioning the ET 200AL on Modbus TCP

Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on a Modbus client.

Requirements for the ET 200AL distributed I/O system on Modbus TCP

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also plan the tests to include any possible foreseeable errors. This will allow you to prevent people or plants from being placed in danger during operation.

Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 1-956 Requirements for the ET 200AL distributed I/O system on Modbus TCP

Step	Procedure	See...
1	Mounting the ET 200AL interface module	Section Mounting (Page 36)
2	Wiring the ET 200AL interface module	Section Connecting (Page 41)
3	Configuring the ET 200AL interface module	Section Configuring (Page 69)
4	Turning on the supply voltage for the ET 200AL interface module	Equipment manual IM 157-1 MF interface module (https://support.industry.siemens.com/cs/ww/en/view/109824723)
5	ET 200AL interface module automatically switches to RUN mode	-

Reference

You can find additional information about configuring the parameters of Modbus TCP in the MultiFieldbus function manual (https://support.industry.siemens.com/cs/ww/en/view/109773209).

10.3.2 Startup on Modbus TCP

Principle of operation

The following figure shows as flow chart schematically the start-up of the ET 200AL distributed I/O system on Modbus TCP. The interface module is the Modbus TCP server in the network and communicates with the client.

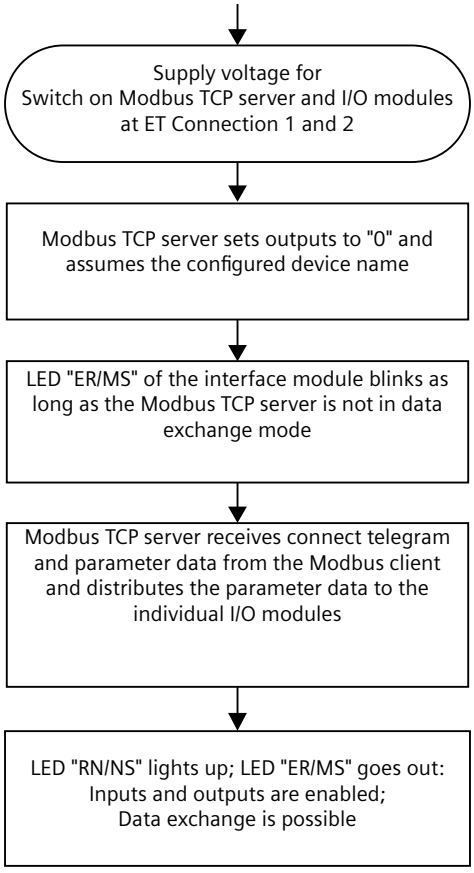


Figure 1-694 Startup of the ET 200AL distributed I/O system on Modubus TCP

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL Modubus TCP interface module as a flow chart.

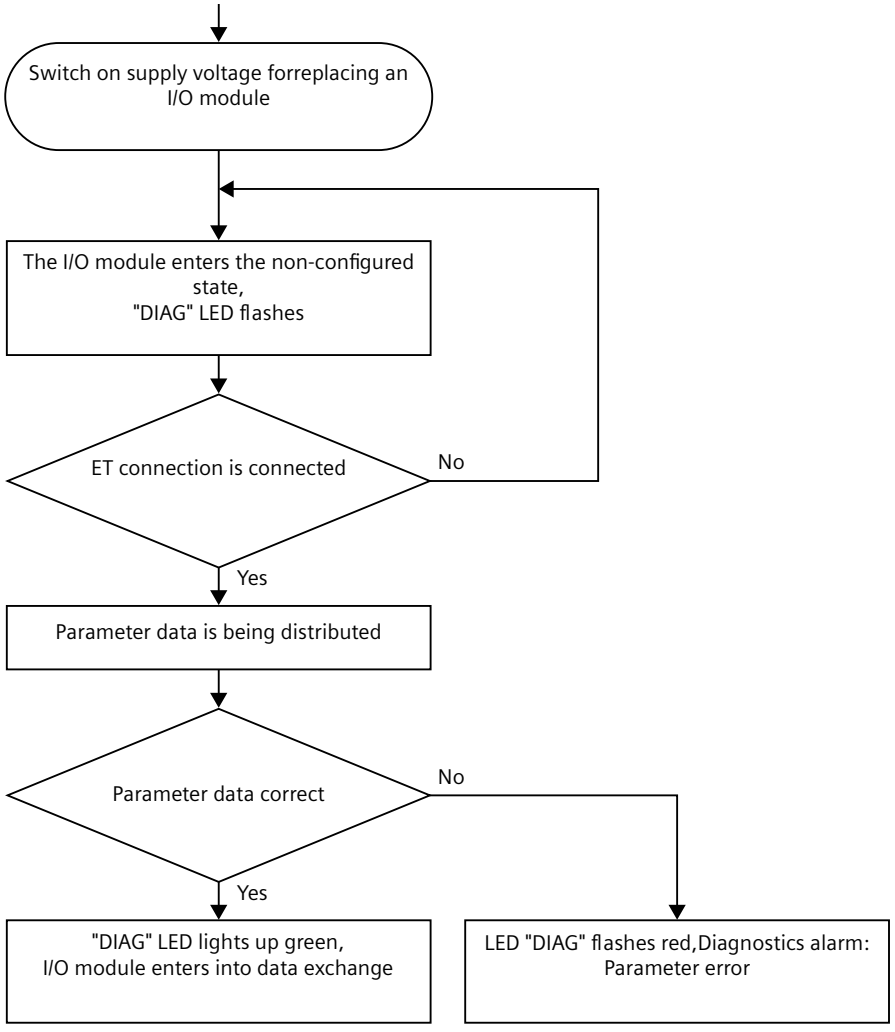


Figure 1-695 Startup of the ET 200AL I/O module

10.4 PROFIBUS DP

10.4.1 Commissioning ET 200AL on PROFIBUS DP

Introduction

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200AL distributed I/O system on a DP master.

Requirements for the ET 200AL distributed I/O system on a PROFIBUS DP

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Also plan the tests to include any possible foreseeable errors. This helps to avoid endangering persons or equipment during operation.

Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 1-957 Requirements for the ET 200AL distributed I/O system on a PROFIBUS DP

Step	Procedure	See...
1	Mounting the ET 200AL interface module	Section Mounting (Page 36)
2	Setting the PROFIBUS DP address on the ET 200AL PROFIBUS interface module	IM 157-1 DP interface module (https://support.industry.siemens.com/cs/ww/en/view/89255073) manual, section Setting the PROFIBUS DP address and terminating resistor
3	Wiring the ET 200AL interface module	Section Connecting (Page 41)
4	Configuring the ET 200AL interface module	Section Configuring (Page 69)
5	Switching on the supply voltage for the ET 200AL interface module	IM 157-1 DP interface module (https://support.industry.siemens.com/cs/ww/en/view/89255073) manual
6	ET 200AL interface module automatically switches to RUN mode	-

10.4.2 Startup on PROFIBUS DP

Principle of operation

The figure below schematically shows the startup of the ET 200AL distributed I/O system on the PROFIBUS DP (= DP slave) as a flow chart.

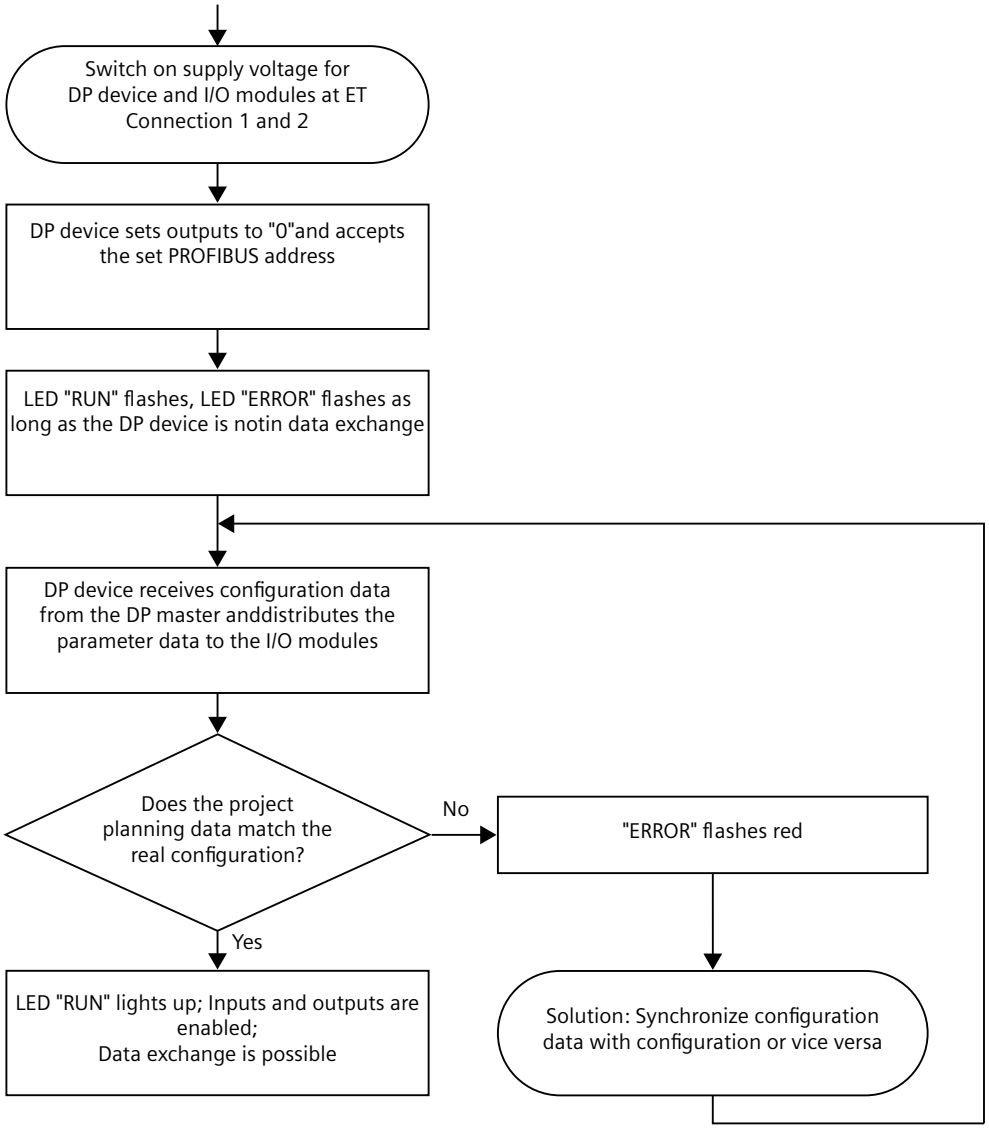


Figure 1-696 Startup of the ET 200AL distributed I/O system on PROFIBUS DP

The figure below schematically shows the startup of an ET 200AL I/O module after an ET 200AL PROFIBUS interface module as flow chart.

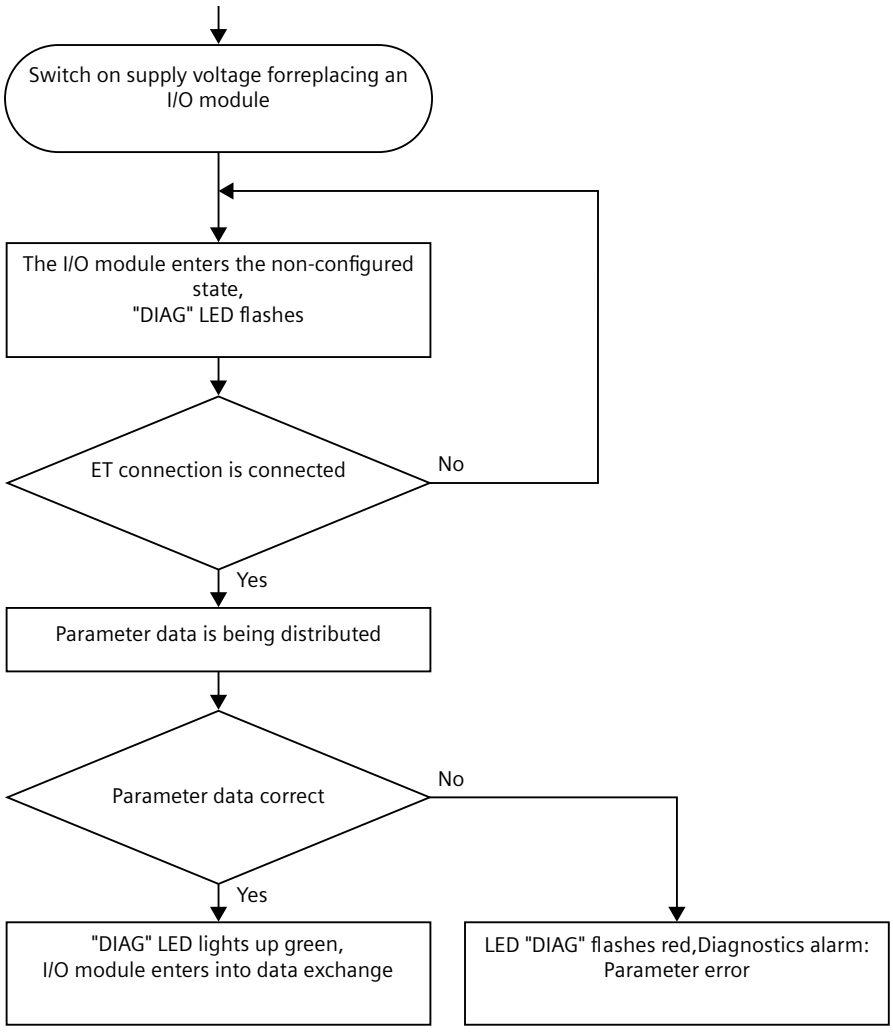


Figure 1-697 Startup of an ET 200AL I/O module

10.5 Identification and maintenance data

10.5.1 Reading out and entering I&M data

Introduction

Identification data I&M is information that is saved either as read-only (I data) or read/write (M data) on the interface module.

Identification data (I&M0): Manufacturer information on the module that is read-only and in some cases is also printed on the module housing, for example, article number, serial number and firmware version.

Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and written to the module.

All modules of the ET 200AL distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a system
- Correcting errors in a system

With the I&M identification data, you have the option of clearly identifying modules online.

Maintenance data (I&M4): Storage of a CRC test value for interface modules IM 157-1 PN and IM 157-1 MF and to ensure data integrity of data used by the interface module.

In STEP 7, the identification data is displayed in the "Module status - IM 157" and "Properties..." tabs (see STEP 7 online help).

Options for reading out I&M data

You have the following options for reading the I&M data:

- Via the user program
- Via STEP 7 or HMI devices

Procedure for reading I&M data by means of the user program

To read the I&M data of the interface module in the user program, use the instruction "RDREC".

Procedure for reading the I&M data using STEP 7

Requirement: There must be an online connection to the interface module.

1. In the project navigation, under "Distributed I/O", select the I/O device or the DP slave, e.g. "IM 157-1 PN".
2. Select: **IO device/DP slave > Online & Diagnostics > Identification & Maintenance**.

Procedure for input of maintenance data using STEP 7

The default module name is assigned by STEP 7. You have the option to enter the following data:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)
- Signature (I&M4), only for PROFINET

To enter the data, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the interface module, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data are also loaded.

Reference

You can find additional information on I&M data of the ET 200SP (mixed configuration) in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

10.5.2 Data record structure for I&M data

Reading I&M data records (distributed via PROFINET IO)

You can directly access specific identification data by selecting **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the associated data record index.

The following table shows the principle behind the structure of data records.

Table 1-958 Basic structure of data records with I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H I&M4: 0024_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H I&M4: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	54 54 16 54 54	I&M0/Index $AFF0_H$ I&M1/Index $AFF1_H$ I&M2/Index $AFF2_H$ I&M3/Index $AFF3_H$ I&M4/Index $AFF4_H$

The following table shows the structure of data records for I&M identification data.

Table 1-959 Data record structure for I&M identification data

Identification data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
VendorIDHigh	read (1 byte)	00_H	This is where the name of the manufacturer is stored (42_D = SIEMENS AG).
VendorIDLow	read (1 byte)	$2A_H$	
Order_ID	read (20 bytes)	6ES7157-1MA00-0AB0	Article number of module (e.g. IM 157-1 MF)
IM_SERIAL_NUMBER	read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	read (2 bytes)	1	Corresponding hardware version
IM_SOFTWARE_REVISION	read	Firmware version	Provides information about the firmware version of the module
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_Enhancement	(1 byte)	00 - FF_H	
• IM_SWRevision_Bug_Fix	(1 byte)	00 - FF_H	
• IM_SWRevision_Internal_Change	(1 byte)	00 - FF_H	
IM_REVISION_COUNTER	read (2 bytes)	0000_H	provides information about configured changes on the module (not used)
IM_PROFILE_ID	read (2 bytes)	0000_H	Generic device
IM_PROFILE_SPECIFIC_TYPE	read (2 bytes)	0005_H	Interface modules
IM_VERSION	read	0101_H	provides information about the version of the identification data (0101_H = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	read (2 bytes)	$001E_H$	provides information about the existing identification data (I&M1 though I&M4)
Maintenance data 1: (data record index AFF1 hex)			
IM_TAG_FUNCTION	Read/write (32 bytes)	-	Enter an identifier for the module here, that is unique plant-wide.
IM_TAG_LOCATION	Read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (data record index AFF2 hex)			
IM_DATE	Read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (data record index AFF3 hex)			
IM_DESCRIPTOR	Read/write (54 bytes)	-	Enter a comment describing the module.
Maintenance data 4: (data record index AFF4 hex)			
USI	Read (4 bytes)	0x63726331	UserstructureIdentifier: Internal, fixed value
CHK_OVERALL	Read (4 bytes)	-	Overall CRC via all individual CRCs
CHK_OVERALL_SUBS	Read (4 bytes)	0 or value*	Overall CRC via all assigned modules of the IM
CHK_STATIC_LOCAL	Read (4 bytes)	-	CRC via static data of the IM

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the associated modules support I&M4 data.

Identification data	Access	Default	Explanation
CHK_STATIC_SUBS	Read (4 bytes)	0 or value*	CRC via all static data of the modules of the IM
CHK_OVERALL_SETUP	Read (4 bytes)	-	Overall CRC via all setup data of the IM and modules of the IM
CHK_REMANENT_LOCAL	Read (4 bytes)	-	CRC via retentive data of the IM
CHK_REMANENT_SUBS	Read (4 bytes)	0 or value*	CRC via all retentive data of the modules of the IM
CHK_WORKING_LOCAL	Read (4 bytes)	-	CRC via the parameters in STEP 7 for the IM
CHK_WORKING_SUBS	Read (4 bytes)	0 or value*	CRC via all parameters in STEP 7 for the modules of the IM
NOT USED	Read (14 bytes)	0	14 reserved bytes

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the associated modules support I&M4 data.

Reading I&M data records with data record 255 (distributed via PROFIBUS DP)

The modules support standardized access to identification data using DR 255 (index 65000 to 65003). For additional information on the DR 255 data structure, refer to the specifications of the Profile Guideline - Order No. 3.502.

Maintenance 11

11.1 Replacing modules

Replacing modules

Replacing a module is not permitted during ongoing operation.

⚠ WARNING

Material damage can occur
If you remove/insert modules with the power connected, this can lead to undefined states in your system.
Material damage to the ET 200AL distributed I/O system may occur as a result.
Only remove or replace modules when the power is disconnected.
Always comply with the required standards and safety guidelines when configuring a system.

⚠ WARNING

Mixing up ET-Connection1 and ET-Connection2
When connecting the modules, always ensure that they are properly connected.
If you mix up the lines for ET-Connection1 and ET-Connection2 when connecting the modules, this can lead to undefined states in your system.

Behavior of ET-Connection

During ongoing operation, a module replacement may be necessary, e.g. because the module is defective. If an I/O module fails in an ET-Connection line, the line remains active up to the failed I/O module. After replacing the I/O module, the ET-Connection line starts up by itself.

Procedure

To replace a module, proceed as follows:

1. Disconnect the supply voltage to the module to be replaced.
2. Completely remove all cables connected to the module.
3. Completely remove the fixing screws of the module

4. Replace the module.

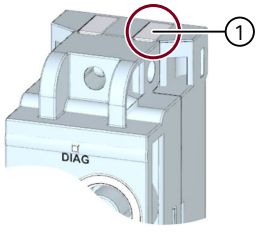
NOTE
"New" module
The removed module may only be replaced by a module of the same type.

5. Fasten the module with a torque of 1.2 Nm.
6. Connect all cables.
7. Turn the supply voltage on.

⚠ WARNING

Pay attention to the slot number of the module
If you mix up the ET 200AL I/O modules when connecting them, this can cause personal injury and damage to the machine.
The ET 200AL distributed I/O system cannot distinguish between modules of the same type during the actual/target comparison.
We recommend that you clearly label the ET 200AL I/O modules with the slot number.

The figure below shows a recommendation for labeling the ET 200AL I/O modules with the slot number.



① Recommendation for labeling the slot number

Figure 1-698 Slot number

Result

The disconnected I/O module and all downstream I/O modules start up again by themselves.

11.2 Firmware update

Introduction

During operation, it can become necessary to update the firmware (e.g. for function extensions).

Firmware updates are used to update the firmware of the interface module and I/O modules.

NOTE

Temporary bus interruption

When you perform a firmware update of an ET 200AL I/O module, then the ET-Connection is temporarily interrupted due to the restart of I/O module. All downstream ET 200AL I/O modules report a pull/plug interrupt.

Options for the firmware update

You have the following options to running a firmware update:

- Online via STEP 7, as of V5.5[1]
- Online with STEP 7, TIA Portal V13 or higher
- Embedded web server running on a SIMATIC CPU[1] or a SIMATIC F-CPU with fail-safe modules
- SIMATIC Automation Tool (SAT)
- Online via MultiFieldbus Configuration Tool (MFCT)

[1)] Not for use with fail-safe ET 200AL I/O modules

NOTE

MultiFieldbus interface module remains in configured fieldbus mode

After a firmware update, the MultiFieldbus interface module remains in the bus protocol in which the update was installed.

If there is an update via EtherNet/IP, for example, the MultiFieldbus interface module remains in EtherNet/IP mode.

Reference

More information about the procedure:

- FAQs on the Internet (https://support.industry.siemens.com/cs/ww/en/view/88778936)
- STEP 7 online help
- SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) equipment manual (included in the SIMATIC Automation Tool).
- MultiFieldbus function manual (https://support.industry.siemens.com/cs/ww/en/view/109773209)

11.3 Resetting interface module to factory settings

This section applies to interface modules with one or more of these communication protocols:

- PROFINET
- EtherNet/IP
- Modbus TCP

Introduction

When you "Reset to factory settings", the interface module is reset to the delivery state settings. This means that all information that was saved internally on the interface module is deleted.

Result after resetting to factory settings

The following table shows an overview of the contents of the memory objects after resetting to factory settings.

Table 1-960 Result after resetting to factory settings

Memory object	Contents
IP address	• Deleted • Can be configured with TIA Portal for a reset: "Retain IP address"/"Delete IP address"
Device name	Deleted
MAC address	Is not deleted
Identification data (I&M0)	Is not deleted
Maintenance data (I&M1, 2, 3, 4)	Are deleted (optional)
Firmware version	Is not deleted

NOTE

Failure of downstream stations is possible
Resetting an interface module to factory settings can lead to failure of downstream stations in a line.

NOTE

Substitute value behavior of I/O modules when resetting to factory settings
When "Resetting to factory settings", the I/O modules in the station take on the non-configured state, which means input data are not entered and output data are not output.

Reset options

You have the following options to reset an interface module device to the factory settings:

- Online with STEP 7 (TIA Portal)
- Online with STEP 7, V5.5 or higher
- SIMATIC Automation Tool (SAT)
- Online via PRONETA
- Online via MultiFieldbus Configuration Tool (MFCT)

Requirement

You need an online connection to reset an interface module to factory settings.

Procedure with STEP 7 (TIA Portal)

Connect the PG/PC to the PROFINET IO interface of the ET 200AL distributed I/O system.

Make sure that there is an online connection to the interface module which is to be reset to factory settings.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button if you want to retain the IP address, or the "Reset IP address" option button if you want to delete the IP address.
4. Click the "Reset" button.
5. Answer the security prompts with "OK".

Result: The interface module performs the "Reset to factory settings" while the RUN LED flashes yellow. When the RUN LED is lit yellow, the interface module has been reset to factory settings and is in the STOP operating mode. The event "Reset to factory settings" is entered in the diagnostics buffer.

Procedure with STEP 7 V5.5 or higher

Connect the PG/PC to the PROFINET IO interface of the ET 200AL distributed I/O system.

Make sure that there is an online connection to the interface module which is to be reset to factory settings.

1. Open the SIMATIC Manager.
2. Select accessible devices.
3. Select the interface module.
4. Navigate through "Menu > Options > Edit Ethernet devices > Reset to factor settings > Reset".

Result: The interface module performs the "Reset to factory settings" while the RUN LED flashes yellow. When the RUN LED is lit yellow, the interface module has been reset to factory settings and is in the STOP operating mode. The event "Reset to factory settings" is entered in the diagnostics buffer.

Procedure using the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) equipment manual (included in the SIMATIC Automation Tool).

Procedure using PRONETA

You can carry out these steps with PRONETA:

- Delete or reassign the device name and IP address
- Reset I&M data
- Remove module from the network and reintegrate

You can find information on this in the "PRONETA user manual (https://support.industry.siemens.com/cs/ww/en/view/109815137)"

Procedure using MFCT

You can find information on the procedure via MFCT under "MultiFieldbus function manual (https://support.industry.siemens.com/cs/ww/en/view/109773209)" in the "Resetting the MF device" section.

Reference

You will find more information on the procedure in the STEP 7 online help.

11.4 Reactions to errors of the F module

Safe state (safety concept)

The basic principle behind the safety concept is the presence of a safe state for all process tags.

NOTE

For digital F-modules, the safe state is "0". The safe state applies to sensors and actuators.

Error reactions and startup of the F-system

In the following situations, the values of the safe state must be connected to the fail-safe channel/channels instead of the process values (passivation of the fail-safe module) due to the safety function:

- When the F-system is started
- When errors are detected in the safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- When errors of the F-I/O or channel errors (e.g. wire break or discrepancy error) are detected

Detected errors are written to the diagnostic buffer of the F-CPU and reported to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. If the system is switched off and then restarted, any pending errors are detected again at startup. However, you can save errors in your safety program.

⚠ WARNING

If channels are set to "disabled", there are no diagnostic or error handling reactions.
For channels that are set to "disabled" in STEP 7, no diagnostic message or error handling is triggered when a channel error occurs. Not even if this channel is indirectly affected by a channel group error ("Channel activated/deactivated" parameter).

Troubleshooting in the F-system

To correct errors in your F-system, proceed as described in IEC 61508-1: Section 7.15.2.4 and IEC 61508-2: Section 7.6.2.1 e.

Perform the following steps:

1. Rung diagnostics and correct the error
2. Revalidate the safety function
3. Record in the service report

Fail-safe values for F-modules

For F-modules with inputs, the F-system provides fail-safe values (0) for the safety program when passivated. The fail-safe values are used instead of the process data at the F-DI.

For F-modules with outputs, the F-system transfers the fail-safe values (0) to the fail-safe outputs during passivation. The fail-safe values are used instead of the output values of the safety program. The fail-safe outputs are de-energized. this process is performed even if the F-CPU goes to the STOP operating state.

It is not possible to set the parameters of fail-safe values.

The fail-safe values are used in the following dependencies for the channel involved or all channels of the I/O module involved:

- F-system used
- Type of error occurred
  - Error in the F-I/O
  - Channel fault
  - Communication error

Re-integration of a fail-safe module or channel

The F-system changes from fail-safe values to process values automatically or after acknowledgment in the safety program by the user. A detailed list of errors can be found in the device manual of the F-module or in the STEP 7 online help.

Procedure after re-integration:

- For an F-module with inputs, the process data pending at the F-DI is provided again to the safety program.
- For an F-module with outputs, the output values provided by the safety program are transferred again to the F-DQs.

Additional information on passivation and re-integration

For additional information on passivation and reintegration of F-I/O modules, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Reaction of the F-module with inputs to communication errors

F-modules with inputs react differently to communication errors than to other errors.

When a communication error is detected, the current process values at the inputs of the F-module remain set. No channels are passivated. The current process values are passivated in the F-CPU.

11.5 Cleaning modules

When wired, ET 200AL modules comply with degree of protection IP65/IP67 and do not require any cleaning. If you do have to clean the modules, then use a dry or damp cloth. Please take care to comply with degree of protection IP65/67 when cleaning with liquids.

Technical specifications

12

12.1 Marks and approvals

Marks and approvals on the nameplate

The following overview provides information about the possible marks and approvals. Only the marks and approvals specified on the nameplate apply to the module.

You can find the associated certificates for download on the Internet. See also: ET 200AL approvals (https://support.industry.siemens.com/cs/ww/en/ps/14245/cert)

CE marking

CE

The ET 200AL distributed I/O system fulfills the requirements and protection targets of the following directives and complies with the harmonized European standards (ES) which have been promulgated for programmable logic controllers in the official gazettes of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)

  Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the member states relating to electromagnetic compatibility; OJ L 96, 29.3.2014, p. 79–106
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment; OJ L 174, 1.7.2011, p. 88–110

The fail-safe modules of the ET 200AL distributed I/O system meet the safety requirements and safety objectives of the following EU directives and comply with the harmonized EU standards (EN) for programmable controllers as specified in the official journals of the European Union.

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)

  Directive of the European Parliament and of the Council of February 26, 2014 on the harmonization of the laws of the member states relating to electromagnetic compatibility; official journal of the EU L96, 29/03/2014, pages 79–106
- 2006/42/EC "Machinery Directive and Supplementary Directive 95/16/EC"

  Directive of the European Parliament and of the Council of 17 May, 2006 on machinery, and amending Directive 95/16/EC (revised); official journal of the EU, L157, 09/06/2006, pages 24–87
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, official journal of the EU L174, 01/07/2011, pages 88–110

The EC Declarations of Conformity are available for the responsible authorities and are kept at the following address:

Siemens Aktiengesellschaft
Digital Industries
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg, Germany

UKCA mark

The ET 200AL distributed I/O system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The ET 200ALdistributed I/O system meets the requirements and protection targets of the following regulations and associated supplements:

- Electromagnetic Compatibility Regulations 2016 (S.I. 2016 No. 1091), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments
- Supply of Machinery (Safety) Regulations 2008 (S.I. 2008 No. 1597), and related amendments

UK Declarations of Conformity are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg, Germany

UL approval

Underwriters Laboratories Inc. according to

- UL 61010-1 and UL 61010-2-201
- CSA C22.2 No. 61010-1 and CSA C22.2 No. 61010-2-201

The following table shows the modules that are approved for UL50 Enclosure Type 4x Indoor use only, watertight.

Table 1-961 Modules approved according to UL50 Enclosure Type 4x, Indoor use only, watertight

Description	Article number
Interface modules	
IM 157-1 DP	6ES7157-1AA00-0AB0
IM 157-1 PN	6ES7157-1AB00-0AB0
Digital modules	
DI 8 x DC24V 8xM8	6ES7141-5BF00-0BA0
DI 8 x DC24V 4xM12	6ES7141-5AF00-0BA0
DI 16 x DC24V 8xM12	6ES7141-5AH00-0BA0
DIQ 4+DQ 4x24VDC/0.5A 8xM8	6ES7143-5BF00-0BA0

Description	Article number
DIQ 4+DQ 4x24VDC/0.5A 4xM12	6ES7143-5AF00-0BA0
DIQ 16x24VDC/0.5A 8xM12	6ES7143-5AH00-0BA0
DQ 8x24VDC/2A 8xM12	6ES7142-5AF00-0BA0
Analog modules	
AI 4xU/I/RTD 4xM12	6ES7144-5KD00-0BA0
AQ 4XU/I, 4XM12	6ES7145-5ND00-0BA0
Communications modules	
CM 4xIO-Link 4xM12	6ES7147-5JD00-0BA0

The following table shows the modules that are approved for UL50 Enclosure Type 1.

Table 1-962 Modules approved according to UL50 Enclosure Type 1

Description	Article number
Interface modules	
IM 157-1 MF	6ES7157-1MA00-0AB0
Digital modules	
DIQ 8x24VDC/0.5A 8xM8	6ES7143-5BF50-0BA0
Analog modules	
AI 4xRTD/TC 4xM12	6ES7144-5KD50-0BA0
Fail-safe modules	
F-DI 4+F-DQ 2x24VDC/2A, 4xM12	6ES7146-5FF00-0BA0
Communications modules	
CM 4xIO-Link 4xM12	6ES7147-5JD01-0BA0
CM 8xIO-Link+DIQ 6x24VDC/0.5A 8xM12	6ES7147-5JJ00-0BA0
Voltage distributor	
PD 24VDC	6ES7194-2CA00-0AA0

RCM Australia/New Zealand



The ET 200AL distributed I/O system meets the requirements of EN 61000-6-4 Generic standards – Emission standard for industrial environments.

Korea Certificate



Please note that this device corresponds to limit value class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.
이기기는업무용(A급) 전자파적합기기로서판매자또는사용자는이점을주의하시기바라며 가정외의지역에서사용하는것을목적으로합니다.

EAC (Eurasian Conformity)



The code EAC (Eurasian Conformity) confirms the conformity with the guidelines (TR) of the Eurasian Economic Union.

WEEE mark (European Union)



Disposal information, observe the local regulations and section "Secure decommissioning (Page 137)".

12.2 Certificates

Shipbuilding certificates

The following shipbuilding certificates are intended for the device:

- ABS (American Bureau of Shipping)
- Bureau Veritas (French marine classification society)
- CCS (China Classification Society)
- Class NK (Nippon Kaiji Kyokai)
- DNV (Det Norske Veritas)
- KR (Korean Register of Shipping)
- LRS (Lloyds Register of Shipping)
- RINA (Registro Italiano Navale)

After a successful approval you can find the certificates with the certified article numbers in the Internet. See also: ET 200AL Marine/Shipbuilding (https://support.industry.siemens.com/cs/ww/en/ps/14245/cert?ct=446)

NOTE

The fail-safe module F DI 4+F DQ 2x24VDC/2A, 4xM12 of the ET 200AL distributed I/O system does not support the specified marine approvals due to the increased supply voltage requirements.

12.3 Standards and requirements

IEC 61131-2

The ET 200AL distributed I/O system fulfills the requirements and criteria of IEC 61131-2 (Programmable controllers, Part 2: Equipment requirements and tests) and the EMC requirements for use in Zone B.

IEC 61010-2-201

The ET 200AL distributed I/O system fulfills the requirements and criteria of standard IEC 61010-2-201.

PROFINET standard

The PROFINET interfaces of the ET 200AL distributed I/O system are based on the standard IEC 61158 Type 10.

PROFIBUS standard

The PROFIBUS interfaces of the ET 200AL distributed I/O system are based on IEC 61158 Type 3.

IO-Link standard

The IO-Link interfaces of the ET 200AL distributed I/O system are based on the standard IEC 61131-9.

Use in industrial environments

The ET 200AL distributed I/O devices are designed for the industrial field. It meets the following standards for this type of use:

- Requirements for interference emission EN IEC 61000-6-4
- Requirements for immunity EN IEC 61000-6-2

Use in residential areas

The ET 200AL distributed I/O system is not intended for use in residential areas. Using the ET 200AL distributed I/O system in residential areas can affect radio or television reception.

Use in mixed areas

Under certain circumstances, you can use the ET 200AL distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact on residents.

If you want to use the ET 200AL distributed I/O system in mixed areas, you must ensure that its radio frequency interference emission complies with the limit classes of the EN 61000-6-3 generic standard. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the ET 200AL distributed I/O system in grounded control cabinets/control boxes
- Use of noise filters in the supply cables

An individual acceptance test is also required.

EtherNet/IP requirement

The EtherNet/IP interfaces of the ET 200AL distributed I/O system are based on the requirements of the CIP network library CIP Networks Library Volume 2 EtherNet/IP Adaptation of CIP.

Modbus TCP requirement

The Modbus TCP interfaces of the ET 200AL distributed I/O system are based on the requirements of the Modbus TCP application protocol specification V1.1b3.

Use in industrial burner and firing environments.

The fail-safe module F-DI 4+F-DQ 2x24VDC/2A, 4xM12 of the ET 200AL distributed I/O system meets the requirements and criteria of the following standards:

- EN 298 (Automatic burner control systems for burners and appliances burning gaseous or liquid fuels)
- EN 50156-1 (Electrical equipment for furnaces and ancillary equipment)
- EN 50156-2 (Electrical equipment for furnaces and ancillary equipment)

Importer addresses

The following table shows the importer addresses for specific countries:

Countries	Address
United Kingdom (UK)	Siemens plc. Manchester M20 2UR
Türkiye (TR)	Siemens San. ve Tic. A.Ş. Yakacık Cad. No:111 34870 Kartal/İstanbul

12.4 Electromagnetic compatibility

Definition

Electromagnetic compatibility is the ability of an electrical apparatus to function in a satisfactory manner in its electromagnetic environment without affecting this environment.

An I/O device of the ET 200AL distributed I/O system fulfills the requirements of the EMC law of the European Union. The requirement for this is that an I/O device of the ET 200AL distributed I/O system meets the specifications and guidelines for electrical configuration.

Pulse-shaped disturbance variables

The table below shows the electromagnetic compatibility of the distributed I/O systems compared to pulse-shaped disturbance variables.

Table 1-963 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Conforms to degree of severity
Electrostatic discharge according to IEC 61000-4-2.[1]	Air discharge: ±8 kV	3
	Contact discharge: ±4 kV	2
Burst pulses (fast transient disturbance variables) according to IEC 61000-4-4.[1]	±2 kV (power supply cable)	3
	±2 kV (PROFIBUS/PROFINET/MultiFieldbus line)	4
	±1 kV (signal line <30 m)	3
	±1 kV (ET-Connection)	3
High-energy single pulse (surge) to IEC 61000-4-5 [2] Signal line < 30 m and only installation within buildings		

Pulse-shaped disturbance variable	Tested with	Conforms to degree of severity
• Asymmetric coupling (phase-ground)[3]	±1 kV (24 V DC supply cable) without protective element	2
	±2 kV (PROFIBUS/PROFINET/MultiFieldbus line)	3
• Symmetric coupling (phase-phase)[3]	±0.5 kV (24 V DC supply cable) without protective element	2

[1] The maximum short-term influencing of analog devices during the duration of the EMC tests can amount to ±10 % of the full-scale value.
[2] Analog value deviation beyond the limits of the nominal range and diagnostics possible.
[3] If greater phase to ground or phase to phase values are required, you will need an additional external protective circuit (see function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566)).

Sinusoidal disturbance variables

The following tables show the electromagnetic compatibility of the distributed I/O systems to sinusoidal disturbance variables.

Table 1-964 RF radiation

RF radiation according to IEC 61000-4-3 Electromagnetic RF field, amplitude modulated		Conforms to degree of severity
80 ... 1000 MHz	10 V/m	3
1.4 ... 6 GHz	3 V/m	2
80% AM (1 kHz)		

Table 1-965 RF coupling (signal and supply cables)

RF coupling according to IEC 61000-4-6.	Conforms to degree of severity
0.15 ... 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

The maximum short-term influencing of analog modules during the duration of the EMC tests can amount to ±1% of the full-scale value.

Emission of radio frequency interference

The following table shows the interference emission of electromagnetic fields according to EN IEC 61000-6-4/EN 55016-2-3.

Table 1-966 Interference emission of electromagnetic fields

Frequency	Interference emission	Measuring distance
30 ... 230 MHz	<40 dB (µV/m) Q	10 m
230 ... 1000 MHz	<47 dB (µV/m) Q	10 m
1 ... 3 GHz	<76 dB (µV/m) P	3 m
3 ... 6 GHz	<80 dB (µV/m) P	3 m

Conducted emission

The following table shows the limit values for the power supply connections according to EN IEC 61000-6-4/EN 55016-2-1.

Table 1-967 Interference emission from the power supply

Frequency	Interference emission
0.15 ... 0.5 MHz	< 89 dB (µV) Q < 76 dB (µV) M
0.5 ... 30 MHz	< 83 dB (µV) Q < 70 dB (µV) M

12.5 Transport and storage conditions

Transport and storage conditions

The modules of the ET 200AL distributed I/O system exceed the specifications regarding transport and storage conditions pursuant to IEC 61131-2. The following table shows the conditions that apply to modules transported or stored in their original packaging.

- Transport condition class: TTH4
- Storage condition class: STH4

Table 1-968 Transport and storage conditions

Type of condition	Permitted range
Free fall	≤0.3 m
Temperature	-40 °C ... +70 °C
Temperature variation	20 K/h
Barometric pressure	1140 ... 540 hPa (Corresponds to an altitude of -1000 m to 5000 m)
Relative humidity	5... 95 %; no condensation

12.6 Mechanical and climatic ambient conditions

Operating conditions

The ET 200AL distributed I/O system is suitable for use in weather-proof, fixed locations.

- The conditions of use exceed the requirements pursuant to IEC 61131-2
  - Class OTH3

You can find the values for the operating conditions in the technical specifications of the manuals or on the Internet (https://support.industry.siemens.com/cs/de/en/view/109742718).

Tests of mechanical ambient conditions

The following table shows the type and scope of the tests on mechanical ambient conditions.

Table 1-969 Tests of mechanical ambient conditions

Condition tested	Test standard	Values
Vibrations	Vibration test according to IEC 60068-2-6.	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. 5 Hz to 12.9 Hz, constant amplitude 15 mm 12.9 Hz to 150 Hz, constant acceleration 10 g Duration of oscillation: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 30g peak value, 18 ms duration Direction of shock: 3 shocks each in ± direction in each of the 3 axes vertical to one another

Climatic ambient conditions

The following table shows the type and scope of the tests on climatic ambient conditions.

Table 1-970 Climatic ambient conditions

Ambient conditions	Fields of application	Comments
Temperature	-25 °C ... 55 °C	All installation positions
Temperature variation	10 K/h	-
Relative humidity	5 ... 100%	With condensation and sealing caps installed
Barometric pressure	1140 ... 540 hPa	Corresponds to an elevation of -1000 to 5000 m
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

The following table shows the modules with functional versions which are permitted to -30 °C.

Table 1-971 Extended temperature range to -30 °C

Description	Article number	As of functional version
Interface modules		
IM 157-1 DP	6ES7157-1AA00-0AB0	FS02
IM 157-1 MF	6ES7157-1MA00-0AB0	FS01
Digital modules		
DI 8 x DC24V 8xM8	6ES7141-5BF00-0BA0	FS03
DI 8 x DC24V 4xM12	6ES7141-5AF00-0BA0	FS03
DI 16 x DC24V 8xM12	6ES7141-5AH00-0BA0	FS03
DIQ 4+DQ 4x24VDC/0.5A 8xM8	6ES7143-5BF00-0BA0	FS03
DIQ 4+DQ 4x24VDC/0.5A 4xM12	6ES7143-5AF00-0BA0	FS03
DIQ 8x24VDC/0.5A 8xM8	6ES7143-5BF50-0BA0	FS01
DIQ 16x24VDC/0.5A 8xM12	6ES7143-5AH00-0BA0	FS03
DQ 8x24VDC/2A 8xM12	6ES7142-5AF00-0BA0	FS03
Analog modules		
AI 4xU/I/RTD 4xM12	6ES7144-5KD00-0BA0	FS04
AI 4xRTD/TC 4xM12	6ES7144-5KD50-0BA0	FS01
AQ 4XU/I, 4XM12	6ES7145-5ND00-0BA0	FS03
Communications modules		
CM 4xIO-Link 4xM12	6ES7147-5JD00-0BA0	FS05
CM 4xIO-Link 4xM12	6ES7147-5JD01-0BA0	FS01
CM 8xIO-Link+DIQ 6x24VDC/0.5A 8xM12	6ES7147-5JJ00-0BA0	FS01
Fail-safe modules		
F-DI 4+F-DQ 2x24VDC/2A, 4xM12	6ES7146-5FF00-0BA0	FS01
Voltage distributor		
PD 24VDC	6ES7194-2CA00-0AA0	FS01

Use above 2000 m is possible.

The following constraints apply to the maximum specified ambient temperature:

Table 1-972 **Derating factor of installation altitude and ambient temperature**

Installation altitude	Derating factor for ambient temperature [1]
-1000 ... 2000 m	1.0
2000 ... 3000 m	0.9
3000 ... 4000 m	0.8
4000 ... 5000 m	0.7

[1] Base value for application of the derating factor is the maximum permissible ambient temperature in °C for 2000 m.

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher elevations due to lower density.
- Make sure that the power supplies used are suitable for altitudes > 2000 m.

NOTE

All markings and certifications are currently based on an elevation of up to 2000 m.

12.7 Details on insulation, protection class, degree of protection and rated voltage

Insulation

The insulation is designed in compliance with the requirements of IEC 61010-2-201.

NOTE

Galvanic isolation with 707 V DC (Type Test) is tested for modules with 24 V DC supply voltage (SELV/PELV).

Pollution class according to IEC 61010-2-201

- Protection class III

Severity for voltage interruption

The I/O devices of the distributed I/O system ET 200AL meet and exceed the severity class PS1 for voltage interruptions with a value of 5 ms.

Pollution degree / overvoltage category pursuant to IEC 61010-2-201

Connected according to the specifications in the "Wiring (Page 62)" section:

- Pollution degree: 3 (macro environment)
- Overvoltage category: II

In delivery state, with one or more open connections:

- Pollution degree: 2 (micro environment)
- Overvoltage category: II

Degree of protection IP65 and IP67

Degree of protection IP65 and IP67 according to IEC 60529 for all modules of the ET 200AL distributed I/O system:

- 1. Code number: Dust-proof and complete protection from contact
- 2. Code number: Protection from water
  - IP65: Protection from water jets from any angle
    (The water may not have any damaging effect)
  - IP67: Protection against temporary submersion
    (The water must not enter the enclosure in harmful quantities)

Rated voltage for operation

The following table shows the nominal voltage and the corresponding tolerance with which the ET 200AL distributed I/O system operates.

Table 1-973 Rated voltage for operation

Rated voltage (SELV/PELV)	Tolerance range
24 V DC	20.4 ... 28.8 V DC

Industrial cybersecurity 13

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

In the first part of this section you will find basic information on the subject of industrial cybersecurity. Subsequent sections describe recommended measures for protecting the entire system and individual components from manipulation and unwanted access.

NOTE

Security-relevant changes to software or devices are documented in the section New properties/functions (Page 22).

13.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

13.2 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction (Page 8) section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. In the "Product tree" filter menu, select your product or your product group, for example "Automation Technology" > "Automation Systems" > "Industrial Automation Systems SIMATIC" > "I/O systems" > "SIMATIC ET 200 systems without control cabinet" > "ET 200AL".
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".
6. Select the document about which you want to receive notifications using the 3 points on the right "Add to my favorites".
7. In the following dialog, select the name, the storage location and the "Notify me" option for the favorite. Then click on the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

13.3 Basic information on industrial cybersecurity

13.3.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (e.g. due to the destruction of data or denial of service (DoS))

13.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial systems and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices without their own security functions

- Use of existing, open and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

13.4 Integrated security concept and security strategies

13.4.1 Comprehensive security concept "Defense in Depth"

With Defense in Depth, Siemens provides a multi-layer security concept that offers industrial plants comprehensive and far-reaching protection in accordance with the recommendations of the IEC 62443 international standard.

Productivity and know-how are protected on 3 levels:

Plant security
Plant security uses various methods to secure the physical access of people to critical components. This starts with classic building access and extends to securing sensitive areas using access control (for example, code card, iris scan, fingerprint or access code).

Network security
Automation networks must be protected against unauthorized access. This is achieved through security measures on the product, but also those in the product-related environment.

System integrity
Targeted measures must be taken to protect existing know-how or to prevent unauthorized access to automation processes. The measures protect against unauthorized configuration changes and highlight attempts at manipulation.

You can find more information on the topics of Defense in Depth, plant security, network security, and system integrity on the SIEMENS Industrial cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) Web page.

You can also visit the download center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) to obtain more information on the topic of industrial cybersecurity. The "Operational Guidelines", for example, provide recommendations on basic security measures for secure machine and plant operation in an industrial environment.

13.4.2 Security management

The ISO 27001 and IEC 62443 standards call for a comprehensive approach in information technology (IT) and operational technology (OT) to protect against cyber attacks.

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

- Defining cybersecurity and IT security as an important criterion in the procurement and selection of machines and software applications.
- Use of suitable measures to protect production resources, data, and communication from manipulation and theft
- Providing all necessary resources and training to employees to fully support these goals

For this purpose, suitable measures must be selected after a risk assessment and a cost-benefit analysis in order to protect material and intellectual property and prevent damage from occurring. These measures should be integrated into corporate processes and procedures, evaluated regularly, and firmly anchored in the corporate culture. In addition to protecting intellectual property, the protection of personal data must be ensured at all organizational units and levels.

Siemens will provide you with information and support. Subscribe to the Security feeds (https://www.siemens.com/cert) for information on vulnerabilities. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home) and create filters to be notified when important information is published. The procedure is described in the section Notification of security updates (Page 129). Consider using Siemens Cybersecurity Services.

Responsibility in the digital supply chain

Cybersecurity should play a critical role in the evaluation and procurement process. The entire life cycle of a product should be considered to ensure protection against current and future risks. These include, for example, security updates throughout the product life cycle, including guidelines for secure disposal of the product.

Siemens plans and announces the provision of security updates, as well as total discontinuation of products, as part of product support.

Employee awareness

Regular training in cybersecurity and continuous testing of training success are essential so that cybersecurity measures are internalized in processes and work instructions. This involves general training in the use of software and IT hardware for company communication and as work equipment e.g.:

- Secure handling of USB devices
- Encrypted communication
- Use of VPN
- Rules for passwords and use of access
- Setting up two-factor authentication
- Educating employees about the dangers posed by malware, phishing, social engineering and other factors

Furthermore, if applicable, production equipment and software training should always include the topic of cybersecurity.

Maintaining the security concept through updates

Keeping software up-to-date is essential, for example, to benefit from the following measures:

- Implementation of new security strategies, protocols and techniques
- Closing of security vulnerabilities
- Elimination of security vulnerabilities

To this end, it is necessary to keep a constant eye on the further development of protective measures and, if necessary, the expansion of requirements.

Recommendations:

- Set up notifications for (security) updates
- Subscribe to information on vulnerabilities
- Monitor and implement the further development of the technology, especially in the area of cybersecurity

Always keep technology and knowledge up to date.

Consideration of the risks posed by cyber attacks in the Threat and Risk Assessment (TRA)

Make an inventory of all software, hardware, and infrastructure devices, in order to identify risks to the location or organization. Incident response procedures must be incorporated into all IT and manufacturing processes. The choice of risk mitigation measures should be based on a cost-benefit analysis and classification of risks. This is followed by the introduction of cybersecurity rules and procedures and the training of personnel.

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

Cybersecurity must be part of the corporate culture and process landscape and must be internalized and lived by all employees.

Continuously monitoring the security situation

You have the following options for continuously monitoring the cybersecurity situation:

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and effectively resolve security vulnerabilities.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network

- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: for example network segmentation, firewalls, VPN, DMZ (demilitarized zones)

13.5 Operational application environment and security assumptions

13.5.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

Operational reliability and intended use

Read the "Special information" in the Introduction (Page 8) section.

Area of application

Refer to the "Application area" section in the System overview (Page 24) chapter.

13.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Threat and risk assessment (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection
In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security
You can ensure the physical security of the company by taking the following measures:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security
You can ensure physical production safety by taking the following measures, among others:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsafe on systems.

13.6 Security properties of the devices

The security properties of the individual devices are listed in the Equipment Manuals.

13.7 Secure operation of the system

This section describes measures recommended by Siemens to protect your system from manipulation and unauthorized access.

13.7.1 Hardening measures

System hardening, simplify referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which restrictive user and rights management system is implemented.

13.7.2 Secure configuration

Secure configuration involves control over all software components, along with their interfaces, ports, and services.

Activated services and ports pose a risk, e.g. of unauthorized access to the network and programs.

To minimize risks, only activate the necessary services for all automation components. Take all activated services (especially Web servers, FTP, remote maintenance etc.) into account in the security concept. Consider the default states of ports and services in your security concept.

You can find an overview of all ports and services used in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

13.7.3 Handling of sensitive data

Data protection information

Siemens Aktiengesellschaft observes the applicable data protection laws, including the General Data Protection Regulation (GDPR), in particular the rules of data minimization and data protection-friendly default settings (privacy by design, privacy by default).

The products do not store any personal data.

If you establish a reference to an identifiable person by linking this functional data with other data (such as shift schedules) or if you store personal data on the same medium (such as a hard disk), you are responsible for ensuring that the data protection regulations are observed.

Information on the secure removal of data is provided in the section Secure decommissioning (Page 137).

Storage of security-related data

When storing your security-relevant data on your PC, independently ensure secure data storage.

13.7.4 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

- Always keep your plant/products up to date to benefit from troubleshooting and to minimize potential risks.
- Use email notifications to be automatically informed about firmware updates.

You can find more information in:

- Section Firmware update (Page 110)
- Section Notification of security updates (Page 129)

13.7.5 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. It can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes security gaps (Vulnerabilities) in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following Siemens Aktiengesellschaft web page: Siemens ProductCERT and Siemens CERT (https://www.siemens.com/global/en/products/services/cert.html?s=SIMATIC&_originalHost=new.siemens.com#SecurityPublications)

"SIMATIC" is preset in the "Search Security Advisories" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please inform us immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

13.7.6 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

13.7.7 Security checks

Security checks for data, files, and archives serve to ensure data integrity at the storage location and during file transmission, protecting against manipulation and transmission errors. This is often achieved using digital checksums that are provided alongside the data. Tools (such as SHA-256 or SHA-512) for calculating and verifying these checksums are provided in many systems and named according to their respective calculation methods.

File Integrity Guidelines describe the prescribed procedure for integrity checks

Integrity protection is a protection function for engineering data and firmware files

Communication integrity means protecting communication against unauthorized manipulations to ensure high system availability. A central element in this regard is, for example, the use of digital checksums when accessing controllers. (Source: Industrial Cybersecurity website (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html))

13.7.8 Secure decommissioning

In the following section, you will find information on how to properly decommission individual components of your automation system. Decommissioning is necessary when the component has reached the end of its service life.

Decommissioning includes environmentally sound disposal and secure removal of all digital data of electronic components with storage medium.

13.7.8.1 Securely removing data

Before disposing of components of your automation system, you should securely delete all data from the storage media of these components. How to securely delete data from the devices so that it cannot be recovered is described below.

NOTICE
Data misuse resulting from non-secure deletion of data Incomplete or non-secure deletion of data from data memories can result in data misuse by third parties. For this reason, ensure secure deletion of data from all storage media used before disposing of the product.

Secure erasure of data from the interface module

With the following tools, you can securely erase the data from the interface module:

- STEP 7 < V19
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

Follow these steps in the order given:

1. Establish an online connection.
2. Open the Online and Diagnostics view of the IM (either from the project context or via "Accessible devices").
3. In the dialog box "Functions > Reset to factory settings", select the option "Delete I&M data" and then the "Reset" button.

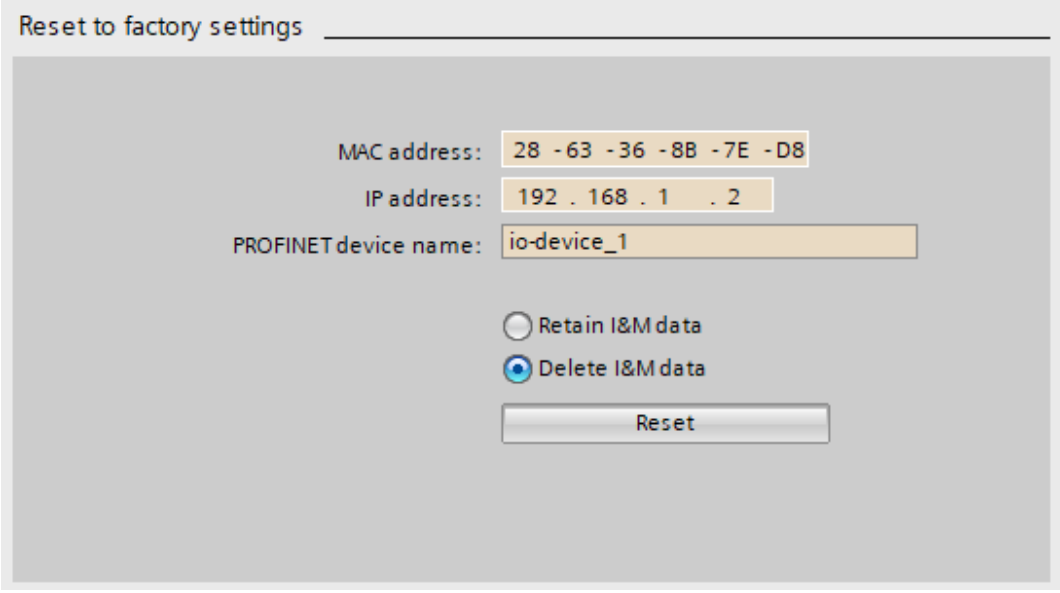


Figure 1-699 Resetting an interface module to factory settings

Result: All the data that was still in the data memories of the interface module was deleted. You can now dispose of the components.

For more information on resetting the interface module to factory settings, refer to the section Resetting an interface module to factory settings (Page 111).

NOTE

STEP 7 ≥ V19

Only the communication parameters will be securely deleted on "Reset to factory settings" with the "Delete I&M data" option enabled when you use STEP 7 ≥ V19.

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

If you want to securely remove all data, use one of the tools listed above for this purpose.

13.7.8.2 Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

13.8 Secure operation of the engineering software

For more information on secure operation of the engineering software, refer to the TIA Portal online help.

13.9 Secure operation of interface modules

Device-specific security information and instructions for interface modules can be found in the respective Equipment Manual.

13.9.1 Data integrity for interface modules

Data integrity refers to the completeness and correctness (integrity) of data, which is an essential prerequisite for the proper functioning of systems.

Measures for data privacy, data consistency, and data security ensure that data used within devices cannot be damaged, altered (manipulated), or deleted during processing or transmission, and at the very least, any changes to the data are detected.

Data integrity for interface modules

To detect intentional or accidental changes to data within an interface module and its associated modules, the possibility of dynamic integrity checking is introduced for PROFINET interface modules.

The ability to detect integrity breaches enhances the resilience of the distributed I/O system.

Data integrity within a distributed I/O system is entirely covered within the interface module and does not pertain to other components of the automation system.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

A CRC (Cyclic Redundancy Check) is always the same for a specific, unchanged memory content. When the memory content changes, the interface module (IM) calculates a different checksum for this content by reading and comparing the I&M4 data. By comparing with the initial CRC, you can determine whether the data in the memory has been modified or not:

- CRC stayed the same: No change in the data within this memory area of the interface module IM
- CRC changed: The data within this memory area of the IM was modified

Only you, as the user, know whether changes to the data of an interface module were intentional or not. If changes were not intentional, you can detect that the data of the interface module has been compromised through changed CRCs and respond accordingly.

I&M data

PROFINET devices provide Identification and Maintenance data (I&M data), which is a set of predefined data structures containing the internal module status. With this data, a module can be identified, its serial number can be determined, etc.

The CRC checksums are mapped in the maintenance data **I&M4** of the interface module.

NOTE

Requirements for calculating the CRCs

The CRCs via the memory contents of the interface module are calculated only when you request to read the I&M4 data.

The CRCs cover not only the interface module itself but can also take into consideration combined checksums from associated modules (refer to the section on the structure of the data record for I&M data). Process data is not included in the calculation of CRCs.

Example:

- You put your distributed I/O system into operation and read the CRC CHK_OVERALL with the value "0x55AAA678" ("16#55AAA678") from the interface module via the I&M4 data.
- As long as no changes have been made to the data of the interface module or the associated modules, each subsequent read will give the value "0x55AAA678" or "16#55AAA678".
- Once you read a different CRC CHK_OVERALL, for example, "0xCC9876FF", you will realize that there must have been changes to the data of the interface module or the associated modules.

The quality of the statement regarding the data integrity of the distributed I/O system improves with each module associated with the interface module that supports I&M4 data. Refer to the Equipment Manual of the respective module to find out if and from which firmware version the module supports I&M4 data.

You can find the structure of I&M data 0 to 4 in the section Record structure for I&M data (Page 105).

Spare parts scenario

The spare parts scenario is still ensured. This means that you can replace interface modules with the same article number. For the "new" interface module, the static data such as the serial number and MAC addresses will change. Note that this is why the replacement will be reflected in the changed identification data CHK_STATIC_LOCAL and consequently also in CHK_OVERALL.

More information on the spare parts scenario and compatibility can be found in the Equipment Manual of the interface module.

13.9.2 Signed firmware update for interface modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect internet source

Information on whether your interface module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of the signed firmware update for interface modules

Firmware updates for interface modules starting with article number 6ES7157-1MA00-0AB0 may include a digital signature. The digitally signed firmware update files are available for download on the Siemens Support Web page.

The interface module verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the interface module can detect a manipulated or corrupted firmware update file and reject it.

Note that the interface module performs the verification only after the complete firmware download has taken place.

Subsequently, a notification is sent to the firmware update tool regarding the success or failure of the signature verification.

You still have all the options for firmware updates, as described in the Firmware update (Page 110) section, when performing signed firmware updates for modules. If the firmware update was not successful, the module will continue to run with the previous firmware.

Diagnostics alarms and remedy

When performing a firmware update for a module with an established connection between the IM and CPU, the following options for notifications are available in the CPU's diagnostic buffer:

- Successful integrity check of the firmware for the module
- Rejection of non-secure firmware for the module

You can find more information in the section on diagnostics alarms in the equipment manual for the respective module.

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file you are using originates from a secure source and was downloaded unchanged. As a check, calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support website.
3. Repeat the firmware update.

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/de/de/view/109483101/en).

13.9.3 Secure Boot

Secure Boot

Secure Boot verifies, before the boot process, whether firmware has been falsified, for example through manipulation or accidental falsification.
Secure Boot ensures the authenticity and integrity of the firmware executed by the device.

Information on whether your interface module supports Secure Boot is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of "Secure Boot" for interface modules

Interface modules verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before being executed.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to signed firmware updates for interface modules, Secure Boot also prevents manipulation of the firmware through physical intervention in the interface module.

Secure Boot is integrated into the interface module and cannot be deactivated for security reasons.

NOTE

Longer startup duration of the interface module
The signature verification of Secure Boot significantly extends the startup time of the interface module. You can find time specifications in the Equipment Manual of the interface module, in the Technical specifications section.

LED display on the interface module

If the Secure Boot verification results in an invalid signature, the LEDs RUN, ERROR, and MAINT on the interface module will flash. In this case, you need to replace the interface module.

13.10 Safe operation of I/O modules

Device-specific security information and instructions for I/O modules can be found in the respective Equipment Manual.

13.10.1 Data integrity for I/O modules

Data integrity for I/O modules

In order to detect intentional or accidental changes to the data of an interface module and the assigned modules, the dynamic integrity check for I/O modules is introduced as of firmware version V2.0. You can also find out whether your I/O module supports the data integrity check in the Technical specifications section of the corresponding equipment manual.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as serial numbers, parameter settings, calibration data and I&M data of I/O modules. The interface module stores the checksums in the I&M4 data area.

You can find more information on the principle of data integrity and I&M4 data in the section Data integrity for interface modules (Page 139).

Spare parts scenario

The spare parts scenario is still ensured. This means that you can replace I/O modules with the same article number. For the "new" I/O module, the static data such as the serial number will change. Note that the replacement is therefore reflected in the following modified I&M4 data of the interface module:

- CHK_STATIC_SUBS
- CHK_OVERALL_SUBS
- CHK_OVERALL

You can find the structure of I&M data in the section Record structure for I&M data (Page 105).

13.10.2 Signed firmware update for I/O modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect internet source

Signed firmware update for I/O modules

Firmware updates for I/O modules as of firmware version V2.0 contain a digital signature. The digitally signed firmware update files are available for download on the Siemens Support Web page.

Principle, diagnostics alarms and remedies as for interface modules

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 141) applies.

Safety-related shutdown of ET200AL standard modules

A

Introduction

The diagram below illustrates the fail-safe shutdown of ET 200AL standard modules.

In the configuration shown in the diagram below, all digital outputs that are operated with the 2L+ and 2M supply of the ET 200AL standard modules are switched to the safe OFF state. This step achieves the safety class SIL2/category 3/PLd.

Principle of operation

The higher-level safety relay (for example: 3SK1) disconnects the 2L+ and 2M supply. This switches all digital outputs operated with the 2L+ and 2M (switched) supply to the safe state. The digital outputs connected to the 1L+ and 1M (non-switched) supply are not intended for functional switching and therefore cannot be shut down safely.

There is no interaction between the outputs supplied by 1L+ and 2L+.

You can also integrate I/O modules that are operated solely at the supply 1L+ and 1M (non-switched) in the structure of your distributed I/O system. These I/O devices must be enabled as reaction-free modules. These I/O modules are not affected by a disconnection, they pass on the supply 2L+ and 2M (switched). The following figure shows this as an example using the DI, AI and AQ modules.

Schematic circuit diagram with 3SK1

The following figure shows a schematic circuit diagram with safety relay 3SK1.

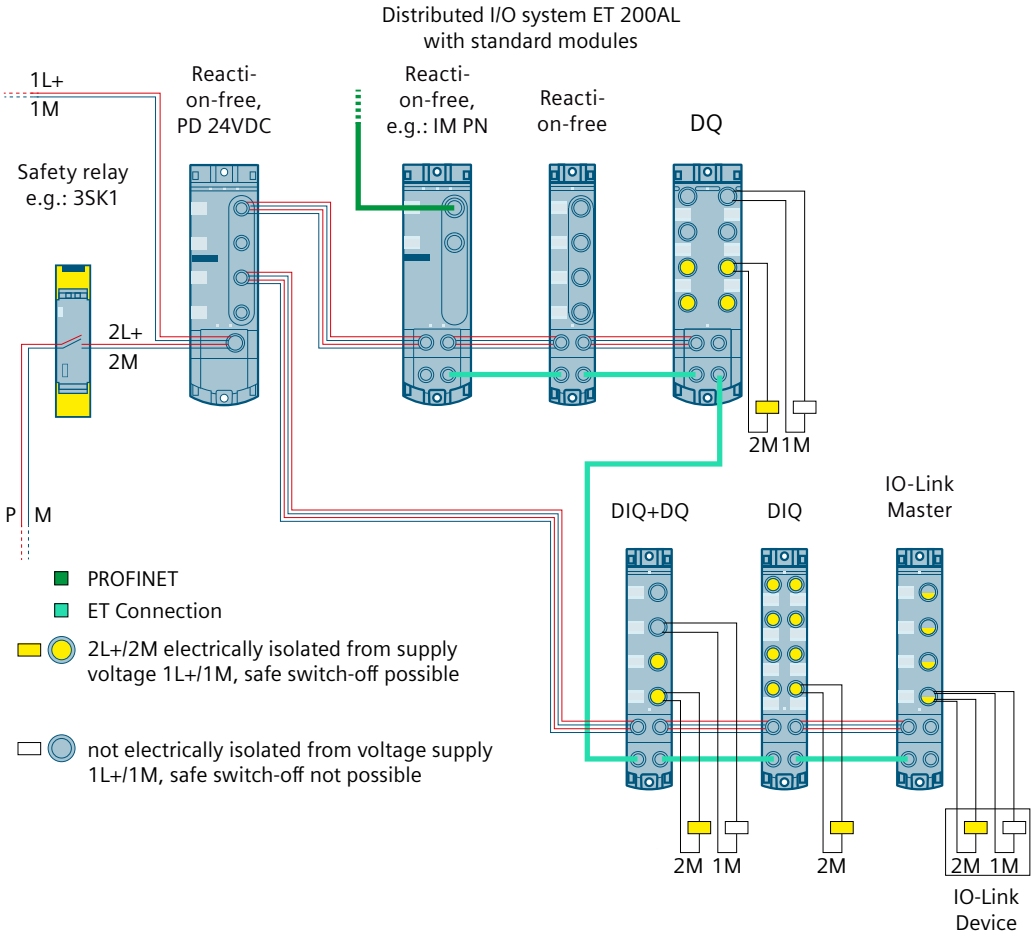


Figure 1-700 Higher-level safety circuit with safety relay

You can find an overview table with the article numbers of the I/O modules and other information in the FAQ on safety-related shutdown (https://support.industry.siemens.com/cs/us/en/view/39198632).

Planning

Note the following points when planning safety circuits.

WARNING

Note potential groups for safety-related shutdown
When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, which leads to elimination of the electrical isolation between 1L+ and 2L+.
The safety-related shutdown is not permitted if the electrical isolation is eliminated.

NOTE

Safe electrical isolation

Maintain safe galvanic isolation for voltages higher than SELV/PELV.

NOTE

Safety-related shutdown for the IO-Link master

For an IO-Link master with IO-Link Port Class B, safety-related shutdown is available for the additional supply (PIN 2 and PIN 5).

The other signals at the port are reaction-free.

Please note that the IO-Link device must have corresponding safety characteristics in order to use safety-oriented tripping.

Limits of the higher-level safety circuit

The ET 200AL standard modules do not fulfill any safety functions. The safety functions are executed by the safety relay in order to bring the system into a safe state.

Adjust the operation inspection interval of the safety switching device with a relay output to the safety class.

Take the following measures if energy that is not provided by the higher-level safety circuit is used to control the safety function.

Cover critical errors in the safety function that are not detected by the higher-level safety circuit (e.g. 3SK1) with suitable safety measures. The "diagnostics" must be performed indirectly via the controlled process.

Specifications for safety-relevant process data:

- Functionally safe
- Read via fail-safe inputs (e.g. F-DI)
- Fail-safe processing unit (e.g. F-CPU) for issuing commands
- Output through fail-safe outputs (e.g. F-DQ) to control the safety function

Requirements on the power supply

Operation requires a SELV/PELV power supply to limit overvoltages to L+ and M (24 V). This measure prevents possible errors from the power supply side at the same time.

Select the power supply according to the requirements of the respective operating instructions for the shutdown device and for the ET 200AL system.

You can find more information on safe SELV/PELV in the data sheets of the power supplies used.

FAQ

The information on the safety-related shutdown of standard modules refers to the status of the issue date. Read the up-to-date information on safety-related shutdown in this FAQ (https://support.industry.siemens.com/cs/us/en/view/39198632).

This FAQ specifies the SIMATIC standard modules that are suitable for a safety-related shutdown and a file with wiring examples.

Request German Technical Inspectorate report (Report no. SN89858T)

You can request copies of the German Technical Inspectorate report at the following address:

Siemens Aktiengesellschaft
Digital Industries
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg, Germany

Dimension drawings

B

2 module widths are available with the distributed I/O system.

The figure below shows the height and width of the modules. The depth of the modules ranges from 40 mm to 46 mm. Detailed information on the dimensions of the individual modules can be found in the manuals for the Interface modules (https://support.industry.siemens.com/cs/ww/en/ps/14246/man) and I/O modules (https://support.industry.siemens.com/cs/ww/en/ps/14247/man) in the section "Dimension drawing".

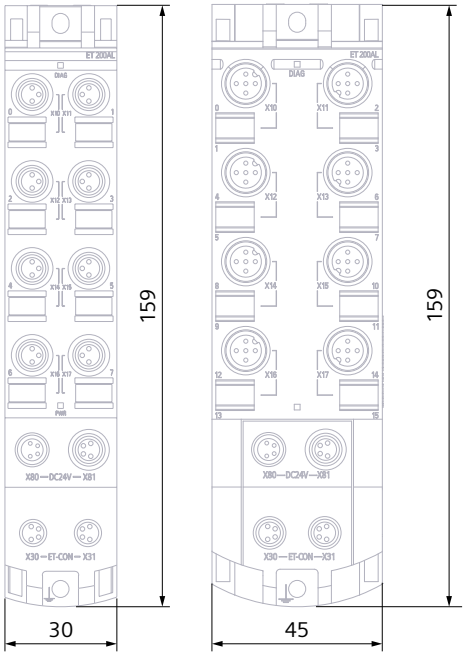


Figure 1-701 Module dimension drawings (front view)

Accessories/spare parts

C

C.1 Accessories/spare parts

Accessories for the ET 200AL distributed I/O system

Table 1-974 Accessories for ET-Connection

Designation	Length	Article number	
Cable		**Standard**	**PUR**
Bus cable for ET-Connection M8, pre-assembled on both sides with 2 x M8 connectors, 4-pin, shielded	0.19 m	6ES7194-2LH02-0AA0	6ES7194-2MH02-0AA0
	0.3 m	6ES7194-2LH03-0AA0	6ES7194-2MH03-0AA0
	1.0 m	6ES7194-2LH10-0AA0	6ES7194-2MH10-0AA0
	2.0 m	6ES7194-2LH20-0AA0	6ES7194-2MH20-0AA0
	5.0 m	6ES7194-2LH50-0AA0	6ES7194-2MH50-0AA0
	10.0 m	6ES7194-2LN10-0AA0	6ES7194-2MN10-0AA0
	15.0 m	6ES7194-2LN15-0AA0	6ES7194-2MN15-0AA0
Bus cable for ET-Connection M8, pre-assembled on both sides with 2 x M8 connectors, angled, 4-pin, shielded	0.3 m	6ES7194-2LH03-0AB0	6ES7194-2MH03-0AB0
	1.0 m	6ES7194-2LH10-0AB0	6ES7194-2MH10-0AB0
	2.0 m	6ES7194-2LH20-0AB0	6ES7194-2MH20-0AB0
	5.0 m	6ES7194-2LH50-0AB0	6ES7194-2MH50-0AB0
	10.0 m	6ES7194-2LN10-0AB0	6ES7194-2MN10-0AB0
	15.0 m	6ES7194-2LN15-0AB0	6ES7194-2MN15-0AB0
Bus cable for ET-Connection M8, pre-assembled on one side with 1 x M8 connector, 4-pin, shielded	2.0 m	6ES7194-2LH20-0AC0	6ES7194-2MH20-0AC0
	5.0 m	6ES7194-2LH50-0AC0	6ES7194-2MH50-0AC0
	10.0 m	6ES7194-2LN10-0AC0	6ES7194-2MN10-0AC0
	15.0 m	6ES7194-2LN15-0AC0	6ES7194-2MN15-0AC0
Connecting cable for bus cable ET-Connection M8, both ends assembled with 2x M8 socket, 4-pin, shielded	0.2 m	6ES7194-2LH02-0AD0	6ES7194-2MH02-0AD0
Connector			
M8 connector for ET-Connection, 4-pin, shielded		6ES7194-2AB00-0AA0	

Table 1-975 Accessories for power supply M8

Designation	Length	Article number	
Cable		**Standard**	**PUR**
Power cable M8, pre-assembled on both sides with M8 connector and M8 socket, 4-pin	0.19 m	6ES7194-2LH02-1AA0	6ES7194-2MH02-1AA0
	0.3 m	6ES7194-2LH03-1AA0	6ES7194-2MH03-1AA0
	1.0 m	6ES7194-2LH10-1AA0	6ES7194-2MH10-1AA0
	2.0 m	6ES7194-2LH20-1AA0	6ES7194-2MH20-1AA0
	5.0 m	6ES7194-2LH50-1AA0	6ES7194-2MH50-1AA0
	10.0 m	6ES7194-2LN10-1AA0	6ES7194-2MN10-1AA0
	15.0 m	6ES7194-2LN15-1AA0	6ES7194-2MN15-1AA0
Power cable M8, pre-assembled on both sides with	0.3 m	6ES7194-2LH03-1AB0	6ES7194-2MH03-1AB0

Designation	Length	Article number	
angled M8 connector and angled M8 socket, 4-pin	1.0 m	6ES7194-2LH10-1AB0	6ES7194-2MH10-1AB0
	2.0 m	6ES7194-2LH20-1AB0	6ES7194-2MH20-1AB0
	5.0 m	6ES7194-2LH50-1AB0	6ES7194-2MH50-1AB0
	10.0 m	6ES7194-2LN10-1AB0	6ES7194-2MN10-1AB0
	15.0 m	6ES7194-2LN15-1AB0	6ES7194-2MN15-1AB0
Power cable M8, pre-assembled on one side with M8 socket, 4-pin	2.0 m	6ES7194-2LH20-1AC0	6ES7194-2MH20-1AC0
	5.0 m	6ES7194-2LH50-1AC0	6ES7194-2MH50-1AC0
	10.0 m	6ES7194-2LN10-1AC0	6ES7194-2MN10-1AC0
	15.0 m	6ES7194-2LN15-1AC0	6ES7194-2MN15-1AC0
Connector			
M8 power connector, pin insert, 4-pin		6ES7194-2AA00-0AA0	
M8 power connector, socket insert, 4-pin		6ES7194-2AC00-0AA0	

Table 1-976 Accessories for power supply M12-L

Designation	Length	Article number
Cable		
M12 CONNECTING CABLE, L-CODED M12 L-cod 4-pol+FE st/st f/m PVC M12 L-cod 4+FE PVC 2,5 mm² Connection cable, straight socket on straight pin, 16 A	1.5 m	Company Harting: 21 33 A7A 8524 015
	5.0 m	Company Harting: 21 33 A7A 8524 050
	10.0 m	Company Harting: 21 33 A7A 8524 100
M12 CONNECTING CABLE, L-CODED M12 L-cod 4-pol+FE st/- f/- PVC M12 L-cod 4+FE PVC 2,5 mm² Connection cable, straight socket on open end, 16 A	1.5 m	Company Harting: 21 33 A70 0524 015
	5.0 m	Company Harting: 21 33 A70 0524 050
	10.0 m	Company Harting: 21 33 A70 0524 100

Table 1-977 M12 connector

Designation		Article number
Non-preassembled connectors for X1 DP1 (pin)		
PROFIBUS M12 plug connector 180° with female insert		6GK1905-0EB00
PROFIBUS M12 plug connector FastConnect 180° with female insert		6GK1905-0EB10
PROFIBUS M12 plug connector, angled with female insert		3RK1902-1DA00
Non-preassembled connectors for X1 DP2 (socket)		
PROFIBUS M12 plug connector 180° with pin insert		6GK1905-0EA00
PROFIBUS M12 plug connector FastConnect 180° with pin insert		6GK1905-0EA10
PROFIBUS M12 plug connector angled with pin insert		3RK1902-1BA00
Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN) socket		
PROFINET M12 plug connector d-coded with FastConnect connection technology, 180	1 unit/ pack	6GK1901-0DB10-6AA0
	8 units/ pack	6GK1901-0DB10-6AA8
PROFINET M12 plug connector, D-coded with fast connect technology 180°	1 unit/ pack	6GK1901-0DB20-6AA0
	8 units/ pack	6GK1901-0DB20-6AA8
PROFINET M12 plug connector, D-coded, angled		3RK1902-2DA00

Table 1-978 Non-preassembled cable M12

Designation	Article number
Non-preassembled cable for X1 DP1 and X1 DP2	
PROFIBUS FC Cable	
FC Standard Cable	6XV1830-0EH10
FC Trailing Cable	6XV1830-3EH10
FC Food Cable (PE sheath)	6XV1830-0GH10
FC Robust Cable (PUR sheath)	6XV1830-0JH10
FC FRNC Cable (FRNC sheath)	6XV1830-0LH10
FC Underground Cable	6XV1830-3FH10
Festoon Cable GP (PVC sheath)	6XV1830-3GH10
FC Flexible Cable GP (PUR sheath)	6XV1831-2K
Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN)	
PROFIBUS FC Cable	
FC Standard Cable	6XV1840-2AH10
FC TP Trailing Cable	6XV1840-3AH10
FC TP Trailing Cable GP	6XV1870-2D
FC TP Marine Cable	6XV1840-4AH10
FC TP Torsion Cable	6XV1870-2F
FC TP Flexible Cable GP (PVC sheath)	6XV1870-2B
FC TP FRNC Cable (FRNC sheath)	6XV1871-2F
FC TP Food Cable (PE sheath)	6XV1871-2L
FC TP Festoon Cable GP (PVC sheath)	6XV1871-2S

Table 1-979 Pre-assembled cable M12

Designation		Article number
Pre-assembled cable for X1 DP1 and X1 DP2		
PROFIBUS M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, 180° (one end with socket, one end with pin)	0.3 m	6XV1830-3DE30
	0.5 m	6XV1830-3DE50
	1.0 m	6XV1830-3DH10
	1.5 m	6XV1830-3DH15
	2.0 m	6XV1830-3DH20
	3.0 m	6XV1830-3DH30
	5.0 m	6XV1830-3DH50
	10.0 m	6XV1830-3DN10
	15.0 m	6XV1830-3DN15
PROFIBUS M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, angled (one end with socket, one end with pin)	1.5 m	6XV1830-3DH15-0SB0
	2.0 m	6XV1830-3DH20-0SB0
	3.0 m	3RK1902-1NB30
	5.0 m	3RK1902-1NB50
	10.0 m	3RK1902-1NC10
	15.0 m	6XV1830-3DN15-0SB0
Pre-assembled cable for X1 P1R PN (LAN) and X1 P2R PN (LAN)		
PROFINET M12 connecting cable, trailing cable, pre-assembled on both ends with M12 connectors 180° (pin)	0.3 m	6XV1870-8AE30
	0.5 m	6XV1870-8AE50
	1.0 m	6XV1870-8AH10

Designation		Article number
PROFINET M12 connecting cable, trailing cable, pre-assembled on both ends with M12 connectors 180° (pin)	1.5 m	6XV1870-8AH15
	2.0 m	6XV1870-8AH20
	3.0 m	6XV1870-8AH30
	5.0 m	6XV1870-8AH50
	10.0 m	6XV1870-8AN10
	15.0 m	6XV1870-8AN15
PROFINET M12 connecting cable, trailing cable, pre-assembled on both ends with M12 connectors, angled (pin)	0.3 m	6XV1870-8AE30-0SB0
	0.5 m	6XV1870-8AE50-0SB0
	1.0 m	6XV1870-8AH10-0SB0
	1.5 m	6XV1870-8AH15-0SB0
	2.0 m	6XV1870-8AH20-0SB0
	3.0 m	3RK1902-2NB30
	5.0 m	3RK1902-2NB50
	10.0 m	3RK1902-2NC10
	15.0 m	6XV1870-8AN15-0SB0
PROFINET M12 connecting cable, trailing cable, pre-assembled on both sides with PROFIBUS M12 connectors, angled (one end with pin, one end open)	3.0 m	3RK1902-2HB30
	5.0 m	3RK1902-2HB50
	10.0 m	3RK1902-2HC10
PROFINET M12 connecting cable, trailing cable, pre-assembled on one end with M12 connectors 180° (pin), other end with RJ45 plug 145°	2.0 m	6XV1871-5TH20
	3.0 m	6XV1871-5TH30
	5.0 m	6XV1871-5TH50
	10.0 m	6XV1871-5TN10
	15.0 m	6XV1871-5TN15

Table 1-980 Y cable

Designation		Article number
SIMATIC DP, Y-cable for distributed I/Os for double connection of I/Os using single cable, 5-pin, M12	0.2 m	6ES7194-6KA00-0XA0
SIMATIC DP, Y-cable, for fail-safe ET 200 distributed I/O, IP 65/67, for connection of single-channel sensors (1oo1 evaluation) 5-pin M12	0.2 m	6ES7194-6KB00-0XA0
SIMATIC DP, Y-cable, for fail-safe distributed I/O ET 200, IP 65/67, for common connection of an F-DQ and F-DI channel by means of 8-pin M12 socket	0.2 m	6ES7194-6KC00-0XA0

Table 1-981 Additional accessories

Designation	Article number
Identification labels 10 x 5 mm RAL9016, composed of 200 labels on frames, per frame 40 labels	6ES7194-2BA00-0AA0
Identification labels 10 x 5 mm RAL1018, yellow, consisting of 200 labels on frames, 40 labels per frame	6ES7194-2BB00-0AA0
Identification labels 10 x 7 mm, yellow, consisting of 816 labels on frames, 48 labels per frame (for eCoding plug connectors)	6ES7194-6HA00-0AA0
Sealing cap M8 for modules IP67	3RK1901-1PN00
Sealing cap M12 for modules IP67	3RX9802-0AA00
Bus connection plug PROFIBUS M12, pin insert, 5 units	6GK1905-0EC00
Stripping Tool for ET-Connection	6ES7194-2KA00-0AA0

Designation	Article number
Stripping Tool for PROFINET	6GK1901-1GA00
Stripping Tool for PROFIBUS	6GK1905-6AA00
eCoding plug connector, stores the F-destination addresses and F-source addresses for F-modules	6ES7194-6KB01-0AA0

Online catalog

Other article numbers for the ET 200AL distributed I/O system can be found on the Internet (https://mall.industry.siemens.com) in the online catalog and the online order system.

C.2 UL-approved cables

In combination with the UL-approved cables for the power supply and the connection of inputs/outputs, the SIMATIC ET 200AL distributed I/O devices meet UL approval. Siemens has UL-approved cables for these applications in the product portfolio.

C.3 Cables

Cables for ET-Connection PVC cable and PUR cable

The cables for ET-Connection are available in the following versions and lengths:

- Bus cable (4-wire), pre-assembled on both sides with 2 M8 connectors, 4-pole, shielded
  - available lengths: 0.19 m, 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Bus cable (4-wire), pre-assembled on both sides with 2 M8 connectors, angled, 4-pole, shielded
  - available lengths: 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Bus cable (4-wire), pre-assembled on one side 1x M8 connector, 4-pole, shielded
  - available lengths: 2 m, 5 m, 10 m, 15 m

The following table shows the technical properties of the bus cable ET-Connection PVC cable.

Table 1-982 Cables for ET-Connection, PVC cable

General information	
Product type designation	BUS CABLE ET-CONNECTION
Function	To connect ET-CONNECTION devices with degree of protection IP65/IP67
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C
maximum	80 °C

* = Applies to cable lengths up to 10 m.

General information	
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	2Y(ST)CY 1x4x0.5/1.0-100-GN
Number of electrical wires	4
Design of shielding	Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires
Outside diameter of the inner conductor	0.5 mm
Outside diameter of the wire insulation	1.0 mm
Outside diameter of the cable sheath	5 mm
Number of bending cycles	1000000; Trailing-chain suitable for 1 million bending cycles with a bending radius of 100 mm, a velocity of 4 m/s and an acceleration of 4 m/s²
Permissible bending radius	
One time bending, min.	20 mm
Multiple bending, min.	40 mm
Constant bending	100 mm
Color of the cable sheath	Green
Color of the wire insulation of the data wires	White, yellow, blue, orange
Weight per length	34 kg/km
Mechanics/material	
Type of cable outlet	180° cable outlet 90° cable outlet (with angled connectors)
Number of connectors	1 or 2
Connector housing material	Metal/plastic
Wire insulation material	PE
Cable sheath material	PVC
Material property halogen free	No
Material property silicon free	Yes

* = Applies to cable lengths up to 10 m.

The following table shows the technical properties of the bus cable ET-Connection, PUR cable.

Table 1-983 Cables for ET-Connection, PUR cable

General information	
Product type designation	BUS CABLE ET-CONNECTION, PUR CABLE
Function	To connect ET-CONNECTION devices with degree of protection IP65/IP67
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C

* = Applies to cable lengths up to 10 m.

General information	
maximum	80 °C
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	2Y(ST)C11Y 2x2x0.5/1.0-100-GN
Number of electrical wires	4
Design of shielding	Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires
Outside diameter of the inner conductor	0.5 mm
Outside diameter of the wire insulation	1.0 mm
Outside diameter of the cable sheath	5 mm
Number of bending cycles	1000000*; trailing-chain suitable for 1 million bending cycles with a bending radius of 100 mm, a velocity of 4 m/s and an acceleration of 4 m/s²
Permissible bending radius	
One time bending, min.	20 mm
Multiple bending, min.	40 mm
Constant bending	100 mm
Color of the cable sheath	Green
Color of the wire insulation of the data wires	White, yellow, blue, orange
Weight per length	34 kg/km
Mechanics/material	
Type of cable outlet	180° cable outlet 90° cable outlet (with angled connectors)
Number of connectors	1 or 2
Connector housing material	Metal/plastic
Wire insulation material	PE
Cable sheath material	PUR
Material property halogen free	Yes
Material property silicon free	Yes

* = Applies to cable lengths up to 10 m.

Connection cable for ET-Connection PVC cable and PUR cable

You can use the connection cable between two cables for ET-Connection.

Typical applications for using connection cable for ET-Connection are:

- Combination of individual cable lengths by joining multiple pre-assembled cables for ET-Connection.
- Selective installation of disconnection points of cables for ET-Connection (for simple changing of cables and cable sections, e.g. with trailing-cable applications).

You can use a maximum of two connection cables between the two modules.
The length of the cables for ET-Connection is limited to maximum 10 m when connection cables are used.

The connection cable for ET-Connection is available in the following design:

- Connection cable for bus cable ET-Connection M8, both ends assembled with 2x M8 socket, 4-pole, shielded, length 0.2 m

The following table shows the technical properties of the connection cable for ET-Connection PVC cable.

Table 1-984 Connection cables for ET-Connection, PVC cable

General information	
Product type designation	Connection cable for bus cable ET-CONNECTION, cable 0.2 M
Function	To connect two bus cables ET-CONNECTION
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C
maximum	80 °C
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	2Y(ST)CY 1x4x0.5/1.0-100-GN
Number of electrical wires	4
Design of shielding	Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires
Cable length	0.2 m
Outside diameter of the inner conductor	0.5 mm
Outside diameter of the wire insulation	1.0 mm
Outside diameter of the cable sheath	5 mm
Permissible bending radius	
One time bending, min.	20 mm
Multiple bending, min.	40 mm
Constant bending	100 mm
Color of the cable sheath	Green
Color of the wire insulation of the data wires	White, yellow, blue, orange
Weight per length	34 kg/km
Mechanics/material	
Type of cable outlet	180° cable outlet
Connector housing material	Metal/plastic
Wire insulation material	PE
Cable sheath material	PVC
Material property halogen free	No
Material property silicon free	Yes

The following table shows the technical properties of the connection cable for ET-Connection, PUR cable.

Table 1-985 Connection cables for ET-Connection, PUR cable

General information	
Product type designation	Connection cable for bus cable ET-CONNECTION, PUR cable 0.2 M
Function	To connect two bus cables ET-CONNECTION
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C
maximum	80 °C
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	2Y(ST)C11Y 2x2x0.5/1.0-100-GN
Number of electrical wires	4
Design of shielding	Overlapped aluminum-lined sheet, coated with shielding made of tin plated copper wires
Cable length	0.2 m
Outside diameter of the inner conductor	0.5 mm
Outside diameter of the wire insulation	1.0 mm
Outside diameter of the cable sheath	5 mm
Permissible bending radius	
One time bending, min.	20 mm
Multiple bending, min.	40 mm
Constant bending	100 mm
Color of the cable sheath	Green
Color of the wire insulation of the data wires	White, yellow, blue, orange
Weight per length	34 kg/km
Mechanics/material	
Type of cable outlet	180° cable outlet
Connector housing material	Metal/plastic
Wire insulation material	PE
Cable sheath material	PUR
Material property halogen free	Yes
Material property silicon free	Yes

Cables for voltage supply PVC cable and PUR cable

The cables for the power supply are available in the following versions and lengths:

- Power cable (4-wire), pre-assembled on both sides with a 4-pole M8 pin connector/socket connector
  - available lengths: 0.19 m, 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Power cable (4-wire), pre-assembled on both sides with a 4-pole M8 pin connector/socket connector, angled
  - available lengths: 0.3 m, 1 m, 2 m, 5 m, 10 m, 15 m
- Power cable (4-wire), pre-assembled on one side with 1x M8 socket connector
  - available lengths: 2 m, 5 m, 10 m, 15 m

The following table shows the technical properties of the power supply line PVC cable

Table 1-986 Cables for power supply, PVC cable

General information	
Product type designation	POWER CABLE M8
Function	For connection of ET 200AL for 24 V DC power supply
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C
maximum	80 °C
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	4 Li9Y 0.50 mm² Y
Number of electrical wires	4
Outside diameter of the inner conductor	0.8 mm
Outside diameter of the wire insulation	1.46 mm
Outside diameter of the cable sheath	5.2 mm
Number of bending cycles	2500000; Trailing-chain suitable for 2.5 million bending cycles with a bending radius of 52 mm, a speed of 3 m/s² and an acceleration of 10 m/s²
Permissible bending radius	
One time bending, min.	26 mm
Multiple bending, min.	52 mm
Constant bending	52 mm
Color of the cable sheath	Gray
Color of the wire insulation of the power wires	White, brown, blue black
Weight per length	44 kg/km
Mechanics/material	

General information	
Type of cable outlet	180° cable outlet 90° cable outlet (with angled connectors)
Number of connectors	1 or 2
Connector housing material	Plastic
Wire insulation material	PP
Cable sheath material	PVC
Material property halogen free	No
Material property silicon free	Yes

The following table shows the technical properties of the power supply, PUR cable

Table 1-987 Cables for power supply, PUR cable

General information	
Product type designation	POWER CABLE M8, PUR CABLE
Function	For connection of ET 200AL for 24 V DC power supply
Degree of protection and protection class	
IP65	Yes
IP67	Yes
Ambient conditions	
Ambient temperature during mounting	
minimum	-30 °C
maximum	80 °C
Storage/transport temperature	
Ambient temperature during transport and storage	
minimum	-40 °C
maximum	80 °C
Cables	
Cable designation	LIF9Y11YFHF 4x0.50 mm²
Number of electrical wires	4
Outside diameter of the inner conductor	1 mm
Outside diameter of the wire insulation	1.46 mm
Outside diameter of the cable sheath	5.1 mm
Number of bending cycles	2000000; trailing-chain suitable for 2 million bending cycles with a bending radius of 51 mm, a velocity of 5 m/s and an acceleration of 5 m/s²
Permissible bending radius	
One time bending, min.	26 mm
Multiple bending, min.	51 mm
Constant bending	51 mm
Color of the cable sheath	Gray
Color of the wire insulation of the power wires	White, brown, blue black
Weight per length	44 kg/km
Mechanics/material	
Type of cable outlet	180° cable outlet 90° cable outlet (with angled connectors)
Number of connectors	1 or 2

General information	
Connector housing material	Plastic
Wire insulation material	PP
Cable sheath material	PE-PUR
Material property halogen free	Yes
Material property silicon free	Yes

C.4 Connectors

The following table shows the technical specifications of the user-configurable connectors.

The following table shows the technical specifications of the connection plug for the ET-CONNECTION connection.

Article number	6ES7194-2AB00-0AA0
General information	
Product type designation	Connection plug
Product description	M8 plug connector with high degree of protection, 4-pin, metal version
Suitability for use	for connecting ET-CONNECTION nodes (e.g. SIMATIC ET 200AL) in degree of protection IP65 / 67
Degree and class of protection	
IP degree of protection	IP65/67
Ambient conditions	
Ambient temperature during assembly, min.	-30 °C
Ambient temperature during assembly, max.	80 °C
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	80 °C
Mechanics/material	
Outgoing feeder type	180° cable outlet
Material of housing	metal
Dimensions	
Width	14 mm
Depth	47 mm

The following table shows the technical specifications of the power connector with female contact insert for the 24 V DC power supply.

Article number	6ES7194-2AC00-0AA0
General information	
Product type designation	Power connector
Product description	M8 plug connector with high degree of protection, socket insert, 4-pin, plastic version
Suitability for use	For connection to ET 200AL for 24 V DC power supply
Degree and class of protection	
IP degree of protection	IP65/67
Ambient conditions	
Ambient temperature during assembly, min.	-30 °C
Ambient temperature during assembly, max.	85 °C
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	85 °C

Article number	6ES7194-2AC00-0AA0
connection method / header	
Connector type	M8, 4-pole
Type of electrical connection for mains supply line	Screw terminals
• connectable cable cross-section for mains supply line, min.	0.14 mm²
• connectable cable cross-section for mains supply line, max.	0.5 mm²
• Connectable conductor cross-section for AWG cables, min.	26
• Connectable conductor cross-section for AWG cables, max.	20
Suitable for cable diameter, min.	4 mm
usable for cable diameter, max.	5.5 mm
Mechanics/material	
Outgoing feeder type	180° cable outlet
Material of housing	plastic
Dimensions	
Width	14 mm
Depth	47 mm

The following table shows the technical specifications of the power connector with male contact insert for the 24 V DC power supply.

Article number	6ES7194-2AA00-0AA0
General information	
Product type designation	Power connector
Product description	M8 plug connector with high degree of protection, 4-pin, plastic version
Suitability for use	For connection to ET 200AL for 24 V DC power supply
Degree and class of protection	
IP degree of protection	IP65/67
Ambient conditions	
Ambient temperature during assembly, min.	-30 °C
Ambient temperature during assembly, max.	85 °C
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	85 °C
connection method / header	
Connector type	M8, 4-pole
Type of electrical connection for mains supply line	Screw terminals
• connectable cable cross-section for mains supply line, min.	0.14 mm²
• connectable cable cross-section for mains supply line, max.	0.5 mm²
• Connectable conductor cross-section for AWG cables, min.	26

Article number	6ES7194-2AA00-0AA0
• Connectable conductor cross-section for AWG cables, max.	20
Suitable for cable diameter, min.	4 mm
usable for cable diameter, max.	5.5 mm
Mechanics/material	
Outgoing feeder type	180° cable outlet
Material of housing	plastic
Dimensions	
Width	14 mm
Depth	47 mm

C.5 Pin assignment and core color

Pin assignment of the sockets for ET-Connection

The tables below shows the pin assignments of the 2 sockets for the connection of ET-Connection.

Table 1-988 Pin assignment for ET-Connection (interface modules)

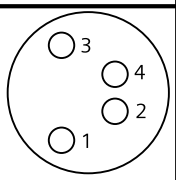
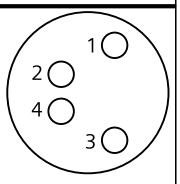
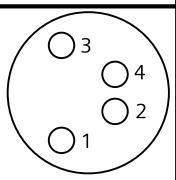
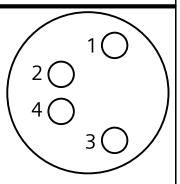
Pin	Assignment		Assignment of the core color of the bus cable for ET-Connection	Front view of the sockets	
	X30 socket (ET-Connection1)	X31 socket (ET-Connection2)		X30	X31
1	RXP	RXP	yellow		
2	TXP	TXP	white		
3	TXN	TXN	blue		
4	RXN	RXN	orange		
Shield-ing	Functional earth FE		-		

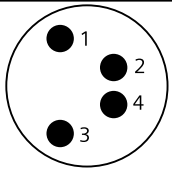
Table 1-989 Pin assignment for ET-Connection (I/O modules)

Pin	Assignment		Assignment of the core color of the bus cable for ET-Connection	Front view of the sockets	
	X30 socket (ET-Connection IN)	X31 socket (ET-Connection OUT)		X30	X31
1	TXP	RXP	yellow		
2	RXP	TXP	white		
3	RXN	TXN	blue		
4	TXN	RXN	orange		
Shield-ing	Functional earth FE		-		

Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment for infeed of the supply voltage.

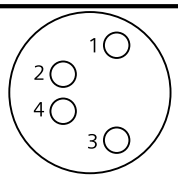
Table 1-990 Pin assignment of the supply voltage connector

Pin	Assignment **X80 connector (power input)**	Assignment of the core color of the power cable	Front view of the connector
1	Supply voltage 1L+ (non-switched)	brown	
2	Ground 2M (switched)	white	
3	Ground 1M (non-switched)	blue	
4	Load voltage 2L+ (switched)	black	

Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment for loop-through of the supply voltage.

Table 1-991 Pin assignment of the supply voltage socket

Pin	Assignment **X81 Socket (power output)**	Assignment of the core color of the power cable	Front view of the socket
1	Supply voltage 1L+ (non-switched)	brown	
2	Ground 2M (switched)	white	
3	Ground 1M (non-switched)	blue	
4	Load voltage 2L+ (switched)	black	

SIMATIC ET 200AL data

D

The EU Data Act, a key component of the European data strategy, entered into force on 11 January 2024.

The following information provides an overview of the data that is generated by the SIMATIC ET 200AL automation system and accessible to you.

D.1 Data of the interface and I/O modules

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to PG/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFIBUS, PROFINET, EtherNet/IP, Modbus TCP (only for interface modules as MultiFieldbus devices)

Continuous and real-time data generation

The interface and I/O modules are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the higher-level CPU.

Data storage and storage duration

Local data storage

The interface and I/O modules store data in integrated memory areas.

Local data storage	Storage capacity	Storage duration
Retentive memory (for I&M data, configuration and parameter data*, service data)	Up to 16 MB for interface modules 1 to 2 MB for I/O modules	Permanent
Work memory (for process data, diagnostics data, fieldbus metadata, configuration and parameter data, service data)	Up to 1 MB for interface modules Several 100 KB for I/O modules	During operation of the module

* only interface modules as MultiFieldbus devices and IO-Link masters

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughput rates up to 1 Gbps via PROFINET
Configuration and parameter data (upload to PG/PC)	TIA Portal (via CPU) S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface, power supply, and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from interface and I/O modules

Interface modules

To delete all data from the data memories of the interface module, the "Reset to factory settings" function is available.

The IM can be reset to factory settings using any of the following:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

I/O modules

The data of an IO-Link master can be deleted using S7-PCT by executing the "Reset to factory settings" function.

For all other I/O modules, no delete function is available.

More information

You can find more information on deleting data in the "Securely removing data (Page 137)" and "Restoring the factory settings (Page 111)" sections.

SIEMENS
SIMATIC

Distributed I/O system ET 200AL

Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function
SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity

- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14245/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14245/cert?ct=444&ci=5596).

Firmware
You will find the latest firmware versions (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/search?t=all&search=et%20200al&type=Download&lc=en-WW).

Documentation
The complete documentation consists of product information, the system manual, equipment and function manuals. You can find these in the Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/95242965) on the Internet.

Retention of the documentation
Retain this documentation for later use.

1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965) and on the nameplate of the device.

NOTE
The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Install products with degree of protection IP65/67 according to IEC 60529 weatherproof and stationary indoors.

⚠ WARNING

Safety functional extra low voltage
The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965) of the fail-safe I/O and in the data sheets of the power supplies to be used.
Use a power supply unit with output voltage that does not exceed 35 V DC even in the event of a fault.
Follow the notes and warnings in the respective manual.

Electromagnetic Compatibility
The I/O system is intended for operation in the EMC environment class Industry.
Ensure an EMC-compliant design of your automation system as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965) for the I/O system.

NOTICE
Interference emission / Interference immunity The operation of the I/O system can cause radio interference in residential areas. If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

Cleaning
When wired, the product complies with degree of protection IP65/IP67 and does not require any cleaning.
If you do have to clean the product, then use a dry or damp cloth. Take care to comply with the conditions of degree of protection IP65/IP67 when cleaning with liquids.

Maintenance and repair
The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal
For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965).

Functional safety

⚠ WARNING
Danger to humans and the environment To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components. For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/95242965) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation.

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether the firmware version is approved for the respective fail-safe I/O.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

2 Use of radio devices and cell phones

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

SIEMENS

SIMATIC

ET 200AL
Digital I/O module F-DI 4+F-DQ 2x24VDC/2A, 4xM12 (6ES7146-5FF00-0BA0)

Equipment Manual

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V1.0, 03/2022
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Preface

Purpose of the documentation

This manual supplements the *ET 200AL distributed I/O system system manual* (https://support.industry.siemens.com/cs/ww/en/view/89254965). Functions that are generally applicable to the ET 200AL distributed I/O system are described there.

The information provided in the present manual, the system manual and the function manuals enables you to commission the ET 200AL distributed I/O system.

⚠ WARNING

The *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* in the current version is the authoritative source for functional safety-related information concerning configuring and programming.

Siemens identifies the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* as the authoritative and/or original source in the case of discrepancies between the manuals.

All warnings in the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* have to be observed. You can find the current version of the manual on the Internet (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

Please observe notes marked as follows:

NOTE

Indicates important product information to which particular attention should be paid.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are

available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

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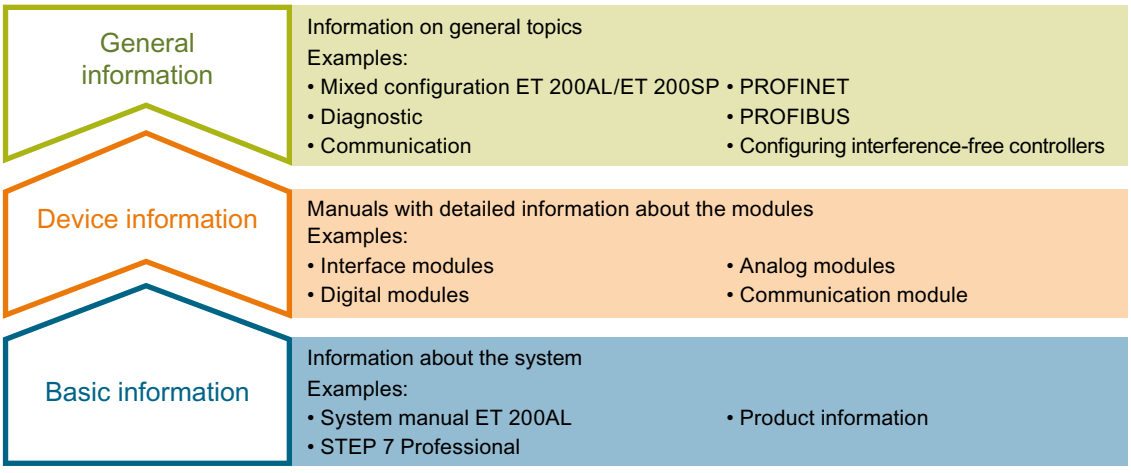
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Documentation guide

1

The documentation for the SIMATIC ET 200AL distributed I/O system is arranged into three areas.



Basic information

The *System Manual* and *Getting Started* describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200AL distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200AL distributed I/O system, e.g. diagnostics, communication, Motion Control, Web server.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742667).

Manual Collection ET 200AL

The Manual Collection contains the complete documentation on the SIMATIC ET 200AL distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/95242965).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/cs/ww/en/my).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/us/en/view/109767888).

Safety technology support

Siemens provides the following online comprehensive support for your use of safety technology:

- Safety Evaluation Tool - assists you in determining required safety levels
- Functional Examples - guides you in your safety applications
- Siemens training (SITRAIN) classes - offers training in safety standards and products
- SIMATIC STEP 7 Safety Advance F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT_calculator) - assists you in calculating your maximum system response time

You can find the Safety Evaluation Tool on the Internet (http://www.siemens.com/safety-evaluation-tool).

You can find Functional Examples on the Internet (http://www.siemens.com/safety-functional-examples).

You can find SITRAIN classes on the Internet (http://www.siemens.com/sitrain-safetyintegrated).

You can find the RT_calculator on the Internet (http://support.automation.siemens.com/WW/view/en/49368678/133100).

Product overview

2

2.1 Properties

Article Number

6ES7146-5FF00-0BA0

View of the Module

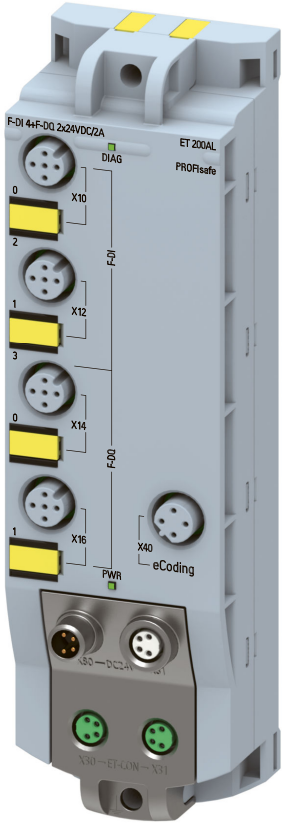


Figure 1-702 View of the F-DI 4+F-DQ 2x24VDC/2A, 4xM12 Fail-Safe I/O module

Properties

The module has the following technical properties:

- Four fail-safe digital inputs and two fail-safe digital outputs (M12 sockets for connection of sensors and actuators)
- One eCoding connection (M12 socket for eCoding plug)
- Two power ports, infeed and loop-through, which contain both logic and input power (1L+) and output power (2L+) (M8 module supply voltage ports)
- Two ET-Connection communication ports (M8 sockets)
- Fail-safe digital inputs:
  - 24 V DC rated
  - Two short-circuit proof sensor supplies
  - External sensor supply possible
  - Configurable diagnostics can be set for each channel
  - Configurable input delay
  - Suitable for switches and 3/4-wire proximity switches
- Fail-safe digital outputs:
  - Rated load voltage 24 V DC
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Output current per output 2.0 A
  - Configurable diagnostics can be set for each channel
- Dimensions 45 x 159 mm

The module supports the following functions:

- Firmware update
- Identification and maintenance data I&M0 to I&M3
- Value status (Quality Information)

The module has the following maximum achievable safety class in safety mode:

Maximum achievable safety class in safety mode	**1-channel input**	**2-channel input**	**Output channel**
Performance level according to EN ISO 13849-1	Cat. 3, PL d	Cat. 4, PL e	Cat. 4, PL e
SIL according to IEC 61508	SIL 2	SIL 3	SIL 3

Accessories

The following components are included in the module package:

- Identification labels (Yellow)
- eCoding plug (Used to store the application's PROFIsafe addresses)

Other components

The following components can be ordered as a spare part:

- Identification labels (Yellow)
- eCoding plug

The following components can be ordered as accessories:

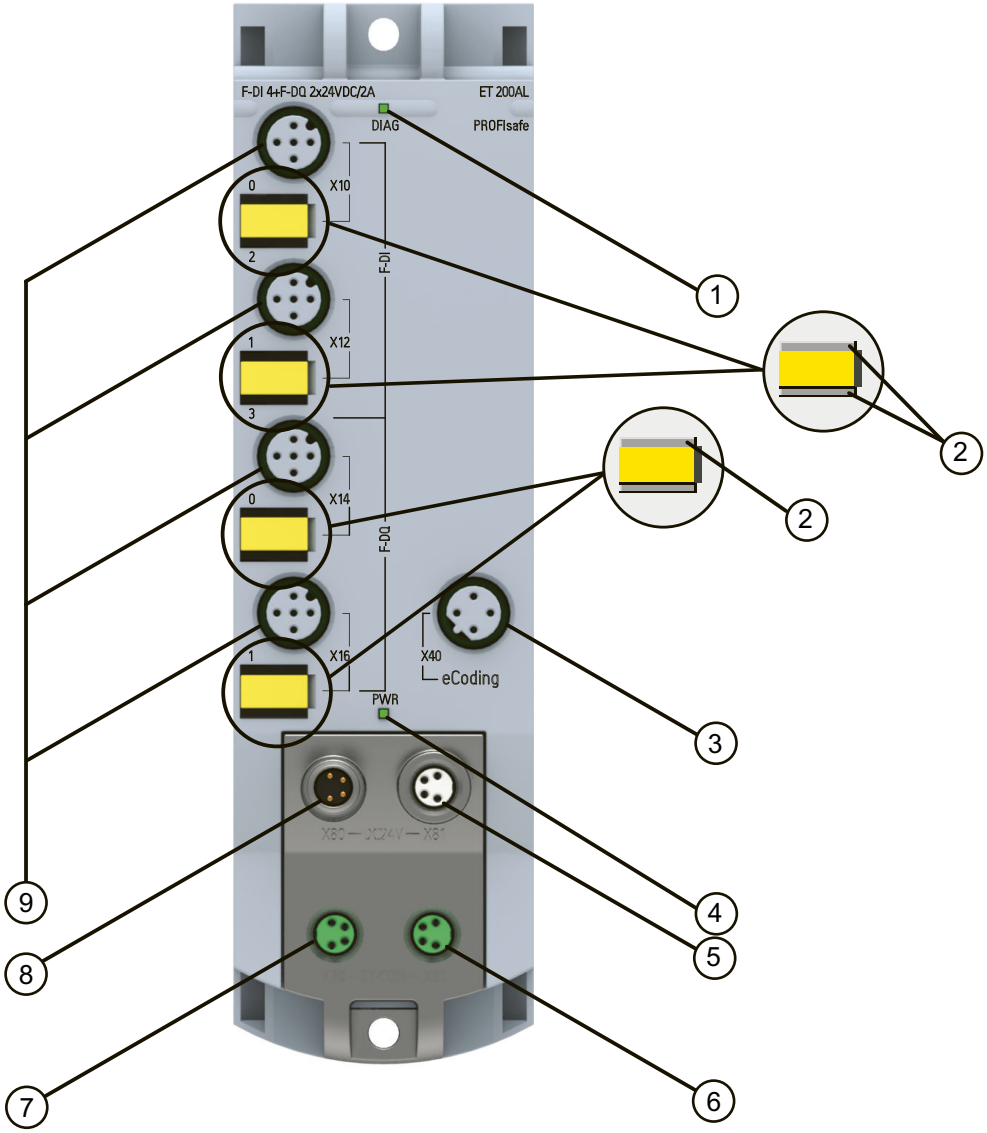
- Connectors
- Cables
- Stripping Tool for ET-Connection
- M8 sealing cap
- M12 sealing cap

See also

You can find more information on accessories in "Accessories/spare parts" in the *ET 200AL distributed I/O system system manual* (https://support.industry.siemens.com/cs/ww/en/view/89254965).

2.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the F-DI 4/F-DQ 2 Fail-Safe module:



① DIAG: LED display for the diagnostic status
② LED displays for the channel status
③ X40: eCoding plug connection
④ PWR: LED display for load voltage 2L+
⑤ X81: Socket for loop-through of the supply voltage (POWER output)
⑥ X31: Socket for ET-Connection OUT
⑦ X30: Socket for ET-Connection IN
⑧ X80: Connector for infeed of the supply voltage (POWER input)
⑨ X10 to X16: Sockets for the input/output signals

Figure 1-703 Operator controls and display elements

2.3 Fail-safe digital inputs

The digital inputs of the F-DI 4/F-DQ 2 Fail-Safe module are rated for connection to 24 V DC sensors/switches and 3/4-wire proximity switches (for example, BEROs: Siemens line of no-touch sensors) and have an EN 61131-2 type 1 input rating.

The fail-safe module has two 0.5 A sensor supply outputs that can power external sensors (inputs). All 1oo1 and 1oo2 application modes, except the "1oo2, 2 channel 3-wire nonequivalent" application mode, use the V_{S1} sensor supply to provide power for channels 0 and 1, and the V_{S2} sensor supply to provide power for channels 2 and 3. The "1oo2, 2 channel 3-wire nonequivalent" application mode uses the V_{S1} sensor supply to provide power for all four inputs and does not use the V_{S2} sensor supply.

Inputs and test circuit

The fail-safe digital inputs consist of four input channels (F-DI x.0 to x.3). You can configure these channels as four one-out-of-one (1oo1) inputs (SIL 2/Cat. 3/PL d), two one-out-of-two (1oo2) inputs (SIL 3/Cat. 3 or Cat. 4/PL e), or combinations of 1oo1 and 1oo2 inputs.

Connections	Input channel pairs
X10	0 and 2
X12	1 and 3

The fail-safe digital inputs use two microcontrollers to implement the safety function. One microcontroller monitors inputs 0 and 1, and the other microcontroller monitors inputs 2 and 3. The corresponding channels (0, 2) and (1, 3) form a 1oo2 channel group. The lower numbered channel of the group is called the primary input and the other channel is called the secondary input. The first of the two inputs in the channel group conveys the signal in a 1oo2 configuration. For example, if you wire F-DI 0.0 and F-DI 0.2 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal state is reported at only the F-DI 0.0 input when you close or open the circuit for both.

When you configure a channel group as 1oo2, the two microcontrollers must sense the same input change within a configured time. Otherwise, the two microcontrollers detect a discrepancy error.

You can enable short-circuit testing if you use a sensor supply output to provide power to a sensor. The short-circuit test checks for shorts to 24 V DC by periodically pulsing the sensor output off and verifying that the associated input is off.

This short-circuit test also checks for shorts to the other circuit in "1oo2, 2 channel equivalent" and "1oo2, 2 channel 4-wire nonequivalent" application modes because the test pulses the two sensor outputs off at different times.

The microcontrollers provide internal test pulses to each other's process input circuits to verify that sensing electronics are responsive to both "1" and "0" inputs.

See also

Accessories for the ET200AL distributed I/O system (https://support.industry.siemens.com/cs/us/en/view/89254965)

2.4 Fail-safe digital outputs

The digital outputs of the F-DI 4/F-DQ 2 Fail-Safe module are for use in fail-safe applications and are suitable for various actuators such as the following:

- Solenoid valves
- DC contactors
- Indicator lights

The two digital outputs each have P- and M-switches that are rated to connect 24 V DC actuators with up to a 2.0 A rating. The two digital outputs use the load voltage 2L+ with a maximum current of 4.0 A. This means that the total current usage by the two digital outputs cannot exceed 3.96 A because the 2L+ supply uses about 40 mA.

Outputs

The fail-safe digital outputs consist of two output channels (F-DQ x.0 to x.1). You can use each output for SIL 3 applications.

Connections	Output channel
X14	0
X16	1

Each output consists of two switches:

- A P-switch connects 24 V DC positive (L+) to the load.
- An M-switch connects the load to M or 24 V DC return.

Both switches must be ON for current to flow to the load.

The fail-safe digital outputs use two microcontrollers to implement the safety function. One microcontroller controls the P-switch while the other microcontroller controls the M-switch. Status of the P-switch is fed back to the other microcontroller (the one that controls the M-switch). Likewise, status of the M-switch is fed back to the other microcontroller (the one that controls the P-switch). The microcontrollers use the feedback to verify that the output switches are operating properly and in the commanded state.

You must configure a "Maximum readback time" that specifies the allowed delay for the output voltage to respond to the switch change.

The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. Your configured "Maximum readback time" also sets the duration of the "OFF" test pulse. You must configure a "Maximum readback time switch on test" which sets the duration of the "ON" test pulse. Choose these durations short enough to not affect your load.

The module can detect a broken wire or missing load when the output PV is OFF. If the broken wire diagnostic is enabled, then the load must be wired in the PM configuration or a broken wire diagnostic will occur (see applications 1, 3 or 4 in section 5.2 Digital output applications (Page 48)).

Wiring

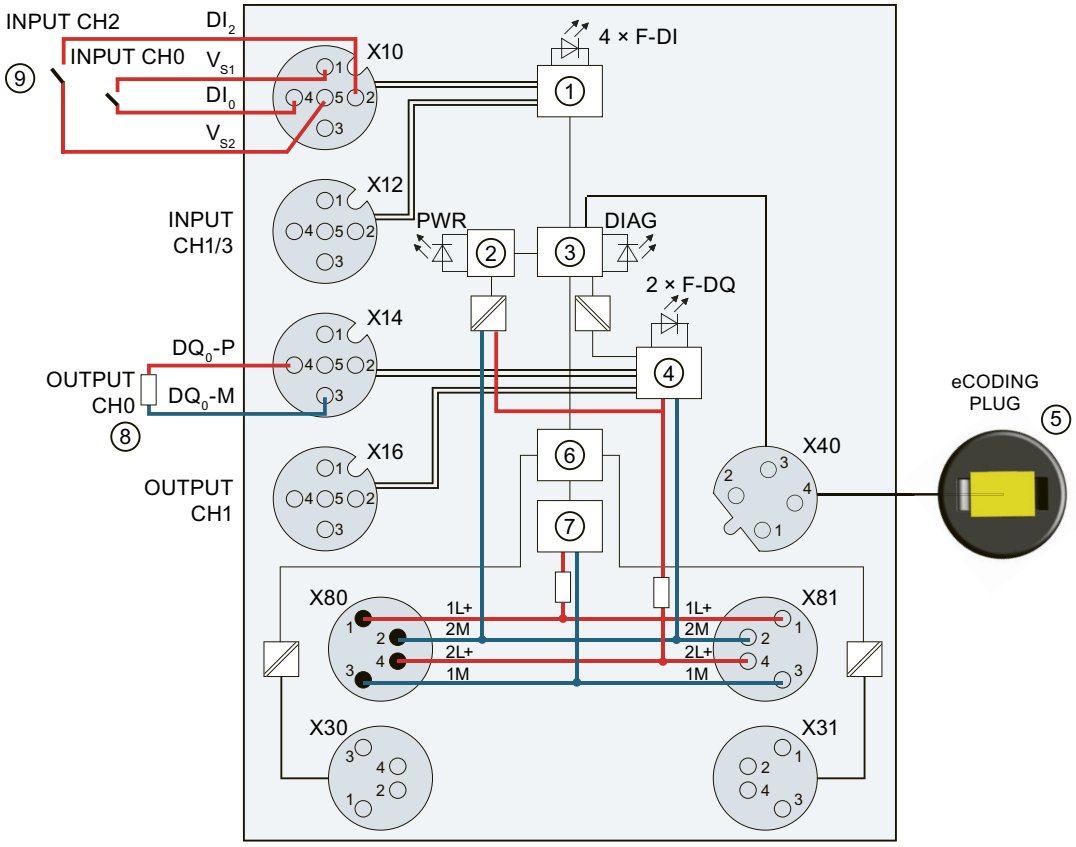
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WARNING

You can come into contact with live electrical wires connected to the main power supply.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
Shut off the supply and load voltage before you wire the fail-safe module.

3.1 Terminal and block diagram

The following figure shows an example of the pin assignment of signal inputs with 4-wire connection as well as signal outputs:



①	F-DI circuit (1L+)	X40	eCoding socket
②	Diagnostic monitoring	X80	Infeed of supply voltages
③	Microcontrollers	X81	Loop-through of supply voltages
④	F-DQ circuit (2L+)	V_{Sn}	24 V sensor supplies
⑤	eCoding plug	1L+	Supply voltage 1L+

⑥	ET-Connection interface	1M	Ground 1M
⑦	Internal supply voltage	2L+	Load voltage 2L+
⑧	Outputs	2M	Ground 2M
⑨	Inputs: Configured as 1oo1 sensor using internal sensor supply	DI_n	Input signal
X10, X12	F-DI input channels	DQ_n-P	Output signal, P-switch
X14, X16	F-DQ output channels	DQ_n-M	Output signal, M-switch
X30	Infeed of the ET-Connection	DIAG	LED diagnostic status (red/green)
X31	Loop-through of the ET-Connection	PWR	LED load voltage 2L+ status (green)

Figure 1-704 Terminal and block diagram

3.2 Pin assignment

NOTE

Color coding

The sockets for ET-Connection and the power supply of the modules are color-coded. These colors correspond to the colors of the offered cables.

Pin assignment of the sockets for fail-safe digital inputs/outputs

The tables below show the pin assignments of the four sockets for connection of the fail-safe digital inputs/outputs:

Table 1-992 Pin assignment for fail-safe digital input sockets

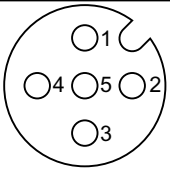
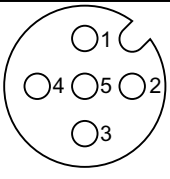
Pin	Assignment	Front view of the sockets
	X10 and X12 - sockets for fail-safe digital inputs	**X10, X12**
1	24 V DC sensor supply V_{S1}	
2	Input signal DI_2: Connector X10 Input signal DI_3: Connector X12	
3	Sensor supply ground 1M	
4	Input signal DI_0: Connector X10 Input signal DI_1: Connector X12	
5	24 V DC sensor supply V_{S2}	

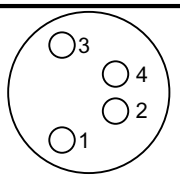
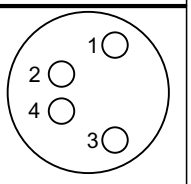
Table 1-993 Pin assignment for fail-safe digital output sockets

Pin	Assignment	Front view of the sockets
	X14 and X16 - sockets for fail-safe digital outputs	**X14, X16**
1	Unassigned	
2	Unassigned	
3	Output signal DQ_0-M: Connector X14 Output signal DQ_1-M: Connector X16	
4	Output signal DQ_0-P: Connector X14 Output signal DQ_1-P: Connector X16	
5	Functional earth FE	

Pin assignment of the sockets for ET-Connection

The table below shows the pin assignments of the two sockets for the connection of ET-Connection:

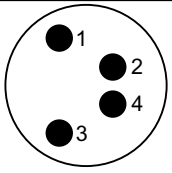
Table 1-994 Pin assignment for ET-Connection

Pin	Assignment		Assignment of the wire color of the bus cable for ET-Connection	Front view of the sockets	
	X30 socket (ET-Connection IN)	X31 socket (ET-Connection OUT)		X30	X31
1	TXP	RXP	Yellow		
2	RXP	TXP	White		
3	RXN	TXN	Blue		
4	TXN	RXN	Orange		
Shielding	Functional earth FE		-		

Pin assignment of the connector for infeed of the supply voltage

The table below shows the pin assignment of the connector for infeed of the supply voltage:

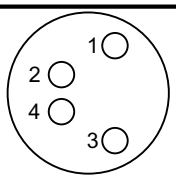
Table 1-995 Pin assignment of the supply voltage connector

Pin	Assignment	Assignment of the wire color of the power line cable	Front view of the connector
	X80 connector (POWER input)		
1	Supply voltage 1L+	Brown	
2	Ground 2M	White	
3	Ground 1M	Blue	
4	Load voltage 2L+	Black	

Pin assignment of the socket for loop-through of the supply voltage

The table below shows the pin assignment of the socket for loop-through of the supply voltage:

Table 1-996 Pin assignment of the supply voltage socket

Pin	Assignment X81 socket (POWER output)	Assignment of the wire color of the power line cable	Front view of the socket
1	Supply voltage 1L+	Brown	
2	Ground 2M	White	
3	Ground 1M	Blue	
4	Load voltage 2L+	Black	

NOTE

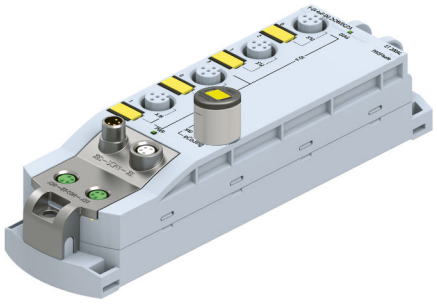
ET-Connection/supply voltage

Installing a supply voltage cable in an ET-connection socket or an ET-connection cable in the supply voltage loop-through socket can destroy the module.

Observe the correct wiring of the M8 sockets for ET-Connection and the supply voltage.

3.3 Connecting the M12 eCoding plug

The eCoding plug (6ES7194-6KB01-0AA0) stores the PROFIsafe addresses that you assign to the F-DI 4/F-DQ 2 Fail-Safe module:

eCoding Plug (side view)	F-DI 4/F-DQ 2 with eCoding Plug Attached (front view)	F-DI 4/F-DQ 2 with eCoding Plug Attached (side view)
		

The eCoding plug stores the following information:

- PROFIsafe source address
- PROFIsafe destination address
- Address validity information

The eCoding plug occupies the X40 M12 socket, utilizing a B-coded plug. You use the eCoding plug to facilitate module replacement.

The eCoding plug stores assigned PROFIsafe source and destination addresses. The "Assign PROFIsafe address option" is selected in STEP 7 during the F-DI 4/F-DQ 2 Fail-Safe module set-up. The module checks the PROFIsafe addresses stored in the eCoding plug against the PROFIsafe reference addresses provided to the module during start-up parameterization.

Protection mechanisms prevent you from damaging the eCoding plug or an I/O channel due to attempted plugging of the eCoding plug into an I/O M12 socket or plugging of an I/O M12 cable into the X40 socket.

Install the eCoding plug into the M12 socket at X40 with a torque of 1 Nm. Do not overtighten the eCoding plug as it could damage the threading.

⚠ WARNING

If you remove/insert the eCoding plug with the power connected, this can lead to undefined states in your system.

Death or serious personal injury and damage to the fail-safe module and associated machines/equipment may result if proper precautions are not taken.

Only remove or replace the eCoding plug when the power is disconnected. Always comply with the required standards and safety guidelines when configuring a system.

NOTE

When replacing the F-DI 4/F-DQ 2 Fail-Safe module, transfer the eCoding plug of the failed module to the replacement module to retain the PROFIsafe addresses stored in the eCoding plug. Otherwise, use STEP 7 to configure the PROFIsafe address in the replacement module. Ensure that the eCoding plug is not accidentally inserted in a module other than the intended F-DI 4/F-DQ 2 Fail-Safe module.

4 Parameters/address space

All connected fail-safe I/O must have their operating properties configured by the STEP 7 Safety configuration software. You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

F-Parameters

You must assign the PROFIsafe addresses (F-destination address together with F-source address) to the F-module before you put it into operation as follows:

- You define the F-source address using the "Central F-source addresses" parameter in the F-CPU.
- An F-destination address unique throughout the project's hardware configuration is automatically assigned for each F-module. You can manually change the F-destination addresses assigned in the hardware configuration.

You can find further information on F-parameters such as the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address), F-parameter signature (with or without addresses) and the F-I/O DB in the *SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/54110126).

4.1 Configuring module I/O properties

To configure fail-safe module I/O properties, follow these steps:

1. Select the image of a fail-safe I/O device (on the Device view or Device overview) and view the module's "Properties" tab.
2. On the "Properties" view, select the "General" tab.
3. Select a property category in the left-side property tree and then set values in the right-side property fields.
4. A successful compile and download of your hardware configuration to one of the following CPUs automatically puts your new configuration settings in the I/O modules:
   - ET 200pro F
   - ET 200SP F
   - S7-1200 F
   - S7-1500 F
   - Prior generation S7-300 F and S7-400 F

4.2 Parameters

The following table shows the parameters for the F-DI 4/F-DQ 2 Fail-Safe module:

Channel	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters				
Manual assignment of F-monitoring time	• disable • enable	disable	no	Module
F-monitoring time	1 to 65535 ms	150 ms	no	Module
F-source address	1 to 65534	1 (always disabled)	no	Module
F-destination address	1 to 65534	65534 (always enabled)	no	Module
F-parameter signature (with addresses)	0 to 65535	always disabled	no	Module
F-parameter signature (without addresses)	0 to 65535	always disabled	no	Module
Behavior after channel fault	• Passivate channel • Passivate entire module	Passivate channel (always enabled)	no	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	All channels manually (always enabled)	no	Module
F-I/O DB manual number assignment	• disable • enable	disable	no	Module
F-I/O DB number	• Fixed value, if DB manual number assignment is disabled • Value can be edited by user, if DB manual number assignment is enabled	Fixed value	no	Module
F-I/O DB name	-	always disabled	no	Module
DI parameters				
Sensor supply				
Short-circuit test	• disable • enable	enable	no	Channel
Interval for short-circuit test	• 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms	25.6 ms	no	Channel
Duration of short-circuit test	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms	1.6 ms	no	Channel

Channel	Value range	Default	Parameter reassignment in RUN	Scope
Channel n, n+2				
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation: – 2 channel equivalent – 2 channel - 3 wire non-equivalent – 2 channel - 4 wire non-equivalent	1oo2 evaluation, 2 channel equivalent	no	Channel
Discrepancy behavior	• Supply value 0 • Supply last valid value	Supply value 0	no	Channel
Discrepancy time	5 ms to 30 s	5 ms	no	Channel
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	no	Channel
Channel n				
Activated	• disable • enable	enable	no	Channel
Input filters	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms	6.4 ms	no	Channel
Channel failure acknowledge	• Automatic • Manual	Manual	no	Channel
Sensor supply	• Internal • External	Internal	no	Channel
DQ parameters				
Maximum test period	• 100 s • 1000 s	1000 s	no	Channel
Channel n				
Wire break	• disable • enable	disable	no	Channel
Activated	• disable • enable	enable	no	Channel
Channel failure acknowledge	• Automatic • Manual	Manual	no	Channel
Maximum readback time	1.0 ms to 400.0 ms	2.0 ms	no	Channel
Maximum readback time switch on test	0.5 ms to 5.0 ms	1.0 ms	no	Channel
Disable dark test (max. SIL 2, Cat. 3, PL d)	• dark test is disabled • dark test is enabled	dark test is enabled	no	Channel

4.3 Explanation of parameters

4.3.1 F-parameters

Information on F-parameters is available in the *SIMATIC Safety – Configuring and Programming* manual (https://support.industry.siemens.com/cs/us/en/view/54110126).

Behavior after channel fault

Use this parameter to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use in S7-300/400 F-CPUs
This parameter is always set to "Adjustable" when you use the fail-safe module in S7- 300/400 F-CPUs. You make the required setting in the F-I/O DB of the fail-safe module.

Use in ET 200pro, ET 200SP and S7-1200/1500 F-CPUs
When using the fail-safe module in ET 200pro, ET 200SP and S7-1200/1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.3.2 DI parameters

Short-circuit test

You can enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with a power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit test switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Duration of short-circuit test".

If a short-circuit is detected, the fault is reported to the F-CPU and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input to another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, nonequivalent) which also detects the cross circuits using discrepancy.

During the execution time (duration of short-circuit test + startup time of sensor after the short-circuit test) of the short-circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

Discrepancy time variation with short-circuit test
If your process input changes near when a short-circuit test is in progress, a discrepancy is detected in less time than your configured discrepancy time.

Elements of discrepancy time variations are defined as follows:

- **Tdisc** = configured discrepancy time
- **Tsct** = configured short circuit test duration
- **Tfilter** = configured input filter time
- **Tda** = actual discrepancy time, time between process signal changes that can be detected as a fault

The range of detected discrepancy time is as follows:

- **If Tfilter < Tsct**: {Tdisc - (Tfilter + Tsct)} <= Tda <= Tdisc
- **If Tfilter >= Tsct**: {Tdisc - (2 x Tsct)} <= Tda <= Tdisc

Your configured discrepancy time should account for this variation to avoid unexpected passivations.

Interval for short-circuit test

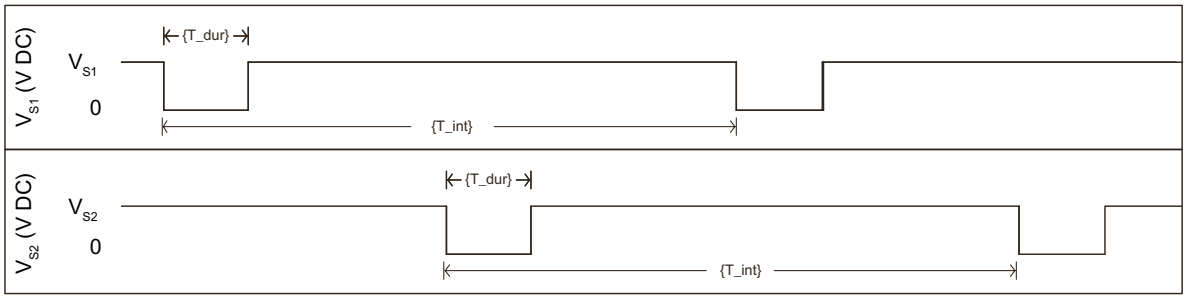
You can specify how often the short-circuit test is executed (Interval) when the "Short-circuit test" check box is selected. The interval defines the period of time between two consecutive sensor supply OFF test pulses.

This value is the time between the OFF pulses of the sensor supply.

NOTE

The interval between pulses must be a minimum of eight times the duration of a pulse.

Short-circuit testing is performed on V_{S1} and V_{S2} independently, allowing module circuitry to detect shorts between the two sensor supplies as follows:



V_{Sn} V_{S1} or V_{S2} sensor supplies (V DC)
T_int Short-circuit test interval (time period) between the OFF pulses of the sensor supply (ms)
T_dur Short-circuit test OFF pulse time duration (ms)

Duration of short-circuit test

You can specify the duration of the test pulse applied to the sensor supply when the "Short-circuit test" check box is selected.

This value is the time that the power supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs.

Sensor evaluation

You can assign whether “channel n” input operates individually (1oo1) or is paired with its companion channel "n+2" input (1oo2).

Defines signal evaluation and wiring definitions. These selections correspond with the various application mode wiring examples.

1oo1 evaluation: One sensor is connected to the module on a single channel.

1oo2 evaluation: Two input channels are occupied by either:

- **2 channel equivalent** (with equivalent signals): One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair.
- **2 channel - 3 wire nonequivalent**: One two-channel nonequivalent sensor is connected to the two channels, in a channel pair.
- **2 channel - 4 wire nonequivalent** One two-channel nonequivalent sensor or two single-channel nonequivalent sensors are connected to the two channels, in a channel pair.

If 1oo2 is selected, you must assign the discrepancy properties.

Refer to "Digital input applications (Page 35)" for illustrations of connection modes.

When you select the channel group as 1oo2, STEP 7 (TIA Portal) enables the parameters in the first channel of the group and completely disables the parameters in the second channel of the group. The second channel derives its parameter values from the first channel's parameter values. When you select the channel group as 1oo1, STEP 7 (TIA Portal) enables all of the parameters in both channels.

NOTE

Safety program access to 1oo2 input data
For 1oo2 evaluation, two paired input channels (for example, F-DI 0 and F-DI 2) are connected to one or two sensors. The F-DI performs the discrepancy analysis and sends the result to the safety program, at the input address of the low-numbered channel of the pair (F-DI 0, in the example).

Discrepancy behavior

A 1oo2 input configuration allows a logical difference between the two signals, without error, for the configured discrepancy time. You assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

NOTE

Sensor-actuator response time is increased when you add more input discrepancy time
The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0" but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0' and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides reliable normal operation. Refer to "Response times (Page 76)" for further information.

Discrepancy time

The two signals in a 1oo2 input configuration will not change exactly at the same time, due to differences in sensors, contacts, and wiring. You can configure a maximum expected duration for a mismatch between signals during transition.

Reintegration after discrepancy error

You can assign whether a zero state must be detected on both 1oo2 inputs before a previously declared discrepancy can be cleared.

"Test 0-signal necessary"
If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels for a duration of at least 100 ms.

If you are using nonequivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, nonequivalent", a 0-signal must be present again at the low order channel of the channel pair.

"Test 0-signal not necessary"
If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists between the two relevant input channels.

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel. Whenever you disable all output channels, you do not have to power 2L+ and 2L+ undervoltage reporting is suspended.

Input filters

The module filters the digital inputs to remove contact bounce and short duration noise. This parameter assigns the duration of the filter time.

Channel failure acknowledge

Controls whether the channel is automatically reintegrated after a fault clears or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults (Page 57)" for the reintegration procedure.

NOTE

The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can determine your ability to modify the "Channel failure acknowledge" parameter's selection.

Sensor supply

You can assign whether to supply 24 V DC power to sensors from the module's integrated sensor supply (internal) or from an external power supply (external).

Short-circuit tests are not performed for any channel where external power is selected.

4.3.3 DQ parameters

Maximum test period

You can assign the time interval between bit pattern tests for F-DQ DC output faults to a value of either 100 seconds or 1000 seconds.

Functional bit pattern tests are applied to the output switches. These tests detect faulted P- or M- output switches and wiring faults. Short circuits to other signals or power rails can be detected. Open circuits between the wiring terminals and the load are not detected.

If an error is detected on a channel, the test interval is shortened to 60 seconds. If an error is no longer detected on any output channel, the configured test interval is used again.

A persistent fault is reported to the fail-safe CPU and the affected channels are passivated.

Wire break

You can enable or disable wire break testing. Wire break is only detected when the channel is in the OFF state (process value is "0").

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

NOTE

Whenever you disable all output channels, you do not have to power 2L+ and 2L+ undervoltage reporting is suspended.

Channel failure acknowledge

Controls whether the channel is automatically reintegrated after a fault clears or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults (Page 57)" for the reintegration procedure.

NOTE

The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can determine your ability to modify the "Channel failure acknowledge" parameter's selection.

Maximum readback time

The maximum readback time is a user-configured parameter that assigns the maximum time allowed for an output to reach the new state (ON or OFF) due to a process value change without generating an error. Also, this is the maximum width of a diagnostic test pulse applied during the bit pattern test to verify that an output can be turned OFF while it is in the ON state. The time of the OFF pulse should be as long as possible, but short enough so that the actuator cannot react.

The "Maximum readback time" parameter allows you to set the maximum time for verification that the channel's output switch states are as expected after a process value change.

If the expected output switch states (as reported by P-readback and M-readback signals) are not reached upon expiration of the "Maximum readback time", the output channel is passivated.

No new process values are switched to the output channels while a test pattern is applied to the outputs. This means that a higher "Maximum readback time" increases the response time of the F-module.

⚠ WARNING

Short-circuit (cross-circuit) detection may not be possible for high frequency signals
Through the configured "Maximum readback time", short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured "Maximum readback time") Hz cannot be detected (50:50 sampling ratio).
You must take this into consideration for your application and respective requirements of your product standards.
Short-circuits (cross-circuits) to an output of the same module are recognized regardless of the frequency of the output channel.
You can adjust the maximum readback time to change the frequency of the signal that can be detected.

The parameter also effects the short-circuit detection (cross-circuit) with a "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Maximum readback time"

Because the fault response time is extended by the configured maximum readback time, we recommend that you set the "Maximum readback time" as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in "Connecting capacitive loads (Page 79)".

If the capacitance of the actuator is not known, it may be necessary for you to determine the value for the "Maximum readback time" by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Maximum readback time" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification, use the process value "0" with a minimum duration that corresponds to the "maximum test period" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated, the "Maximum readback time" is too small for the connected capacitive load. The discharge cannot take place within the configured "Maximum readback time". Increase the "Maximum readback time".

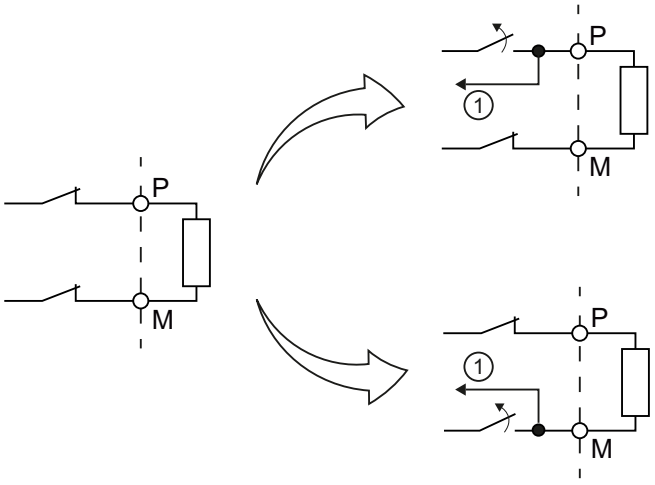
If you have set the "Maximum readback time" to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacitance is outside the permitted range.

Dark test

Dark tests are switch-off tests which occur during an output bit-pattern test sequence.

When dark test is disabled on an output channel, the parameter "Maximum readback time" is only relevant for the process value change.

For a dark test, one of the output channel's switches is briefly turned OFF while the output channel is active (output signal "1"). As a result, current flow through the output is interrupted for a short time. A sufficiently slow actuator does not respond to this and remains switched on.



① Readback

Figure 1-705 Functional principle of the dark test (PM switching)

Test pulses of the dark test

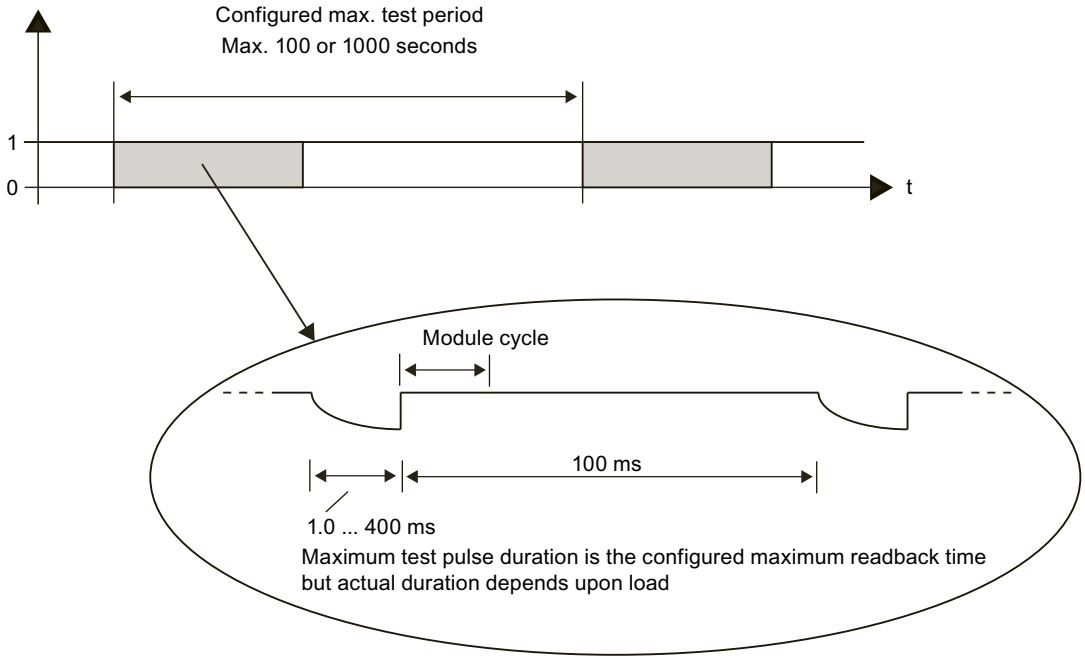


Figure 1-706 Test pulses of the dark test

You configure the time between output bit pattern test sequences to either 100 or 1000 seconds. Each output bit pattern test sequence includes multiple test pulses. The interval between two test pulses is at least 100 ms.

Maximum readback time switch on test

You can configure the maximum readback time switch on test parameter to assign the maximum time for which the P-switch or the M-switch of a channel that is currently in OFF state can be switched ON during a bit pattern test step. This action tests the P- and M-switches on a channel such that only one switch is turned on at a time. Unless there is a fault in the system (for example, actuator shorted to ground), the actuator is not energized during either the P- or M-switch on tests. Under single fault conditions (either internal or external to the module), test pulses applied to either the P- or the M-switch of channels in the OFF state can repeatedly energize the actuator. You must select the parameter so that the duration of such pulses is too short to cause the actuator to react and, therefore, cannot have a hazardous effect on the equipment under control.

Disable dark test (max. SIL 2, Cat. 3, PL d)

You can select the check box to disable channel dark testing.

To prevent an unwanted reaction of the actuator to a dark test, you can disable the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive.

A capacitive load that does not meet the load curve (see "Switching of loads (Page 79)") can result in a passivation of the output in case of a process value change or switch-on test, even if the dark test is disabled.

You can only reach up to SIL 2/Cat. 3/PL d with the dark test disabled.

⚠ WARNING

Loss of SIL 2/Cat. 3/PL d rating, loss of output control due to potential undetected faults
With the dark test disabled, an output that is turned on for more than 1 year may not be able to be turned off.
SIL 2/Cat. 3/PL d requires that there is a signal change from "1" to "0" at the corresponding output at least once a year.
Ensure the "0" signal has a duration of at least 2 seconds. It is not enough to simply turn off the supply or load voltage of the F-module and turn it on again.

⚠ WARNING

Loss of cross-circuit detection between channels
When you use the function "Disable dark test", cross-circuits between channels with "1" signal are not detected.
You must take this into consideration for your application and respective requirements of your product standards.
You must also take into consideration the respective requirements of your product standards regarding error detection time.

4.4 Address space

NOTE

The F-DI 4/F-DQ 2 Fail-Safe module uses more I and Q memory than required for the physical number of inputs and outputs on the module. The extra bytes carry the PROFIsafe safety status and data integrity information. The number of input (I) bytes and output (Q) bytes that the F-DI 4/F-DQ 2 Fail-Safe module requires depends upon which PROFIsafe profile your fail-safe CPU uses.

Module	PROFIsafe profile	Input (I) bytes required	Output (Q) bytes required
F-DI 4+F-DQ 2x24VDC/2A, 4xM12	V2.4 (with S7-300/S7-400)	7	5
	V2.6 (with ET 200pro, ET 200SP and S7-1200/1500)	8	6

The figure below shows the assignment of the address space for the F-DI 4/F-DQ 2 Fail-Safe module with value status (Quality Information (QI)).

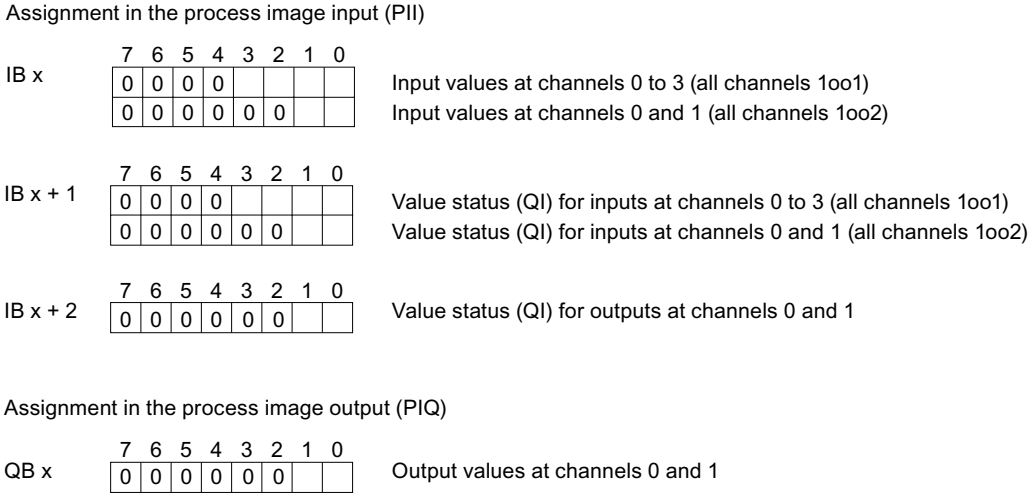


Figure 1-707 Address space

Evaluating the value status

The value status bits provide information regarding the validity of the digital values or channel status:

- Bit = 1: Corresponding process value is valid
- Bit = 0: Channel is passivated

Applications of the F-I/O module

5

The PLC system has an extremely low failure rate and therefore contributes only a small part of the total probability of dangerous failure of an automated system. The probability of dangerous failures of the sensors and actuators is typically far larger than the probability of dangerous failure per hour (PFH)/probability of dangerous failure on demand (PFD) of the PLC system. Estimates for quantitative safety properties like PFD and PFH are calculated using the following methods:

- standard data tables
- calculation methods according to international standards which include the following standards:
  - IEC 61508
  - ISO 13849
  - IEC 61131-6

The values are based on the following assumptions:

- continuous full nominal load
- nominal voltage
- equipment ambient temperature of 55 °C

Faults in the wiring system can also be a substantial contributor to failures.

To achieve a targeted level of safety performance for each safety function, perform these actions:

- Choose an appropriate architecture.
- Choose sensors and actuators that are appropriately rated.
- Provide a safety program that meets the requirements of the safety function.
- Provide diagnostics and proof-tests to maintain the ratings of the sensors and actuators.
- Use wiring installation practices, diagnostics, and proof-tests to assure wiring integrity.
- Generate and control operating and maintenance procedures for the lifetime of the installation.

The ET 200AL, ET 200pro, ET 200SP, and S7-1200/1500 Fail-Safe systems provide a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each fail-safe PLC component is stated assuming there is no field proof-test within the lifetime of the product. Sensors and actuators typically require regular proof-tests to maintain an expected level of safety performance.

The reaction time of each safety function depends on the reaction time of each component, including the sensor, the PLC system, and the actuator. "Maximum response time (Page 76)" gives further information on delay times through the PLC components. You must choose PLC parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to the total delay from the safety demand input to the safe actuator response, you must consider these additional time-related factors. Refer to "Maximum response time (Page 76)" for exact information:

- To be assured of a safety response, a safety demand signal from the input sensor lasts long enough to be seen by the safety program. Your configured filter time, discrepancy resolution time, and short-circuit test duration all contribute to determining the required signal duration.
- The F-DI 4/F-DQ 2 Fail-Safe module digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. The OFF test pulse duration can be as long as your configured "Maximum readback time". The ON test pulse duration can be as long as your configured "Maximum readback time switch on test". For a given output, the ON test pulse is only provided to one of the P- or M-switches at a time, but in the presence of single fault this could apply energy to your load. Your actuator should not respond to an OFF signal up to the "Maximum readback time" duration, or to an ON signal up to the "Maximum readback time switch on test" duration.
- The F-DI 4/F-DQ 2 Fail-Safe module digital outputs expect to complete and confirm any commanded transition from the ON to OFF output state. After your program changes the process output value from "1" to "0", do not change the "0" back to a "1" until the output's configured "Maximum readback time" has elapsed. The affected output passivates on commanded "0" states that are too short to confirm.

⚠ WARNING

The safety performance of your installation depends on your design and continued maintenance of each complete safety function.
The ET 200pro, ET 200SP and S7-1200/1500 Fail-Safe CPUs and F-DI 4/F-DQ 2 Fail-Safe module provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.
Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.
You must choose all components of your installation and complete your design and maintenance according to accepted safety standards and practices to achieve your required level of safety.

5.1 Digital input applications

You should consider the application modes presented here along with the features of the F-DI 4/F-DQ 2 Fail-Safe module as described in the overview. Refer to "Fail-safe digital inputs (Page 13)".

The main features of the F-DI 4/F-DQ 2 Fail-Safe module digital inputs include the following items:

- Inputs are 24 V DC rated inputs that meet the requirements of IEC 61131-2 as Type 1 inputs.
- Configure each channel as 1oo1 or part of a 1oo2 channel group. The corresponding channels (x.0, x.2) and (x.1, x.3) form a 1oo2 channel group. The lower numbered channel of the group is called the primary input and the other channel is called the secondary input. Within this restriction, you can assign 1oo1 and 1oo2 in any order.

- Short-circuit testing requires use of the internal sensor supply. For all evaluation and sensor interconnections except for 1oo2, 2 channel - 3 wire nonequivalent, use V_{S1} with inputs x.0 to x.1 and V_{S2} with inputs x.2 to x.3. For evaluation and sensor interconnection for 1oo2, 2 channel - 3 wire nonequivalent, use V_{S1} with inputs x.0 to x.3, and do not use V_{S2}.
- If you enable the short-circuit test, you configure both V_{S1} and V_{S2} with the same parameters. All channels that you configure for internal sensor supply are subject to the same short-circuit test. You configure a test duration (length of dark time) and test interval (time between the start of the dark tests).
- The module performs these short-circuit functions for F-DI channels:
  - Monitors the sensor supply to detect short-circuit or overload.
  - Cycles the sensor supply once on each power up to assure control and readback are working. This ensures operational integrity of the sensor supply at power up even when disabled.
  - Monitors the readback during input short-circuit tests.
- Configure a discrepancy time to identify unacceptable differences between 1oo2 inputs.
- Configure a filter time for each channel or each 1oo2 pair.

You can achieve Cat. 3 in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach Cat. 3 by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failures unless you apply additional measures.

You can achieve Cat. 4 in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Cat. 4.
- The duplicated external wiring of two sensors to two input points is vulnerable to accumulated fault dangerous failure unless you apply additional measures.

The fail-safe digital inputs are certified for SIL 3/PL e only when you select 1oo2 evaluation.

Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

The following are the minimum conditions which must be met for achieving the corresponding safety requirements:

Table 1-997 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Sensor supply [1]	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
1	Internal	1oo1 evaluation	Single input	1 channel	2/3/d	
2	External					
3	Internal	1oo2 evaluation	Two inputs	2 channel equivalent	3/3/e	3/4/e
4	External				3/3/e	
5	Internal			2 channel - 3 wire nonequivalent	3/3/e	3/4/e
6	External				3/3/e	
7	Internal			2 channel - 4 wire nonequivalent	3/3/e	3/4/e
8	External				3/3/e	

[1] The F-DI 4/F-DQ 2 Fail-Safe module uses M12 I/Oconnections and is intended for use outside a cabinet in IP67 applications (everything sealed). If you require the use of an external supply, cut the M12 cable and make the connection inside a sealed cabinet or inside a sealed sensor. For external supplies, do not connect the pin 1 wire (V_{S1}) or the pin 5 wire (V_{S2}) in the M12 cable. This action prevents the sensor supply (which may be ON due to a different channel being configured as internal) from being shorted to the external 24 V DC. In addition, make the external 24 V DC connection inside a sealed cabinet or inside a sealed sensor.

Refer to "Pin assignment" (Page 16) for further information on connector pin assignments.

5.1.1 Applications 1 and 2: 1oo1 evaluation of single-channel sensors

F-DI application mode 1

This application mode uses single-channel sensors with a 1oo1 evaluation as shown in the following illustrations. When you use an internal sensor supply, you can successfully perform short-circuit detection.

NOTE

To incorporate F-DI application mode 1 into a SIL 2-rated application, ensure the sensors are appropriately qualified devices.



Figure 1-708 F-DI application mode 1: Internal sensor supply (1oo1 evaluation of a single-channel sensor shown)

Use Y cable (6ES7194-6KB00-0XA0) for F-DI application mode 1 to connect two single-channel sensors in 1oo1 evaluation as follows:

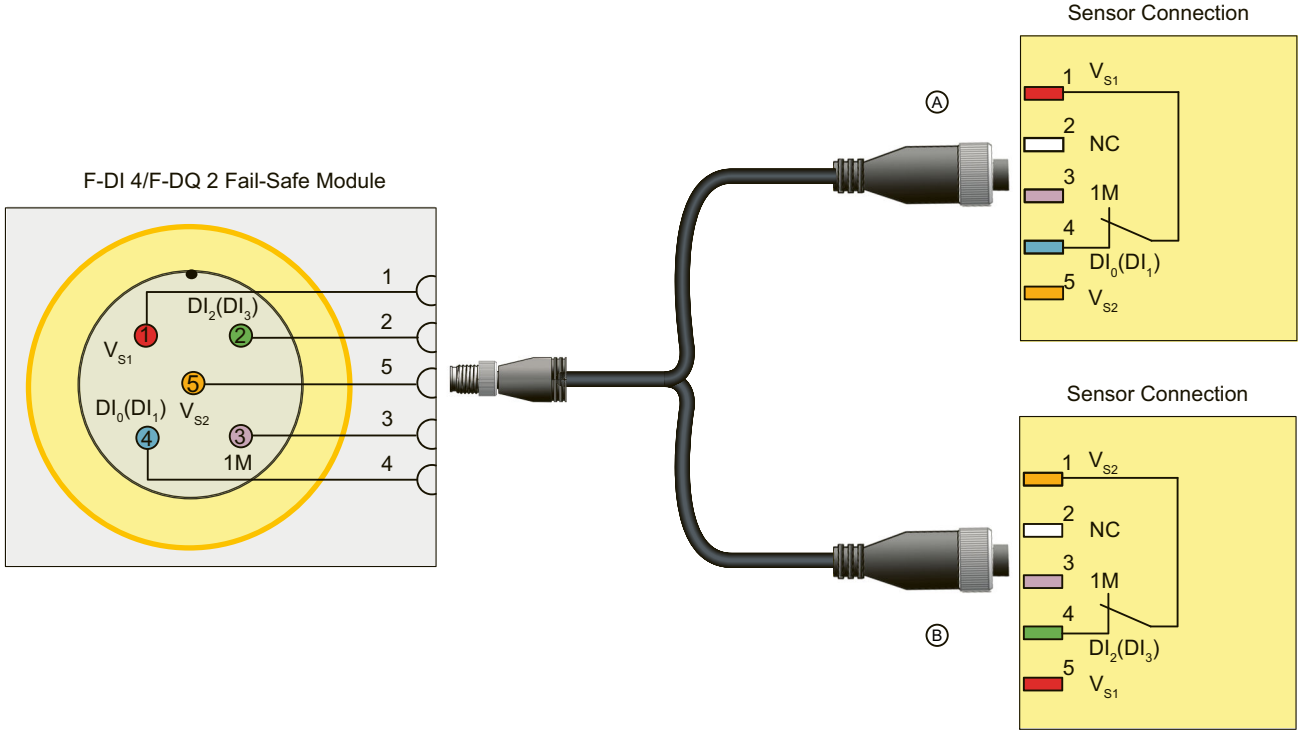


Figure 1-709 F-DI application mode 1: Internal sensor supply (1oo1 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 2

This application mode uses single-channel sensors with a 1oo1 evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

NOTE

To incorporate F-DI application mode 2 into a SIL 2-rated application, ensure the sensors are appropriately qualified devices.

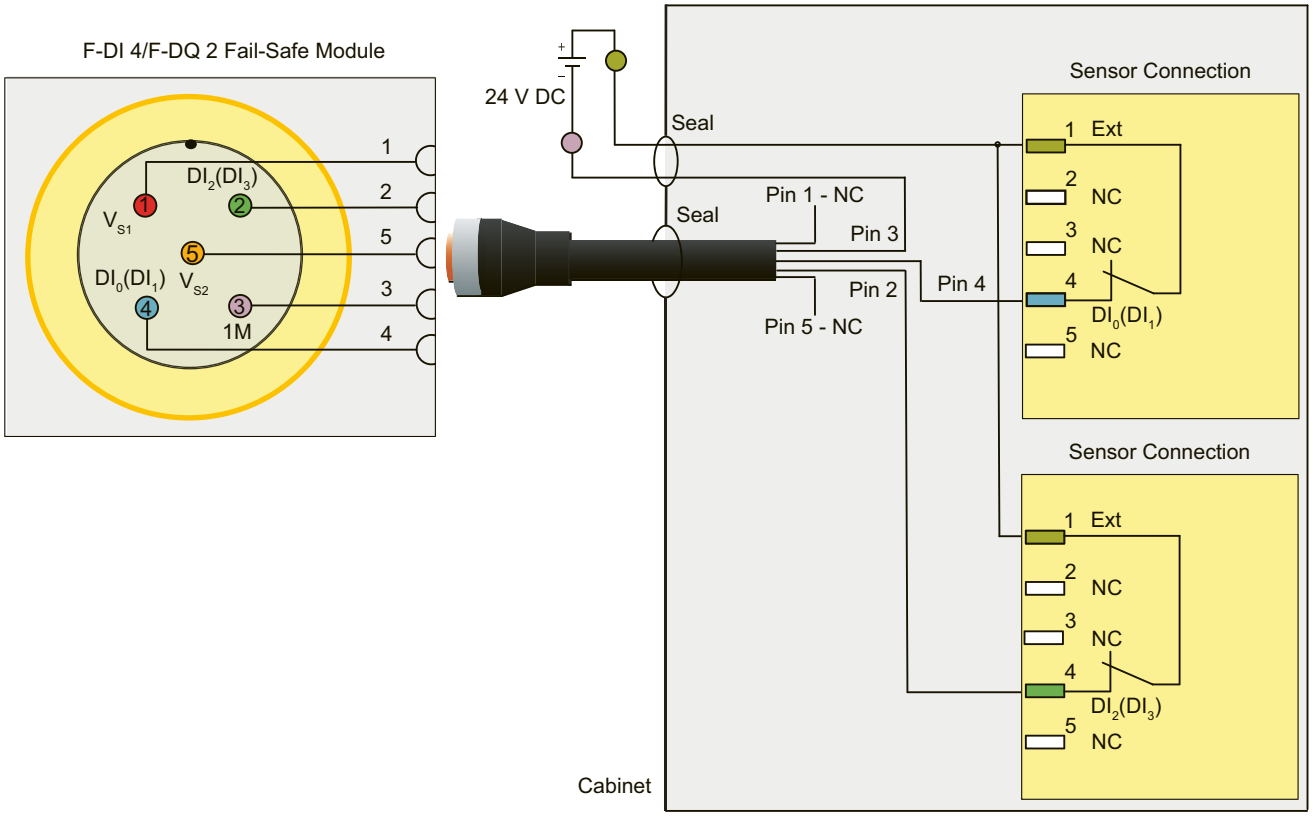


Figure 1-710 F-DI application mode 2: External sensor supply (1oo1 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	External

5.1.2 Applications 3 and 4: 1oo2 evaluation of equivalent sensors

F-DI application mode 3

This application mode uses a two-channel sensor or two single-channel sensors in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection.

NOTE

To incorporate F-DI application mode 3 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.



Figure 1-711 F-DI application mode 3: Internal sensor supply (1oo2 evaluation of two-channel sensor shown)

Use Y cable (6ES7194-6KB00-0XA0) for F-DI application mode 3 as follows:

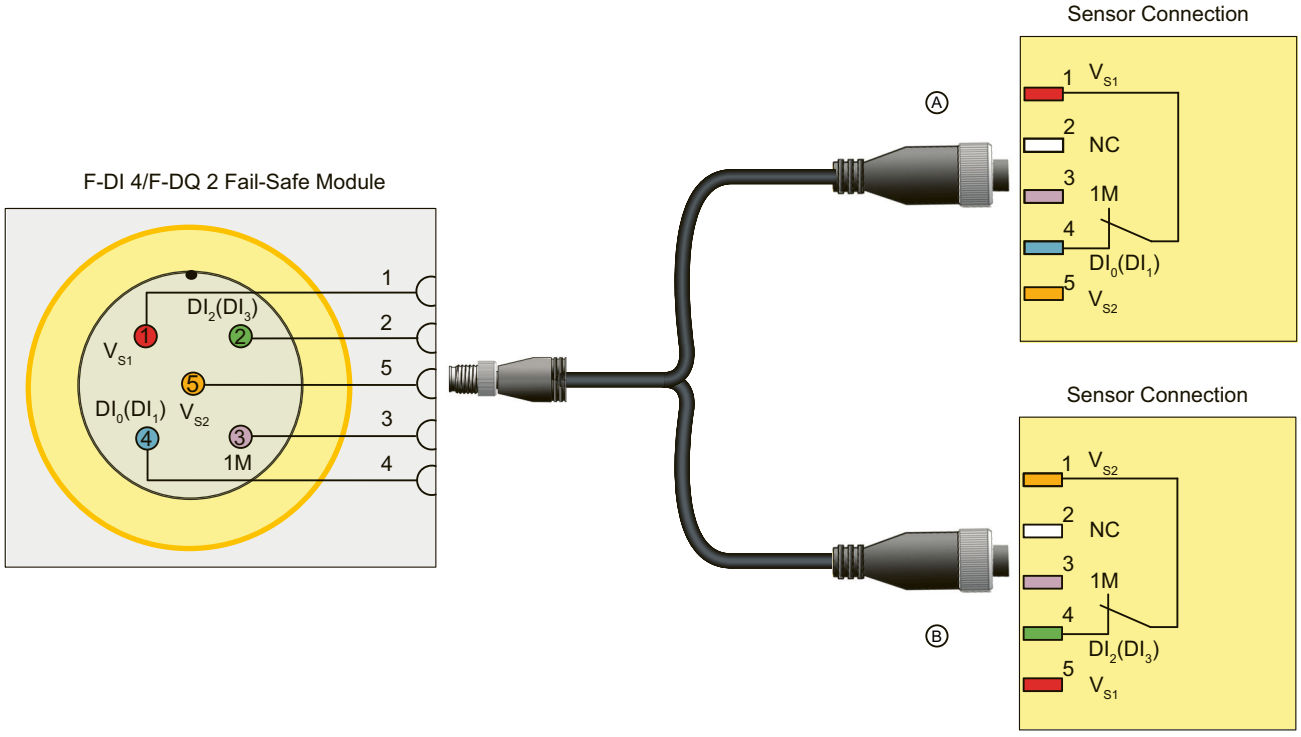


Figure 1-712 F-DI application mode 3: Internal sensor supply (1oo2 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel equivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 4

This application mode uses a two-channel sensor or two single-channel sensors in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

NOTE

To incorporate F-DI application mode 4 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

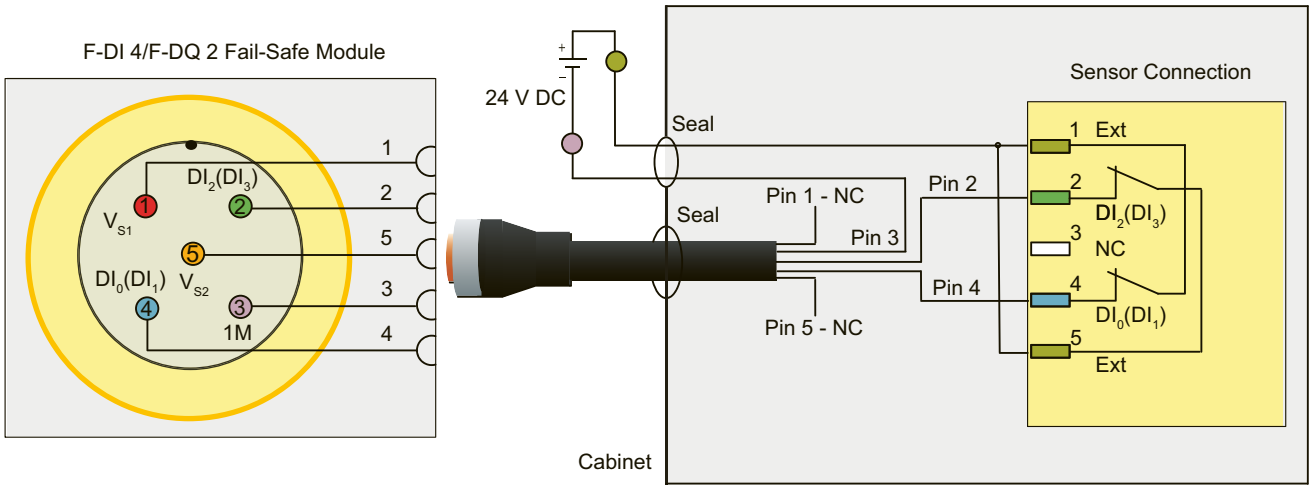


Figure 1-713 F-DI application mode 4: External sensor supply (1oo2 evaluation of two-channel sensor shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel equivalent
Sensor supply	External

5.1.3 Applications 5 and 6: 1oo2 evaluation of a 3-wire, nonequivalent sensor circuit

F-DI application mode 5

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

NOTE

To incorporate F-DI application mode 5 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

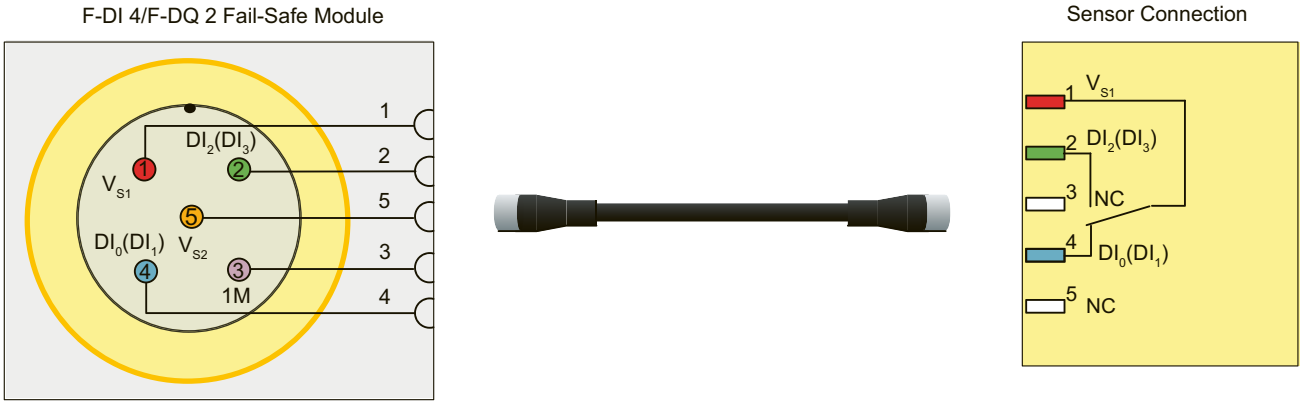


Figure 1-714 F-DI application mode 5: Internal sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES7194-6KA00-0XA0) for application mode 5 as follows:

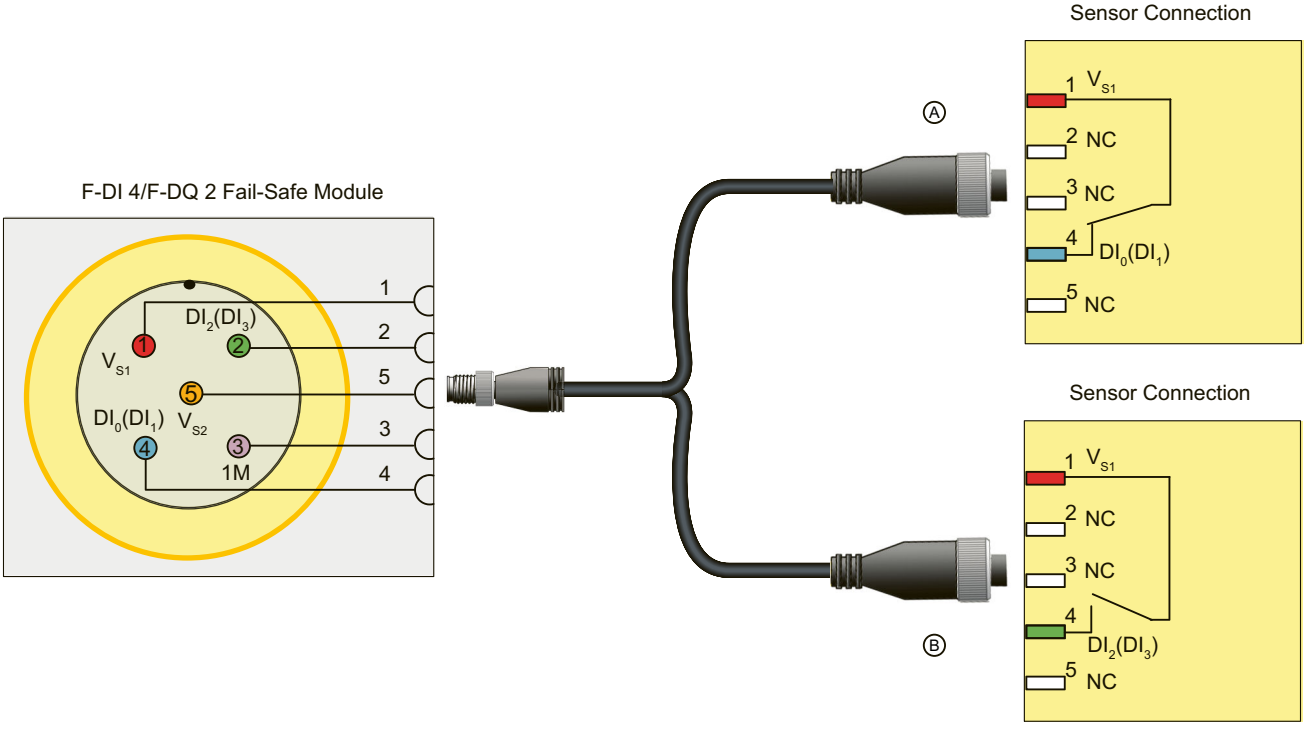


Figure 1-715 F-DI application mode 5: Internal sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire nonequivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 6

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

NOTE

To incorporate F-DI application mode 6 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

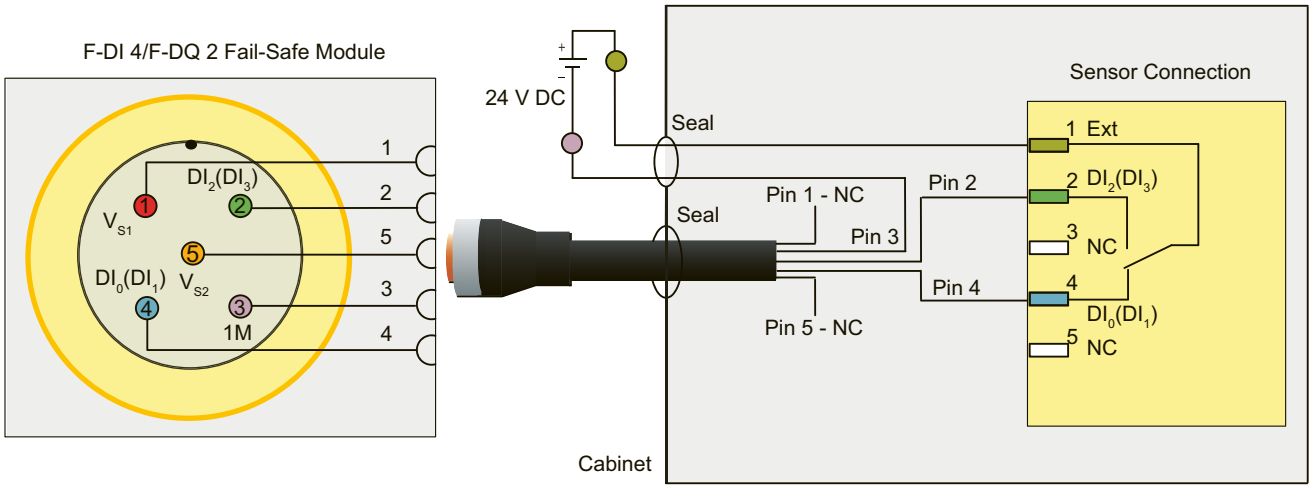


Figure 1-716 F-DI application mode 6: External sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire nonequivalent
Sensor supply	External

5.1.4 Applications 7 and 8: 1oo2 evaluation of a 4-wire, nonequivalent sensor circuit

F-DI application mode 7

This application mode uses a two-channel sensor or two single-channel sensors in nonequivalent configuration (4-wire connection) in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

NOTE

To incorporate F-DI application mode 7 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.



Figure 1-717 F-DI application mode 7: Internal sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES7194-6KB00-0XA0) for application mode 7 as follows:

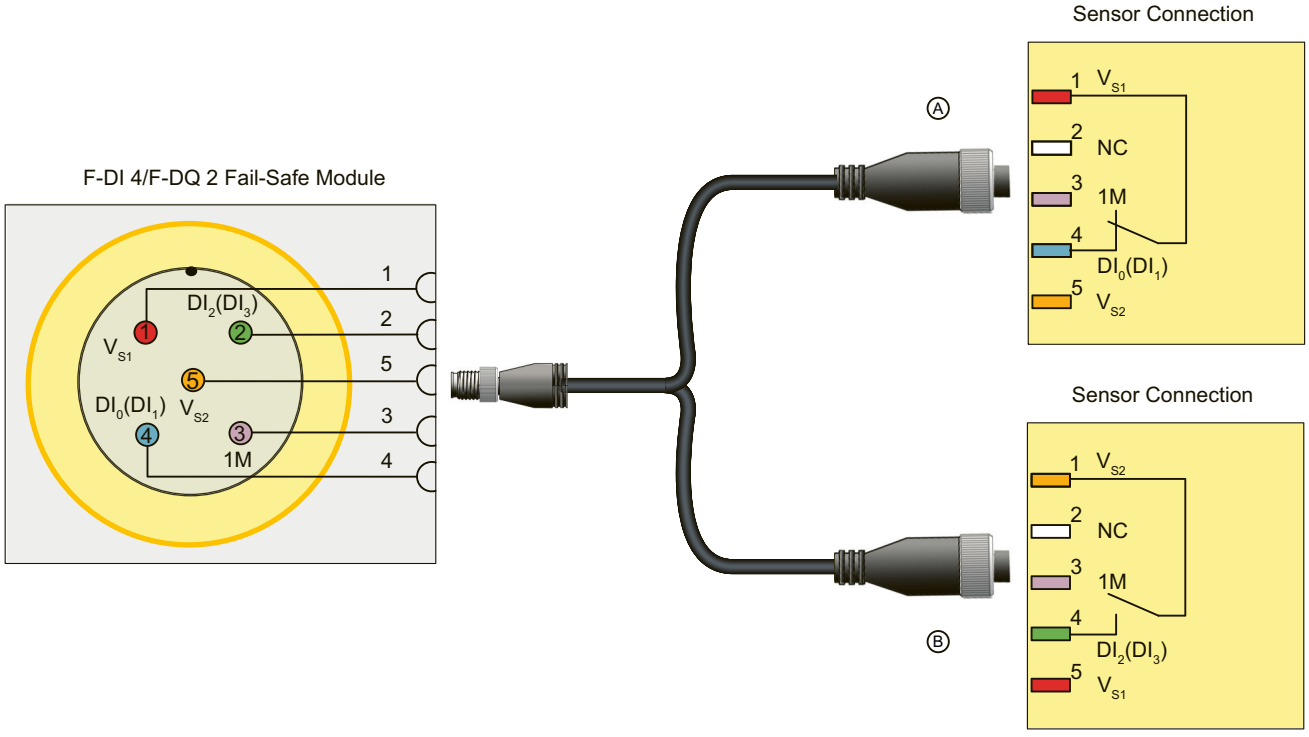


Figure 1-718 F-DI application mode 7: Internal sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire nonequivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 8

This application mode uses two single-channel sensors or a two-channel sensor with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 2 and 3) is the inverted input of the nonequivalent configuration
- Pin 4 (channels 0 and 1) is the non-inverted input of the nonequivalent configuration

NOTE

To incorporate F-DI application mode 8 into a SIL 3-rated application, ensure the sensors are appropriately qualified devices.

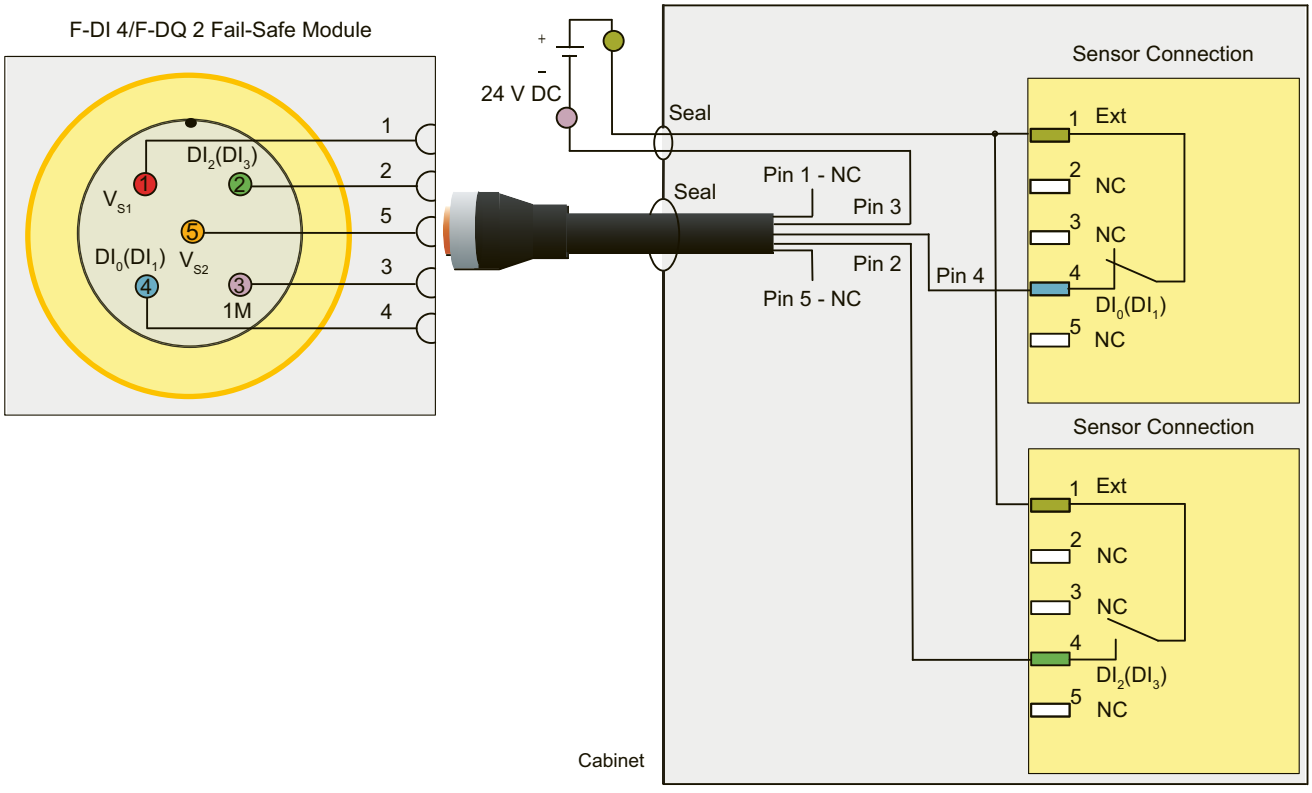


Figure 1-719 F-DI application mode 8: External sensor supply (1oo2 evaluation of two single channel sensors with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire nonequivalent
Sensor supply	External

5.2 Digital output applications

You should consider the application modes presented here along with the features of the F-DI 4/F-DQ 2 Fail-Safe module as described in the overview. Refer to "Fail-safe digital outputs (Page 14)".

The main features of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs include the following items, which apply to each output channel:

- The fail-safe module separately controls current flow in the P output and M output.
- The voltage at the P and M outputs is read back to confirm proper state.
- The P and M outputs are regularly tested with short ON and OFF pulses to confirm control.

Ensure that the following steps are accomplished:

- Configure readback times that are sufficiently long to allow the channel's external voltages to respond to process value changes and applied test patterns from the bit pattern test. However, configuring readback times that are too long can cause your load to physically respond to applied test patterns during dark tests.
- Verify that internal current limiting as described in the data sheet is sufficient in combination with your 24 V DC supply. Consider whether additional current limits or fuses are necessary. Refer to "Specifications" and "Connecting" in the *ET 200AL distributed I/O system* system manual (https://support.industry.siemens.com/cs/ww/en/view/89254965).

The module controls all output channels as 1oo2 with cross-diagnostics.

All applications shown are capable of reaching SIL 3/Cat. 4/PL e unless you have dark testing disabled.

To reach Cat. 4, ensure that the following conditions are met:

- The dark testing is enabled.
- The external contactors are SIL-rated with sense contacts.
- The diagnostics are within limits when you read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs.

Output architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

The following are the minimum conditions which must be met for achieving the corresponding safety requirements:

Table 1-998 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Type of actuator connection	Achievable SIL/Category/PL	
		Dark test disabled	Dark test enabled
1	Directly-connected SIL-rated actuator	2/3/d	3/4/e
2	External contactors: Separate P and M controlled contactors	2/3/d	3/4/e
3	External contactors: Parallel-connected contactors between P and M	2/3/d	3/4/e
4	External contactors: Separate output channels for each contactor	2/3/d	3/4/e

Refer to "Pin assignment (Page 16)" for further information on connector pin assignments.

Refer to "Disable Dark Test (max. SIL 2, Cat. 3, PL d)" in "DQ parameters (Page 28)" for additional information on enabling and disabling dark testing.

5.2.1 Application 1: Wiring a directly-connected SIL-rated actuator

The module supports application mode 1, where there is a direct connection of a load between the P and M outputs of one channel. Both switches are opened when de-energizing the load.

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if neither channel is configured to disable the dark test.

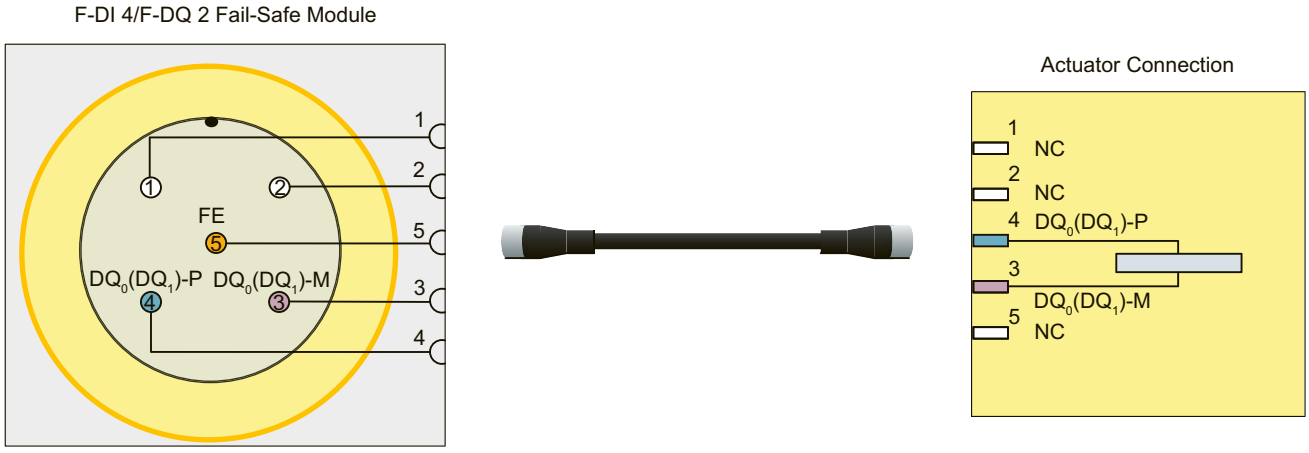


Figure 1-720 F-DQ application mode 1

5.2.2 Application 2: Wiring external contactors: Separate P and M controlled contactors

The module supports application mode 2, where the module controls the load using series-connected, normally-open contacts of two relays. The coil of one relay connects the P-output of a channel and M. The coil of the other relay connects the M-output of the same channel and L+.

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if you fulfill the following conditions:

- The CPU checks the relay status (feedback) using a separate digital input.
- You adequately protect the wiring against shorts from the P output to L+ and shorts from the M output to M. The CPU cannot switch off the actuator if both faults occur.
- You do not disable dark test for either output.

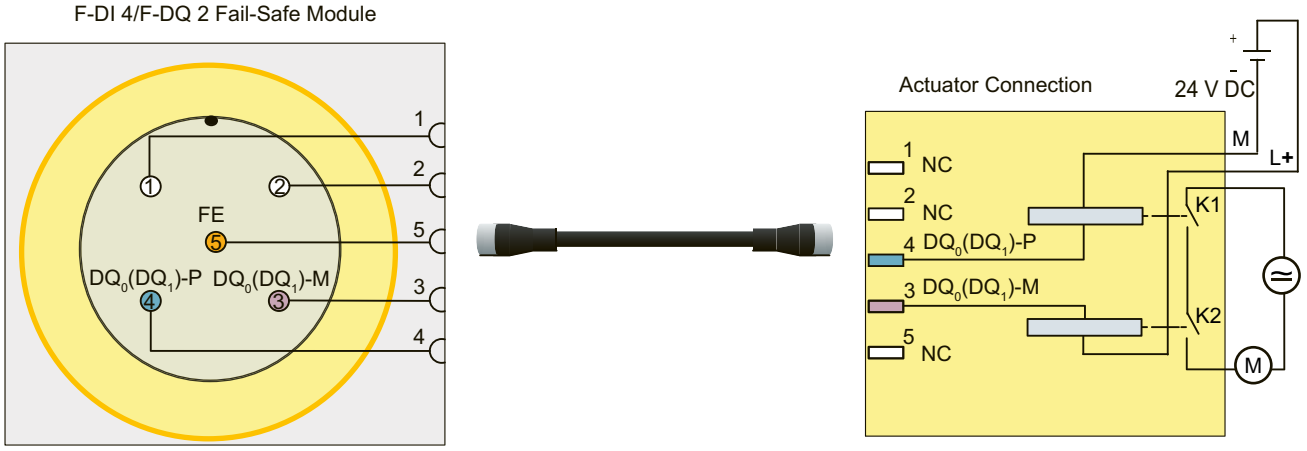


Figure 1-721 F-DQ application mode 2

5.2.3 Application 3: Wiring external contactors: Parallel-connected contactors between P and M

The module supports application mode 3, where the module controls the load using the series-connected, normally-open contacts of two relays. You connect the coils of both relays, in parallel, across the outputs of one channel.

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if the CPU checks the relay status (feedback) using a separate digital input and if neither channel is configured to disable the dark test. Application mode 3 is the preferred way of controlling an actuator using relays in a safety-related application. Application mode 3 avoids the problems mentioned for Application mode 2, regarding short-circuits of the P and M outputs.

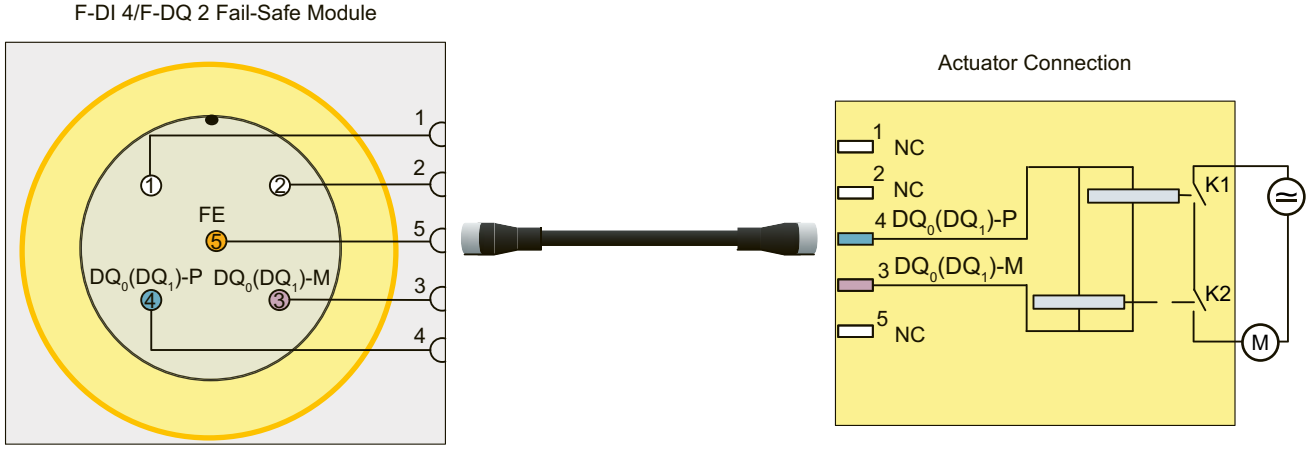


Figure 1-722 F-DQ application mode 3

5.2.4 Application 4: Wiring external contactors: Separate output channels for each contactor

The module supports application mode 4, where the module controls the load using the series-connected, normally-open contacts of two relays. Connect the coils of both relays across the outputs of two channels. In the safety program, write the same process value (ON or OFF) to both output channels.

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if the CPU checks the relay status (feedback) using a separate digital input and neither channel is configured to disable the dark test.

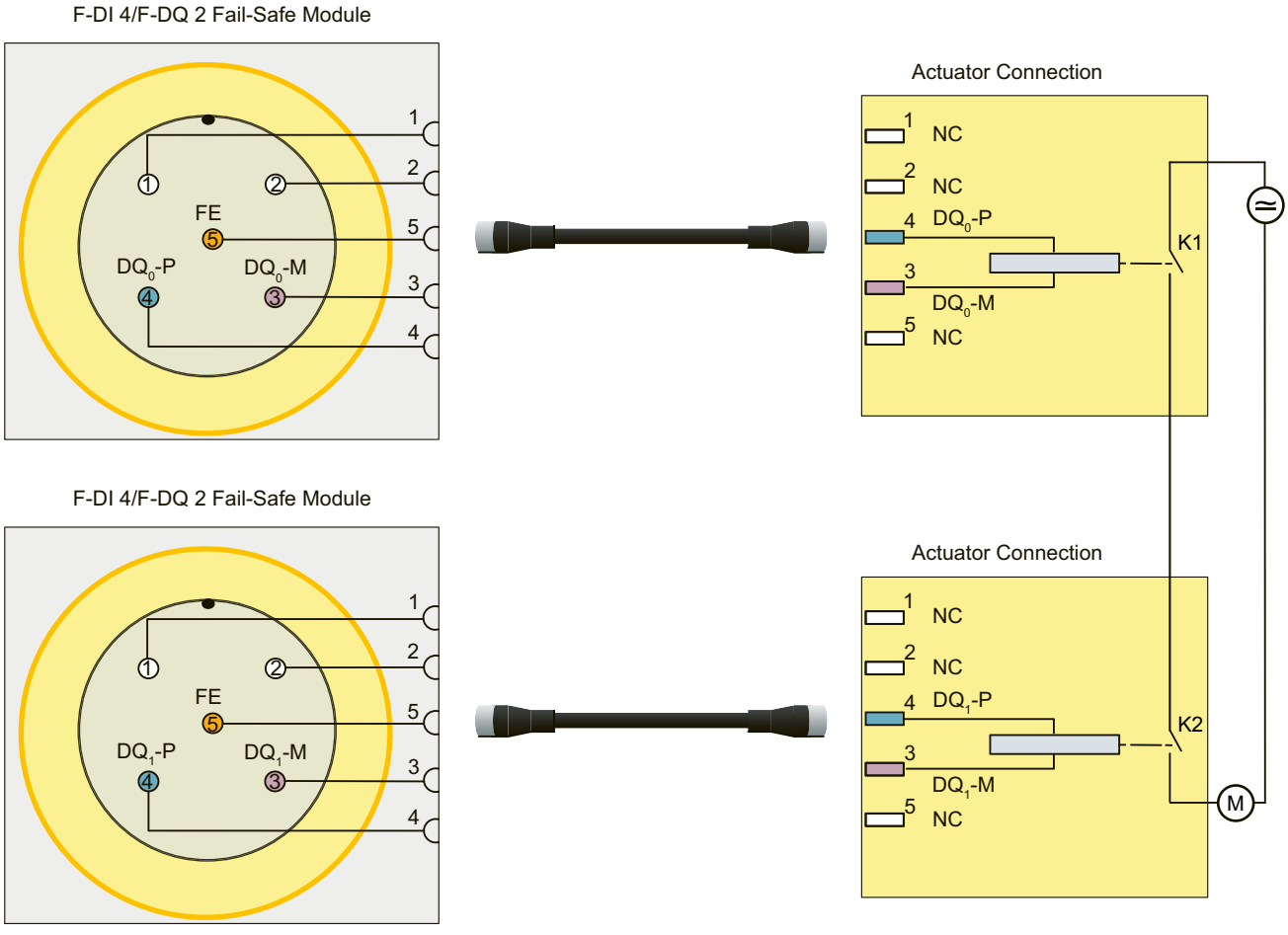


Figure 1-723 F-DQ application mode 4

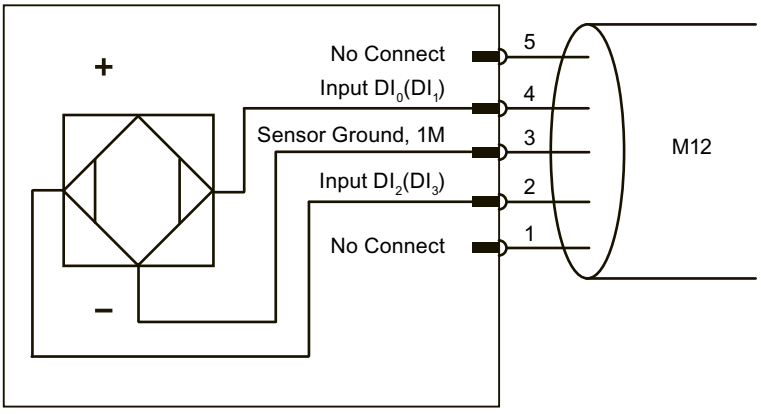
5.3 Examples of application modes for the F-DI 4/F-DQ 2 Fail-Safe module

You can connect field devices to the F-DI 4/F-DQ 2 Fail-Safe module as shown below.

Laser scanner (1oo2 evaluation)

For the output signal switching device (OSSD) sensors of a Laser Scanner, use F-DI application mode 4 to connect the Laser Scanner output signal switching device with 1oo2 evaluation to the F-DI 4/F-DQ 2 Fail-Safe module:

Laser Scanner (1oo2)

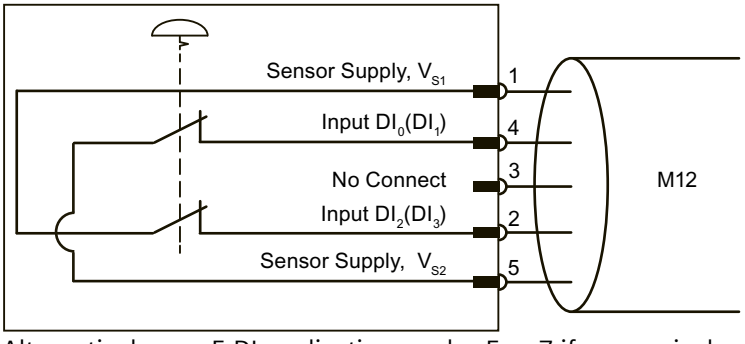


Alternatively, use F-DI application mode 3 and disable the parameter "Short-circuit test" for both sensor supplies.

ESTOP (Emergency Stop) (1oo2 evaluation)

For the ESTOP, use F-DI application mode 3 to connect an ESTOP device with 1oo2 evaluation to the F-DI 4/F-DQ 2 Fail-Safe module:

ESTOP (1oo2)

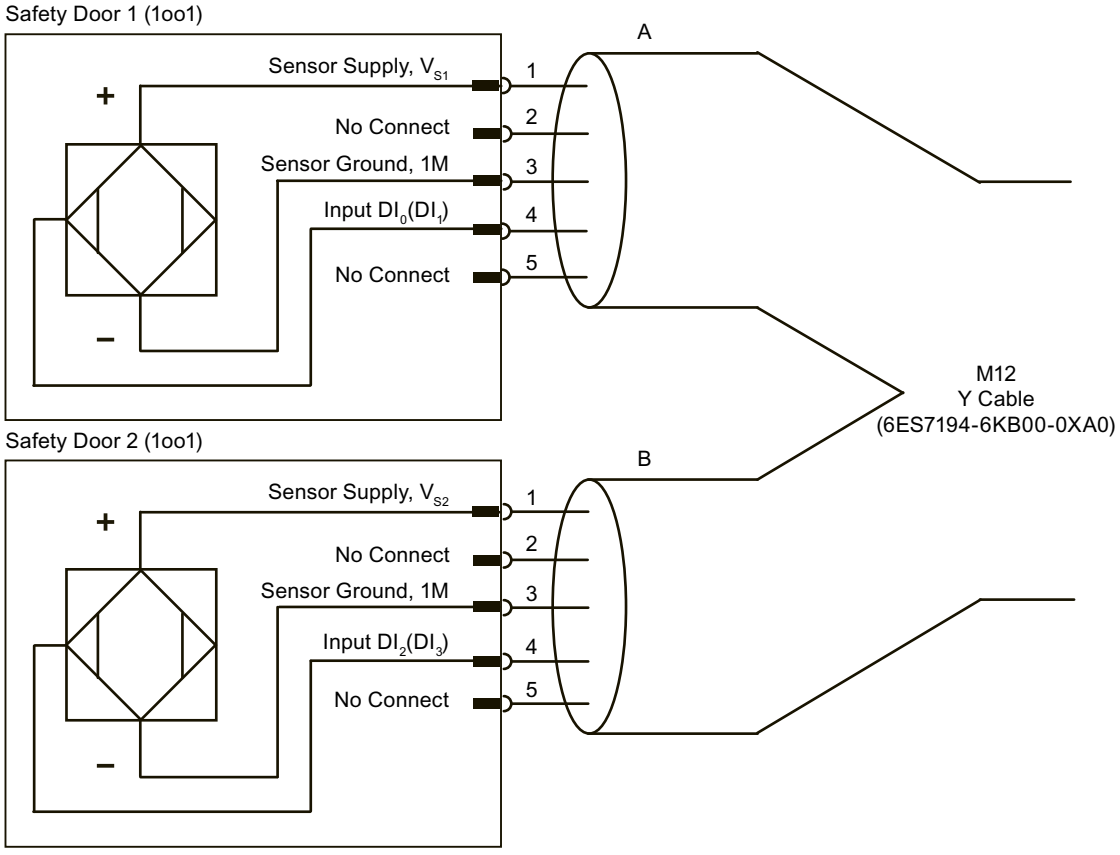


Alternatively, use F-DI application modes 5 or 7 if nonequivalent evaluation is required for your ESTOP device.

Safety doors (1oo1 or 1oo2 evaluation)

For the Safety Doors, you can do one of the following:

- Use F-DI application mode 1 with the fail-safe Y cable (6ES7194-6KB00-0XA0) to connect two single-channel sensors with 1oo1 evaluation to one input connection of the F-DI 4/F-DQ 2 Fail-Safe module.
- Use F-DI application mode 3 (1oo2 evaluation), using two single-channel sensors on the same safety door.



Alternatively, use F-DI application mode 5 with the fail-safe Y cable (6ES7194-6KA00-0XA0) to connect two nonequivalent single-channel sensors with 1oo2 evaluation on the same safety door.

Safety position switch with interlock (1oo2 evaluation)

Use F-DI application mode 3 and F-DQ application mode 1 to connect the safety position switch with interlock to the F-DI 4/F-DQ 2 Fail-Safe module.

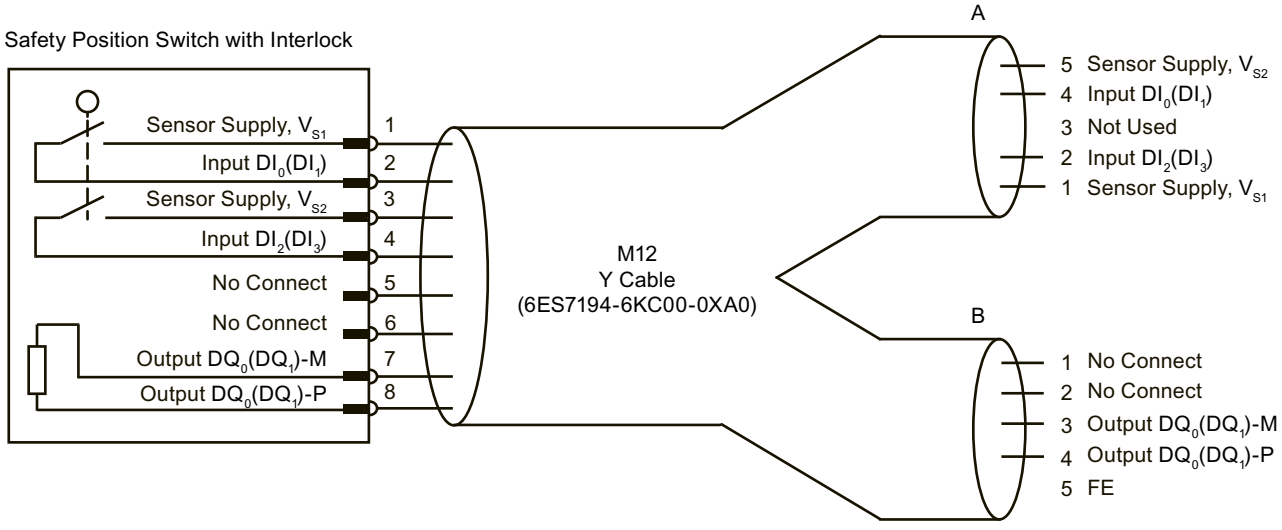
Use inverted Y cable (6ES7194-6KC00-0XA0) for a safety position switch with interlock. The inverted Y cable is designed to properly connect the fail-safe module F-inputs and F-output to the safety position switch.

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if neither output channel is configured to disable the dark test.

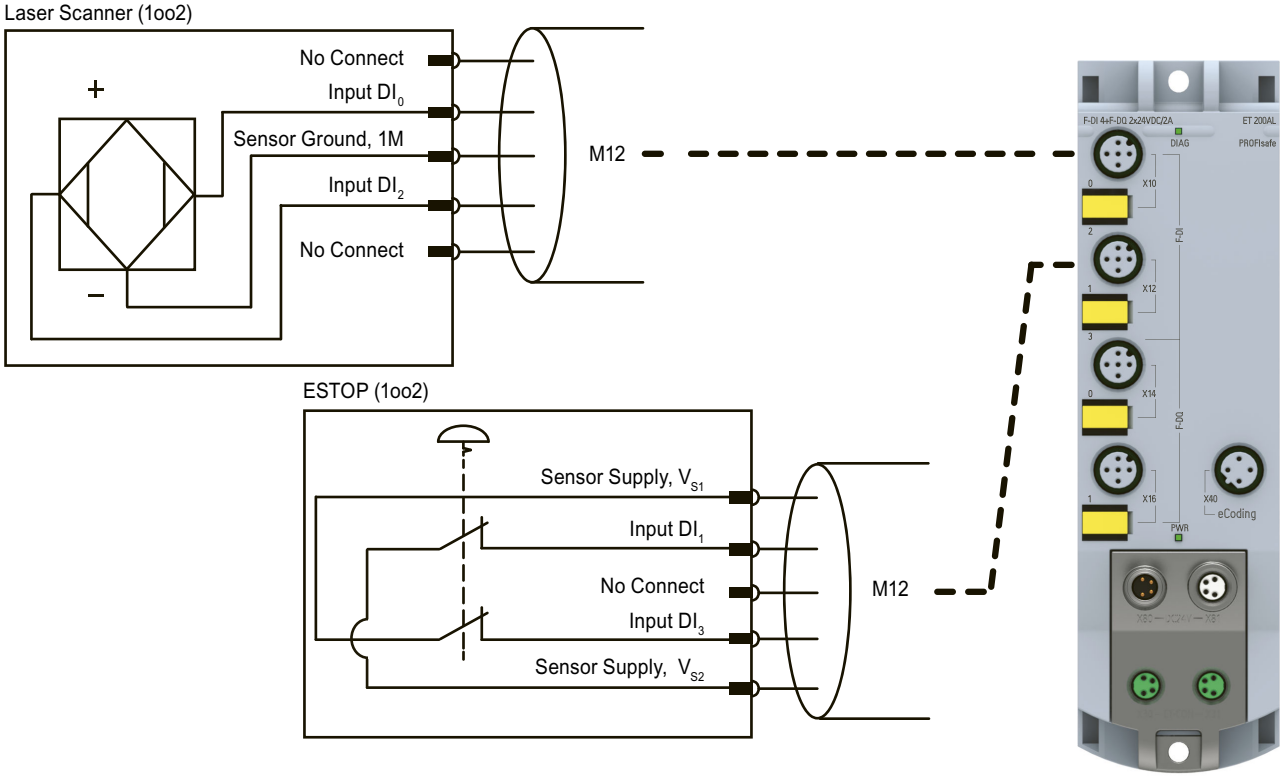
NOTE

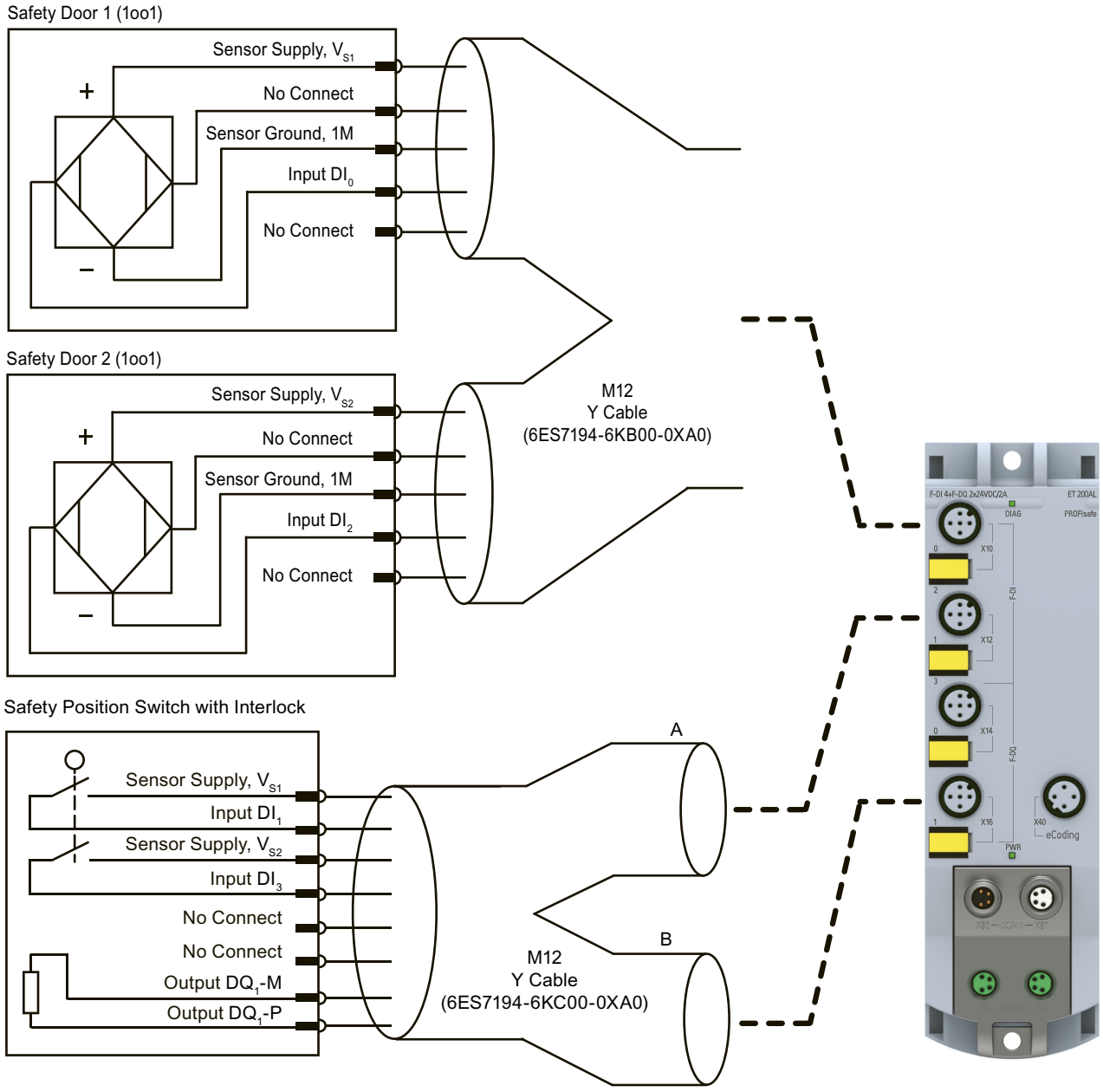
To incorporate this application into a SIL 3-rated application, ensure the sensors are appropriately qualified devices: either SIL 3 or SIL 2 with the Systematic Capability rules defined in the SIRIUS documentation. For further information, refer to the *Industrial Controls, Detecting devices SIRIUS 3SE5/3SF1/3SE66/3SE67 position switches configuration manual* on the Internet (https://support.industry.siemens.com/cs/us/en/view/43920150).



Connect devices to F-DI 4/F-DQ 2 Fail-Safe module

The figures below are examples of field devices connected to the input and output sockets of the F-DI 4/F-DQ 2 Fail-Safe module:




Safety Door 1 (1oo1)
Sensor Supply, V_{S1}
No Connect
Sensor Ground, 1M
Input DI_0
No Connect
+
–
Safety Door 2 (1oo1)
Sensor Supply, V_{S2}
No Connect
Sensor Ground, 1M
Input DI_2
No Connect
+
–
M12
Y Cable
(6ES7194-6KB00-0XA0)
Safety Position Switch with Interlock
Sensor Supply, V_{S1}
Input DI_1
Sensor Supply, V_{S2}
Input DI_3
No Connect
No Connect
Output DQ_1-M
Output DQ_1-P
A
B
M12
Y Cable
(6ES7194-6KC00-0XA0)
F-DI 4xF-DQ 2x24VDC/2A
ET 200AL
DIAG
PROFIsafe
X10
X12
X14
X16
X40
eCoding
PWR
F-DI
F-DQ

Interrupts/diagnostic messages/diagnostics 6

6.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

The safety function requires that safe state values be applied to the fail-safe channel(s) instead of process values (passivation of the fail-safe module or channel(s)) in the following situations:

- When the fail-safe system is started up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters information about detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, the modules detect any faults still existing again. The exception to this is a permanent deactivation fault such as "sustained overvoltage".

Fail-Safe value for fail-safe modules

If digital input channels are passivated, the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If digital output channels are passivated in the fail-safe module digital outputs, the fail-safe system always transfers safe state values "0" to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

NOTE

In the **F-DI 4/F-DQ 2 Properties** > **F-parameter**s > "Behavior after channel fault" field, if you select "Passivate the entire module", a single channel fault will result in passivation of all channels.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates all module channels.

Table 1-999 Module signal type and passivation result

Module signal type	Passivation result
Fail-safe digital inputs	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective inputs. • If a channel fault occurs for a 1oo1 configuration, depending on your configuration, only the affected channel or all channels may be passivated. For a 1oo2, both inputs of the channel group in the 1oo2 configuration are passivated.
Fail-safe digital outputs	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective outputs. • Diagnostic evaluations are performed separately for each of the two switches of a channel. Depending on your configuration, failure detection for one switch may lead to passivation of only the affected channel or all channels.

Response to faults in the fail-safe system

You should prepare maintenance procedures for your system to assure that return to operation after a detected fault is controlled and documented.

Perform the following steps:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe module

A channel or module can be reintegrated after diagnostics determine that a fault has cleared successfully.

You can configure reintegration as automatic or manual. You can make this selection on a per channel basis in the Device Configuration. Module wide errors such as PROFIsafe communication errors or supply voltage errors are always manually reintegrated. Fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

Automatic

Channels that you select to be automatically reintegrated are immediately reintegrated when the fault has cleared.

Manual

Channels that you select to be manually reintegrated are acknowledged in your program after the fault has cleared.

The "ACK_REQ" bit for that module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Reintegration after high stress events

High temperature, high voltage, or excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure may be increased.

⚠ WARNING

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.
Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the module, refer to "Fault types, causes, and corrective measures (Page 65)".

At reintegration, the following occurs:

- For a fail-safe module digital input, the process values pending at the fail-safe inputs are again provided for the safety program.
- For a fail-safe module digital output, the output values provided in the safety program are again transferred to the fail-safe outputs.

Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O are not being diagnosed and are subject to dangerous failure without warning.

If any error persists for 100 hours, the entire module is passivated and can only be recovered by power cycling.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs are removed from any operating F-CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

Do not depend on deactivation or lack of configuration to maintain safe state in any circumstances.

⚠ WARNING

Unintentional activation of F-I/O module with fail-safe output
If a fail-safe output is passivated for a period longer than the safety repair time (> 100 hours) and the fault remains uncorrected, you need to be aware that an F-output could be activated unintentionally due to a second fault. This would place the F-system in a dangerous state. Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of a fail-safe output by using measures for the physical circuits or other organizational measures. One possibility is the shutdown of the power supply to the affected F-module. Required measures are often standardized for operations with defined design and risk reduction principles. For all other situations, necessary measures must be defined and approved.

Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

Diagnostic messages (Page %getreference)

6.2 Fault diagnostics overview

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe module, communication with the CPU, or external circuits. Diagnostic information is assigned either to a single channel or to the entire fail-safe module.

Most diagnostics operate without user selection. You can configure the following diagnostic options:

- Short-circuit testing using the digital input sensor supply can be enabled. The interval and duration of short-circuit tests is configurable.
- The readback times for 24 V DC digital outputs are configurable.
- The timeout intervals for failures in the safety communication or failure of a safety program to run is configurable.
- Dark testing of the digital outputs can be disabled (max. SIL 2, Cat. 3, PL d).

Refer to "Parameters/address space (Page 20)" for a complete description of these options.

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These reports are offered as maintenance and debugging aids. Observe and interpret the reports with caution.

In the presence of single faults, any or all LED indications can be wrong. You should not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages may fail to be delivered, or the numerical event ID or text message can be wrong. You should not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

⚠ WARNING

Diagnostic and status reports through LEDs and text messages are subject to single point failure errors.
Reliance on such reported information to determine that a system or I/O point is in a safely-controlled state can result in death, severe personal injury, or property damage.
If the integrity of your fail-safe system is in doubt, you should use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.

6.3 Diagnostics performed at startup

Each fail-safe module executes self-diagnostics at power-up to assure that the electronics and software meet testable expectations before allowing the module to participate in process control. If tests are not successful, the module passivates either individual or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

The F-DI 4/F-DQ 2 Fail-Safe module executes tests for its digital outputs of the P- and M-switches as defined by your configured parameters for "Maximum readback time" and "Maximum readback time switch on test" after receiving configuration parameters from the fail-safe CPU at power-up. P- and M-switch ON tests are sequenced so that normally or in the presence of a single detected fault, there is no complete PM circuit to energize the load.

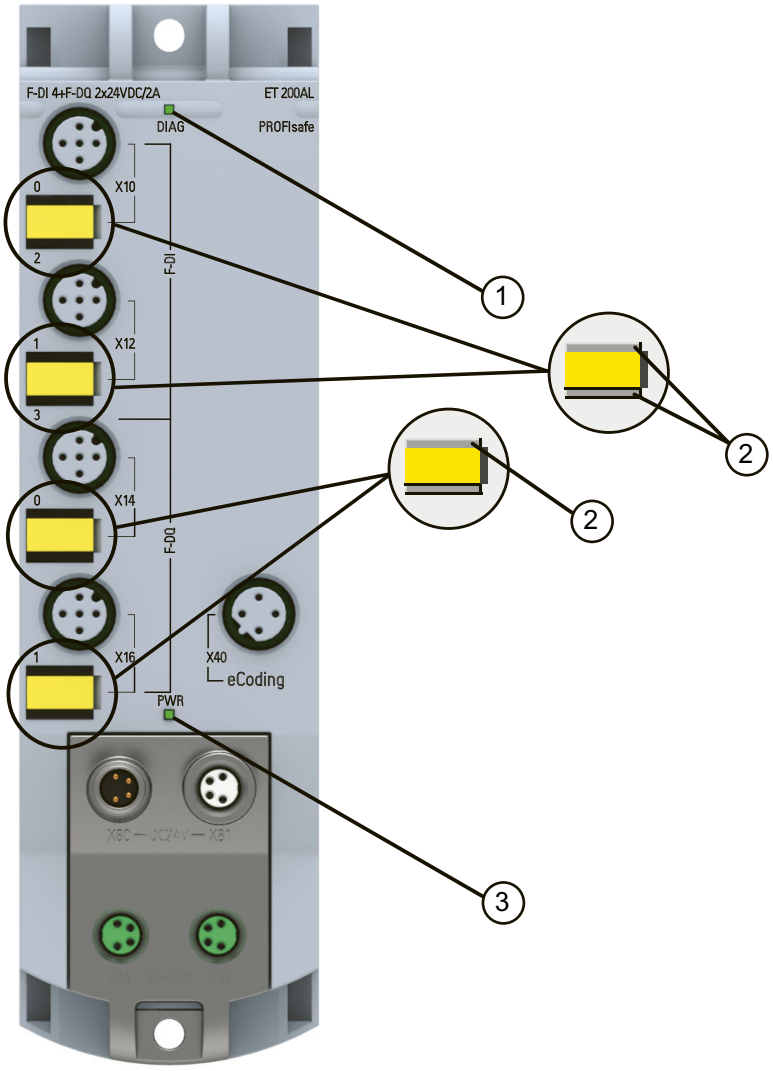
The F-DI 4/F-DQ 2 Fail-Safe module executes tests for its digital inputs of the sensor supply at power-up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the module also executes a short-circuit test according to your configured parameters after receiving the parameters from the fail-safe CPU at power-up.

6.4 Diagnostics by LED display

6.4.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the F-DI 4/F-DQ 2 Fail-Safe module:



① Diagnostic status (DIAG (red/green))
② Channel status and channel error (red/green) for each channel (F-DI 0 - 3, F-DQ 0 and 1)
③ Load voltage 2L+ status (PWR (green))

Figure 1-724 LED displays

Meaning of the LEDs

The following tables set out the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Fault types, causes, and corrective measures (Page 65).

PWR LED

Table 1-1000 Meaning of the PWR LED

PWR	Meaning
Off	Load voltage 2L+ missing or supply voltage 1L+ is too low or not present
On green	Load voltage 2L+ available

DIAG LED

Table 1-1001 Meaning of the DIAG LED

DIAG LED	Meaning
Off	No supply voltage 1L+
Flashes green	Configuration/parameterization has not been received and no module diagnostics
Alternately Flashes red/green	Module-wide reintegratable faults such as the following are resolved and are awaiting reintegration: • Overvoltage • Undervoltage • PROFIsafe CRC error • PROFIsafe timeout error
On green	Module parameters assigned and no module or channel diagnostics
Flashes red	• Module diagnostic and/or one or more channel diagnostics • Module has inconsistent hardware and/or firmware versions

Channel LED for 1oo1 input channels

Table 1-1002 Meaning of the channel LED for 1oo1 input channels

DIAGInput LEDs	Meaning
Off	Process signal = 0
On green	Process signal = 1
On red	Channel fault or module fault affecting the channel
Alternately Flashes red/green	Fault resolved, awaiting reintegration

Channel LEDs for 1oo2 input channels

Table 1-1003 Meaning of the channel LEDs for 1oo2 input channels

Primary input LED	Secondary input LED	Meaning
Off	Off	Process signal = 0 (equivalent)
On green	On green	Process signal = 1 (equivalent)
Off	On green	Process signal = 0 (nonequivalent)
On green	Off	Process signal = 1 (nonequivalent)
On red	On red	Channel fault or module fault affecting the channel
Alternately Flashes red/green	Alternately Flashes red/green	Fault resolved, awaiting reintegration

Channel LED for output channels

Table 1-1004 Meaning of the channel LED for output channels

Output LED	Meaning
Off	Process signal = 0 or channel deactivated
On green	Process signal = 1
On red	Channel fault or module fault affecting the channel
Alternately Flashes red/green	Fault resolved, awaiting reintegration

6.5 Fault types, causes, and corrective measures

The "Fault types, causes, and corrective measures" table below lists the messages of the F-DI 4/F-DQ 2 Fail-Safe module. These messages are displayed in the TIA Portal under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight an individual text line in the diagnostic buffer, the Event ID for that text item is displayed, along with module identity and location that generated the message. You may need to expand the window to see all information.

Table 1-1005 Fault types, causes, and corrective measures

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0001	Short-circuit	F-DI 4/F-DQ 2 digital outputs	A channel problem has been detected where either the P terminal or M terminal is at an unexpected potential	• Short-circuit of the output • Short-circuit between channels with different signals • Output overload • "Maximum readback time switch on test" value is configured too small • Short-circuit of output to M • Defective output driver	• Eliminate the short-circuit • Eliminate the overload • Increase "Maximum readback time switch on test" if permissible • Replace the fail-safe module
16x0005	Overtemperature	Module	• Overtemperature at microcontoller • Overtemperature at I/O	Shutdown due to violation of high temperature limit value in the module case	Check the ambient temperature. Once the fault has been eliminated, switch the power off and on
16x0006	Wire break	Module	Wire break failure. The module can detect a wire break when all of the following are true: • The channel is wired using a PM load • The PV=0 • The wire break diagnostic is enabled	Output is activated: • No load is connected to the PM output • Output is wired in output application mode 2 • Too small of a load is detected	• Change the output load characteristics • Deactivate unused channels • Disable wire break diagnostic for the offending channels
16x0009	Hardware revision mismatch	Module	• The module detects hardware mismatch • DIAG LED is flashes red		Replace module

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0010	Parameterization failure (invalid parameters)	Module	When the module receives new parameters, the module checks for parameter failures. On detection of invalid parameters, the module stays in the configured state and signals the rejection of the faulty parameter to the fail-safe CPU. The module LEDs give an immediate indication of this fault.	• i-Parameter CRC error • Invalid i-parameters (for example, invalid selection, parameter out-of-range, unsupported feature selected, and wrong value of reserved field) • Any PROFIsafe parameterization problem detected by the PROFIsafe driver	Correct the parameter assignment
	Parameterization failure (address assignment failure)	Module	• On detection of an address assignment failure that indicates a hardware fault, the module enters the fatal error state. • The module performs this fault reaction if the address verification information provided by the F parameters is different than what has been previously assigned to the module	• Indicates assignment of an incorrect F address to one or more module(s) • Missing eCoding plug	• Reinsert the eCoding plug • Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal) • Replace the eCoding plug
16x0040	Mismatch of safety destination address (F_Dest_Add)	Module	The PROFIsafe driver has detected a destination address mismatch. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective • Incorrect F-source address was downloaded as part of hardware configuration	• Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal) • Replace the eCoding plug • Correct the F-destination address in hardware configuration and re-download
16x0041	Safety destination address not valid (F_Dest_Add)	Module	The PROFIsafe driver has detected an invalid destination address. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective	• Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal) • Replace the eCoding plug

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0042	Safety source address not valid (F_Source_Add)	Module	The PROFIsafe driver has detected a source address mismatch or an invalid source address. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective • Incorrect F-source address was downloaded as part of hardware configuration	• Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal) • Replace the eCoding plug • Correct the F-source address in hardware configuration and re-download
16x004B	Inconsistent iParameters (iParCRC error)	Module	The firmware of the F-module has detected a CRC error.	• Communication between the F-CPU and F-module is disturbed • Impermissibly high electromagnetic interference is present	• Check PROFINET communications between the F-module and F-CPU • Eliminate the electromagnetic interference • Power switched OFF and ON for station • Reassign the PROFIsafe F addresses using STEP 7 (TIA Portal)
16x004D	PROFIsafe communication error (CRC)	Module	Transmission error in data message frame: Data inconsistent (CRC (cyclic redundancy check) error). Checked after new output telegram received.	Communication interference between the fail-safe CPU and the fail-safe module (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)	• Check the communications connection • Eliminate the interference
16x004E	PROFIsafe communication failure (timeout)	Module	Monitoring time exceeded for data message frame (timeout). Checked after new output telegram received.	F-monitoring time exceeded. Transmission error: timeout (watchdog time 1 or 2 elapsed)	• Adjust F-monitoring time • Check Safety program and all other CPU activities for excessive execution or demands: – Interrupts – Ethernet communication – OB scheduling conflicts – Long program paths
16x004F	Channel failure acknowledgement	Module	Channel configured for manual acknowledgement is ready to reintegrate	Manual acknowledgement required	Manually acknowledge correction of channel fault so that reintegration can occur
16x0100	Module is defective	Module	Fatal internal error	Fail-safe module is defective	Replace the fail-safe module

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0103	Watchdog tripped	Module	The watchdog timer in the module communications processor timed out	Fail-safe module is defective	Replace the fail-safe module
16x0105	Short-circuit to L+	F-DI 4/F-DQ 2 digital outputs	Output shorted to P. The fail-safe module detects a channel problem where the P-terminal is unexpectedly at L+ potential.	• Short-circuit to L+ • Short-circuit between channels with different signals • Defective output driver • "Maximum readback time" value is configured too small	• Eliminate the short-circuit • Increase readback time • Replace the fail-safe module
16x0106	Short-circuit to ground	F-DI 4/F-DQ 2 digital outputs	The fail-safe module detects a channel problem where the M-switch output terminal is unexpectedly at M potential	• Short-circuit of output to M, ground, or another channel • Defective output driver • "Maximum readback time" value is configured too small	• Eliminate the short-circuit • Increase readback time • Replace the fail-safe module
16x011B	Invalid/ inconsistent firmware present	Module	Inconsistency between bus ASIC firmware and fail-safe controller firmware.	A firmware update operation was performed using an update file not suitable for the module (incorrect article number or hardware revision)	• The firmware update operation should be repeated with a suitable update file • Replace the fail-safe module
16x013E	Diagnostic event queue overflow	Module	Overflow of the diagnostic events queue has occurred. A newly-occurred diagnostic event could not be queued for transmission to the CPU because the buffer is full.	This can happen if channel errors come and go very quickly (for example, discrepancy errors)	Examine the Diagnostics buffer to see what errors are occurring, then address that issue

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0300	Discrepancy failure, channel state 0/0	F-DI 4/F-DQ 2 digital inputs	External discrepancy failure: Channel state 0/0 with 1oo2 nonequivalent configuration	• Process signal faulty, sensor may be defective • Configured discrepancy time too short • Short-circuit • Sensor mechanical activation or alignment out of tolerance	• Check the process signal, replace sensor if necessary • Check the configured discrepancy time • Check the wiring • Check that both sensors are mounted and aligned to be activated together
16x0301	Discrepancy failure, channel state 0/1	F-DI 4/F-DQ 2 digital inputs	External discrepancy failure: Channel state 0/1 with 1oo2 equivalent configuration		
16x0302	Discrepancy failure, channel state 1/0	F-DI 4/F-DQ 2 digital inputs	External discrepancy failure: Channel state 1/0 with 1oo2 equivalent configuration		
16x0303	Discrepancy failure, channel state 1/1	F-DI 4/F-DQ 2 digital inputs	External discrepancy failure: Channel state 1/1 with 1oo2 nonequivalent configuration		
16x0306	Internal sensor supply short-circuit to P	F-DI 4/F-DQ 2 digital inputs	Module-provided sensor supply voltage shorted to P	• Sensor supply shorted to P • Short-circuit test duration configured too short • Failed sensor supply	• Eliminate the short-circuit • Increase short-circuit test duration • Replace the fail-safe module
16x0307	Overload or internal sensor supply short-circuit to ground	F-DI 4/F-DQ 2 digital inputs	Internal sensor supply voltage shorted to M, ground, or excessive load on sensor supply	• Short-circuit • Excessive load on sensor supply • Failed sensor supply	• Eliminate the short-circuit • Reduce load on sensor supply • Replace the fail-safe module
16x030D	F-address memory not accessible	Module	The memory where the F-address is stored is not accessible	• eCoding plug is missing • eCoding plug is defective	• Install an eCoding plug into X40 of the module • Replace the defective eCoding plug
16x030E	No valid F-address available	Module	Fail-safe address is not valid (F-address and CRC inconsistent)	• eCoding plug has never been assigned a PROFIsafe address • eCoding plug is defective	• Assign the PROFIsafe Address • Replace the eCoding plug
16x0311	Frequency too high	F-DI 4/F-DQ 2 digital outputs	Switching frequency exceeded; readback not in time	Process value from safety program changing too rapidly for module to follow	Change Safety program logic to guarantee more time between output changes
16x0312	Undertemperature	Module	• Under-temperature at microcontrollers • Under-temperature at I/O	Shutdown due to violation of low temperature limit value in the module case	• Check the ambient temperature • Once the fault has been eliminated, switch the power off and on

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Event ID	Diagnostic message	F-DI 4/F-DQ 2 Fail-Safe module	Description	Possible causes	Corrective measures [1]
16x0313	Failure in the input circuit	F-DI 4/F-DQ 2 digital inputs	Internal fault at the read circuit/test circuit	• The module digital inputs detect a failure during bit pattern testing of inputs • EMI or module hardware fault	• If intermittent, it is probably due to interference; eliminate the interference • If persistent, or repeats after efforts to eliminate interference, replace the fail-safe module
16x031C	Input shorted to P	F-DI 4/F-DQ 2 digital inputs	Input shorted to P failure	• External wiring or sensor shorts input signal to L+ • Input configured for internal sensor supply with short-circuit detection enabled, but wired to external L+ • Input defective	• Check/correct external short-circuit • Make wiring and configuration agree • Replace the fail-safe module
16x031E	Read back failure	F-DI 4/F-DQ 2 digital outputs	The module has detected a channel problem where the expected terminal voltage(s) are not reached	• "Maximum readback time" or "Maximum readback time switch on test" configured value is too small • Output switch failure	• Increase readback time • Replace the fail-safe module if output does not respond
16x0320	Overload	F-DI 4/F-DQ 2 digital outputs	Overload condition at the output driver that leads to passivation of the channel	Overload at output	Eliminate overload
16x0321	Supply or load voltage too high	Module	Supply voltage (1L+) or load voltage (2L+) maximum exceeded	Supply or load voltage is set too high	Adjust supply or load voltage
16x0322	Supply or load voltage too low	Module	Supply voltage (1L+) or load voltage (2L+) minimum exceeded	Supply or load voltage is set too low	Adjust supply or load voltage

[1] Once the fault is eliminated, reintegrate the fail-safe module (return to normal state) from passivation into the safety program.

Electromagnetic interference and diagnostic reports

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not apparently relate to an identifiable device failure, wiring problem, programming, or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load inrush currents.

Technical specifications

7

7.1 Specifications

	6ES7146-5FF00-0BA0
General information	
Product type designation	F-DI 4+F-DQ 2x24VDC/2A, 4xM12
HW functional status	FS01
Firmware version	V1.0.x
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	Step 7 V17 or higher
Operating mode	
DI	Yes
DQ	Yes
Supply voltage	
Load voltage 1L+	
Rated value (DC)	24 V
permissible range, lower limit (DC)	20,4 V
permissible range, upper limit (DC)	28,8 V
Reverse polarity protection	Yes; against destruction
Load voltage2 L+	
Rated value (DC)	24 V
permissible range, lower limit (DC)	20,4 V
permissible range, upper limit (DC)	28,8 V
Reverse polarity protection	Yes; against destruction; outputs applied with reversed polarity for loads connected between M-switch and 2L+ will conduct
Input current	
Current consumption (rated value)	55 mA (1L+) / 40 mA (2L+); without load
from load voltage 1L+ (unswitched voltage)	4 A; Maximum value
from load voltage 2L+, max.	4 A; Maximum value
Encoder supply	
Number of outputs	2
24 V encoder supply	
Short-circuit protection	Yes; per load voltage, electronic (response threshold 0.7 A to 1.7 A)
Output current, max.	1 A; total current of all encoders, max. 0.5 A per load voltage; maximum of 2.0 V drop
Power loss	
Power loss, typ.	4,7 W

	6ES7146-5FF00-0BA0
Digital inputs	
Number of digital inputs	4
Input characteristic according to IEC 61131	Type 1
Number of simultaneously controllable inputs	
all mounting positions	
up to 55 °C, max.	4
Input voltage	
Rated value (DC)	24 V
for signal "0"	-30 to +5 V
for signal "1"	+15 to +30 V
Input current	
for signal "1", typ.	4,85 mA
Input delay (for rated value of input voltage)	
for standard inputs	
parameterizable	Yes
at "0" to "1", min.	0,8 ms
at "0" to "1", max.	12,8 ms
at "1" to "0", min.	0,8 ms
at "1" to "0", max.	12,8 ms
Cable length	
unshielded, max.	30 m
Digital outputs	
Number of digital outputs	2
in groups of	2
Short-circuit protection	Yes; per channel, electronic
Response threshold, typ.	10 A; measured at M-switch, threshold for P-switch is higher
Open-circuit detection	Yes; per channel, only detects when output is off
Overload protection	Yes
Response threshold, typ.	3,4 A; measured at P-switch
Limitation of inductive shutdown voltage to	P-switch: -26 V DC referenced to 2M, M-switch: +48 V DC referenced to 2M
Switching capacity of the outputs	
on lamp load, max.	10 W
Load resistance range	
lower limit	12 Ω
upper limit	2 kΩ
Output voltage	
for signal "1", min.	L + (-2.0 V), P-switch is L+ (-1.5 V), M-switch is 0.5 V
Output current	
for signal "1" rated value	2 A
for signal "0" residual current, max.	0,5 mA
Switching frequency	
with resistive load, max.	30 Hz
with inductive load, max.	0,1 Hz
on lamp load, max.	10 Hz

	6ES7146-5FF00-0BA0
Total current of the outputs	
Current per group, max.	4 A
Cable length	
unshielded, max.	30 m
Encoder	
Connectable encoders	
2-wire sensor	No
permissible quiescent current (2-wire sensor), max.	0.5 mA
Interrupts/diagnostics/status information	
Substitute values connectable	No
Alarms	
Diagnostic alarm	Yes; Parameterizable
Diagnoses	
Monitoring the supply voltage	Yes
Wire-break	Yes; outputs when off
Short-circuit	Yes; inputs, outputs, encoder supply
Diagnostics indication LED	
Channel status display	Yes; green LED
for channel diagnostics	Yes; red LED
for module diagnostics	Yes; green/red LED
For load voltage monitoring	Yes; green LED
Potential separation	
between the load voltages	Yes
Potential separation channels	
between the channels. in groups of	4 DI channels are isolated from 2 DQ channels
between the channels and backplane bus	Yes
between the channels and the power supply of the electronics	DI channels are not isolated from supply voltage 1L+ and DQ channels are isolated from supply voltage 1L+
Isolation	
Isolation tested with	707 V DC (type test)
Degree and class of protection	
IP degree of protection	IP65/67
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
Performance level according to ISO 13849-1	PLd (DI single-channel), PLe (DI two-channel, DQ)
Category according to ISO 13849-1	Cat. 3 (DI single-channel), Cat. 4 (DI two-channel, DQ)
SIL acc. to IEC 61508	SIL 2 (DI single-channel), SIL 3 (DI two-channel, DQ)
Probability of failure (for service life of 20 years and repair time of 100 hours)	
Low demand mode: PFDavg in accordance with SIL2	< 1.0E-03 DI single-channel; < 1.0E-03 DQ with dark test disabled
Low demand mode: PFDavg in accordance with SIL3	< 1.0E-05 DI two-channel; < 2.0E-05 DQ with dark test enabled

	6ES7146-5FF00-0BA0
High demand/continuous mode: PFH in accordance with SIL2	< 1.0E-08 1/h DI single-channel; < 1.0E-07 1/h DQ with dark test disabled
High demand/continuous mode: PFH in accordance with SIL3	< 1.0E-09 1/h DI two-channel; < 1.0E-08 1/h DQ with dark test enabled
Ambient conditions	
Ambient temperature during operation	
min.	-30 °C
max.	55 °C
Connection method	
Design of electrical connection for the inputs and outputs	M12, 5-pin
Design of electrical connection for supply voltage	M8, 4-pin
ET-Connection	
ET-Connection	M8, 4-pin, shielded
Dimensions	
Width	45 mm
Height	159 mm
Depth	40 mm
Weights	
Weight, approx.	220 g

Dimension drawing

A

A.1 Dimension drawing

The figure below shows the dimension drawing of the F-DI 4/F-DQ 2 Fail-Safe module in front and side views. The dimensions are in mm.

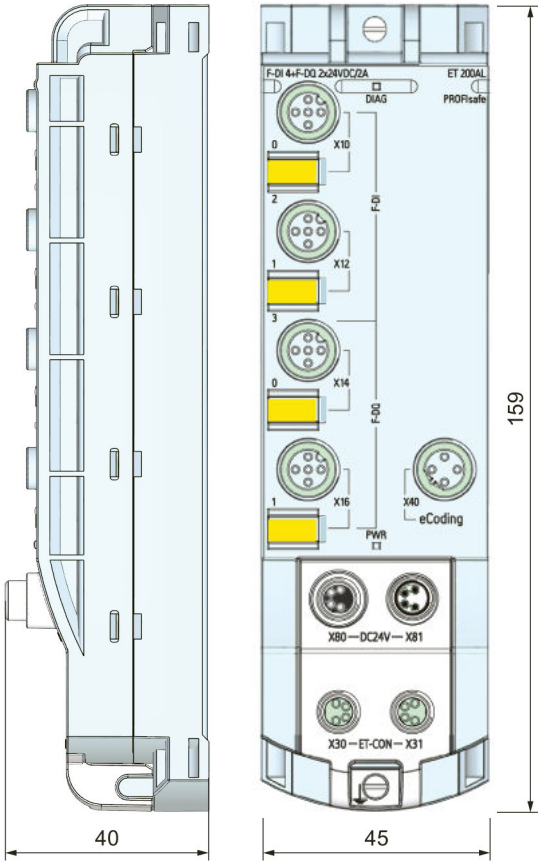


Figure 1-725 Dimension drawing

Response times

B

B.1 Maximum response time

This section shows the response times of the F-DI 4/F-DQ 2 Fail-Safe module. The response times are included in the calculation of the F-system response time.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the ET-Connection and the signal change at the digital output.

Times required for the calculation

Maximum cycle time: T_{cycle} = 23 ms

Maximum acknowledge time (Device Acknowledge Time): T_{dat} = 18 ms

You assign the "Maximum readback time" and "Maximum readback time switch on test" settings in STEP 7.

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (http://support.automation.siemens.com/WW/view/en/49368678/133100)" Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{cycle} parameter values given above include an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you can include in your calculations.

B.2 Response time parameters for the F-DI 4/F-DQ 2 digital inputs

Maximum Device Acknowledge Response Time of the F-DI 4/F-DQ 2 Fail-Safe module digital inputs

1oo1 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$

$T_{OFDT_i} = T_{WCDT_i} + T_{scf}$

1oo2 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$

$T_{OFDT_i} = T_{WCDT_i} + MAX (T_{scf}, T_{dis})$

Where:

T_{cycle}	Internal cycle time of the fail-safe module
T_{dis}	Discrepancy time: • Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" • Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior You should include the expected discrepancy time between your sensor inputs in your external sensor delay. Your configured T_{dis} contributes to T_{OFDT_i} as the time delay for the fail-safe module's digital inputs to passivate the channel due to fault case extension of the discrepancy time. This parameter can be listed separately in the RT_calculator. Do not include T_{dis} in the value of T_{OFDT_i} that you enter into the RT_calculator if you enter T_{dis} as a separate item.
T_{filter}	Configured "Input filters" time for the channel
T_{OFDT_i}	One Fault Delay Time: Maximum response time for the fail-safe module's digital input to report a channel as passivated
T_{scf}	Time delay for short-circuit fault duration: • Configured "Interval for short-circuit test", when operating in high demand or continuous mode and depending on the short-circuit test to achieve your required level of safety integrity • "0" when not depending on the short-circuit test to achieve your required level of safety integrity
T_{sct}	Time delay for short-circuit test duration: • "0" if no short-circuit test configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in equation for T_{WCDT_i} if short-circuit test is configured.)
T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the reliable availability of the safety message frame available for the fail-safe CPU request

The term "2 x T_{cycle}" for "maximum response time of the fail-safe module" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

B.3 Response time parameters for the F-DI 4/F-DQ 2 digital outputs

Maximum response time of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs

$T_{WCDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

$T_{OFDT_q} = T_{WCDT_q}$

When dark testing is disabled, a channel fault might not be detected until a process value change "1" to "0" takes place on the corresponding output. When dark testing is disabled and the process value is "1" for a given channel, the respective output switches are not manipulated by the various safety measures.

Where:

T_{cycle}	Internal cycle time of the fail-safe module
T_{OFDT_q}	One Fault Delay Time: Maximum response time for the module's digital outputs to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel
T_{WCDT_q}	Worst Case Delay Time: Maximum response time of the fail-safe module's digital output DC from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output

The term "2 x T_{cycle}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

After the fail-safe module's digital outputs command the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Minimum permissible OFF time for F-DI 4/F-DQ 2 Fail-Safe module digital outputs

The fail-safe module's digital outputs expect to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than T_{WCDT_q} can cause the channel to passivate.

Switching of loads

C

C.1 Connecting capacitive loads

If an F-DI 4/F-DQ 2 Fail-Safe module is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

Load capacitance can delay the voltage response as seen at the P- and M-switches of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs. For a capacitive load with capacitance C across P and M, and a parallel load resistance R, the "Maximum readback time" needs to be in the range of 2.0 to 2.5 time constant (R * C) of the load. This allows enough time for an appreciable voltage change to be seen when you briefly de-energize an energized load during bit pattern testing. If the resulting "Maximum readback time" is too long for your application, you can reduce this time constant by adding parallel resistance across the load to reduce the realized R * C time constant.

Alternatively, you can add a diode between the P-output and the load (capacitor and resistors) so that when you turn off the output, the voltage on the capacitor is not present at the P-output. Typically, power supplies with input capacitors that have reverse voltage protection have this diode built into the power supply. Using the added diode, you can greatly reduce the "Maximum readback time" to some portion of the hold-up time of the power supply/capacitor. This reduced "Maximum readback time" allows the load to operate normally (load stays ON) during the bit pattern tests.

Stray capacitance between the load circuit and ground, M, and P increases the time required for the "Maximum readback time switch on test". When module diagnostics switch "ON" a P- or M-switch to a de-energized load during bit pattern testing, both sides of the load are driven towards L+ or M, limited by stray capacitance. This effect is typically small.

Your "Maximum readback time switch on test" setting should be long enough for the load circuit voltage to react, but short enough that if one side of the load faults to P or M, testing of the opposite switch should not cause the load to mechanically react.

Capacitive loads (including power supplies with input capacitors) with low series resistance can have a large inrush current. If you have a large capacitive load, you should add series resistance to reduce the inrush current to reduce the risk of opened fuses or overcurrent fault detection on normal load switch ON events.

C.2 Switching of inductive loads

The diagram below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the F-DI 4/F-DQ 2 Fail-Safe module digital outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the F-DI 4/F-DQ 2 Fail-Safe module digital output switch. External suppression conducts the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression.

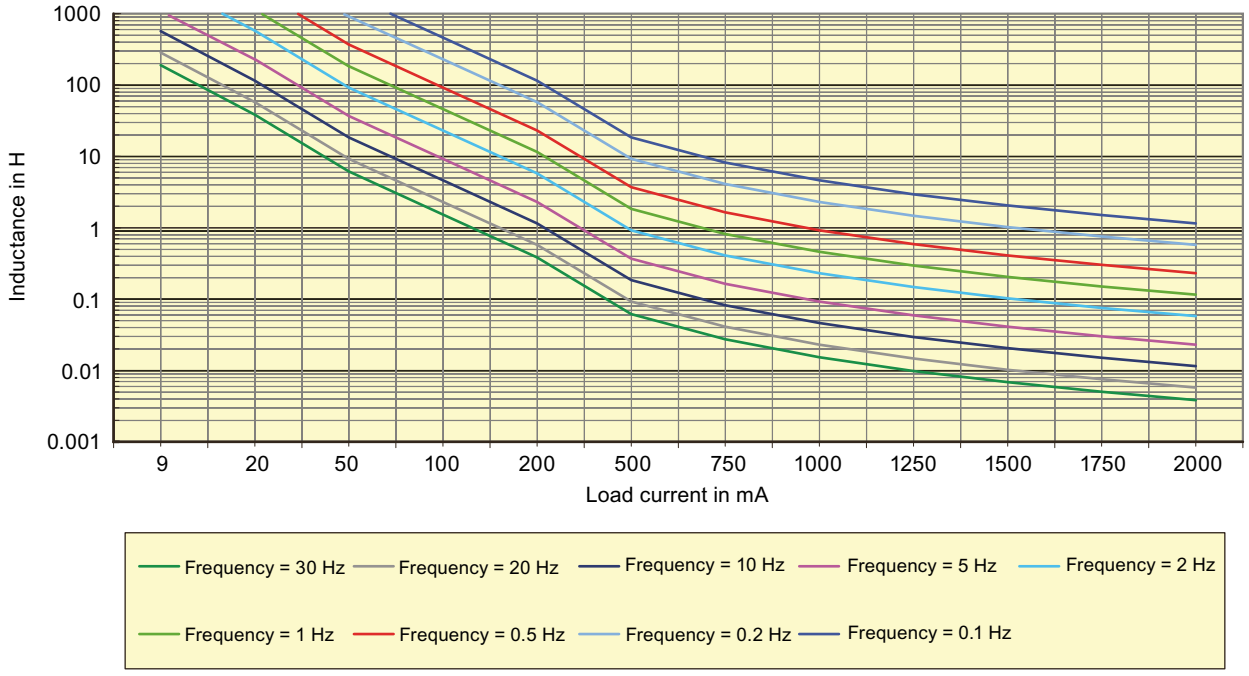


Figure 1-726 Switching of inductive loads for the F-DI 4/F-DQ 2 Fail-Safe module depending on the load current and switching frequency

⚠ WARNING

Unsuppressed inductive loads can lead to failures.
The following failures can result:

- Unsuppressed inductive loads can lead to early "stuck-on"' failures of the fail-safe module digital outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
You should use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.

SIEMENS

SIMATIC
ET200
Update to the ET 200AL F-DI 4 + F-DQ 2x24 VDC/2A, 4xM12 Manual, edition 03/2022

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Overview to Documentation Update for the ET 200AL F-DI 4 + F-DQ 2x24 VDC/2A, 4xM12

In spite of efforts to ensure the accuracy and clarity in the product documentation, some of the pages in the *ET 200AL System Manual* contain information that has been identified as being incomplete, incorrect or misleading.

Scope of the product information
This product information includes amendments and corrections to the documentation of the *ET 200AL System Manual*. The statements provided herein should be considered to be more up-to-date than other documentation if uncertainties arise.

This document contains the following updates

- Addition of statement for use of radio devices and cell phones in reading ID Link (Page 1)
- Update to statement for eCoding plug installation (Page 2)

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Addition of statement for use of radio devices and cell phones in reading ID Link

The following Warning is applicable to the ET 200AL F-DI 4 + F-DQ 2x24 VDC/2A, 4xM12:

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones

Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.

If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.

Power off radio devices in the immediate proximity of the F-I/O.

Update to statement for eCoding plug installation

The text in Section 3.3, "Connecting the M12 eCoding plug", has been corrected as follows:
The statement "The eCoding plug must be installed before power is applied to the module." now precedes the statement "You use the eCoding plug to facilitate module replacement." Further, the statement "You use the eCoding plug to facilitate module replacement" now reads "You also use the eCoding plug to facilitate module replacement."

SIEMENS

SIMATIC
ET200
Product Information for ET 200AL F-IO Firmware Update V1.0.1

Product Information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Description

Description
The firmware update V1.0.1 for the ET 200AL F-IO module is now available.

The firmware update includes the following features:

- Corrections for problems with the delivery of diagnostic messages. In some situations, diagnostic messages for resolved fault conditions were not successfully delivered by the module.

Refer to the ET 200AL System Manual (https://support.industry.siemens.com/cs/us/en/view/95242965) for more information about the ET 200AL product family. Refer to the the description on the Internet (https://support.industry.siemens.com/cs/us/en/view/109475743) of how to perform a firmware update for the SIMATIC ET 200AL.

NOTE

You cannot accomplish firmware update V1.0.1 by means of a SIMATIC Memory Card installed in a CPU. Please use one of the following approaches:

- Online via PROFINET (with STEP 7)
- Via the integrated web server of an F-CPU
- Via the SIMATIC Automation Tool

Table: Models affected by ET 200AL F-IO firmware update V1.0.1

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ET 200AL model	Description	Article number
ET 200AL F-IO	ET200AL F-DI 4+F-DQ 2x24VDC/2A, 4xM12	6ES7146-5FF00-0BA0

SIEMENS
SIMATIC

Distributed I/O system ET 200eco PN/ET 200eco PN M12-L

Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function
SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity

- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=444&ci=5596).

Firmware
You will find the latest firmware versions (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/search?t=all&search=ET%20200eco%20PN&type=Download&lc=en-WW).

Documentation
The complete documentation consists of product information, the system manual, equipment and function manuals. You can find these in the Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/109781058) on the Internet.

Retention of the documentation
Retain this documentation for later use.

1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058) and on the nameplate of the device.

NOTE
The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Install products with degree of protection IP65/67 according to IEC 60529 weatherproof and stationary.

⚠ WARNING

Safety functional extra low voltage
The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058) of the fail-safe I/O and in the data sheets of the power supplies to be used.
Use a power supply unit with output voltage that does not exceed 35 V DC even in the event of a fault.
Follow the notes and warnings in the respective manual.

Electromagnetic Compatibility
The I/O system is intended for operation in the EMC environment class Industry.
Ensure an EMC-compliant design of your automation system as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058) for the I/O system.

NOTICE

Interference emission / Interference immunity
The operation of the I/O system can cause radio interference in residential areas.
If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

ATEX-/UKEX device intended for use in hazardous area
If the product is intended for use in a potentially explosive atmosphere (gas/air or gas/dust mixture), observe the special information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058). The intended use (e.g. ATEX zone, degree of protection, temperature class) is indicated on the product (in the declaration of conformity and usually also on the nameplate).

NOTE

As a rule, country-specific requirements for the operator also apply when a product is used in a potentially explosive atmosphere (e.g. Directive 1999/92/EC for the EU).

Safety in potentially hazardous atmospheres
SIMATIC systems are suitable for use in zones with occasional presence of hazardous gas atmospheres (equipment group II, Cat. 3, gases, vapors, mists). You can find information, restrictions and special conditions in the respective system manuals. To avoid damage, determine a suitable installation location and select suitable products. It is mandatory to define the following points before planning your automation system:

- Hazardous plant areas
- Potentially existing atmosphere
- Relevant requirements for the products

⚠ WARNING

Explosion hazard
If work in areas with potentially hazardous atmospheres is not carried out correctly, an explosion may occur. Explosions can lead to serious personal injury or damage to the plant.
Only suitably qualified specialists are allowed to plan and perform activities in areas with potentially hazardous atmospheres.
In hazardous areas, always de-energize the SIMATIC system before starting activities.

Cleaning
When wired, the product complies with degree of protection IP65/IP67 and does not require any cleaning.
If you do have to clean the product, then use a dry or damp cloth. Take care to comply with the conditions of degree of protection IP65/IP67 when cleaning with liquids.

Maintenance and repair
The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal
For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058).

Functional safety

⚠ WARNING

Danger to humans and the environment
To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components. For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109781058).

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether the firmware version is approved for the respective fail-safe I/O.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

2 Use of radio devices and cell phones

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones

Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.

If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.

Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

SIEMENS

SIMATIC

ET 200eco PN
Distributed I/O system ET 200eco PN M12-L

System Manual

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Introduction

1

Purpose of the documentation

This documentation provides you with important information on configuring, installing, wiring and commissioning the SIMATIC ET 200eco PN M12-L distributed I/O devices.

The ET 200eco PN M12-L I/O devices are the innovation of the proven product family ET 200eco PN. You can recognize the I/O devices of the new innovation level by the suffix **M12-L**.

Basic knowledge required

This manual requires general knowledge of automation engineering.

This manual contains a description of the components that were valid at the time the manual was published. We reserve the right to issue a Product Information which contains up-to-date information about new components and new versions of components.

Validity of the documentation

This documentation applies to the SIMATIC ET 200eco PN M12-L distributed I/O devices.

Safety of the plant or the system

Safety is the responsibility of the assembler
The safety of any plant or system incorporating the equipment is the responsibility of the assembler of the plant or system.

Conventions

Also observe notes marked as follows:

NOTE

A note contains important information:

- On the product described in the documentation
- On handling the product
- On the part of the documentation to which special attention is drawn, as this can result in damage.

Standards

You can find a dated reference to the respective standards or the EU Declaration of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=444&ci=526).

ID Link for the digital nameplate



Figure 1-727 ID Link example DI 16x24VDC 8xM12

The ID Link is a globally unique identifier according to IEC 61406, which you will find in the future as a QR code on your product.

The figure shows an example of an ID Link for the I/O device digital inputs DI 16x24VDC 8xM12.

You can recognize the ID Link by the frame with a black frame corner at the bottom right. The ID Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner or reader app. Call the ID Link.

In the digital nameplate, you will find product data, manuals, Declarations of Conformity, certificates, and other helpful information about your product.

Additional support

- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps).
- You can find more information in section SiePortal (Page 7).

1.1 SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**
  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).
- **Product support**
  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**
  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**
  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**
  For answers and solutions concerning automation technology.
- **mySiePortal**
  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

1.2 Guide to ET 200eco PN M12-L

1.2.1 Information classes ET 200eco PN M12-L



The documentation for the SIMATIC ET 200eco PN M12-L distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/de/en/view/109742718).

Basic information



The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200eco PN M12-L distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200eco PN M12-L System Manual
- Online help in the TIA Portal

Device information



Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- I/O Device Digital Inputs Equipment Manuals
- I/O Device Digital Inputs Equipment Manuals
- I/O Device Digital Inputs/Outputs Equipment Manuals
- IO-Link Master I/O Device Communication Module Equipment Manual
- I/O Device Analog Inputs Equipment Manual

General information



The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200eco PN M12-L distributed I/O system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- Function Manual Designing Interference-free Controllers
- IO-Link System Function Manual
- MultiFieldbus Function Manual

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer

- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 S7 Port Configuration Tool (S7-PCT)

SIMATIC S7-PCT

The Port Configuration Tool (PCT) is a PC-based software for the parameter assignment of Siemens IO-Link Master modules and IO-Link devices from any manufacturer.

You integrate IO-Link-devices using the standardized device description "IODD", which you get from the respective device manufacturer. S7-PCT supports version 1.0 and V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link Master from STEP 7. When STEP 7 is not used or the IO-Link Master is not operated on a SIMATIC controller, "standalone"-operation is also possible.

You can find additional information on IO-Link on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html).

1.2.4 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.2.5 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)
     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:
     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions

2

2.1 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

2.2 Safety related icons for ET 200eco PN M12-L

The following table explains the symbols located on the I/O device with the degree of protection IP65/IP67 and IP69K, on its packaging or in the accompanying documentation.

Symbol	Meaning
	General warning sign **Caution/Notice** You must follow the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
	The assigned safety symbols apply to devices with Ex approval. You must follow the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
	General warning sign **Hot surface** The surface of I/O modules with the marking 'Hot surface' can heat up significantly during operation.
	Read the information provided by the product documentation. ISO 7010 M002
	Be aware that the device is only approved for the industrial field and only for indoor use.
	Ensure the device is only installed by an electrically skilled person. IEC 60417 No. 6182

Symbol	Meaning
	Note that a device of Protection Class III can only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-DB symbol 5180 "Class III equipment"
	Note that the device must be constructed and connected in accordance with EMC regulations.
	Note that connected lines must be designed according to the expected minimum and maximum ambient temperature.

2.3 Intended use

The system is used to control machines and plants.

Intended use also includes observance of this documentation, in particular the safety instructions and conditions of use. See section Technical specifications (Page 84).

2.4 Changes to the device and spare parts

Modifications to the module may affect the safety and the function of the module:

- Do not make any changes or attachments to the module.
- Do not remove or paste over safety instructions on the module.
- Only use original spare parts and accessories.

2.5 Target group and personnel qualifications

All persons working with this module require the following knowledge:

- Contents of this document as well as contents of the enclosed documents.
- Handling the module (after instruction)
- Relevant standards and regulations
- Accident prevention regulations

The following activities are reserved for specially qualified personnel:

Working on electrical parts
Work on electrical parts may only be performed by the following persons:

- Qualified electricians
- Persons trained in electrical engineering under the direction and supervision of qualified personnel.

Commissioning and configuration
Commissioning and configuration requires general knowledge in the field of automation technology.

2.6 Working on electrical parts

Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 16)).

- Always observe the country-specific safety rules.
- Notify all those who will be affected by the procedure.
- Follow the 5 safety rules according to DIN EN 50110-1 (VDE 0105-1):

1. Disconnect
2. Secure to prevent reconnection
3. Verify safe isolation from the supply (all poles)
4. Ground and short-circuit
5. Erect barriers around or cover adjacent live parts

After completing work:

- Restore operational readiness in reverse order.

2.7 Residual risks

Despite all the technical and procedural risk reductions that have been carried out, not all dangers can be avoided. The following sections describe these residual risks and measures to avoid them.

2.7.1 Live parts

Operation

- Do not open the module.
- Do not use damaged modules.
- Pull the plug and not the cable.

Installation and connection

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 16)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 17))
- Fuse the connection cables according to the current-carrying capacity of the cable used, taking into account the applicable standards.
- Ground the module according to regulations.
- For the 24 V DC supply (SELV/PELV), only use power supply units that provide safe electrical extra-low voltage in accordance with IEC 61131-2 or IEC 61010-2-201.

Maintenance

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 16)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 17)).

2.7.2 Conductive pollution

Malfunctions may occur if electrical energy is transmitted via conductive soiling.
Seal unused connections with a suitable and approved sealing cap.

2.7.3 Overheating

Smoke development and fire due to overheating of module and cables may result in burns and life-threatening injuries (death).

To avoid overheating:

- Ensure the correct installation position.
- Ensure sufficient air supply (e.g. observe mounting clearances).
- Only use undamaged cables.
- Only use correctly dimensioned cables.
- Ensure that the cable protection is dimensioned correctly.

Installation and connection

- Follow the instructions for the mounting position.
- Adhere to the specified ventilation clearances.
- Fuse the connecting cables according to the cable cross-section.
- Ensure for the connection that the overvoltage protection is sufficient.

Maintenance

- Check plug-in connections and cables regularly for damage.

2.7.4 Unsafe operating states

Unsafe operating states may result in personal injury of unknown extent.
The following factors can be triggers:

- Manipulation of the software, e.g. viruses, trojans or worms.

Manipulation of the software, e.g. viruses, trojans or worms.

- Adhere to the protective measures against tampering with the software (see section Industrial cybersecurity (Page 100)).
- Perform available updates in a timely manner.
- Protect files stored on removable media from malware with appropriate protective measures, e.g. virus scanner.
- Set up access protection for the CPU.

2.8 Behavior in case of emergency

The safety of any plant or system incorporating the equipment is the responsibility of the assembler of the plant or system. If an emergency occurs in the plant or the system, follow the instructions of the assembler and operator.

When the safe operating state has been restored, the person responsible for the plant ensures that the system starts up in a controlled manner.

2.9 Material damage

2.9.1 Transport and storage

- Only pack, store, transport and ship electronic components, modules or devices in the original product packaging or in other suitable materials.
- Observe the limits during transport and storage. See section Technical specifications (Page 84).

2.9.2 Installation and connection

Ensure for the connection that the overvoltage protection is sufficient.

Installation/disassembly with voltage switched on

- Install the ET 200eco PN M12-L distributed I/O devices only with disconnected supply and load voltages.
  Refer to section Mounting (Page 29)
- If you connect or disconnect the I/O devices with the power connected, this can lead to undefined states in your system.
  As a result material damage may occur at the distributed I/O device ET 200eco PN M12-L.
  Only remove or replace the I/O device when the voltage is switched off. Always comply with the required standards and safety guidelines when configuring a system.

Refer to section Maintenance (Page 77)

- When disconnecting plug-in connections during running operation, personal injury and material damage may occur in potentially explosive atmospheres.
  In potentially explosive atmospheres, de-energize the ET 200eco PN M12-L I/O device before disconnecting plug connections.

  Observe the special conditions for hazardous areas in these sections:

  – Codes and approvals (Page 84)
  – Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas (Page 98)

New properties/functions

3

3.1 Changes compared to previous version

What's new in the ET 200eco PN M12-L System Manual, 08/2025 edition compared to the 11/2024 edition?

What's new?		What are the customer benefits?	Where can I find information?
New contents	ID link	Here you will find a description of the ID link	Section Introduction (Page 6)
	Importer addresses	You can find the importer addresses for specific countries here.	Section Standards and requirements (Page 89)
	SIMATIC ET 200eco PN M12-L data	This section provides an overview of the data that is generated by the SIMATIC ET 200eco PN M12-L automation system and accessible to you.	Section SIMATIC ET 200eco PN M12-L data (Page 125)
Changed contents	Technical specifications	Various specifications have been adapted in the "Technical specifications" section	Section Technical specifications (Page 84)
	Industrial cybersecurity	The contents relating to measures and protection of your plants and systems against cyber attacks have been modified.	Section Industrial cybersecurity (Page 100)

What's new in the ET 200eco PN M12-L System Manual, 11/2024 edition compared to the 06/2024 edition?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Firmware update and reset to factory settings as of STEP 7 V5.6	The firmware update and the reset to factory settings is possible online with STEP 7 as of version V5.6.	Section Firmware update (Page 79) Section Resetting the I/O device to factory settings (Page 81)
	Temperature of the cables, connectors and plugs for hazardous areas	The requirements for the cables, connectors and plugs for the hazardous area have been modified.	Section Codes and approvals (Page 84)
	Industrial cybersecurity	The contents relating to measures and protection of your plants and systems against cyber attacks have been modified.	Section Industrial cybersecurity (Page 100)
	IP69 accessories	Addition of the accessories with IP69 cable for the power supply.	Section Accessories/spare parts (Page 120)

What's new in the ET 200eco PN M12-L System Manual, 06/2024 edition compared to the 03/2024 edition?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Cleaning the I/O device	Supplementing the description with more details.	Section Cleaning the I/O device (Page 83)
	Shipping and storage conditions	Supplementing the transport condition class and storage condition class.	Section Transport and storage conditions (Page 93)

What's new in the ET 200eco PN M12-L System Manual, 03/2024 edition compared to the 11/2023 edition?

What's new?		What are the customer benefits?	Where can I find information?
New contents	Signed firmware update	A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.	Section Signed firmware update (Page 111)
Changed contents	I/O device technology	The I/O device technology is included in the description and list.	Section What are the SIMATIC ET 200eco PN M12-L distributed I/O devices? (Page 24) Section Wiring (Page 51)
	UL-approved cables	Noted that Siemens offers UL-approved cables for UL applications in the product portfolio.	Section UL-approved cables (Page 123)

What's new in the ET 200eco PN M12-L System Manual, 11/2023 edition compared to the 08/2023 edition?

What's new?		What are the customer benefits?	Where can I find information?
New contents	Approval for hazardous areas	According to the specifications in the information for use, the I/O devices are suitable for Zone 2/Zone 22 hazardous areas.	Starting with section System overview (Page 24)
	Tests for advanced environmental conditions	After approval you use the I/O devices under specific conditions in the outdoors.	Section Mechanical and climatic ambient conditions (Page 94)
	Safety information	The safety instructions are summarized in the new chapter.	Section Safety instructions (Page 15)
	Industrial cybersecurity	The new section contains the specifications and recommendations for the measures with which you can protect your plants and systems against cyber attacks.	Section Industrial cybersecurity (Page 100)

What's new in the ET 200eco PN M12-L System Manual, 08/2023 edition compared to the 03/2023 edition?

What's new?		What are the customer benefits?	Where can I find information?
New contents	Calibrating analog I/O devices	Certain directives require calibration for all components of a measuring circuit at regular intervals.	Section Calibrating an analog I/O device (Page 80)
	IP69K degree of protection	Approval of the IP69K degree of protection means you can now use the I/O devices in a wider range of applications.	Starting with section System overview (Page 24)
Changed contents	Safety-oriented tripping of ET 200eco PN M12-L	With safety-oriented tripping, you can shut down certain outputs of standard devices in a fail-safe manner.	Section Safety-related shutdown of ET 200eco PN M12-L (Page 113)

What's new in the ET 200eco PN M12-L System Manual, 03/2023 edition compared to the 02/2022 edition?

What's new?		What are the customer benefits?	Where can I find information?
New contents	EtherNet/IP	With MultiFieldbus, the I/O devices support the PROFINET IO, EtherNet/IP, and Modbus TCP communication protocols.	Section EtherNet/IP (Page 64)
	Modbus TCP		Section Modbus TCP (Page 65)

System overview

4

4.1 What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?

SIMATIC ET 200eco PN M12-L

The SIMATIC ET 200eco PN M12-L distributed I/O devices are part of a scalable and highly flexible, distributed I/O system for connecting the process signals to a higher-level controller via MultiFieldbus. MultiFieldbus supports the following communication protocols:

- PROFINET IO
- EtherNet/IP
- Modbus TCP

The connection interface is marked PN/MF.

Customer benefits of the system

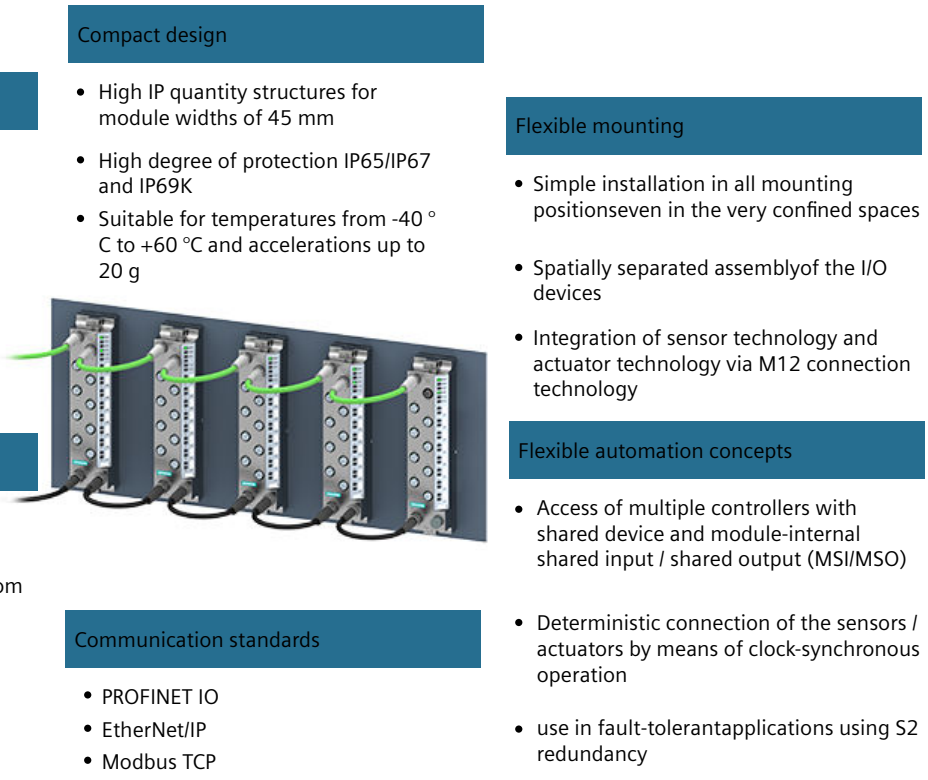


Figure 1-728 ET 200eco PN M12-L benefits

Area of application

The areas of application of the ET 200eco PN M12-L are derived from its special properties.

- A robust design and degrees of protection IP65/IP67 and IP69K make the ET 200eco PN M12-L distributed I/O device suitable for use in harsh industrial environments
- The distributed I/O ET 200eco PN M12-L with the IP54 degree of protection is suitable for use in Zone 2/Zone 22 hazardous areas.
- The compact design of the ET 200eco PN M12-L enables use in confined areas without control cabinets.
- The easy handling of ET 200eco PN M12-L facilitates fast commissioning and maintenance.

Configuration

The SIMATIC ET 200eco PN M12-L distributed I/O system is made up of the following I/O devices:

- I/O device analog inputs
- I/O device digital inputs
- I/O device digital outputs
- Digital inputs/outputs of the I/O device
- I/O device IO-Link Master
- I/O device technology

The I/O devices of the ET 200eco PN M12-L are connected to an IO controller via MultiFieldbus.

Configuration example

The figure below shows an example configuration with the ET 200eco PN M12-L distributed I/O devices in a PROFINET IO network.

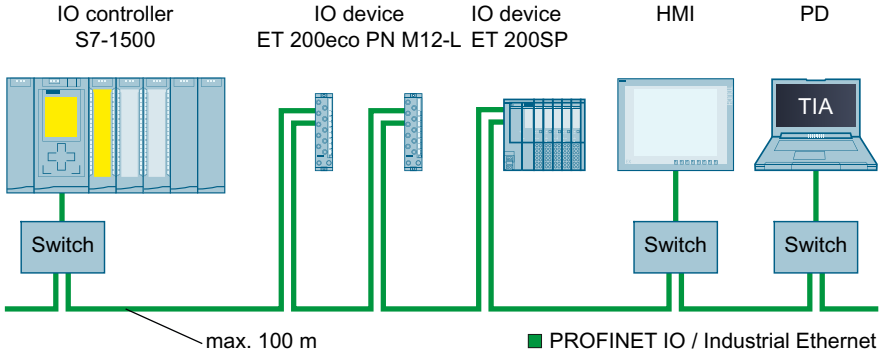


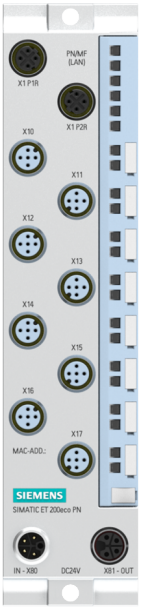
Figure 1-729 Configuration example of the ET 200eco PN M12-L

4.2 Components

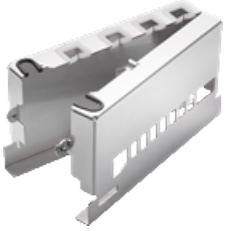
Components of the ET 200eco PN M12-L distributed I/O system

The following table shows and explains the function of the most important components of the ET 200eco PN M12-L distributed I/O system.

Table 1-1006 Overview of components

Component	Function	Figure
I/O device	• The I/O device exchanges data with the IO controller via MultiFieldbus • The I/O device provides the interface to the process • Recording and controlling the current process status via the connected sensors and actuators	
Mounting rail	• Simple installation of several I/O devices next to one another. • Without drilling holes for I/O devices	
Profile screws for mounting rail	• Suitable screw for mounting the I/O device on the mounting rail.	

Component	Function	Figure
Identification labels	• The identification labels come with the module • They can be machine-printed • They can be ordered separately	
Sealing cap	• Caps for unused connections • IP protection class is maintained through use	
PROFINET IO cable and M12-D plug	• Connection to the MultiFieldbus	
Power connecting cable and M12-L plug / coupling	• Connection of supply and load voltages • Looping through of supply and load voltages to other devices	

Component	Function	Figure
Y cable	• Double connection of actuators or sensors to one socket • IP protection class is maintained when 2 actuators or sensors are connected to one socket	
Y-connector	• Double connection of actuators or sensors to one socket • IP protection class is maintained when 2 actuators or sensors are connected to one socket	
Plug cover	• For use in Zone 2 / Zone 22 hazardous area	

Mounting

5

5.1 Basics

Introduction

All ET 200eco PN M12-L distributed I/O devices are designed for IP65/IP67 and IP69K degrees of protection. This means that you can directly mount these I/O devices in your plant. Only use such accessories which are permitted for the required degree of protection.

Mounting position

You can mount the ET 200eco PN M12-L distributed I/O devices in any mounting position.

Minimum clearances

Ensure that the I/O devices are installed with a minimum clearance of 2 cm.

If the installation distance to other devices or objects is less than 2 cm, the ambient temperature must be reduced by 5 K (for example, 60 °C ⇒ 55 °C). This also applies to the derating diagrams in the equipment manuals.

The plug cover is an accessory for protecting the connected connectors on the I/O device. The plug cover may be necessary for use in hazardous areas. If you use the plug cover, the minimum distances from section Installing the plug cover (Page 33) apply.

Simple installation

The ET 200eco PN M12-L distributed I/O devices are designed for easy installation.

- The I/O device should be mounted on a level solid surface.
- The I/O device can be pre-wired.

Mounting rules

When mounting the I/O device, you do not need to following any special rules.

The plug cover is an accessory for protecting the connected connectors on the I/O device. The plug cover may be necessary for use in hazardous areas. If you use the plug cover, the installation rules from section Installing the plug cover (Page 33) apply.

NOTE

Mounting of the I/O devices

Install the ET 200eco PN M12-L distributed I/O devices only with disconnected supply and load voltages.

Configuration variants

There are two mounting variants:

- Without mounting rail
- With mounting rail

You can find additional information in the following sections.

5.2 Mounting without mounting rail

Introduction

The ET 200eco PN M12-L distributed I/O devices are designed for installation on a level, firm surface.

The axially symmetric drill holes allow you to fasten the I/O devices to an aluminum or carrier profile.

The following picture shows an aluminum mounting rail on which the I/O devices can be mounted.

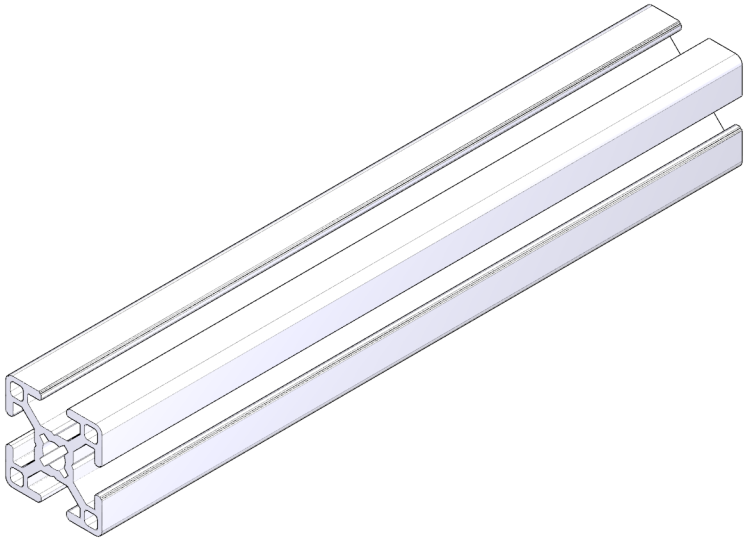


Figure 1-730 Aluminum profile

Required tools

For the installation you need a screwdriver, suitable for the screws used.

Required screws

For mounting, use screws with a diameter of 5 mm and a length of at least 35 mm.

Drill holes of the I/O device

All enclosures of the ET 200eco PN M12-L distributed I/O devices have a uniform hole pattern.

The housings of the I/O devices are axially symmetric. The distance between the drill holes is identical for all I/O devices.

Installing the I/O device

The I/O devices have an attachment point on top and on the bottom. You can also attach the I/O devices to the side.

To install the I/O device, follow these steps:

1. Drill two fixing holes at a distance of 191 mm.
   The drilling hole diameter depends on your chosen installation.
2. Fasten the I/O device with the screws at both fastening points to the flat base surface.
   The torque is 3 Nm

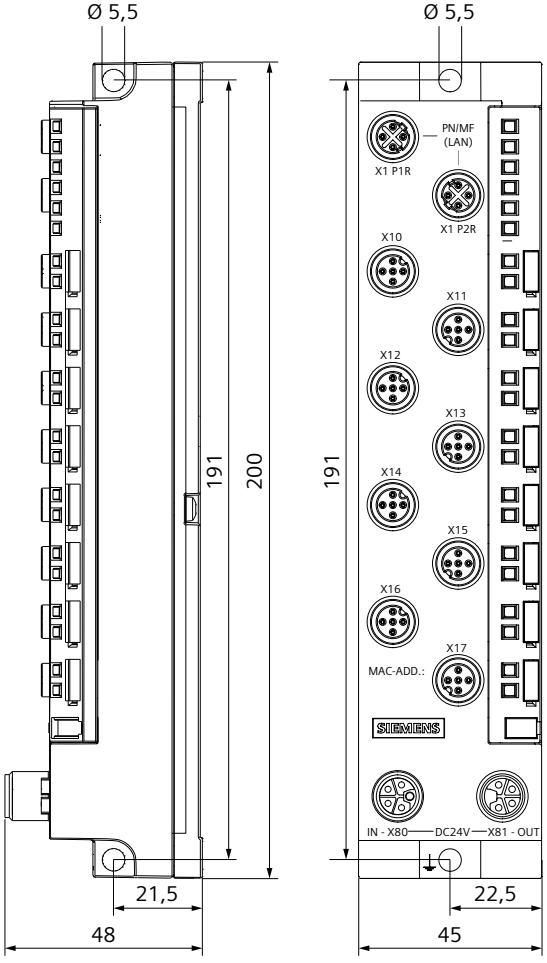


Figure 1-731 Mounting dimensions of the I/O device

5.3 Mounting with mounting rail

Introduction

A suitable mounting rail and profile screws are available as accessories for mounting the I/O devices.

Advantages of the mounting rail:

- Mounting rail can be cut to size for the application
- No drill holes required for the individual I/O devices
- I/O devices can be easily mounted on the mounting rail by simply screwing in the profile screws.

Required tools

For the installation you need a screwdriver, suitable for the screws used.

Required screws

For mounting rail
To mount the mounting rail, use screws with a diameter of 8 mm and a length of at least 20 mm.

For I/O devices on the mounting rail
To mount the I/O device on the mounting rail, use the mounting rail screws for the mounting rail ET 200eco PN M12-L**.**

Version

The mounting rail is available in a length of 500 mm.

Installing the mounting rail

The mounting rail with 500 mm length must be cut to length according to your requirements.

To install the mounting rail with 500 mm length, follow these steps:

1. Drill the mounting holes for screws with 8 mm diameter.
   We recommend that, after an initial distance of 12 mm, the mounting holes be provided at regular intervals of 182 mm.
2. Fasten the mounting rail with the screws.

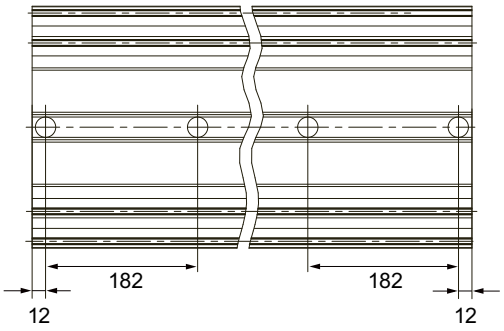


Figure 1-732 Installing the mounting rail

Installing the I/O device

The I/O devices have an attachment point at top and bottom for front mounting and side mounting.

The mounting rail has a groove at the top and bottom in which the profile screws are simply screwed in without drilling.

To install the I/O device, follow these steps:

1. Insert a profile screw through the mounting point of the I/O device and in a groove of the mounting rail.
2. Use the screwdriver to screw the I/O device to the mounting rail.
3. Align the I/O device on the mounting rail.
4. Insert a profile screw through the other mounting point of the I/O device and in the other groove of the mounting rail.
5. Screw the I/O device to the mounting rail. The tightening torque is 1.5 Nm.

Accessories

The accessories for mounting the distributed I/O device can be found in section Accessories/spare parts (Page 120).

5.4 Installing the plug cover

The plug cover is an accessory for protecting the connected connectors on the I/O device. The plug cover may be necessary for use in hazardous areas. Complete the following tasks before installing the plug cover:

- Mounting the I/O device
- Wiring of the I/O device
- Various tests on the system

Mounting rules

The use of the plug cover is possible with the following mounting rules:

- Cables with straight connection of the socket or plug
- Maximum outer diameter of socket/plug is 16 mm
- Maximum per cable holder
  - 3 cables
  - Maximum outer diameter is 7 mm
- Adherence to the minimum clearance
- Maximum 10 mounting and disassembly operations of the cables in the cable holders permitted

Minimum clearances

Maintain the following minimum clearances.

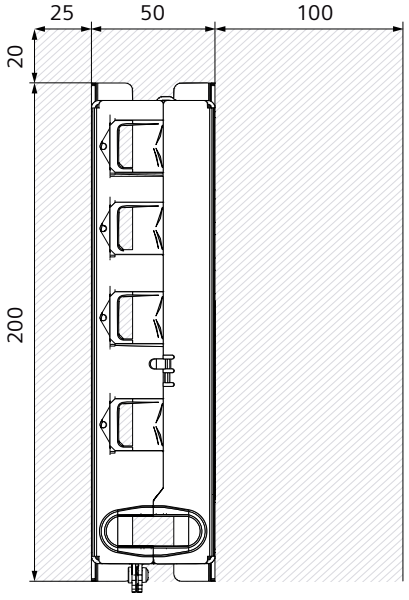


Figure 1-733 Minimum clearances

Dimensions of plug cover

The figure below shows the dimensions of the plug cover.

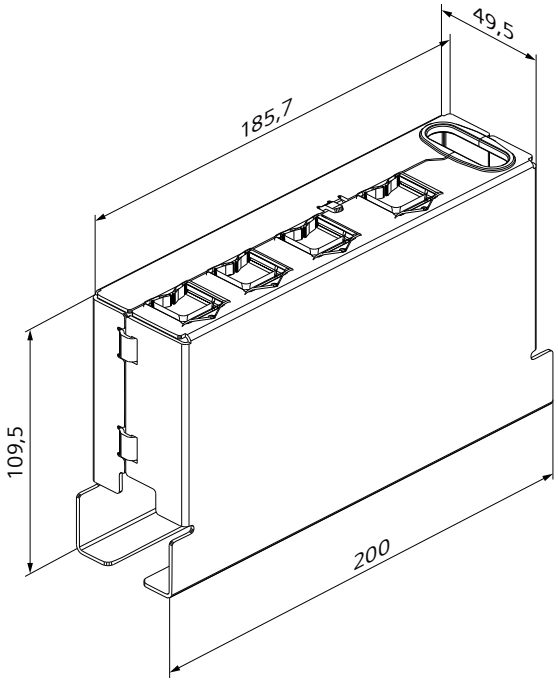


Figure 1-734 Dimensions of plug cover

Requirement

The mounting of the I/O module is prepared according to the description of these sections:

1. Basics (Page 29)
2. The planned mounting variant:
   - Mounting without mounting rail (Page 30)
   - Mounting with mounting rail (Page 32)

Required tools

For the mounting you will need:

- A screwdriver, suitable for the fixing screws used for the module.
- A TX 10 screwdriver for the plug cover

Installing the plug cover

For the installation, follow the steps below.

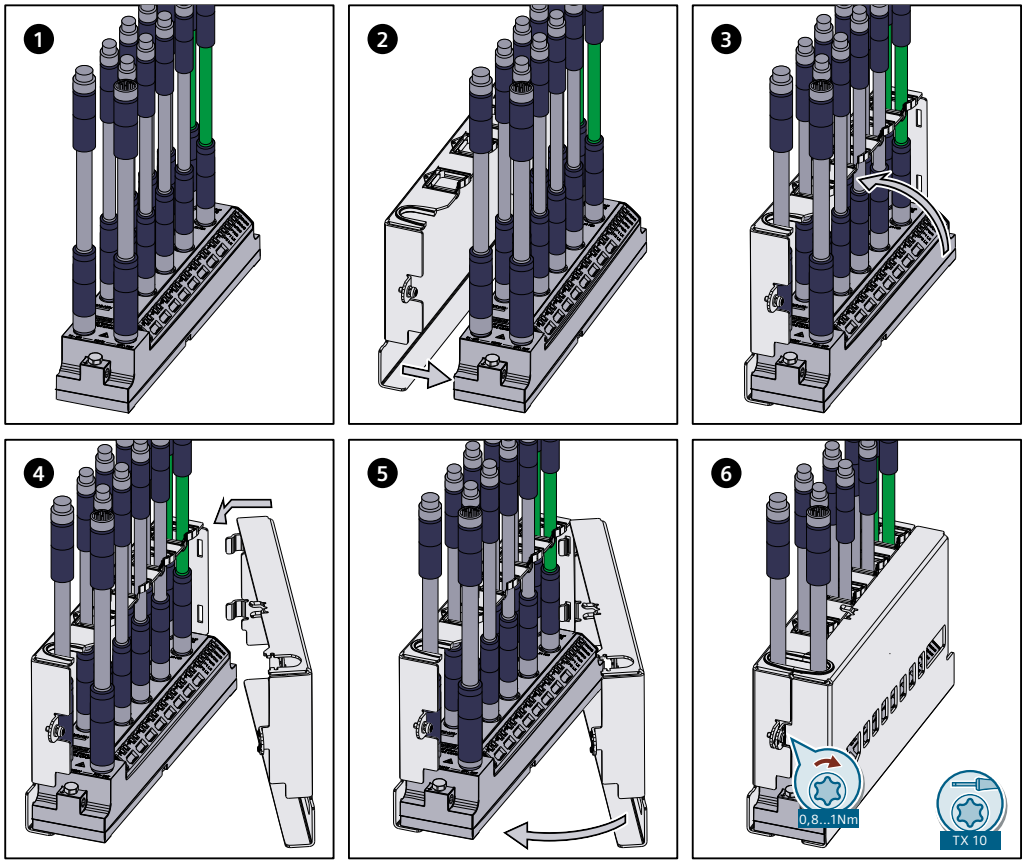


Figure 1-735 Installing the plug cover

1. Loosen the mounting screws of the I/O device
2. Slide the plug cover part with the cable cutouts under the I/O device.
3. Snap the connected cables into the provided cable holders
4. Hook the plug cover with the cutouts for the LED display into the plug cover with the cable cutouts.
5. Close the plug cover.
6. Close the plug cover with the connecting screw. Tightening torque: 0.8 to 1 Nm
7. Screw the cover into place on the I/O device, including the functional ground connection, with the fixing screws

Connecting

6

6.1 Rules and regulations for operation

Introduction

The ET 200eco PN M12-L distributed I/O devices are part of plants and systems. Depending on the area of application, follow the special rules and regulations.

This section provides an overview of the most important rules to be followed for integrating the ET 200eco PN M12-L distributed I/O devices into a plant or a system.

Specific application

Follow the safety and accident prevention regulations applicable to specific applications, e.g. the Machinery Directive.

EMERGENCY-STOP device

Emergency off devices according to IEC 60204-1 (corresponds to DIN VDE 0113-1) must remain effective in all operating modes of the plant or system.

Excluding hazardous system conditions

Hazardous plant states must not occur.

Ensure that dangerous system conditions are excluded, even in the following situations:

- In the event of a voltage dip / power outage
- When the plant restarts after a voltage dip or power outage.
- When the ET 200eco PN M12-L distributed I/O system restarts after interruption of MultiFieldbus communication

If necessary, force the EMERGENCY STOP.

An uncontrolled or undefined startup is not permitted after the "EMERGENCY STOP" is unlocked.

Cables and wires

The cables and lines used including plug must fulfill the following requirements:

- Designed for at least the supply voltage used.
- Conductor cross-section suitable for the application and fusing.
- Designed for a continuous ambient temperature of min. 20K (at 8 A) to 40K (at 12 A) above the ambient temperature of the ET 200eco PN M12-L. Please refer to the "Deratings of the input currents while maintaining the minimum clearance" table and the information enclosed with the cables.

External fuses/switches

External fuses and switches must be installed so that they meet the standards for cable and device protection applicable to your application.

Line voltage

The points to note for line voltage are set out below:

- For stationary plants or systems without an all-pole line disconnector, there must be a disconnector unit (all-pole) fitted in the building installation.
- For load current supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200eco PN M12-L distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

You can find more information in section Details on insulation, protection class, degree of protection and rated voltage (Page 96).

24 V supply

The points to note for 24 V power supply are set out below:

- For buildings:
  If there is a danger due to overvoltages, you must take lightning protection measures for external lightning protection (e.g. lightning protection elements).
- For 24 V DC supply lines and signal lines:
  In the event of danger through overvoltage, you must provide lightning protection measures for internal lightning protection (e.g. lightning protection elements). Additional information can be found in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

- For 24 V DC supply:
  Ensure that there is a safe electrical separation of extra-low voltage (SELV/PELV) according to IEC 61010-2-201 or IEC 60950-1.
  Secure all feeding supply voltages with a UL/IEC approved fuse. This fuse must match the cable cross-section and must not exceed 24 V DC / 12 A.

NOTE

Wet environment
Other SELV/PELV values apply when using the I/O device in wet environments.

The specifications for a correct connection of the I/O device are listed in the System Manual and the device manuals. If you do not comply with the specifications, malfunctions, interferences, failure or destruction of the peripheral device or connected peripherals can result.

Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- To protect against electromagnetic faults, connect the I/O devices to functional earth.
- Ensure correct installation and wiring of the supply, signal lines and bus lines.
- Configure the plant/system in such a way that an error does not result in undefined states.
  - Line/wire break
  - Cross-circuit in the line

Reference

Additional information can be found in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

6.2 Operation on grounded/non-grounded infeed

Introduction

Information is provided below on the overall configuration of an ET 200eco PN M12-L distributed I/O system on a grounded incoming supply (TN-S network). The specific subjects discussed are:

- Disconnecting devices, short-circuit and overload protection to IEC 60364 (corresponding to DIN VDE 0100) and IEC 60204 (corresponding to DIN VDE 0113)
- Load current supplies and load circuits
- Supply voltages of the ET 200eco PN M12-L distributed I/O system

Grounded infeed

In grounded incoming supplies, the neutral conductor of the supply system is grounded. A ground fault between a live conductor and ground or a grounded plant unit causes the protective devices to trip.

Supply voltages

Provide the ET 200eco PN M12-L distributed I/O devices with a SELV/PELV supply voltage for 1L+.
The supplied SELV/PELV load voltage for 2L+ can be switched, depending on the application.

- 1L+: Supply voltage (non-switched)
- 2L+: Load voltage (switched)

Safe electrical isolation (SELV/PELV)

Power packs/power supply modules with safe electrical isolation SELV/PELV are necessary for operating the ET 200eco PN M12-L distributed I/O devices. These power supplies/power supply modules must comply with IEC 61010-2-201 or IEC 60950-1.

The wiring of SELV/PELV circuits must be separated from the wiring of non-SELV/PELV circuits. The insulation of all conductors must be dimensioned for the higher voltage.

NOTICE
Operation in damp / wet environment When operating in a damp / wet environment, voltage limits apply for SELV/PELV andere according to IEC 61010-2-201.

Configuring ET 200eco PN M12-L with grounded reference potential (PELV)

When configuring the ET 200eco PN M12-L distributed I/O devices with grounded reference potential, occurring interference currents are discharged into functional earth. The connections must be externally connected. Establish a connection between 1M or 2M and functional earth.

Configuring ET 200eco PN M12-L with non-grounded reference potential (SELV)

When configuring the ET 200eco PN M12-L distributed I/O devices with grounded reference potential, occurring interference currents are discharged into functional earth via an internal RC network. You do not need external connection between 1M, 2M and functional earth.

Components and protective measures

Various components and protective measures are stipulated for setting up a complete plant. The types of components and the degree to which the protective measures are mandatory depend on the IEC regulation that applies to your plant setup.

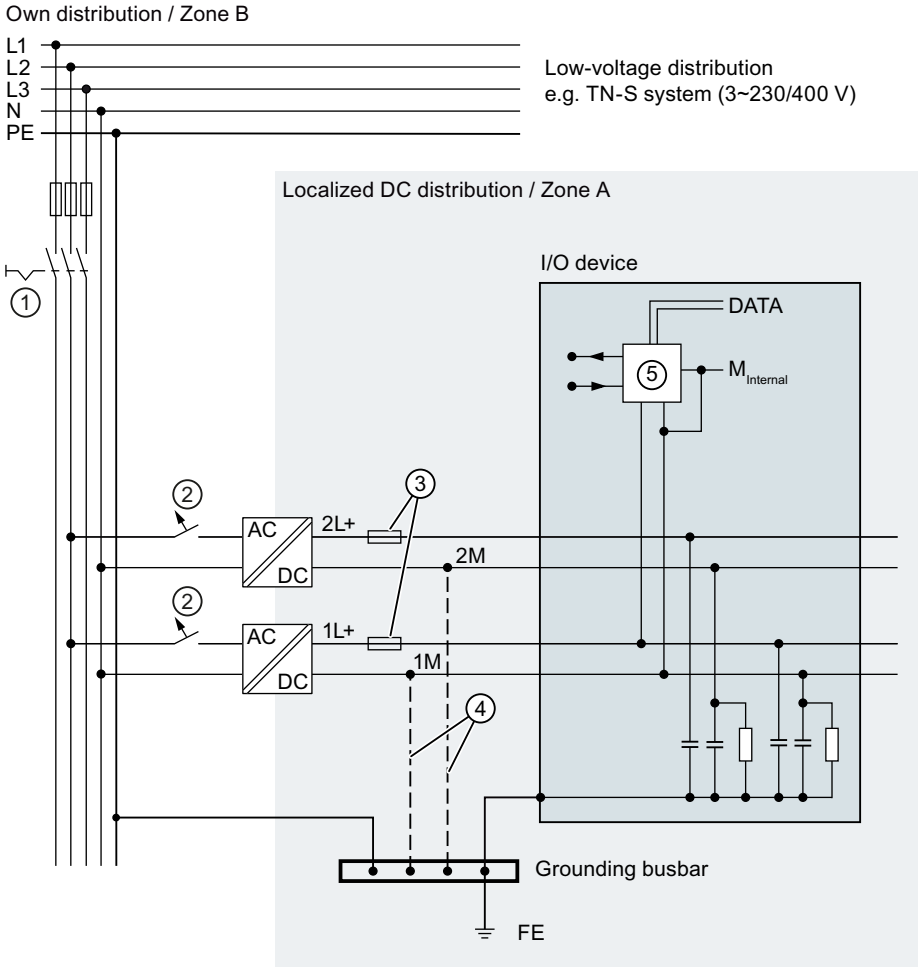
The following table shows the components of the electrical configuration with reference to the "Electrical configuration" figure below and compares the IEC regulations.

Table 1-1007 Components of electrical configuration

	Reference to illustration	**IEC 60364 DIN VDE 0100**	**IEC 60204 DIN VDE 0113**
Disconnection element for controller, sensors, and actuators	①	IEC 60364-4-41 VDE 0100 Part 460: Main switch	IEC 60204-1 VDE 0113 Part 1: Disconnector unit according to VDE 0113-1
Short-circuit / overload protection	②	IEC 60364-5-55 VDE 0100 Part 557: • Grounded secondary circuit: Secure single pole • Non-grounded secondary circuit: Secure all poles Execution according to the line "Cable protection ③"	IEC 60204-1 VDE 0113 Part 1: • Grounded secondary circuit: Secure single pole • Another grounded secondary circuit: Secure all poles
Cable protection	③	IEC 60364-4-41 VDE 0100 Part 460: Protection of cables and wires against overcurrent Protect all incoming supply cables with a circuit breaker.	IEC 60204-1 VDE 0113 Part 1: Overcurrent protection

Overall configuration of ET 200eco PN M12-L

The following figure shows a ET 200eco PN M12-L distributed I/O device with electrical overall configuration.



① Main switch
② Short-circuit and overvoltage protection
③ Fuses for cable protection
④ When configuring the ET 200eco PN M12-L distributed I/O devices with non-grounded reference potential, no connection is made between 1M, 2M and functional earth.
⑤ Circuit logic

Figure 1-736 Electrical configuration

NOTE

If you connect ET 200eco PN M12-L distributed I/O devices via upstream local power supplies to own distribution (or batteries), then you do not have to provide any additional protective measures against overvoltages.

Insulation monitoring

In the following situations, you must provide insulation monitoring:

- When setting up the ET 200eco PN M12-L distributed I/O devices with non-grounded reference potential
- If dangerous system states occur due to error

6.3 Electrical configuration of the ET 200eco PN M12-L

Electrical isolation

The electrical configuration of the ET 200eco PN M12-L features electrical isolation between:

- 1L+: Non-switched supply voltage (electronics/sensor/load supply):
  Isolated from MultiFieldbus and 2L+ (load voltage supply)
- 2L+: Switched supply voltage (load current supply):
  Electrical isolation from all other circuit components.
  Can be switched off without affecting the 1L+

- MultiFieldbus interface:
  Electrical isolation from all other circuit components.

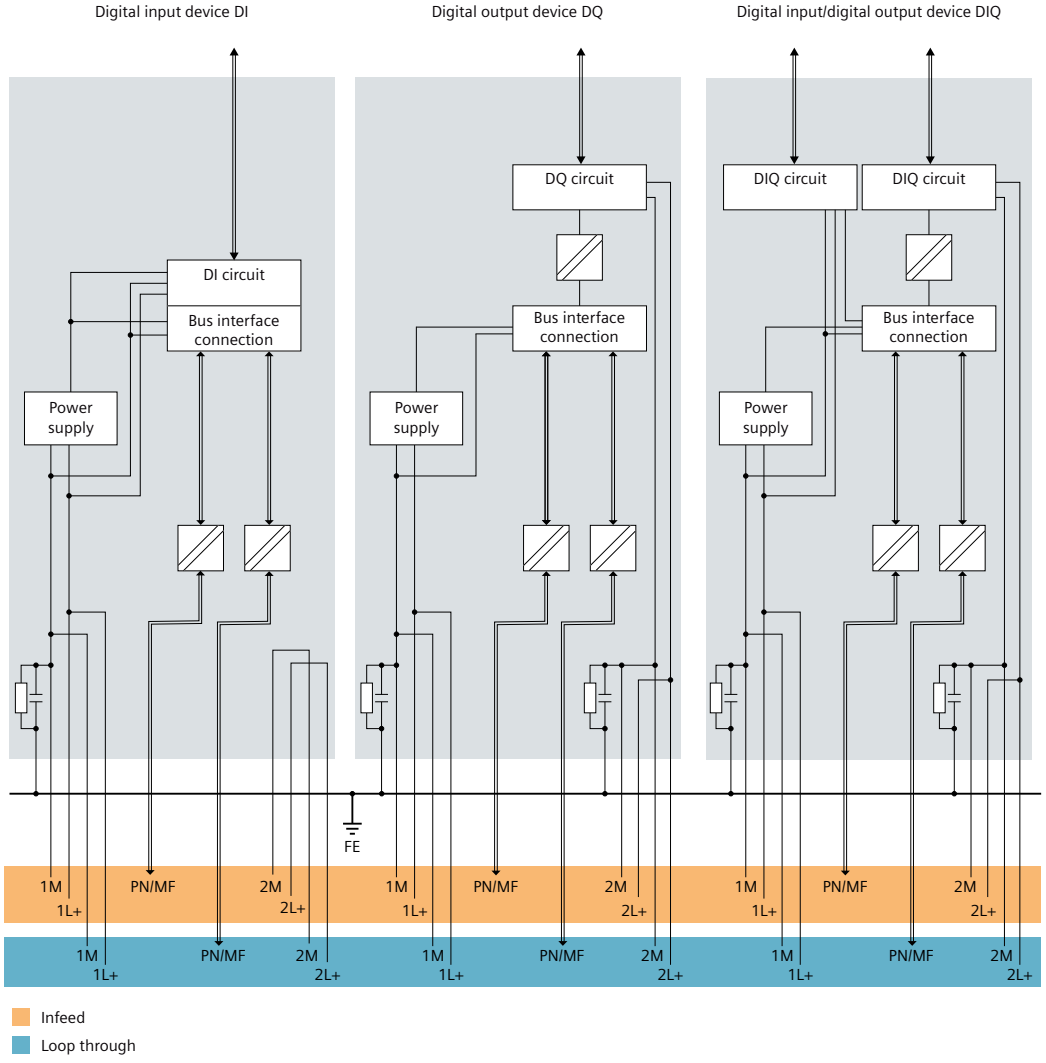


Figure 1-737 Electrical relationships

Connection of a digital output with a digital input

NOTICE
Pay attention to the potential groups When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+. The possible compensating currents can destroy the digital module.

⚠ WARNING

Note potential groups for safety-related shutdown
When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, which leads to elimination of the electrical isolation between 1L+ and 2L+.
The safety-related shutdown is not permitted if the electrical isolation is eliminated.

Cable protection

According to DIN VDE 0100, cable protection is required. Therefore, you must always protect the supply lines externally.

Protect the 24 V DC supply lines against short-circuits and overloads.

Select a protective device that meets the following criteria:

- 24 V DC supply voltage
- Suitable for cable cross-section and type of installation
- Suitable for other conditions, such as temperature

Power supply of the configuration

Two voltage groups are available for the ET 200eco PN M12-L distributed I/O devices.

- 1L+ (supply voltage / non-switched)
- 2L+ (load voltage / switched)

A renewed voltage supply of 1L+ and 2L+ may be necessary.

- To configure different potential groups
- Because of the voltage drop in long lines or several I/O devices

Create a supply/consumption balance for the selection of the infeed point of the supply voltages.

NOTE

Turning 1L+ and 2L+ on and off
In contrast to the load voltage 2L+, the operational switching on and off of the supply voltage 1L+ results in a restart of the I/O devices.

Reference

You will find more information on electrical configuration and the voltage drop in the section Connecting cables for ET 200eco PN M12-L (Page 50).

6.4 Connecting ET 200eco PN M12-L to the functional earth

Introduction

You must connect the ET 200eco PN M12-L distributed I/O devices to the functional earth.

What is functional earth?

All ET 200eco PN M12-L I/O devices feature a functional-earth connection. This connection is used to suppress interference sensitivity, but not for protection purposes. With the functional earth connection, you create an electrical connection to a point of your system or shielding. This discharges the EMC interference directly into the earth. By discharging the EMC interference, the interference immunity of the entire I/O device is increased.

The figure below shows the symbol with which the functional earth connection is identified on the ET 200eco PN M12-L I/O devices.

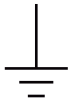


Figure 1-738 Functional earth

6.4.1 Mounting ET 200eco PN M12-L on conductive surface

Requirement

Conductive substrate for mounting of the I/O device.

Required tools

To connect to functional earth, you need the following tools:

- Screwdriver

Required accessories:

To connect to functional earth, you need the following accessories:

- 2 x 5 mm fixing screws

Mounting

Proceed as follows to connect ET 200eco PN M12-L distributed I/O devices to functional earth with a conductive mounting surface:

1. Drill two fastening holes. The dimensions of the I/O device can be found in the section Dimension drawing (Page 118).
2. Screw the module with the 5 mm fastening screws using a torque of 3 Nm.

NOTE

Earthing with conductive mounting substrate

If you attach a ET 200eco PN M12-L distributed I/O device to a conductive, grounded base, the two fixing screws establish a conductive connection to the ground potential.

Ensure that there is a low-impedance connection between the I/O device and conductive surface as well as between the conductive surface and the functional grounding.

Reference

You will find more information on installing the I/O devices in the section Mounting (Page 29).

6.4.2 Mounting ET 200eco PN M12-L on non-conductive surface

Requirement

Non-conductive substrate for mounting of the I/O device.

Required tools

To connect to functional earth, you need the following tools:

- Screwdriver
- Stripping tool
- Crimp tool

Required accessories:

To connect to functional earth on a non-conductive fastening substrate, you need the following accessories:

- 2 x 5 mm fixing screws
- Cable lug, suitable for 5 mm screws
- Spring lock washer
- Washer
- Grounding cable (braided copper cable) with a minimum cross section of 4 mm^2

Mounting

To connect ET 200eco PN M12-L distributed I/O devices to functional earth, proceed as follows:

1. Drill two fastening holes. The dimensions of the I/O device can be found in the section Dimension drawing I/O device (Page 118).
2. Strip the grounding cable.
3. Fasten the cable lug to the grounding cable.
4. Screw the I/O device and the cable lug with the 5 mm fastening screws using a torque of 3 Nm.

The figure below shows how to connect functional earth.

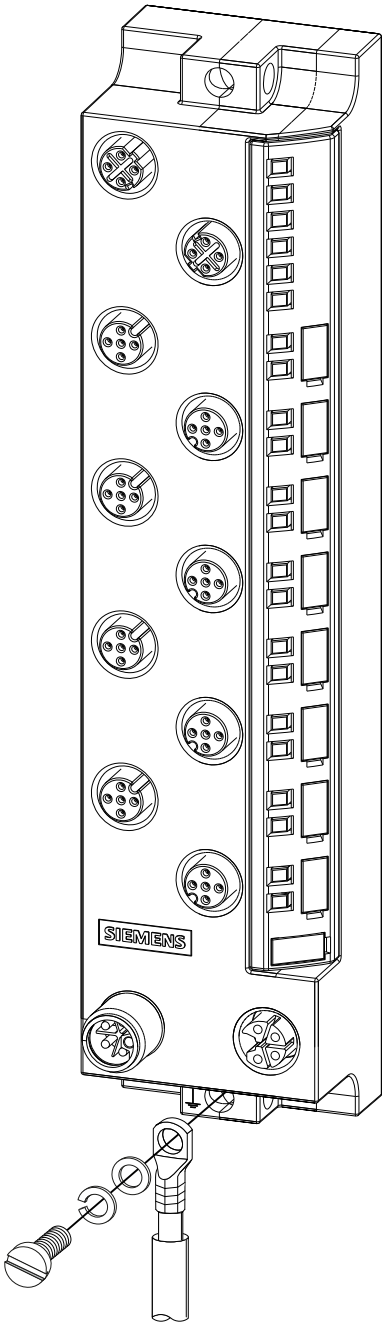


Figure 1-739 Connecting the functional earth

NOTE

Earthing with non-conductive mounting substrate

Make sure there is a low-impedance connection between the I/O device and the functional earth.

Reference

You will find more information on installing the I/O devices in the section Mounting (Page 29).

6.5 Connecting cables for ET 200eco PN M12-L

Impact of cable length on the supply voltage

When you wire your configuration, you must take into account the impact of the cable length on the supply voltage of the ET 200eco PN M12-L distributed I/O system.

⚠ CAUTION

Pay attention to maximum incoming currents

For each power supply (1L+, 2L+), you can feed in a maximum of 12 A.

If you exceed the maximum incoming currents and do not comply with the required cable cross sections, an increased incoming current could lead to overheating of the cable insulation and the contacts. This could result in damage to the I/O devices.

To estimate the voltage drop in your ET 200eco PN M12-L distributed I/O system, you must add the voltage drops of the different cables. For every I/O device used, you must factor in an additional voltage drop of around 0.1 V.

Example

When using a 10 m cable with Ø 1.5 mm^2, the voltage will drop by 2.5 V at a load of 10 A. This is equivalent to 0.25 V at a load of 1 A.

Derating of the input currents

The table below shows the maximum permissible input current of the distributed I/O systems depending on the ambient temperature.

Table 1-1008 Deratings of the input currents while maintaining the minimum clearance

Ambient temperature	Max. input current 1L+	Max. input current 2L+
40 °C	12 A	12 A
50 °C	10 A	10 A
60 °C	8 A	8 A

NOTE

Adherence to the minimum clearance

The I/O devices may be used at an installation distance of 2 cm up to max. 60 °C ambient temperature.

If the installation distance to other devices or objects is less than 2 cm, the ambient temperature must be reduced by 5 K (for example, 60 °C ⇒ 55 °C). This must also be taken into consideration for the derating diagrams of the Equipment Manuals.

6.6 Wiring

Wiring

Connect all cables to the front side of the I/O device:

- Supply voltage to the 4-pin M12-L coded round connectors and round sockets
- Signal lines to the 5-pin M12-A coded round sockets
- PROFINET IO/MultiFieldbus lines on the 4-pin M12-D coded round sockets
- Signal lines at the 8-pin M12 round sockets

Requirement

Wire the I/O devices with the supply voltage off.

Use in hazardous areas

The plug cover is an accessory for protecting the connected connectors on the I/O device. The plug cover may be necessary for use in hazardous areas. If you use the plug cover, the minimum distances specified in the Installing the plug cover (Page 33) section apply for installation.

Required tools

If you are not using pre-assembled cables, you need the following tools:

- Stripping tool
- Screwdriver to wire the connection plugs

Accessories required when connecting the supply voltage

You need the following accessories:

- Pre-assembled power cable 4-pin M12-L coded
  or
- Flexible 4-wire copper cable (wire cross section: 1.5 to 2.5 mm^2) and a connection plug 4-pin M12-L coded.

Accessories required for the connection of MultiFieldbus

You need the following accessories:

- Pre-assembled PROFINET M12 connecting cables with D-coded round connector
  or
- PROFINET cable and PROFINET M12 connector D-coded

Connecting the supply voltage, MultiFieldbus and sensor cable/actuator cable

To connect M12 plugs, proceed as follows:

1. Insert the plug into the respective round socket on the I/O device.
   Ensure the correct alignment of the coding between plug and socket.
2. Tighten the knurled screw of the connector with a torque of 1 Nm.

The figure below shows the connection of several I/O devices to the supply voltage and the MultiFieldbus as an example.

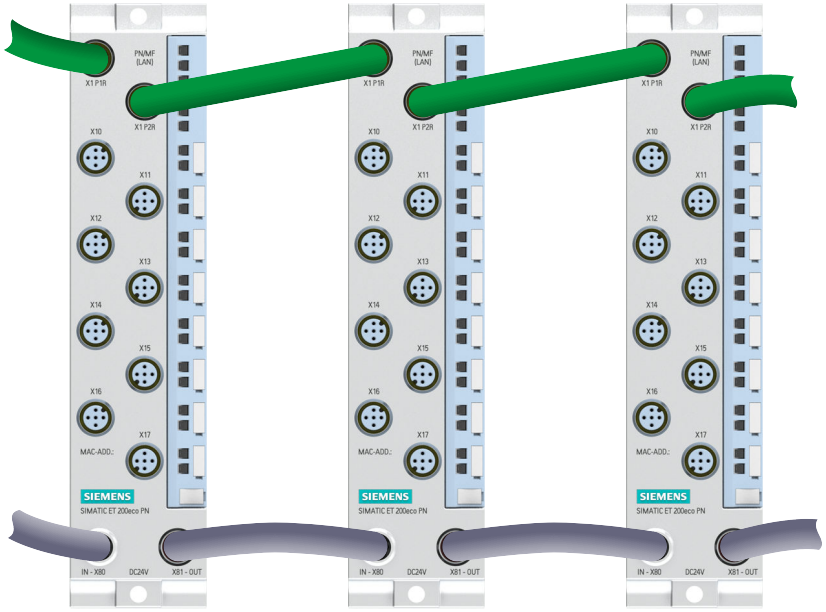


Figure 1-740 Connecting the supply voltage and MultiFieldbus

The figure below shows the connection of the sensor/actuator M12 plugs.

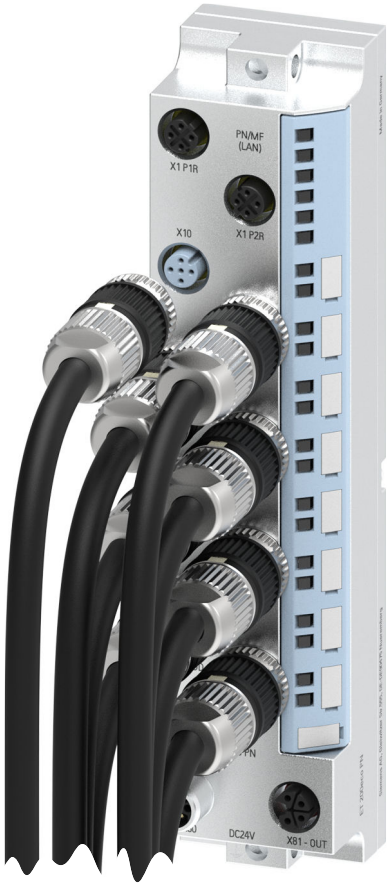


Figure 1-741 Connect sensor/actuator cable

Pin assignments of the sockets

You can find the pin assignment of the sockets in the Equipment Manuals of the I/O devices, in the section on pin assignment.

Y- connection

The Y-connection allows you to connect two actuators or sensors to the inputs or outputs of the I/O devices.

The use of a Y-cable or the Y-connector is particularly recommended when two channels are occupied for each socket of an I/O device. The Y-cable or the Y-connector distributes the two channels to two circular connectors.

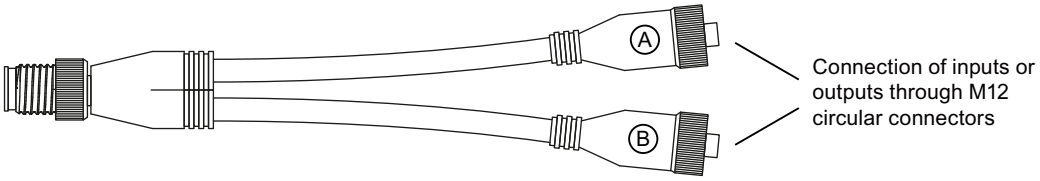


Figure 1-742 Y cable

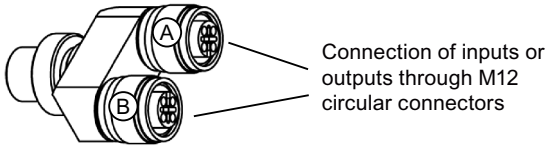


Figure 1-743 Y-connector

The figure below shows the wiring of the Y-connection.

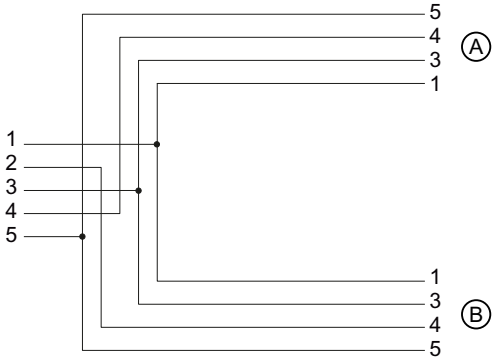


Figure 1-744 Wiring of the Y-connection

Sealing of unused sockets

To ensure IP65/IP67 or IP69K degree of protection, seal off all unused sockets with sealing caps. The sealing caps must be permitted for the required degree of protection.

Article numbers for accessories/spare parts

You will find the labels and article numbers in the Accessories/spare parts (Page 120) section.

6.7 Marking the ET 200eco PN M12-L

6.7.1 Factory markings

Introduction

For better orientation, the ET 200eco PN M12-L distributed I/O system is identified using various markings which will help you when configuring and connecting the I/O devices.

Marking of the interfaces

The interfaces of the I/O devices are factory-labeled.

The table below shows the labeling of the interfaces.

Table 1-1009 Interface labeling

interface	Labeling
MultiFieldbus interfaces	X1 P1R and X1 P2R
I/O input and output interfaces	X10 to X17
Power supply interfaces	X80 (IN) and X81 (OUT)

6.7.2 Optional markings

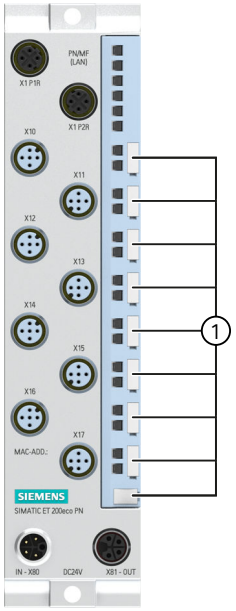
Introduction

In addition to the factory markings, there are also optional possibilities for labeling and/or identifying interfaces and I/O devices on the ET 200eco PN M12-L distributed I/O system.

Identification label

The identification labels come with each I/O device as strips and can be machine-printed. A strip has 10 identification labels measuring 10 x 5 mm in the color RAL9016. The identification labels can be inserted into every I/O device at the points provided. The identification labels are used for channel and I/O device labeling.

The figure below shows all points where you can attach the identification labels.



① Identification labels

Figure 1-745 Optional marking

6.7.3 Mounting identification labels

Introduction

This section describes how to mount or remove identification labels.

Required tools

You need a screwdriver with 3 mm blade width (only to remove identification labels).

Mounting procedure

To mount an identification label, proceed as follows:

1. Print the identification label using commercially available marking systems.
2. Press the identification label out of its holder.
3. Stick the identification labels into the cutouts provided, as shown in the figure Optional marking (Page 56).

Mounting the identification labels is the same for all I/O devices.

Removal procedure

To remove an identification label, proceed as follows:

1. Carefully use a screwdriver to pull out the identification label.

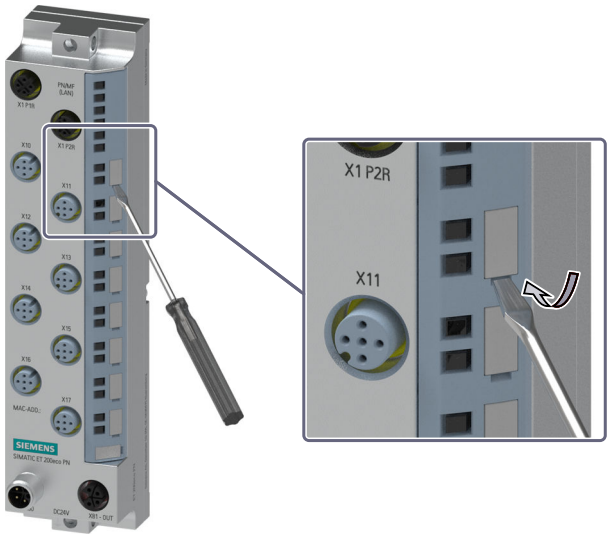


Figure 1-746 Replacing labels

Removing identification labels is the same for all I/O devices.

Configuring

7

7.1 MultiFieldbus engineering

MultiFieldbus Configuration Tool (MFCT)

You create and load the configuration and parameter assignment of the I/O modules with MFCT. The configuration and parameter assignment are retentively stored in the I/O module.

MFCT creates the following files and makes them available:

- User Defined Data Types (UDT) file (file extension *.l5x), enables structured access to I/O data with Ethernet/IP.
- Electronic Data Sheet (EDS) according to CIP specification Vol.1 for integration into EtherNet/IP configuration systems (the EDS file is also available for download)
- Comma Separated Values (CSV), contains the I/O data mapping of your configuration

You can find additional information on MFCT in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

7.2 Detect active fieldbus

For exclusive operation on a fieldbus (not MF Shared Device) you can recognize the active fieldbus by the number of green LEDs on the MF Device.

This requires that there are no errors and that the MF Device is in cyclic data exchange with a controller.

Active fieldbus:	RN/NS	ER/MS	MT/IO
PROFINET	■ Green	□ Off	□ Off
Modbus TCP	■ Green	■ Green	□ Off
EtherNet/IP	■ Green	■ Green	■ Green

7.3 PROFINET IO

Introduction

By configuring, parameterizing and connecting the individual hardware components of the ET 200eco PN M12-L distributed I/O devices, you determine their configuration (preset configuration) and their mode of operation. You perform the work needed for this in STEP 7 in *Devices & Networks*.

"**Configuring**" refers to the arranging, setup and networking of devices and modules within the *Devices & Networks* of STEP 7. STEP 7 graphically represents the I/O devices.

"**Assigning parameters**" refers to the setting of the properties of the I/O devices used.

STEP 7 compiles the hardware configuration (the result of "Configuring" and "Assigning parameters") and loads the configuration into the IO controller and/or into I/O devices of the plant.

7.3.1 Configuring the ET 200eco PN M12-L

Introduction

You configure and assign parameters to the ET 200eco PN M12-L distributed I/O device with STEP 7 or in the configuration software of another manufacturer.

Requirements

Table 1-1010 Requirements for installation

Configuration software	Requirements	Installation information
STEP 7 (TIA Portal) as of V16 with HSP 0299	PROFINET	STEP 7 online help
STEP 7 TIA Portal as of V14	PROFINET GSD file	The GSD versions are largely downward compatible.
STEP 7 V5.6 or higher	PROFINET GSD file	STEP 7 online help
Software of another manufacturer		Manufacturer documentation

Configuring the ET 200eco PN M12-L with STEP 7 TIA Portal

Information on the configuration can be obtained from the STEP 7 online help and in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) system manual.

Configuring the ET 200eco PN M12-L with STEP 7 Classic

The procedure for STEP 7 Classic can be found in the manual Programming with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/109751825).

Overview of PROFINET IO functions

The table below provides an overview of various PROFINET IO functions and the firmware version from when this function is supported.

Function	Firmware version
Isochronous real-time communication	FW 1.0.x or higher
Isochronous mode	FW 1.0.x or higher
Shared device	FW 1.0.x or higher
Module-internal shared input / shared output (MSI/MSO)	FW 1.0.x or higher
System redundancy S2	FW 1.1.x or higher

Function	Firmware version
Prioritized startup	FW 1.1.x or higher
Device replacement without programming device	FW 1.0.x or higher
Media redundancy	FW 1.0.x or higher

7.3.2 Isochronous real-time communication

Isochronous real-time communication

Synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available within the send cycle for IRT I/O data. The reserved bandwidth ensures that the IRT data is also transmitted in time-synchronized intervals, unaffected by other high network loads (e.g. TCP/IP communication or additional real-time communication).

- IRT option:
  A topological configuration is required (STEP 7 V5.5 and higher).

NOTE

When an IO controller is used as sync master for IRT communication, the following must be observed:
Operate the IO controller also as a sync master when configuring IRT communication. Otherwise, IRT and RT configured IO devices can fail if the sync master fails.

Detailed information

You can find additional information on the topic of **isochronous real-time communication** in the STEP 7 online help and in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

7.3.3 Isochronous mode

Isochronous mode

The input and output data of distributed I/O modules in the system is simultaneously acquired and simultaneously output. For this purpose, the I/O data, the transmission cycle via PROFINET IO, and the user program are synchronized. The constant PROFINET IO cycle forms the corresponding clock generator. The I/O devices support isochronous mode of I/O data to the IO controllers starting at 250 µs. The I/O device can exchange isochronous process data with a maximum of one IO controller.

NOTE

Restriction with STEP 7 TIA Portal
The isochronous mode function is fully usable in STEP 7 TIA Portal from V16 Update 1. In the previous versions, it depended on the respective configuration whether and to what extent isochronous mode could be used. If an error occurs, the I/O device rejects the configuration with the alarm message "Parameter error".

For configuration with GSDML, select a configuration in the hardware catalog that provides the value status (QI) in order to use isochronous mode.

Detailed information

You can find additional information on the topic of **isochronous mode** in the STEP 7 online help and in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

7.3.4 Shared device

Shared device

IO device that makes its data available to up to two IO controllers.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. Assign each module or submodule to only one IO controller. Multiple assignment will result in an error as the module or submodule will only be available in the first controller.
- If you reconfigure shared device configurations without the validity check mentioned above, you have to commission the ET 200eco PN M12-L once again. This means you must download the projects of all involved IO controllers to the respective CPU again after reconfiguration. If necessary, perform a POWER OFF/POWER ON of the IO controller and the I/O device.

NOTE

In the case of a shared device application, make sure that all controllers work with the same send clock. If the controller does not have the same send clock, this may result in communication relationships not being set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

Detailed information

You can find additional information on the topic of **shared device** in the STEP 7 online help and in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

7.3.5 Module-internal shared input / shared output (MSI/MSO)

Module-internal shared input / shared output (MSI/MSO)

The module-internal shared input function allows an input module to make its input data available to several IO controllers. Each controller has read access to the same channels.

The module-internal shared output function allows an output module to be operated by several IO controllers. One IO controller has write access. A second IO controller can have read access to the same channels.

Detailed information

You can find additional information on the topic of **Module-internal shared input / shared output (MSI/MSO)** in the STEP 7 online help and in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

7.3.6 System redundancy S2

System redundancy S2

An IO device with S2 system redundancy supports redundant connections to 2 IO controllers (ARs).

In a redundant system, an IO device with system redundancy S2 has a redundant AR for each of the two CPUs (IO controllers). If one CPU fails, the IO device with S2 system redundancy remains accessible to the remaining IO controller via the AR.

The I/O devices support system redundancy S2 (as of FW V1.1.0) on S7-400H CPUs (as of FW V3.0) and on S7-1500R/H CPUs (as of FW V2.6).

Detailed information

You can find more information on the topic of **system redundancy S2** in the STEP 7 online help and in the Function Manual SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856).

7.3.7 Prioritized startup

Prioritized startup

Prioritized startup denotes the PROFINET functionality for accelerating the startup of IO devices operated on a PROFINET IO system with RT and IRT communication.

The function reduces the time that the correspondingly configured IO devices require to return to the cyclic user data exchange in the following cases:

- After the supply voltage has returned
- After station recovery
- After IO Devices have been activated

The prioritized startup function is supported by the ET 200eco PN M12-L I/O devices operated in a PROFINET IO system as of these FW versions.

- RT communication as of FW V1.0.0
- IRT communication as of FW V1.1.0

You recognize valid input values and output values from value status QI = 1. In the case of analog devices and IO-Link master communication modules, the determination of the analog value or the establishment of the IO-Link connection can take more time, for example. You receive invalid values with value status QI = 0 until then.

Detailed information

You can find more information in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) system manual.

7.3.8 Device replacement without programming device (PG)

Requirement

A topology must be created in the project.

Device replacement without programming device

IO devices with this function can be easily replaced:

- The device name does not have to be assigned with the programming device.

The replaced IO device receives the device name from the IO controller, no longer from the programming device. For this purpose, the IO controller uses the configured topology and the neighborhood relationships determined by the IO devices. The configured setpoint topology must agree with the actual topology.

If an I/O device was already in operation, reset it to factory settings before further use.

Detailed information

You can find more information in the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) system manual.

7.3.9 Media redundancy

Media redundancy

Function for ensuring the network and system availability. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails (STEP 7 V5.5 and higher).

For additional information, refer to the STEP 7 online help and the SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) manual.

7.4 EtherNet/IP

7.4.1 Introduction to configuring

Introduction

By configuring, parameterizing and connecting the individual hardware components of the ET 200eco PN M12-L distributed I/O devices, you determine their configuration (preset configuration) and their mode of operation. You perform the work needed for this in MFCT. The full range of functions is not ensured with other software.

"**Configuring**" refers to the arranging, setting up and networking of devices and modules in the MFCT or in another software.

"**Assigning parameters**" refers to the setting of the properties of the I/O devices used.

MFCT or another software compiles the hardware configuration (the result of "Configuring" and "Assigning parameters"). Then the configuration is loaded into I/O devices of the plant and the configuration files prepared for the controller.

NOTE

Temporary bus interruption

The ET 200eco PN M12-L I/O device starts again once the configuration is loaded. The reboot interrupts the MultiFieldbus for all downstream devices. The bus interruption is evaluated by the software used and the controller.

Detailed information

You can find more information in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

7.4.2 EtherNet/IP functions

The I/O modules can be configured with MFCT or another user program via EtherNet/IP.

The following table shows the supported EtherNet/IP functions with the configuration software MFCT V1.3 SP1 or higher:

Function	Firmware version
I/O communication with scanner	FW 5.1.x or higher
Reading diagnostics	FW 5.1.x or higher
Normative CIP objects	FW 5.1.x or higher
Hardware interrupt	FW 5.1.x or higher
Transfer data records	FW 5.1.x or higher
Resetting I/O module modules to factory setting	FW 5.1.x or higher
Diagnostics bit in data status of cyclic I/O data per submodule	FW 5.1.x or higher
Shared device	FW 5.1.x or higher
Module-internal shared input / shared output (MSI/MSO)	FW 5.1.x or higher

IP address

For the EtherNet/IP bus protocol, the IP address and the gateway address must not be identical.

NOTE

Setting the IP address
If there is an active connection to the controller and the IP address is set, an error message may be displayed in some configuration software.
Procedure:

1. Stop the connection to the controller.
2. Enter the IP address.

7.5 Modbus TCP

7.5.1 Introduction to configuring

Introduction

By configuring, parameterizing and connecting the individual hardware components of the ET 200eco PN M12-L distributed I/O devices, you determine their configuration (preset configuration) and their mode of operation. You perform the work needed for this in MFCT. The full range of functions is not ensured with other software.

"**Configuring**" refers to the arranging, setting up and networking of devices and modules in the MFCT or in another software.

"**Assigning parameters**" refers to the setting of the properties of the I/O devices used.

MFCT or another software compiles the hardware configuration (the result of "Configuring" and "Assigning parameters"). Then the configuration is loaded into I/O devices of the plant and the configuration files prepared for the controller.

NOTE

Temporary bus interruption
The ET 200eco PN M12-L I/O device starts again once the configuration is loaded. The reboot interrupts the MultiFieldbus for all downstream devices. The bus interruption is evaluated by the software used and the controller.

Detailed information

You can find more information in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

7.5.2 Modbus TCP functions

Modbus TCP functions

The following table shows the supported functions of the I/O modules in the Modbus TCP mode with the configuration software MFCT as of V1.3 SP1:

Function	Firmware version
I/O communication with scanner	FW 5.1.x or higher
Reading diagnostics	FW 5.1.x or higher
Hardware interrupt	FW 5.1.x or higher
Transfer data records	FW 5.1.x or higher
Resetting I/O module modules to factory setting	FW 5.1.x or higher
Diagnostics bit in data status of cyclic I/O data per submodule	FW 5.1.x or higher
Shared device	FW 5.1.x or higher
Module-internal shared input / shared output (MSI/MSO)	FW 5.1.x or higher

7.6 MF Shared Device

Number of connections via the MultiFieldbus

The distributed I/O devices support 2 simultaneous connections via the same connection type. A combination of various connection types is not possible.

The module objects are displayed in the MFCT or in other software during the selection.

Detailed information

You can find more information in the MF Shared Device section of the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

Commissioning

8

8.1 Commissioning ET 200eco PN M12-L on MultiFieldbus

Introduction

The commissioning of your distributed I/O devices depends on the respective plant configuration. The following procedure describes how to commission the ET 200eco PN M12-L on an IO controller.

Requirements for commissioning on the MultiFieldbus

NOTE

Performing tests

You must ensure the safety of your plant. You need to run a complete functional test and perform the required safety checks before the commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This prevents you from putting persons or equipment at risk during operation.

Procedure

The following table shows the chapters/documents in which the required actions are described.

Table 1-1011 Requirements for the ET 200eco PN M12-L on the MultiFieldbus

Step	Procedure	Reference
1	Mounting the ET 200eco PN M12-L	Section Mounting (Page 29)
2	Wiring the ET 200eco PN M12-L	Section Connecting (Page 37)
3	Configuring the ET 200eco PN M12-L	Section Configuring (Page 58)
4	Switching on supply voltage for the IO controller	IO controller manual
5	IO controller is in RUN mode	IO controller manual

Commissioning the ET 200eco PN M12-L

1. Switch on the supply voltage 1L+ non-switched for the ET 200eco PN M12-L.
2. Switch on the power supply 2L+, if necessary.

Reference

Additional information on the commissioning:

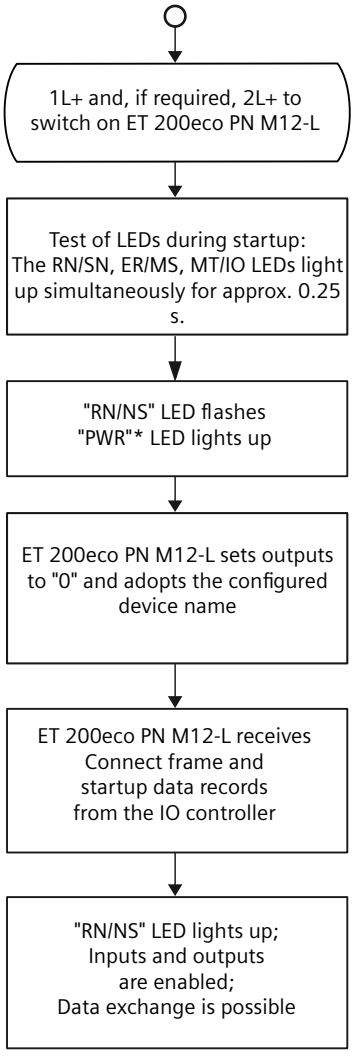
- STEP 7 online help
- In the manual SIMATIC PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856)
- In the MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209) function manual

8.2 Startup of the I/O device

8.2.1 Unconfigured on PROFINET IO

Startup without parameter assignment on PROFINET IO

The following schematic diagram shows the startup of the ET 200eco PN M12-L in factory setting, without PROFINET IO:

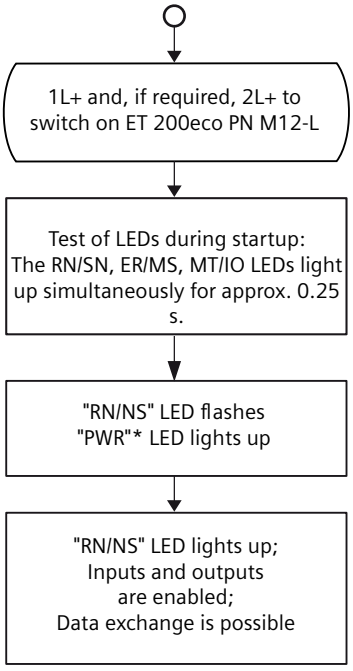


* "PWR" only for I/O devices that use 2L+ and when 2L+ is connected

8.2.2 Configured on PROFINET IO

Startup configured on PROFINET IO

The following schematic diagram shows the startup of the ET 200eco PN M12-L I/O device on PROFINET IO:

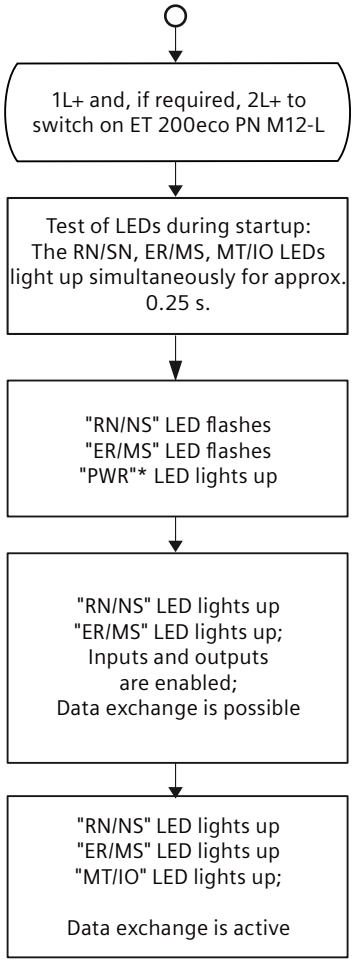


* "PWR" only for I/O devices that use 2L+ and when 2L+ is connected

8.2.3 Configured on EtherNet/IP

Startup configured on EtherNet/IP

The following schematic diagram shows the startup of the ET 200eco PN M12-L I/O device on EtherNet/IP:

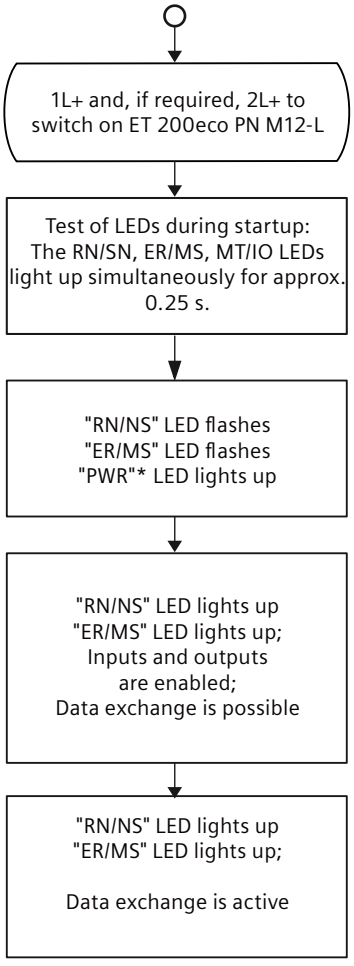


* "PWR" only for I/O devices that use 2L+ and when 2L+ is connected

8.2.4 Configured on Modbus TCP

Startup configured on Modbus TCP

The following schematic diagram shows the startup of the ET 200eco PN M12-L I/O device on Modbus TCP:

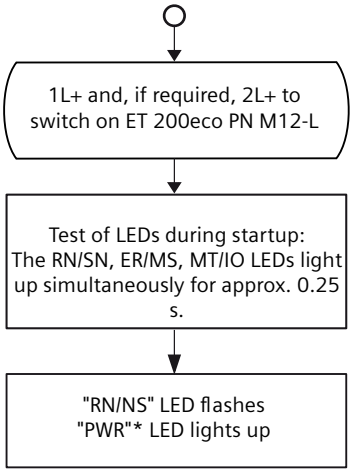


* "PWR" only for I/O devices that use 2L+ and when 2L+ is connected

8.2.5 Unconfigured without communication to fieldbus

Startup without parameter assignment, without communication to fieldbus

The following schematic diagram shows the startup of the ET 200eco PN M12-L with factory settings, displayed schematically without communication to the fieldbus:



* "PWR" only for I/O devices that use 2L+ and when 2L+ is connected

8.3 Identification and maintenance data

8.3.1 Reading out and entering I&M data

Introduction

I&M identification data is information which is stored on the I/O device either as read-only data (I-data) or read/write data (M-data).

Identification data (I&M0): Manufacturer information on the I/O device that is read-only and in some cases is also lasered on the I/O device housing, for example, article number, serial number and firmware version.

Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during the configuration and written to the I/O device.

All modules of the ET 200eco PN M12-L distributed I/O system support identification data and maintenance data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a system
- Correcting errors in a system

With the I&M identification data, you have the option of clearly identifying I/O devices online.

In STEP 7, the identification data is displayed in the "Module status" and "Properties..." tabs (see STEP 7 online help).

Options for reading out I&M data

You have the following options for reading the I&M data:

- Via the user program
- Via STEP 7 or HMI devices

Procedure for reading I&M data by means of the user program

To read the I&M data of the I/O devices in the user program, use the instruction "RDREC".

With third party software, the "read record" instruction may be named differently.

You can find more information in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

Procedure for reading the I&M data using STEP 7

Requirement: An online connection to the I/O device must be available.

1. Select the I/O device in project tree under "Distributed I/O".
2. Select: **IO device/DP slave > Online & Diagnostics > Identification & Maintenance**.

Procedure for input of maintenance data using STEP 7

The default module name is assigned by STEP 7. You have the option to enter the following data:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)

To enter the data, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the I/O device, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data is also loaded.

8.3.2 Data record structure for I&M data

Reading I&M data records (distributed via PROFINET IO)

You can directly access specific identification data by selecting **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the associated data record index.

The following table shows the principle behind the structure of data records.

Table 1-1012 Basic structure of data records with I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	54 54 16 54	I&M0/Index $AFF0_H$ I&M1/Index $AFF1_H$ I&M2/Index $AFF2_H$ I&M3/Index $AFF3_H$

The following table shows the structure of data records for I&M identification data.

Table 1-1013 Data record structure for I&M identification data

Identification data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
VendorIDHigh	read (1 byte)	00_H	This is where the name of the manufacturer is stored (42_D = SIEMENS AG).
VendorIDLow	read (1 byte)	$2A_H$	
Order_ID	read (20 bytes)	6ES7141-6BG00-0BB0	Order number of the I/O device (e.g. of the digital input module)
IM_SERIAL_NUMBER	read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	read (2 bytes)	1	Corresponding hardware version
IM_SOFTWARE_REVISION	read	Firmware version	Provides information about the firmware version of the I/O device
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_Enhancement	(1 byte)	00 - FF_H	
• IM_SWRevision_Bug_Fix	(1 byte)	00 - FF_H	
• IM_SWRevision_Internal_Change	(1 byte)	00 - FF_H	
IM_REVISION_COUNTER	read (2 bytes)	0000_H	Provides information about configured changes on the I/O device (not used)
IM_PROFILE_ID	read (2 bytes)	0000_H	Generic device

Identification data	Access	Default	Explanation
IM_PROFILE_SPECIFIC_TYPE	read (2 bytes)	0005_H	Interface modules
IM_VERSION	read	0101_H	provides information about the version of the identification data (0101_H = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	read (2 bytes)	$000E_H$	Provides information about the available identification data (I&M1 to I&M3)
Maintenance data 1: (data record index AFF1 hex)			
IM_TAG_FUNCTION	Read/write (32 bytes)	-	For the I/O device, enter an identifier that is unique plant-wide here.
IM_TAG_LOCATION	Read/write (22 bytes)	-	Enter the installation location of the I/O device here.
Maintenance data 2: (data record index AFF2 hex)			
IM_DATE	Read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the I/O device here.
Maintenance data 3: (data record index AFF3 hex)			
IM_DESCRIPTOR	Read/write (54 bytes)	-	Enter a comment about the I/O device here.

Maintenance

9

9.1 Replacing an I/O device

Replacing an I/O device

Replacing an I/O device is not permitted during ongoing operation.

NOTICE
Material damage can occur If you connect or disconnect the I/O devices with the power connected, this can lead to undefined states in your system. Material damage to the ET 200eco PN M12-L distributed I/O device can occur as a result. Only remove or replace I/O devices when the power is disconnected. Always comply with the required standards and safety guidelines when configuring a system.

Behavior of MultiFieldbus

When an I/O device fails in the MultiFieldbus line, the line remains active up to the failed I/O device. After the I/O device has been replaced, the following I/O devices of the line log in again automatically in MultiFieldbus.

NOTE

MRP ring with PROFINET

When set up as an MRP ring topology in the PROFINET bus protocol, only the affected I/O device fails.

Procedure

To replace an I/O device, follow these steps:

1. Disconnect the supply voltage to the I/O device to be replaced.
2. Completely remove all cables connected to the I/O device.
3. Loosen the fixing screws of the I/O device completely.
4. Replace the I/O device.

NOTE

"New" I/O device

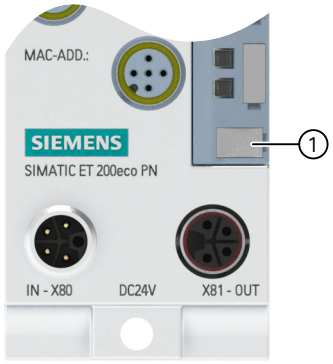
Replace the remote I/O device with an I/O device of the same type.

5. Fasten the I/O device with a torque of 3 Nm.
6. Connect all cables.
7. Turn the supply voltage on.

⚠ WARNING

Observe the connection sequence of I/O devices
If you mix up the ET 200eco PN M12-L I/O devices or lines when connecting them, this can cause personal injury and damage to the machine.
We recommend that you clearly label the ET 200eco PN M12-L I/O devices with the device number.

The figure below shows a recommendation for labeling the ET 200eco PN M12-L I/O devices with the device number.



① Recommendation for labeling the device number

Figure 1-747 Device number

Result

Topological configuration:

1. The new I/O device automatically receives the device name with PROFINET IO via the IO controller.

   NOTE
   New or factory setting
   The I/O device only obtains the device names automatically with PROFINET IO with:
   – New I/O device
   – Set to factory settings

2. The new I/O device receives the connect telegram and startup data record from the IO controller.
3. The new I/O device and all downstream I/O devices start up again by themselves.

No topological configuration:

1. The new I/O device must have the same name as the device name of the I/O device to be replaced.
2. The new I/O device receives the connect telegram and startup data record from the IO controller.
3. The new I/O device and all downstream I/O devices start up again by themselves.

Reference

You will find information on the device name in the STEP 7 online help or the MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209) function manual.

9.2 Firmware update

Introduction

During operation, it may become necessary to update the firmware (e.g. for function extensions).

Firmware updates are used to update the firmware of the I/O device.

NOTE

Temporary bus interruption

When you update the firmware of an ET 200eco PN M12-L I/O device, then the MultiFieldbus is briefly interrupted due to the reboot of the I/O device. This interruption generates an alarm in the controller for all downstream MultiFieldbus devices.

Options for the firmware update

You have the following options for installing a firmware update:

- Online with STEP 7, V5.6 or higher
- Online via STEP 7, TIA Portal
- Online via SIMATIC Automation Tool
- Online via MultiFieldbus Configuration Tool (MFCT)

NOTE

I/O device remains in configured fieldbus mode

After a firmware update, the I/O device remains in the bus protocol in which the update was installed.

For example, at an update via EtherNet/IP, the I/O device remains in EtherNet/IP mode.

Reference

More information about the procedure:

- FAQs on the Internet (http://www.siemens.com/automation/service&support)
- STEP 7 online help
- SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) Equipment Manual (included in the SIMATIC Automation Tool)
- MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209) function manual

9.3 Calibrating an analog I/O device

Introduction

Calibration checks the process values measured by the I/O device analog inputs, determines their deviation from the actual values and compensates the measuring errors.

Calibration

The analog inputs I/O device is calibrated before delivery. The I/O device has a high long-term stability, so that calibration during operation is not necessary. Certain directives require calibration for all components of a measuring circuit at regular intervals.
The calibration procedure is described in the Function Manual SIMATIC Analog Value Processing.

NOTE

Restriction during calibration

You cannot calibrate the I/O device with the following settings:

- Configured as 1 x 8-channel I/O device MSI.
- Configured as 2 x 4-channel I/O device

Reference

You can find information on the procedure in the Function Manual SIMATIC analog value processing (https://support.industry.siemens.com/cs/ww/en/view/67989094).

9.4 Resetting the I/O device to factory settings

Introduction

When you "Reset to factory settings", the I/O device is reset to the "delivery state". All information that was saved internally on the I/O device is deleted. The I/O device switches to PROFINET IO mode.

Result after resetting to factory settings

The following table shows an overview of the contents of the saved items after resetting to factory settings.

Table 1-1014 Result after resetting to factory settings

Memory object	Contents
IP address	Deleted (configurable when resetting: "Retain IP address"/ "Delete IP address")
Device name	Deleted
MAC address	Not deleted
Identification data (I&M0)	Not deleted
Maintenance data (I&M1, 2, 3):	Deleted
Firmware	Not deleted
Configuration	Deleted
Parameters	Deleted
MultiFieldbus	Switches to PROFINET IO

NOTE

Failure of downstream stations is possible

Resetting an I/O device to factory settings can lead to failure of downstream stations in a line.

NOTE

Substitute value behavior of I/O devices when resetting to factory settings

The I/O devices take on the unconfigured state after "Reset to factory settings". There is no I/O data exchange.

Reset options

You have the following options to reset an I/O device to the factory settings:

- Online with STEP 7 (TIA Portal)
- Online with STEP 7, V5.6 or higher
- Online via SIMATIC Automation Tool (SAT)
- Online via PRONETA
- Online via MultiFieldbus Configuration Tool (MFCT)

Requirement

You need an online connection to reset an I/O device to factory settings.

Procedure with STEP 7 (TIA Portal)

Connect the PG/PC to the MultiFieldbus interface of the ET 200eco PN M12-L distributed I/O system.

Make sure that there is an online connection to the I/O device which is to be reset to factory settings.

1. Open the Online and Diagnostics view of the I/O device.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Select the "Retain IP address" option button if you want to retain the IP address, or the "Reset IP address" option button if you want to delete the IP address.
4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The I/O device executes "Reset to factory settings". The RN/NS, ER/MS and MT/IO LEDs light up simultaneously for approximately 2 s while "Reset to factory settings" is running.

Procedure with STEP 7 V5.6 or higher

Connect the PG/PC to the MultiFieldbus interface of the ET 200eco PN M12-L distributed I/O system.

Make sure that there is an online connection to the I/O device which is to be reset to factory settings.

1. Open the SIMATIC Manager.
2. Select accessible devices.
3. Select the I/O device.
4. Navigate through "Menu > Options > Edit Ethernet devices > Reset to factor settings > Reset".

Result: The I/O device executes "Reset to factory settings". The RN/NS, ER/MS and MT/IO LEDs light up simultaneously for approximately 2 s while "Reset to factory settings" is running.

Procedure using the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) Equipment Manual (included in the SIMATIC Automation Tool).

Procedure using PRONETA

With PRONETA you can follow these steps:

- Delete or reassign device name and IP address
- Resetting I&M data
- Remove the module from the network and reintegrate it

You can find information on this in the "PRONETA User Manual (https://support.industry.siemens.com/cs/ww/en/view/109815137)"

Procedure using MFCT

You can find information on the procedure via MFCT under "MultiFieldbus function manual (https://support.industry.siemens.com/cs/ww/en/view/109773209)" in the "Resetting the MF device" section.

Reference

You will find more information on the procedure in the STEP 7 online help.

9.5 Maintenance and repair

The components of the SIMATIC ET 200eco PN M12-L system are maintenance-free.

NOTE

Repairs to an ET 200eco PN M12-L I/O device may only be carried out by the manufacturer.

9.6 Cleaning the I/O device

The I/O devices do not require cleaning from the manufacturer perspective. When wired, ET 200eco PN M12-L I/O devices comply with the IP65/IP67 and IP69K degrees of protection and can be cleaned, if necessary.

Note the following points during cleaning:

- Observe the IP65/IP67 and IP69K degrees of protection.
- Use checked liquids only
  - Material compatibility test of the ECOLAB® company (Page 89)

Technical specifications

10

10.1 Codes and approvals

Codes and approvals on the type plate

The following overview provides information about the possible codes and approvals. Only the codes and approvals specified on the type plate apply for the device.

You can find the associated certificates for download on the Internet. See also: ET 200eco PN approvals (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert)

CE marking

CE

The ET 200eco PN M12-L distributed I/O devices meet the requirements and protection targets of the following directives. The distributed I/O devices comply with the harmonized European standards (EN) for programmable logic controllers published in the official gazettes of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)

  Directive of the European Parliament and of the Council of February 26, 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility; OJ L 96, 29/3/2014, pp. 79–106
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

  Directive of the European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment; OJ L 174, 1/7/2011, pp. 88–110
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)

  Directive of the European Parliament and of the Council of February 26, 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres; Official Journal of the European Union L96, 29/03/2014, pp. 309–356

The EC Declarations of Conformity are available for the responsible authorities and are kept at the following address:

Siemens Aktiengesellschaft
Digital Factory

Factory Automation
DI FA TI COS TT
Postfach 1963
D-92209 Amberg

UKCA mark

The object of the declaration described above complies with the relevant Union harmonization legislation and the designated British regulations, depending on the components used, as described in the EMC, ATEX/UKEX, RoHS annexes, which form an integral part of this declaration of conformity:

- Electromagnetic Compatibility Regulations 2016 (S.I. 2016 No. 1091), and related amendments
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (S.I. 2016 No. 1107), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments

UK Declarations of Conformity are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Digital Factory
Factory Automation
DI FA TI COS TT
Postfach 1963
D-92209 Amberg

UL approval

Underwriters Laboratories Inc.:

- UL 61010-1, UL 61010-2-201
- CSA C22.2 NO. 61010-1, CSA C22.2 No. 61010-2-201

ATEX approval

According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and EN 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").

II 3 G Ex ec IIC T4 Gc
II 3 D Ex tc IIIB T90 °C Dc
DEKRA 22ATEX0081X

Special conditions in hazardous areas:
To prevent electrostatic charging, wipe the housing surface only with a wet cloth.
You must only use the devices in an environment in which they are protected against UV light.
Cables, plug-in connectors and plugs must fulfill these requirements:

- Suitable for 90 °C or higher
- Minimum degree of protection IP54 in accordance with EN IEC 60079-0

For use in Zone 2/22, the devices must be installed in a suitable protective enclosure which fulfills the requirements of the impact resistance test according to EN IEC 60079-0, e.g. connector cover 6ES7194-6JA00-0BB0.

The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the devices in an area with a degree of pollution 2 according to EN 60664-1.
- Provisions must be taken to prevent the rated operating voltage from being exceeded by transient disturbance voltages of more than 119 V.
- In the case of use in Zone 2/22, the I/O devices are approved for -20 °C to +60 °C and IP54.

More information
You can find the explosion protection with the approved ET 200eco PN M12-L I/O devices here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=441).
The multilingual product information "Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas" is available here on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109814099).

UKEX approval



According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and EN 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").
II 3 G Ex ec IIC T4 Gc
II 3 D Ex tc IIIB T90 °C Dc
DEKRA 22UKEX6018X

Special conditions in hazardous areas:
To prevent electrostatic charging, wipe the housing surface only with a wet cloth.
You must only use the devices in an environment in which they are protected against UV light.
Cables, plug-in connectors and plugs must fulfill these requirements:

- Suitable for 90 °C or higher
- Minimum degree of protection IP54 in accordance with EN IEC 60079-0

For use in Zone 2/22, the devices must be installed in a suitable protective enclosure which fulfills the requirements of the impact resistance test according to EN IEC 60079-0, e.g. connector cover 6ES7194-6JA00-0BB0.
The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the devices in an area with a degree of pollution 2 according to EN 60664-1.
- Provisions must be taken to prevent the rated operating voltage from being exceeded by transient disturbance voltages of more than 119 V.
- In the case of use in Zone 2/22, the I/O devices are approved for -20 °C to +60 °C and IP54.

More information
You can find the explosion protection with the approved ET 200eco PN M12-L I/O devices here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=441).
The multilingual product information "Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas" is available here on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109814099).

IECEX approval



According to IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and IEC 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").

Ex ec IIC T4 Gc
Ex tc IIIB T90 °C Dc
IECEx DEK 22.0080X

Special conditions in hazardous areas:
To prevent electrostatic charging, wipe the housing surface only with a wet cloth.
You must only use the devices in an environment in which they are protected against UV light.
Cables, plug-in connectors and plugs must fulfill these requirements:

- Suitable for 90 °C or higher
- Minimum degree of protection IP54 in agreement with IEC 60079-0

For use in Zone 2/22, the devices must be installed in a suitable protective enclosure which fulfills the requirements of the impact resistance test according to EN IEC 60079-0, e.g. connector cover 6ES7194-6JA00-0BB0.
The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the devices in an area with a degree of pollution 2 according to IEC 60664-1.
- Provisions must be taken to prevent the rated operating voltage from being exceeded by transient disturbance voltages of more than 119 V.
- In the case of use in Zone 2/22, the I/O devices are approved for -20 °C to +60 °C and IP54.

More information
You can find the explosion protection with the approved ET 200eco PN M12-L I/O devices here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=441).
The multilingual product information "Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas" is available here on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109814099).

CCCEx approval



According to GB/T 3836.3 (Explosive atmospheres - Part 3: Equipment protection by type of protection "e"), GB/T 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements) and GB/T 3836.31 (Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t").

Ex ec IIC T4 Gc

Ex tc IIIB T90°C Dc

Special conditions in hazardous areas:
To prevent electrostatic charging, wipe the housing surface only with a wet cloth.
You must only use the devices in an environment in which they are protected against UV light.
Cables, plug-in connectors and plugs must fulfill these requirements:

- Suitable for 90 °C or higher
- Minimum degree of protection IP54 in agreement with GB/T 3836.1

For use in Zone 2/22, the devices must be installed in a suitable protective enclosure which fulfills the requirements of the impact resistance test according to GB/T 3836.1, e.g. connector cover 6ES7194-6JA00-0BB0.
The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the devices in an area with a degree of pollution 2 according to GB/T 16935.1.
- Provisions must be taken to prevent the rated operating voltage from being exceeded by transient disturbance voltages of more than 119 V.
- In the case of use in Zone 2/22, the I/O devices are approved for -20 °C to +60 °C and IP54.

More information
You can find the explosion protection with the approved ET 200eco PN M12-L I/O devices here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=441).
The multilingual product information "Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas" is available here on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109814099).

RCM Australia/New Zealand



The ET 200eco PN M12-L distributed I/O system meets the requirements of EN 61000-6-4 Generic standards – Emission standard for industrial environments.

Korea Certificate



Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.
이기기는업무용(A급) 전자파적합기기로서판매자또는사용자는이점을주의하시기바라며 가정외의지역에서사용하는것을목적으로합니다.

EAC (Eurasian Conformity)



The code EAC (Eurasian Conformity) confirms the conformity with the guidelines (TR) of the Eurasian Economic Union.

WEEE mark (European Union)



Disposal information, observe the local regulations and section "Recycling and disposal (Page 111)".

10.2 Certificates

Shipbuilding certificates

The following shipbuilding certificates are intended for the device:

- ABS (American Bureau of Shipping)
- Bureau Veritas (French marine classification society)
- CCS (China Classification Society)
- Class NK (Nippon Kaiji Kyokai)
- DNV (Det Norske Veritas)
- KR (Korean Register of Shipping)
- LRS (Lloyds Register of Shipping)
- RINA (Registro Italiano Navale)

After a successful approval you can find the certificates with the certified article numbers in the Internet. See also: ET 200eco PN Marine/Shipbuilding (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=446)

Material compatibility test

The distributed I/O devices ET 200eco PN M12-L have been tested by the ECOLAB® company with the following liquids.

- Topactive 200
- Topax MD3
- Topaz AC3
- Topaz AC4
- Topax 91
- Topax 990
- Topax 960
- Alcodes

The testimonial from the ECOLAB® company is available for downloading on the Internet. See also: ET 200eco PN M12-L Ecolab Testimonial (https://support.industry.siemens.com/cs/ww/en/view/109805757)

10.3 Standards and requirements

IEC 61131-2

The ET 200eco PN M12-L distributed I/O system fulfills the requirements and criteria of IEC 61131-2 (Programmable controllers, Part 2: Equipment requirements and tests) and the EMC requirements for use in Zone B.

IEC 61010-2-201

The ET 200eco PN M12-L distributed I/O system fulfills the requirements and criteria of standard IEC 61010-2-201.

PROFINET standard

The ET 200eco PN M12-L distributed I/O system is based on standard IEC 61158 Type 10.

EtherNet/IP requirement

The ET 200eco PN M12-L distributed I/O system is based on the requirements of the CIP network library CIP Networks Library Volume 2 EtherNet/IP Adaptation of CIP.

Modbus TCP requirement

The ET 200eco PN M12-L distributed I/O system is based on the requirements of the Modbus TCP Application Protocol Specification V1.1b3.

IO-Link standard

The ET 200eco PN M12-L distributed I/O system is based on standard IEC 61131-9.

Use in industrial environments

The ET 200eco PN M12-L distributed I/O devices are designed for the industrial field. It meets the following standards for this type of use:

- Requirements for interference emission EN 61000-6-4
- Requirements for immunity EN 61000-6-2

Use in mixed areas

Under certain circumstances, you can use the ET 200eco PN M12-L distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact on residents.

If you want to use the ET 200eco PN M12-L distributed I/O system in mixed areas, you must ensure that its radio frequency interference emission complies with the limit classes of the EN 61000-6-3 generic standard. Suitable measures for observing these limits for use in a mixed area are, for example:

- Use of noise filters in the supply cables

An individual acceptance test is also required.

Use in residential areas

The ET 200eco PN M12-L distributed I/O system is not intended for use in residential areas. Using the ET 200eco PN M12-L distributed I/O system in residential areas can affect radio or television reception.

Importer addresses

The following table shows the importer addresses for specific countries:

Countries	Address
United Kingdom (UK)	Siemens plc. Manchester M20 2UR
Türkiye (TR)	Siemens San. ve Tic. A.Ş. Yakacık Cad. No:111 34870 Kartal/İstanbul

10.4 Electromagnetic compatibility

Definition

Electromagnetic compatibility is the ability of an electrical apparatus to function in a satisfactory manner in its electromagnetic environment without affecting this environment.

An ET 200eco PN M12-L distributed I/O device fulfills the requirements of the EMC law of the European Union. The prerequisite for this is that the electrical configuration of the ET 200eco PN M12-L distributed I/O device complies with the specifications and guidelines for the electrical configuration.

Pulse-shaped disturbance variables

The table below shows the electromagnetic compatibility of the distributed I/O systems compared to pulse-shaped disturbance variables.

Table 1-1015 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Corresponds with degree of severity
Electrostatic discharge according to IEC 61000-4-2.[1]	Air discharge: ±8 kV	3
	Contact discharge: ±6 kV	3
Burst pulses (fast transient disturbance variables) according to IEC 61000-4-4.[1]	±2 kV (power supply cable)	3
	±2 kV (MultiFieldbus line)	4
	±2 kV (signal line)	4
High-energy single pulse (surge) to IEC 61000-4-5 [2] • For installation within buildings: – Signal line < 30 m • For installation outdoors – Signal line < 30 m – Use of shielded IP lines – Grounding of the shielding at both ends according to IEC 61000-4-5		

1 The maximum short-term influencing of analog devices during the duration of the EMC tests can amount to ±10 % of the full-scale value.

2 Analog value deviation beyond the limits of the nominal range and diagnostics possible.

Pulse-shaped disturbance variable	Tested with	Corresponds with degree of severity
• Asymmetric coupling	±1 kV (24 V DC supply cable) without protective element	2
	±1 kV (MultiFieldbus line) without protective element	2
• Symmetric coupling	±0.5 kV (24 V DC supply cable) without protective element	2

1 The maximum short-term influencing of analog devices during the duration of the EMC tests can amount to ±10 % of the full-scale value.

2 Analog value deviation beyond the limits of the nominal range and diagnostics possible.

Sinusoidal disturbance variables

The following tables show the electromagnetic compatibility of the distributed I/O systems to sinusoidal disturbance variables.

Table 1-1016 RF radiation

RF radiation according to IEC 61000-4-3 Electromagnetic RF field, amplitude modulated		Corresponds with degree of severity
80 ... 1000 MHz	10 V/m	3
1.4 ... 6 GHz	3 V/m	2
80% AM (1 kHz)		

Table 1-1017 RF coupling (signal and supply cables)

RF coupling according to IEC 61000-4-6.	Corresponds with degree of severity
0.15 ... 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

The maximum short-term influencing of analog modules during the duration of the EMC tests can amount to ±1 % of the full-scale value.

Emission of radio frequency interference

The following table shows the interference emission of electromagnetic fields according to EN IEC 61000-6-4/EN 55016-2-3.

Table 1-1018 Interference emission of electromagnetic fields

Frequency	Interference emission	Measuring distance
30 ... 230 MHz	< 40 dB (µV/m) Q	10 m
230 ... 1000 MHz	< 47 dB (µV/m) Q	10 m
1 ... 3 GHz	< 76 dB (µV/m) P	3 m
3 ... 6 GHz	< 80 dB (µV/m) P	3 m

Conducted emission

The following table shows the limits for power supply connections in accordance with EN IEC 61000-6-4/EN 55016-2-1.

Table 1-1019 Interference emission from the power supply

Frequency	Interference emission
0.15 ... 0.5 MHz	< 89 dB (µV) Q < 76 dB (µV) M
0.5 ... 30 MHz	< 83 dB (µV) Q < 70 dB (µV) M

10.5 Transport and storage conditions

Shipping and storage conditions

The I/O devices of the ET 200eco PN M12-L distributed I/O system exceed the specifications regarding transport and storage conditions pursuant to IEC 61131-2. The following table shows the conditions that apply to I/O devices transported or stored in their original packaging.

- Transport condition class: TTH4
- Storage condition class: STH4

Table 1-1020 Shipping and storage conditions

Type of condition	Permitted range
Free fall	≤0.3 m
Temperature	-40 °C ... +70 °C
Temperature variation	20 K/h
Barometric pressure	1140 ... 540 hPa (corresponds to an altitude of -1000 m to 5000 m)
Relative humidity	5 ... 95%; no condensation

10.6 Mechanical and climatic ambient conditions

Rated conditions

The ET 200eco PN M12-L distributed I/O system is suitable for use in weather-proof, fixed locations.

- The rated conditions exceed the requirements according to IEC 61131-2
  - Class OTH4

You can find the values for the rated conditions in the technical specifications of the Equipment Manuals or on the Internet (https://support.industry.siemens.com/cs/de/en/view/109742718).

Tests of mechanical ambient conditions

The following table shows the type and scope of the tests on mechanical ambient conditions.

Table 1-1021 Tests of mechanical ambient conditions

Condition tested	Test standard	Values
Sinusoidal vibrations, I/O device mounted without mounting rail[1]	Vibration test according to IEC 60068-2-6	Type of oscillation: Frequency sweeps at a rate of change of 1 octave/minute. 10 Hz ≤ f ≤ 58 Hz, constant amplitude 1.5 mm 58 Hz ≤ f ≤ 150 Hz, constant acceleration 20 g Period of oscillation: 10 frequency sweeps per axis at each of three vertically aligned axes
Sinusoidal vibrations, I/O device mounted on mounting rail		Type of oscillation: Frequency sweeps at a rate of change of 1 octave/minute. 5 ≤ f ≤ 9.1 Hz, constant amplitude 15 mm 9.1 ≤ f ≤ 150 Hz, constant acceleration 5 g Period of oscillation: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 30 g peak value, 18 ms duration Direction of shock: 3 shocks each in ± direction in each of the 3 axes vertical to one another

[1] When using the plug cover, use the "I/O device mounted on mounting rail" parameters for checking

Extended environmental conditions for use outdoors

The table below provides important information with respect to the type and scope of the test of extended ambient conditions for use in the outdoors. Consider further specifications and constraints for use in the outdoors.

Table 1-1022 Test of extended environmental conditions

Condition tested	Test standard	Conditions/remarks
Salt spray	IEC 60068-2-52	Degree of severity 1 for products that are used at sea or in the immediate vicinity of the sea: 4 cycles with each: • 2 h with 5 % NaCl at 35 °C • 6 days + 22 h at 40 °C/93 % relative humidity

Condition tested	Test standard	Conditions/remarks
200 h salt spray test	IEC 60068-2-11	5 % NaCl at 35 °C for 200 hours pH value: 6.5-7.2
UV resistance	IEC 61215-2	• Irradiance (E): 550 W/m² • Black standard temperature (BST): 55 °C
Condensed water alternating climate	EN ISO 6270-2	84 cycles with each: • 8 h at 40 °C with 100 % relative humidity (condensation) • 16 h at 18 °C to 28 °C with 100 % relative humidity
Temperature shock	IEC 60068-2-14	Temperature: -40 °C/+85 °C Duration: 250 cycles (250 h) Device in switched-off state
Icing	EN 60068-2-1	Check according to section 5.4
IP test	ISO 20653	IP69K (water and dust)

Climatic ambient conditions

The following table shows the type and scope of the tests on climatic ambient conditions.

Table 1-1023 Tests for climatic ambient conditions

Ambient conditions	Fields of application	Comments
Temperature	-40 ... 60 °C	All mounting positions*
Temperature variation	10 K/h	-
Relative humidity	5 ... 100%	With condensation and mounted covers
Barometric pressure	1140 ... 540 hPa	Corresponds to an elevation of -1000 to 5000 m
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

* Follow the instructions for the minimum distances in section Basics (Page 29).

Use above 2000 m is possible.

The following constraints apply to the maximum specified ambient temperature:

Table 1-1024 **Derating factor of installation elevation and ambient temperature**

Installation elevation	Derating factor for ambient temperature [1]
-1000 ... 2000 m	1.0
2000 ... 3000 m	0.9
3000 ... 4000 m	0.8
4000 ... 5000 m	0.7

[1] Base value for application of the derating factor is the maximum permissible ambient temperature in °C for 2000 m.

NOTE

- Linear interpolation between elevations is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher elevations due to lower density.
- Make sure that the power supplies you use are rated for elevations > 2000 m.

NOTE

All markings and certifications are currently based on an elevation of up to 2000 m.

10.7 Details on insulation, protection class, degree of protection and rated voltage

Insulation

The insulation is designed in compliance with the requirements of IEC 61010-2-201.

NOTE

In the case of I/O devices with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Pollution class according to IEC 61010-2-201

- Protection class III

Severity for voltage interruption

The I/O device of the distributed I/O system ET 200eco PN M12-L meet the severity class PS2 for voltage interruption (10 ms).

Pollution degree / overvoltage category according to IEC 61010-2-201

Connected according to the specifications in the "Wiring (Page 51)" section:

- Pollution degree: 3 (macro environment)
- Overvoltage category: II

In delivery state, with one or more open connections:

- Pollution degree: 2 (micro environment)
- Overvoltage category: II

Degree of protection IP65/67, IP69K

Degree of protection of the ET 200eco PN M12-L distributed I/O system:

IP65/IP67 according to IEC 60529

- 1. Code number IP6x: Dust-proof and complete protection from contact
- 2. Code number: Protection from water
  - IPx5: Protected against water jets (nozzle) from any angle
    Water directed as a jet against the housing from any direction must have no harmful effects.
  - IPx7: Protected against the effects of temporary immersion in water
    Water must not enter in a quantity to cause harmful effects when the enclosure is temporarily immersed in water under standardized pressure condition and time conditions.

IP69K in accordance with ISO 20653

- 1. Code number IP6x: Dust-proof
- 2. Code number IPx9K: Protected against water at high pressure/steam-jet cleaning
  Water directed as a jet against the housing from any direction must not have any harmful effects or affect the performance.

Rated voltage for operation

The following table shows the nominal voltage and the corresponding tolerance with which the ET 200eco PN M12-L distributed I/O system operates.

Table 1-1025 Rated voltage for operation

Rated voltage (SELV/PELV)	Tolerance range
24 V DC	DC 20.4 ... 28.8 V

10.8 Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas

Introduction

This section contains important notes on the ET 200eco PN M12-L distributed I/O device for installation in the Zone 2/Zone 22 hazardous areas.

The multilingual product information in different EU official languages is available here: Use of the ET 200eco PN M12-L in Zone 2/Zone 22 hazardous areas (https://support.industry.siemens.com/cs/ww/en/view/109814099)

Approved I/O devices ET 200eco PN M12-L

The I/O devices have these explosion approvals:

- ATEX approval
- UKEX approval
- IECEX approval
- CCCEx approval

You can find the explosion protection certificates with the approved ET 200eco PN M12-L I/O devices here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=441).

⚠ WARNING

Personal injury and material damage
When disconnecting plug-in connections during running operation, personal injury and material damage may occur in potentially explosive atmospheres.
In potentially explosive atmospheres, de-energize the ET 200eco PN M12-L I/O device before disconnecting plug connections.

Special conditions

- Set up the I/O devices so that the risk of mechanical danger is low.
- Adhere to the technical specifications for the I/O devices as specified in the EU -type examination certificate:
  - Supply voltage of the ET 200eco PN M12-L
  - Currents of inputs and outputs
  - Ambient temperatures
- All M12 connection plugs (for MultiFieldbus, supply voltage, encoders and actuators) must not be connected or disconnected under voltage.

NOTE

Prerequisites when using the plug cover

The plug cover is an accessory for protecting the connected connectors on the I/O device. If you use a plug cover, the cables with connectors must fulfill the following requirements:

- The cables have a straight plug outlet
- The maximum outer diameter of the connector is 16 mm

Plug cover

The figure below shows the plug cover. The plug cover is an accessory for protecting the connected connectors on the I/O device. The plug cover may be necessary for use in hazardous areas. You will find the article numbers in the Accessories/spare parts (Page 120) section.

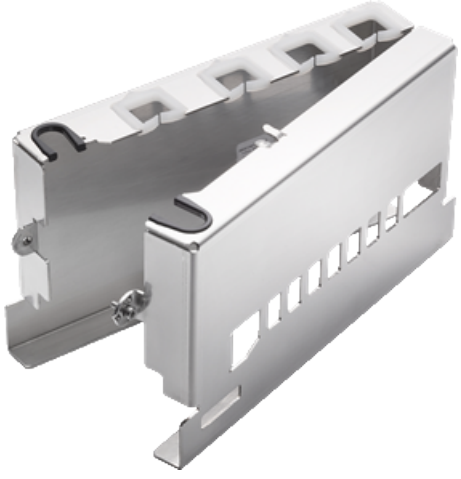


Figure 1-748 Plug cover

Industrial cybersecurity 11

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

In the first part of this section you will find basic information on the subject of industrial cybersecurity. Subsequent sections describe recommended measures for protecting the entire system and individual components from manipulation and unwanted access.

NOTE

Security-relevant changes to software or devices are documented in the section New properties/functions (Page 21).

11.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

11.2 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction (Page 6) section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. In the "Product tree" filter menu, select your product or your product group, for example "Automation technology" > "Automation systems" > " SIMATIC Industrial Automation Systems" > "I/O systems" > "SIMATIC ET 200 systems without control cabinet" > "ET 200eco PN".
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".
6. Select the document about which you want to receive notifications using the 3 points on the right "Add to my favorites".
7. In the following dialog, select the name, the storage location and the "Notify me" option for the favorite. Then click on the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

11.3 Basic information on industrial cybersecurity

11.3.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (e.g. due to the destruction of data or denial of service (DoS))

11.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices without their own security functions

- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

11.4 Integrated security concept and security strategies

11.4.1 Comprehensive security concept "Defense in Depth"

With Defense in Depth, Siemens provides a multi-layer security concept that offers industrial plants comprehensive and far-reaching protection in accordance with the recommendations of the IEC 62443 international standard.

Productivity and know-how are protected on 3 levels:

Plant security
Plant security uses various methods to safeguard critical components from physical access by people. This starts with classic building access and extends to securing sensitive areas using access control (for example, code card, iris scan, fingerprint or access code).

Network security
Automation networks must be protected against unauthorized access. This is achieved through security measures on the product, but also those in the product-related environment.

System integrity
Targeted measures must be taken to protect existing know-how or to prevent unauthorized access to automation processes. The measures protect against unauthorized configuration changes and highlight attempts at manipulation.

You can find more information on the topics of Defense in Depth, plant security, network security, and system integrity on the SIEMENS Industrial cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) Web page.

You can also visit the download center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) to obtain more information on the topic of industrial cybersecurity. The "Operational Guidelines", for example, provide recommendations on basic security measures for secure machine and plant operation in an industrial environment.

11.4.2 Security management

The ISO 27001 and IEC 62443 standards call for a comprehensive approach in information technology (IT) and operational technology (OT) to protect against cyber attacks.

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

- Defining cybersecurity and IT security as an important criterion in the procurement and selection of machines and software applications
- Use of suitable measures to protect production resources, data, and communication from manipulation and theft
- Providing all necessary resources and training to employees to fully support these goals

For this purpose, suitable measures must be selected after a risk assessment and a cost-benefit analysis in order to protect material and intellectual property and prevent damage from occurring. These measures should be integrated into corporate processes and procedures, evaluated regularly, and firmly anchored in the corporate culture. In addition to protecting intellectual property, the protection of personal data must be ensured at all organizational units and levels.

Siemens will provide you with information and support. Subscribe to the Security feeds (https://www.siemens.com/cert) for information on vulnerabilities. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home) and create filters to be notified when important information is published. The procedure is described in the section Notification of security updates (Page 101). Consider using Siemens Cybersecurity Services.

Responsibility in the digital supply chain

Cybersecurity should play a critical role in the evaluation and procurement process. The entire life cycle of a product should be considered to ensure protection against current and future risks. These include, for example, security updates throughout the product life cycle, including guidelines for secure disposal of the product.

Siemens plans and announces the provision of security updates, as well as total discontinuation of products, as part of product support.

Employee awareness

Regular training in cybersecurity and continuous testing of training success are essential so that cybersecurity measures are internalized in processes and work instructions. This involves general training in the use of software and IT hardware for company communication and as work equipment, e.g.:

- secure handling of USB devices
- encrypted communication
- use of VPN
- rules for passwords and use of access
- setting up two-factor authentication
- Educating employees about the dangers posed by malware, phishing, social engineering and other factors

Furthermore, if applicable, production equipment and software training should always include the topic of cybersecurity.

Maintaining the security concept through updates

Keeping software up-to-date is essential, for example, to benefit from the following measures:

- Implementation of new security strategies, protocols and techniques
- Closing of security vulnerabilities
- Elimination of security vulnerabilities

To this end, it is necessary to keep a constant eye on the further development of protective measures and, if necessary, the expansion of requirements.

It is recommended to:

- Set up notifications for (security) updates
- Subscribe to information on vulnerabilities
- Monitor and implement the further development of the technology, especially in the area of cybersecurity

In short: Always keep technology and knowledge up to date.

Consideration of the risks posed by cyber attacks in the Threat and Risk Assessment (TRA)

Make an inventory of all software, hardware, and infrastructure devices, in order to identify risks to the location or organization. Incident response procedures must be incorporated into all IT and manufacturing processes. The choice of risk mitigation measures should be based on a cost-benefit analysis and classification of risks. This is followed by the introduction of cybersecurity rules and procedures and the training of personnel.

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

Cybersecurity must be part of the corporate culture and process landscape and must be internalized and lived by all employees.

Continuously monitoring the security situation

Continuous monitoring of the cybersecurity situation through:

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and effectively resolve security vulnerabilities.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network

- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: for example network segmentation, firewalls, VPN, DMZ (demilitarized zones)

11.5 Operational application environment and security assumptions

11.5.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

Operational reliability and intended use

Read the "Special information" in the Introduction (Page 6) section.

Area of application

Observe the "Area of application" section in System overview (Page 24) chapter.

11.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Conducting a threat and risk assessment (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection
In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security
Physical enterprise security can be ensured by the following measures:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security
The following measures can be included in assuring physical production security:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsafe on systems.

11.6 Security properties of the devices

The security properties of the individual devices are listed in the Equipment Manuals.

11.7 Secure operation of the system

This section describes measures recommended by Siemens to protect your system from manipulation and unauthorized access.

11.7.1 Hardening measures

System hardening, also simply referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which a restrictive user and rights management system is implemented.

11.7.2 Secure configuration

Secure configuration involves control over all software components, along with their interfaces, ports, and services.
Activated services and ports pose a risk.

- One possible risk is unauthorized access to the network.
- Another risk is unauthorized access to programs.

To minimize risks, only the necessary services should be activated for all automation components.

- Take all activated services (especially Web servers, FTP, remote maintenance etc.) into account in the security concept.
- Consider the default states of ports and services in your security concept.

You can find an overview of all ports and services used in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

11.7.3 Handling of sensitive data

Data protection information

Siemens Aktiengesellschaft observes the applicable data protection laws, including the General Data Protection Regulation (GDPR), in particular the rules of data minimization and data protection-friendly default settings (privacy by design, privacy by default).

The products do not store any personal data.

If you establish a reference to an identifiable person by linking this functional data with other data (such as shift schedules) or if you store personal data on the same medium (such as a hard disk), you are responsible for ensuring that the data protection regulations are observed.

Information on the secure removal of data is provided in the section Secure decommissioning (Page 109).

Storage of security-related data

When storing your security-relevant data on your PC, independently ensure secure data storage.

11.7.4 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

- Always keep your plant/products up to date to benefit from troubleshooting and to minimize potential risks.
- Use email notifications to be automatically informed about firmware updates.

You can find more information in:

- Section Firmware update (Page 79)
- Section Notification of security updates (Page 101)

11.7.5 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. It can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes security gaps (Vulnerabilities) in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following Siemens Aktiengesellschaft web page: Siemens ProductCERT and Siemens CERT (https://www.siemens.com/global/en/products/services/cert.html?s=SIMATIC&_originalHost=new.siemens.com#SecurityPublications)

"SIMATIC" is preset in the "Search Security Advisories" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters

- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please inform us immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

11.7.6 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

11.7.7 Security checks

Security checks for data, files, and archives serve to ensure data integrity at the storage location and during file transmission, protecting against manipulation and transmission errors. This is often achieved using digital checksums that are provided alongside the data. Tools (such as SHA-256 or SHA-512) for calculating and verifying these checksums are provided in many systems and named according to their respective calculation methods.

- File Integrity Guidelines describe the prescribed procedure for integrity checks
- Integrity protection is a protection function for engineering data and firmware files
- Communication integrity means protecting communication against unauthorized manipulations to ensure high system availability. A central element in this regard is, for example, the use of digital checksums when accessing controllers. (Source: Industrial Cybersecurity website (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html))

11.7.8 Secure decommissioning

In the following section, you will find information on how to properly decommission individual components of your automation system. Decommissioning is necessary when the component has reached the end of its service life.

Decommissioning includes environmentally sound disposal and secure removal of all digital data of electronic components with storage medium.

11.7.8.1 Securely removing data

Before disposing of components of your automation system, you should securely delete all data from the storage media of these components. How to securely delete data from the devices so that it cannot be recovered is described below.

NOTICE
Data misuse resulting from non-secure deletion of data Incomplete or non-secure deletion of data from data memories can result in data misuse by third parties. For this reason, ensure secure deletion of data from all storage media used before disposing of the product.

Secure erasure of data from the I/O device

With the following tools, you can securely erase the data from the I/O device:

- STEP 7 < V19
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

Follow these steps in the order given:

1. Establish an online connection.
2. Open the Online and Diagnostics view of the I/O device (either from the project context or via "Accessible devices").
3. In the dialog box "Functions > Reset to factory settings", select the option "Delete I&M data" and then the "Reset" button.

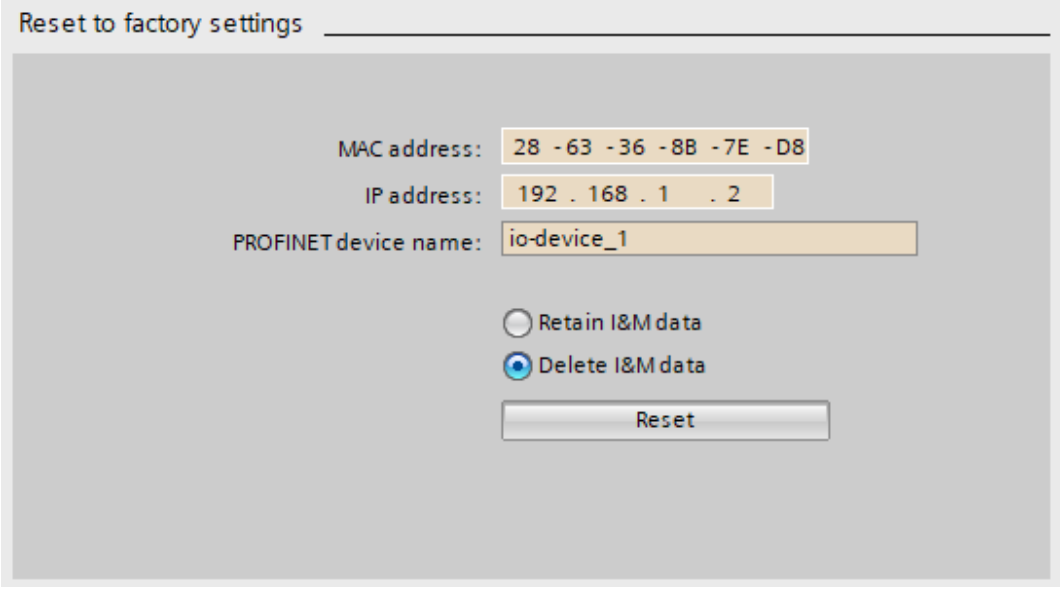


Figure 1-749 Resetting the I/O device to factory settings

Result: All the data that was still in the data memories of the I/O device was deleted. You can now dispose of the components.

For more information on resetting the I/O device to factory settings, refer to the section Resetting an interface module to factory settings (Page 81).

NOTE

STEP 7 ≥ V19

Only the communication parameters will be securely deleted on "Reset to factory settings" with the "Delete I&M data" option enabled when you use STEP 7 ≥ V19.

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

If you want to securely remove all data, use one of the tools listed above for this purpose.

11.7.8.2 Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

11.8 Secure operation of the engineering software

For more information on secure operation of the engineering software, refer to the TIA Portal online help.

11.9 Secure operation of I/O devices

11.9.1 Secure operation of I/O devices

Device-specific security information and notes on I/O devices can be found in the respective Equipment Manual.

11.9.2 Signed firmware update

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect internet source

Information on whether your I/O device supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of the signed firmware update for I/O device

Firmware updates of I/O devices may include a digital signature. The digitally signed firmware update files are available for download on the Siemens Support Web page.

The I/O device verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the I/O device can detect a manipulated or corrupted firmware update file and reject it.

Note that the I/O device performs the verification only after the complete firmware download has taken place.

Subsequently, a notification is sent to the firmware update tool regarding the success or failure of the signature verification.

You still have all the options for firmware updates, as described in the Firmware update section, when performing signed firmware updates for I/O devices. If the firmware update was not successful, the I/O device will continue to run with the previous firmware.

Diagnostics alarms and remedy

When performing a firmware update for an I/O device with an established connection between the I/O device and CPU, the following options for notifications are available in the CPU's diagnostic buffer:

- Successful integrity check of the firmware for the I/O device
- Rejection of non-secure firmware for the I/O device

For more information, refer to the Channel Diagnostics table in the Equipment Manual of the I/O device.

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file you are using originates from a secure source and was downloaded unchanged. As a check, calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support website.
3. Repeat the firmware update.

Information on the procedure for calculating and comparing hash values is available on the Internet (https://support.industry.siemens.com/cs/de/de/view/109483101/en).

Safety-related shutdown

A

A.1 Safety-related shutdown of ET 200eco PN M12-L

Introduction

The setup below describes how you shut down ET 200eco PN M12-L standard modules in a fail-safe manner.

With the illustrated setup (e.g. with safety relay 3SK1 or electronic module ET 200SP F-PM-E), all outputs that are connected to load voltage 2L+/2M (24 V switched) of the ET 200eco PN M12-L standard modules are switched to the safe OFF state. The ET 200eco PN M12-L standard modules are operated at supply voltage 1L+/1M. Supply voltage 1L+/1M is electrically isolated from load voltage 2L+/2M.

The maximum performance level achieved by the illustrated setup is SIL2/Category 3/PL d. The component with the lowest safety standard determines the maximum performance level a system achieves.

Principle of operation

A higher-level electromechanical safety relay (e.g. 3SK1) or an electronic fail-safe module (e.g. ET 200SP F-PM-E) isolates the load voltage 2L+/2M (24 V switched). The outputs of the ET 200eco PN M12-L standard modules operated at 2L+/2M (24 V switched) are switched to the safe state. The outputs connected to 1L+/1M (24 V non-switched) are not intended for functional switching and therefore cannot be shut down safely.

You can also integrate I/O devices that are operated exclusively at supply voltage 1L+/1M (non-switched) in the setup of your distributed I/O system. These I/O devices must be enabled as reaction-free modules. Reaction-free modules relay the load voltage 2L+/2M and are not affected by a shutdown. The following schematic circuit diagrams illustrate this.

Schematic circuit diagram with 3SK1

The following figure shows a schematic circuit diagram with safety relay 3SK1.

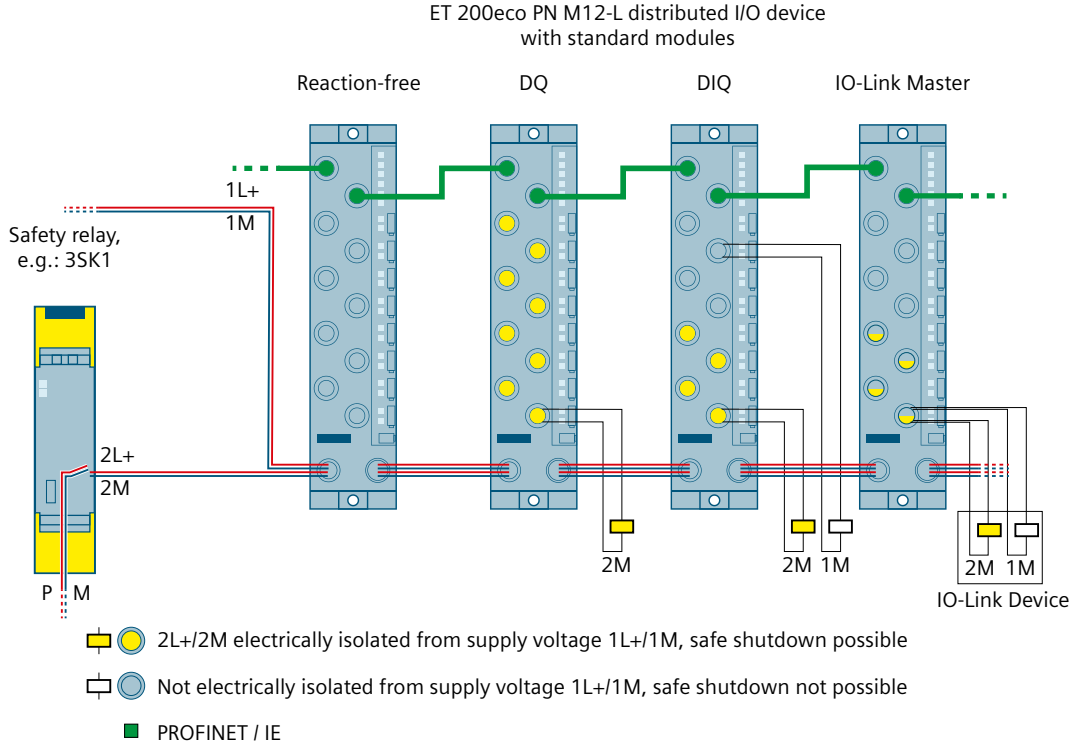


Figure 1-750 Higher-level safety circuit of the outputs

You can find an overview table with the article numbers of the I/O devices and other information in the FAQ on safety-related shutdown (https://support.industry.siemens.com/cs/ww/en/view/39198632).

Schematic circuit diagram with ET 200SP F-PM-E

The following figure shows a schematic circuit diagram with electronic module ET 200SP F-PM-E.

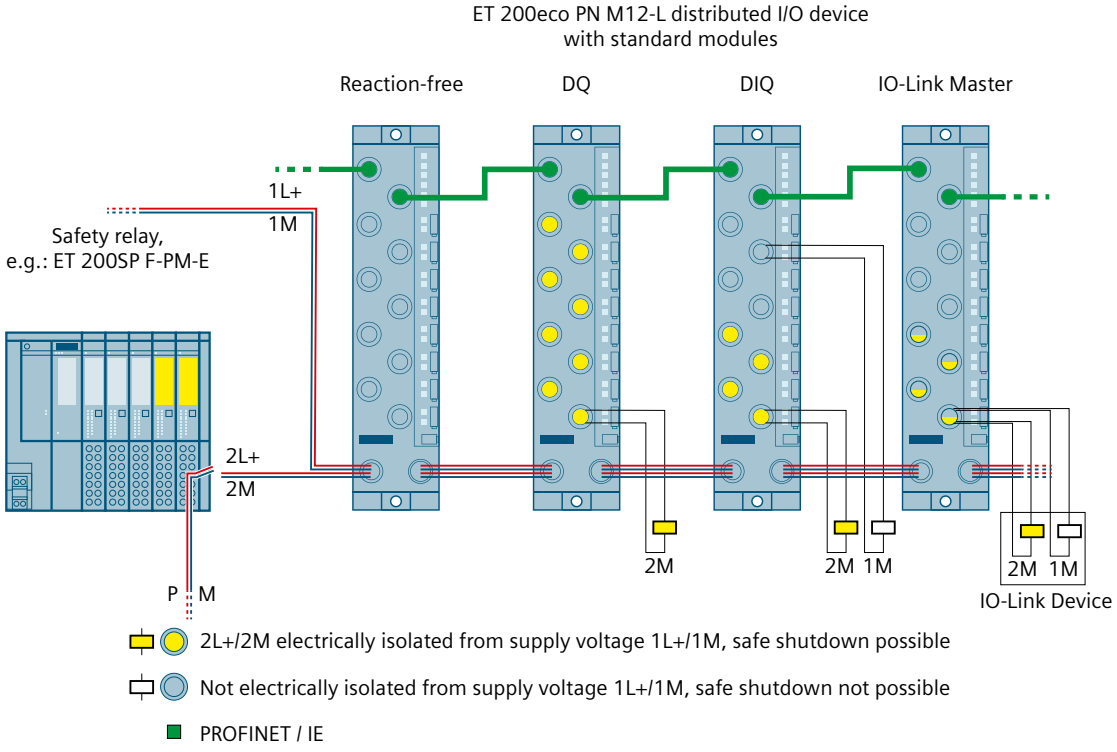


Figure 1-751 Higher-level safety circuit of the outputs

You can find an overview table with the article numbers of the I/O devices and other information in the FAQ on safety-related shutdown (https://support.industry.siemens.com/cs/ww/en/view/39198632).

Planning

Note the following points when planning safety circuits.

WARNING

Pay attention to potential groups for safety-related shutdown
When a digital output is connected to a digital input, pay attention to the potential groups. Depending on the configuration, 1M and 2M can then be connected, which leads to elimination of the electrical isolation between 1L+ and 2L+.
Safety-related shutdown is not permitted if electrical isolation has been eliminated.

⚠ WARNING

24 V encoder supply $2U_S$ for DIQ channels at 2L+/2M
Use only the 24 V encoder supply $2U_S$ provided by the I/O device for the encoder supply for DIQ channels.
If you use a different encoder supply, this eliminates the electrical isolation of the whole safety circuit. This prevents you from establishing a safe state in the entire system.

NOTE

Safe electrical isolation
Ensure protection by electrical separation for voltages greater than SELV/PELV.
If, for example, the actuators switch 230 V, there must be protection by electrical separation between the outputs and the 230 V components.

NOTE

Safety-related shutdown for the IO-Link master
For an IO-Link master with IO-Link Port Class B, safety-related shutdown is available for the additional supply (PIN 2 and PIN 5).
The other signals at the port are reaction-free if you ensure electrical isolation from PIN 2 and PIN 5 of the port.
Note that the IO-Link device must have corresponding safety characteristics in order to use the safety-related shutdown.

ET 200SP F-PM-E documents

If you use an electronic module ET 200SP F-PM-E for a safety circuit, observe the information in these documents:

- Manual for Power Module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/ww/en/view/78645796)
- Product information for Power Module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/ww/en/view/109761777)

Settings for ET 200SP F-PM-E

Consider the whole system when setting and planning. Here is a small excerpt of various settings.

- Operation only as a PM-switching module as shown in figure Safety-related shutdown of ET 200eco PN M12-L (Page 113)
- Disabling of dark test (max. SIL 2, Cat.3/PL d) since it causes outputs to drop out briefly
  Observe the information in Manual for Power Module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/ww/en/view/78645796) and Product information for Power Module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/ww/en/view/109761777)
- Switching of capacitive loads
  Observe the information in section "Connecting capacitive loads" in Manual for Power Module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/ww/en/view/78645796)

Limits of the higher-level safety circuit

The ET 200eco PN M12-L standard modules do not fulfill any safety functions. The safety functions are executed by the safety relay in order to bring the system into a safe state. Adjust the operation inspection interval of the safety relay according to the safety class. Use the operating instructions and related documents of the utilized safety relay for this.
Take the following measures if energy that is not provided by the higher-level safety circuit is used to control the safety function.

Prevent dangerous faults in the safety function that are not detected by the higher-level safety circuit (e.g. 3SK1 or ET 200SP F-PM-E) by adopting suitable safety measures. The "diagnostics" must be performed indirectly via the controlled process.

Requirements for safety-related process data:

- Functionally safe
- Read via fail-safe inputs (e.g. F-DI)
- Fail-safe processing unit (e.g. F-CPU) for output of commands
- Output through fail-safe outputs (e.g. F-DQ) for controlling the safety function

If these criteria are not met, bring the standard modules to the safe state through the higher-level safety circuit.

- Process error
- Faulty standard modules

Take the fault tolerant time interval (FTTI) of the process into account for this.

Requirements for the power supply

Operation requires a SELV/PELV power supply for limiting overvoltages on L+ and M (24 V). This measure prevents possible errors from the power supply side at the same time.

Select the power supply unit according to the requirements of the respective operating instructions for the shutdown device and for the ET 200eco PN M12-L system.

You can find more information on safe SELV/PELV in the data sheets of the utilized power supply units.

FAQ

The information on the safety-related shutdown of standard modules refers to the status of the issue date. Read the up-to-date information on safety-related shutdown in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/39198632).

This FAQ specifies the SIMATIC standard modules that are suitable for a safety-related shutdown and a file with wiring examples.

Request TÜV report (Report no. SN96753T)

You can request copies of the TÜV report at the following address:

Siemens Aktiengesellschaft
Digital Industries
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg, Germany

Dimension drawings

B

B.1 Dimension drawing I/O device

The following figure shows the dimensions of an I/O device of the distributed I/O system ET 200eco PN M12-L.

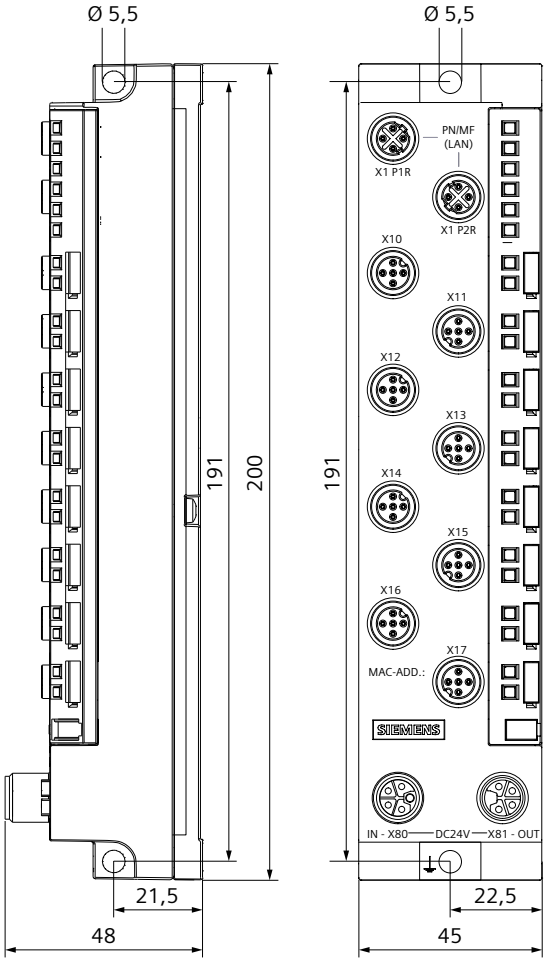


Figure 1-752 Dimension drawing of an I/O device

B.2 Dimension drawing of plug cover

The figure below shows the dimensions of the plug cover for a distributed I/O device ET 200eco PN M12-L.

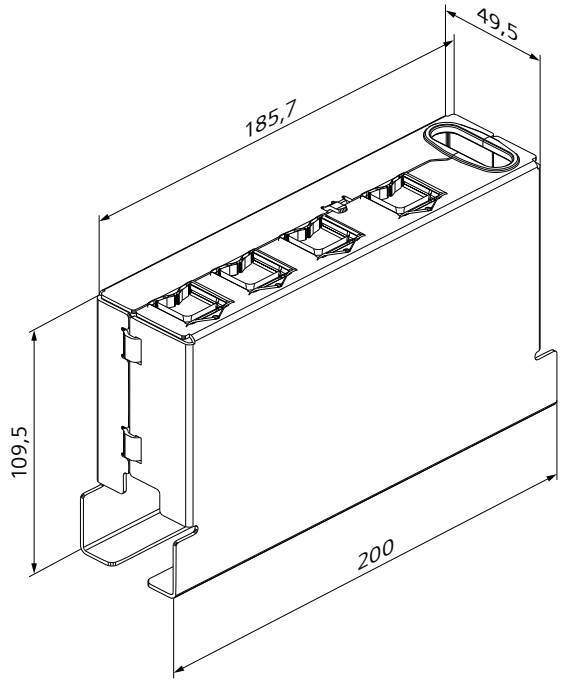


Figure 1-753 Dimension drawing of plug cover

Accessories/spare parts

C

C.1 Accessories/spare parts

Accessories for the ET 200eco PN M12-L distributed I/O system

The following tables show a selection of the suitable accessories. You can find a detailed overview of suitable plugs and cables for the ET 200eco PN distributed I/O system in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109781065).

Table 1-1026 Accessories for power supply

Designation	Length	Article number
Cable is pre-assembled		
CONNECTING CABLE M12, L-CODED Power connecting cable M12-180/M12-180 for power supply of ET 200 Pre-assembled cable with M12 plug and M12 socket, L-coded, 4-pin	0.5 m	6XV1801-6DE50
	1.0 m	6XV1801-6DH10
	1.5 m	6XV1801-6DH15
	2.0 m	6XV1801-6DH20
	3.0 m	6XV1801-6DH30
	5.0 m	6XV1801-6DH50
	10.0 m	6XV1801-6DN10
	15.0 m	6XV1801-6DN15
M12 CONNECTING CABLE, L-CODED, ANGLED Power connecting cable M12-90/M12-90 for power supply of ET 200 Pre-assembled cable with M12 plug and M12 socket, L-coded, 4-pin	0.5 m	6XV1801-6GE50
	1.0 m	6XV1801-6GH10
	1.5 m	6XV1801-6GH15
	2.0 m	6XV1801-6GH20
	3.0 m	6XV1801-6GH30
	5.0 m	6XV1801-6GH50
	10.0 m	6XV1801-6GN10
	15.0 m	6XV1801-6GN15
Robust Power Connecting Cable M12-180/M12-180; IP69; 4x1.5 mm2 for power supply of end devices/network components; prefabricated cable with M12 connector and M12 socket; L-coded; 4-pole	0.5 m	6XV1801-6EE50
	1.0 m	6XV1801-6EH10
	1.5 m	6XV1801-6EH15
	2.0 m	6XV1801-6EH20
	3.0 m	6XV1801-6EH30
	5.0 m	6XV1801-6EH50
	10.0 m	6XV1801-6EN10
	15.0 m	6XV1801-6EN15

Designation	Length	Article number
Cable can be assembled in the field		
Power M12 Plug PRO; M12 connector with male contact insert, 4-pin, L-coded		6GK1906-0EA00
Power M12 Cable Connector PRO; M12 connector with female contact insert, 4-pin, L-coded		6GK1906-0EB00
Energy Cable 4 x 1.5; power cable (4-wire), by the meter, unassembled		6XV1801-2B

Table 1-1027 Non-preassembled connector **PROFINET** M12

Designation		Article number
Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN) socket		
PROFINET M12 connector D-coded with FastConnect connection system, 180°	1 unit/ pack	6GK1901-0DB10-6AA0
	8 units/ pack	6GK1901-0DB10-6AA8
PROFINET M12 connector, D-coded with FastConnect connection system, 180°	1 unit/ pack	6GK1901-0DB20-6AA0
	8 units/ pack	6GK1901-0DB20-6AA8
PROFINET M12 connector, D-coded, angled		3RK1902-2DA00

Table 1-1028 Non-preassembled cable **PROFINET** (sold by the meter)

Designation	Article number
Non-preassembled connectors for X1 P1R PN (LAN) and X1 P2R PN (LAN)	
PROFINET FC cable	
FC TP Standard Cable	6XV1840-2AH10
FC TP Trailing Cable	6XV1840-3AH10
FC TP Trailing Cable GP	6XV1870-2D
FC TP Marine Cable	6XV1840-4AH10
FC TP Torsion Cable	6XV1870-2F
FC TP Flexible Cable GP (PVC sheath)	6XV1870-2B
FC TP FRNC Cable (FRNC sheath)	6XV1871-2F
FC TP Food Cable (PE sheath)	6XV1871-2L
FC TP Festoon Cable GP (PVC sheath)	6XV1871-2S

Table 1-1029 Pre-assembled cable PROFINET M12

Designation		Article number
Pre-assembled cable for X1 P1R PN (LAN) and X1 P2R PN (LAN)		
PROFINET M12 connecting cable, trailing cable, pre-assembled on both sides with M12 plugs 180° (pin)	0.3 m	6XV1870-8AE30
	0.5 m	6XV1870-8AE50
	1.0 m	6XV1870-8AH10
	1.5 m	6XV1870-8AH15
	2.0 m	6XV1870-8AH20
	3.0 m	6XV1870-8AH30
	5.0 m	6XV1870-8AH50
	10.0 m	6XV1870-8AN10
	15.0 m	6XV1870-8AN15

Designation		Article number
PROFINET M12 connecting cable, trailing cable, pre-assembled on both sides with M12 plugs, angled (pin)	0.3 m	6XV1870-8GE30
	0.5 m	6XV1870-8GE50
	1.0 m	6XV1870-8GH10
	1.5 m	6XV1870-8GH15
	2.0 m	6XV1870-8GH20
	3.0 m	6XV1870-8GH30
	5.0 m	6XV1870-8GH50
	10.0 m	6XV1870-8GN10
	15.0 m	6XV1870-8GN15
PROFINET M12 connecting cable, trailing cable, pre-assembled on one side with M12 plug, angled (one end with pin, one end open)	3.0 m	3RK1902-2HB30
	5.0 m	3RK1902-2HB50
	10.0 m	3RK1902-2HC10
PROFINET M12 connecting cable, trailing cable, pre-assembled on one side with M12 plug 180° (pin), other side with RJ45 plug 145°	2.0 m	6XV1871-5TH20
	3.0 m	6XV1871-5TH30
	5.0 m	6XV1871-5TH50
	10.0 m	6XV1871-5TN10
	15.0 m	6XV1871-5TN15
IE robust connecting cable M12-180/M12-180, IP69, pre-assembled IE FC robust food cable GP 2x2, with 2 M12 plugs (D-coded)	1.0 m	6XV1881-5AH10
	2.0 m	6XV1881-5AH20
	3.0 m	6XV1881-5AH30
	5.0 m	6XV1881-5AH50

Table 1-1030 Y- connection

Designation		Article number
SIMATIC DP, Y cable for distributed I/O devices for double connection of I/O devices using single cable, 5-pin, M12	0.2 m	6ES7194-6KA00-0XA0
SIMATIC DP, Y-connector for distributed I/O devices for double connection of I/O devices using single cable, 5-pin, M12	1 unit/ pack	6ES7194-1KA01-0XA0

Table 1-1031 Additional accessories

Designation		Article number
Mounting rail for ET 200ECO PN	0.5 m	6ES7194-6GA00-0AA0
Profile screws for mounting rail ET 200ECO PN	50 unit/ pack	6ES7194-6MA00-0AA0
Identification labels 10 x 5 mm	200 unit/ pack	6ES7194-2BA00-0AA0
SEALING CAP M12 AS-Interface accessories M12 sealing cap for IP67 modules external diameter 12 mm without O-ring	100 unit/ pack	3RX9802-0AA00
AS-I SEALING CAP M12 F. IP67 MODULES AS-Interface accessories M12 sealing cap for IP67 modules external diameter 15 mm with O-ring	100 unit/ pack	3RK1901-1KA00

Designation		Article number
AS-I SEALING CAP M12 F. IP67 MODULES AS-Interface accessories M12 sealing cap for IP67 module manipulation-proof model external diameter 15 mm with O-ring	100 unit/ pack	3RK1901-1KA01
Stripping Tool for PROFINET		6GK1901-1GA00
Plug cover for ET 200ecoPN M12-L For use of ET 200ecoPN M12-L in Zone 2/22 hazardous areas	1 unit/pack	6ES7194-6JA00-0BB0

Online catalog

Other article numbers for the ET 200eco PN M12-L distributed I/O system can be found on the Internet (http://www.siemens.com/automation/service&support) in the online catalog and the online order system.

C.2 UL-approved cables

In combination with the UL-approved cables for the power supply and the connection of inputs/outputs, the SIMATIC ET 200eco PN M12-L distributed I/O devices meet UL approval. Siemens has UL-approved cables for these applications in the product portfolio.

C.3 Plug cover for ET 200ecoPN M12-L

The following table shows the technical specifications for plug cover for ET 200ecoPN M12-L.

Article number	6ES7194-6JA00-0BB0
General information	
Product description	connector cover for ET200ecoPN M12-L
Degree and class of protection	
IP degree of protection	IP20
Ambient conditions	
Ambient temperature during assembly, min.	-40 °C
Ambient temperature during assembly, max.	80 °C
Ambient temperature during operation	
• min.	-40 °C
• max.	60 °C
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	80 °C
Mechanics/material	
Material of housing	stainless steel with plastic edge protection
Material property	
• Silicone-free	Yes

Article number	6ES7194-6JA00-0BB0
Dimensions	
Width	50 mm
Height	200 mm
Depth	110 mm
Weights	
Weight, approx.	710 g

SIMATIC ET 200eco PN M12-L data

D

The EU Data Act, a key component of the European data strategy, entered into force on 11 January 2024.

The following information provides an overview of the data that is generated by the SIMATIC ET 200eco PN M12-L automation system and accessible to you.

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to PG/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFINET, EtherNet/IP, Modbus TCP

Continuous and real-time data generation

The I/O devices are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the higher-level CPU.

Data storage and storage duration

Local data storage

The I/O devices store data in integrated memory areas.

Local data storage	Storage capacity	Storage duration
Retentive memory (for I&M data, configuration and parameter data, service data)	I/O devices up to 16 MB	Permanent
Work memory (for process data, diagnostics data, fieldbus metadata, configuration and parameter data, service data)	I/O devices up to 1 MB	During operation of the I/O device

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughputs up to 1 Gbps via PROFINET
Configuration and parameter data (upload to PG/PC)	TIA Portal (via CPU) S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT (for interface modules as MultiFieldbus devices)	Via fieldbus without authentication Via CPU (https://support.industry.siemens.com/cs/de/de/view/59193101-/en)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the I/O devices to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deleting data from I/O devices

To delete all data from the data memories of the I/O device, the "Reset to factory settings" function is available.

To reset the I/O device to factory settings, the following access options are available:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

More information

You can find more information on deleting data in the "Securely removing data (Page 110)" and "Restoring the factory settings (Page 81)" sections.

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SIMATIC

Distributed I/O ET 200eco PN

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Distributed I/O ET 200eco PN

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Preface

Purpose of the manual

The information in this manual enables you to run the ET 200eco PN distributed I/O device on PROFINET IO as IO device.

Basic knowledge required

This manual presumes a general knowledge in the field of automation engineering.

The manual describes the components based on the data valid at the time of its release. SIEMENS reserves the right of including a product information for each new component, and for each component of a later version.

Scope of this manual

This manual applies to the ET 200eco PN distributed I/O device.

Changes compared to the previous version

Compared with the previous version, this manual includes the following changes/additions:

- Updates in section Standards and certifications (Page 88)

Standards and certifications

You can find information on the standards and approvals that are fulfilled by the ET 200eco PN distributed I/O device in the section Standards and certifications (Page 88).

Scope of information

In addition to this manual, you need:

- The manual for the IO Controller you are using
- The PROFINET System Description (https://support.industry.siemens.com/cs/ww/en/view/19292127) system manual,
- The From PROFIBUS DP to PROFINET IO (https://support.industry.siemens.com/cs/ww/en/view/19289930) programming manual.
- The IO-Link System (https://support.industry.siemens.com/cs/ww/en/view/65949252) function manual.

Guide

This manual describes the hardware of the ET 200eco PN distributed I/O device. It consists of instructive sections and reference sections (specifications).

Topics covered in this manual include

- Installation and wiring of the ET 200eco PN distributed I/O device
- Commissioning and diagnostics of the ET 200eco PN distributed I/O device
- Components of the ET 200eco PN distributed I/O system
- Article numbers
- Important terms are explained in the glossary.
- The index helps you to quickly find all texts relevant to your keyword.

Recycling and disposal

For ecologically compatible recycling and disposal of your old device, contact a certificated waste disposal service for electronic scrap. Dispose of the equipment according to the applicable regulations in your country.

Training Centers

Siemens offers corresponding courses to get you started with your ET 200eco PN distributed I/O device and the SIMATIC S7 automation system. Please contact your local training center.

Additional information can be found on the Internet (http://www.sitrain.com/index_en.html).

Technical Support

Expert advice on technical questions with a wide range of demand-optimized services for all our products and systems.

You can find Technical Support at the following address on the Internet (https://support.industry.siemens.com/cs/ww/en/sc/2090).

Additional support

If you have any further questions about the use of products described in this manual, and do not find the right answers there, contact your local Siemens representative:

You can find your representative on the Internet (http://www.automation.siemens.com/partner/guiwelcome.asp?lang=en).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Internet (https://support.industry.siemens.com).

The online catalog and ordering systems are available on the Internet (http://mall.industry.siemens.com).

See also

Back-up oriented shutdown of ET 200eco PN standard modules (Page 243)
General rules and regulations for operating an ET 200eco PN (Page 26)
I/O device analog input (Page 142)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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Product overview

1

1.1 Distributed I/O device – Overview

Distributed I/O systems – application area

A plant configuration quite often features a process I/O configuration in a central automation system.

The wiring of process I/O components installed at a grated distance away from an automation system may soon may soon become highly complex and susceptible for electromagnetic interference.

Distributed I/O systems are are the perfect solution for such configurations.

- The controller CPU is located in a central rack.
- The I/O systems (inputs and outputs) are operated locally in a distributed configuration.

What is PROFINET IO?

PROFINET IO is an open transmission system with real-time functionality defined in accordance with the PROFINET standard. This standard defines a manufacturer-independent communication, automation and engineering model.

Industrial-strength connections are available for wiring the PROFINET components.

- PROFINET discards the hierarchical PROFIBUS master/slave concept. and deploys a provider/consumer principle instead. The IO Devices that will be subscribed to by an IO Controller are defined within the planning phase.
- The quantity structures are extended in accordance with the available quantities for PROFINET IO. Parameter limits are not exceeded during configuration.
- The transmission rate is 100 Mbps.
- The configuration interface for users is generally the same as that for PROFIBUS DP (the system is configured in **STEP 7 > HW Config**).

Structure of a PROFINET IO network

The figure below illustrates a typical PROFINET IO network structure. Existing PROFIBUS slaves can be integrated using an IE/PB Link.

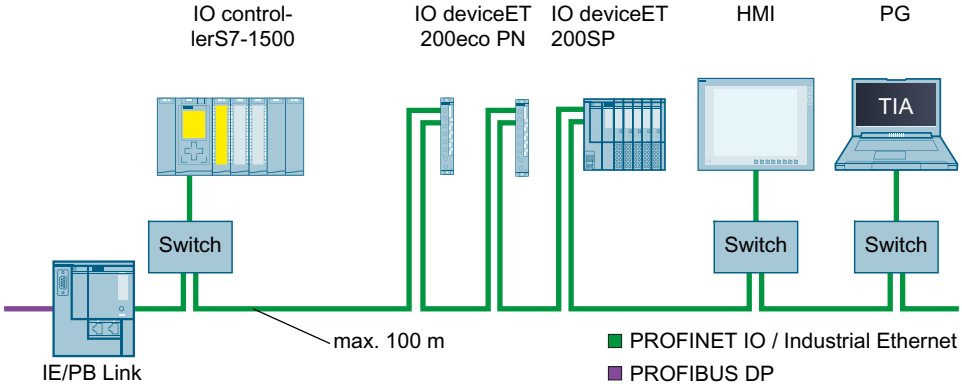


Figure 1-754 Typical structure of PROFINET IO

1.2 ET 200eco PN Distributed I/O Device

Definition

The ET 200eco PN distributed I/O device is a compact PROFINET IO device in degree of protection IP65/66 or IP67 and UL Enclosure Type 4x, Indoor use only.

Field of application

The fields of application of the ET 200eco PN are derived from its special properties.

- A robust design and degree of protection IP65/66 or IP67 make the ET 200eco PN distributed I/O device suitable in particular for use in rugged industrial environments.
- The compact design of the ET 200eco PN is particularly favorable for applications in confined areas.
- The easy handling of ET 200eco PN facilitates efficient commissioning and maintenance.

Properties

The ET 200eco PN has the following properties:

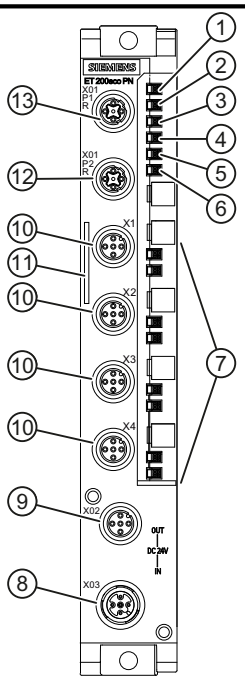
- Integrated switch with 2 ports
- Supported Ethernet services:
  - ping
  - arp
  - Network diagnostics (SNMP)
  - LLDP
  - DCP

- Interrupts
  - Diagnostics interrupts
  - Maintenance interrupts
  - Hardware interrupts
- Port diagnostics
- Isochronous real-time communication
- Prioritized startup
- Device replacement without programming device
- Media redundancy

Components of ET 200eco PN

The tables below provide an overview of the most important components of ET 200eco PN:

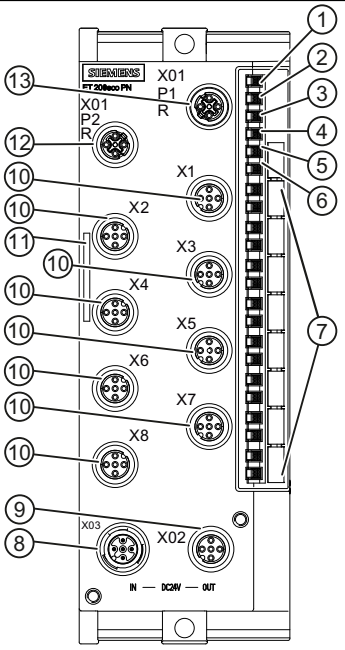
Table 1-1032 Components of ET 200eco PN (30 mm)

Component	Function	Figure
I/O device	You connect the sensors and actuators to the I/O device. The I/O device is available in the following variants: • 8 DI DC 24V 4×M12 • 8 DO DC 24V/1,3A 4×M12 • 8 DO DC 24V/0,5A 4×M12	

① SF/MT LED
② BF LED
③ ON LED
④ DC 24V LED (for digital output device only)
⑧ X03: Voltage infeed
⑨ X02: Loop through of the voltage
⑩ Input/output signal
⑪ MAC address

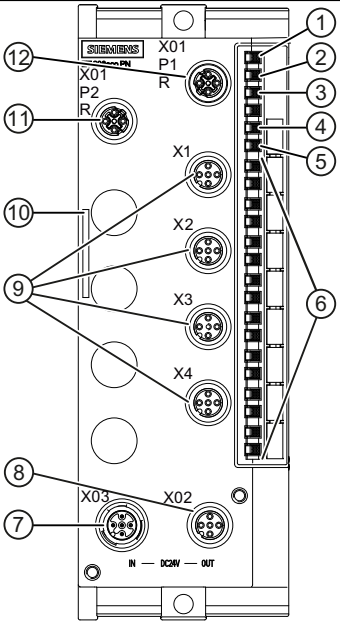
⑤ P1 LK LED
⑥ P2 LK LED
⑦ Channel status/channel fault
⑫ X01 P2 R LAN: PROFINET IO connection
⑬ X01 P1 R LAN: PROFINET IO connection

Table 1-1033 Components of ET 200eco PN (60 mm)

Component	Function	Figure
I/O device	You connect the sensors and actuators to the I/O device. The I/O device is available in the following variants: • 8 DI DC 24V 8×M12 • 16 DI DC 24V 8×M12 • 8 DO DC 24V/1,3A 8×M12 • 8 DO DC 24V/2,0A 8×M12 • 16 DO DC 24V/1,3A 8×M12 • 8 AI 4 U/I + 4 RTD/TC 8×M12 • 8 AI RTD/TC 8×M12 • 8 DIO DC 24V/1,3A 8×M12	

① SF/MT LED
② BF LED
③ ON LED
④ DC 24V LED (for digital output device only)
⑤ P1 LK LED
⑥ P2 LK LED
⑦ Channel status/channel fault
⑧ X03: Voltage infeed
⑨ X02: Loop through of the voltage
⑩ Input/output signal
⑪ MAC address
⑫ X01 P2 R LAN: PROFINET IO connection
⑬ X01 P1 R LAN: PROFINET IO connection

Table 1-1034 Components of ET 200eco PN (60 mm)

Component	Function	Figure
I/O device	You connect the sensors and actuators to the I/O device. The I/O device is available in the following variants: • 4 AO U/I 4×M12	

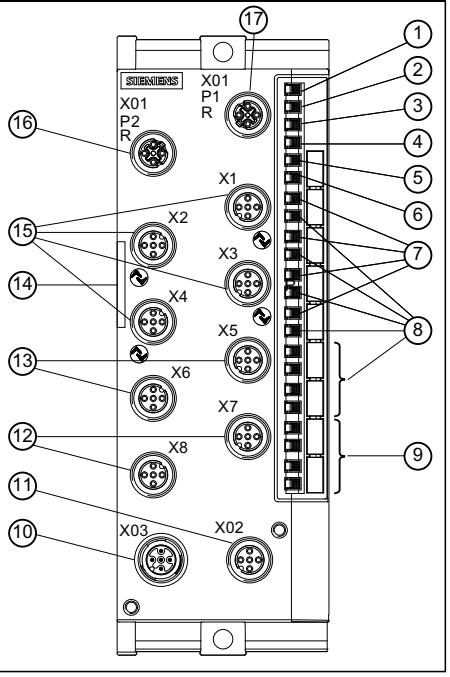
① SF/MT LED
② BF LED
③ ON LED
④ P1 LK LED
⑤ P2 LK LED
⑥ Channel status/channel fault
⑦ X03: Voltage infeed
⑧ X02: Loop through of the voltage
⑨ Input/output signal
⑩ MAC address
⑪ X01 P2 R LAN: PROFINET IO connection
⑫ X01 P1 R LAN: PROFINET IO connection

What is an IO-Link Master?

IO-Link is a point-to-point connection to conventional and intelligent sensors/actuators via unshielded standard cable in proven 3- or 5-conductor technology. IO-Link Masters are backwards compatible with all DI standard sensors. Switching state and data channel designed in proven 24 VDC technology.

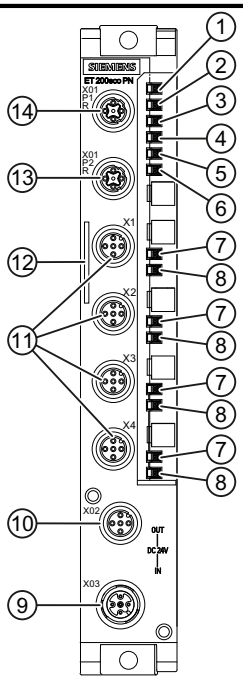
Supports mixed operation of sensors/actuators in the IO-Link, digital input and digital output operating modes on all four ports of the IO-Link Master.

Table 1-1035 IO-Link Master (6ES7148-6JA00-0AB0)

Component	Function	Figure
IO-Link master	Connect the following to I/O device: • X1 to X4: IO-Link Devices or sensors/actuators • X5, X6: Sensors • X7, X8: Actuators	

① SF/MT LED
② BF LED
③ ON LED
④ DC 24V LED
⑤ P1 LK LED
⑥ P2 LK LED
⑦ Status display / Communication
⑧ Digital input: Channel status/channel fault
⑨ Digital output: Channel status/channel fault
⑩ X03: Voltage infeed
⑪ X02: Loop through of the voltage
⑫ X7/X8: Output signal
⑬ X5/X6: Input signal
⑭ MAC address
⑮ X1 to X4: IO-Link ports/input signal
⑯ X01 P2 R LAN: PROFINET IO connection
⑰ X01 P1 R LAN: PROFINET IO connection

Table 1-1036 IO-Link Master (6ES7148-6JD00-0AB0)

Component	Function	Figure
IO-Link master	Connect IO-Link devices or encoders/actuators to the I/O device.	

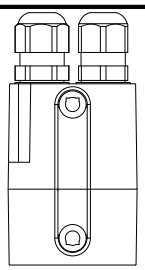
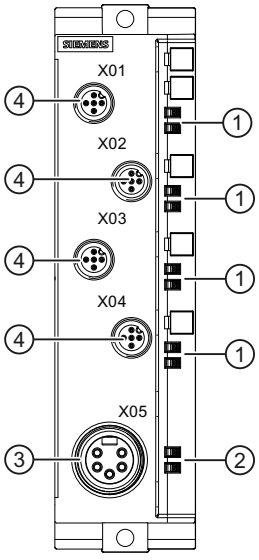
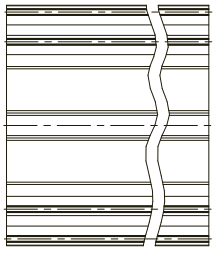
① SF/MT LED
② BF LED
③ ON LED
④ DC 24V LED
⑤ P1 LK LED
⑥ P2 LK LED
⑦ Q1 ... Q4: Channel status in the SIO mode
⑧ IO-L1 ... IO-L4: Channel status/channel fault IO-Link communication
⑨ X03: Voltage infeed
⑩ X02: Loop through of the voltage
⑪ X1 to X4: IO-Link ports
⑫ MAC address
⑬ X01 P2 R LAN: PROFINET IO connection
⑭ X01 P1 R LAN: PROFINET IO connection

LEDs

For information on the meaning of the LED displays, see section Diagnostics by means of LED display (Page 76).

Further components of ET 200eco PN

Table 1-1037 Further components of ET 200eco PN

Component	Function	Figure
Terminal block	You can connect up to 10 A per voltage to the terminal block for distribution to the I/O devices. A maximum of 4 A per voltage is available short-circuit protected for each I/O device.	
Voltage distributor	You can supply up to 8 A per voltage at the PD DC 24V 1×7/8" 4×M12 and distribute up to 4 A per voltage and connector short-circuit-protected through 4 connectors.	 ① LEDs for forwarding 1L/2L ② LEDs for forwarding 1L/2L ③ X05: Status of voltage supply ④ X01 ... X04: Loop through of the voltage
Mounting rail	You can install several I/O devices on the mounting rail.	

IO Controller

The ET 200eco PN can communicate with all IO controllers that conform to IEC 61158.

At least STEP 7 V5.4, SP4 is required to configure a ET 200eco PN.

The ET 200eco PN can be configured starting from a CPU with extended diagnostics, see FAQ (https://support.automation.siemens.com/WW/view/en/23678970).

For information on the individual PROFINET properties that are available for the respective versions of the ET 200eco PN, refer to theFAQ (https://support.automation.siemens.com/WW/view/en/44383954).

Installing

2

Two installation variants

There are two installation variants:

- With mounting rail
- Without mounting rail

For corresponding conditions, refer to the next chapters.

2.1 Installation without mounting rail

Simple installation

The ET 200eco PN distributed I/O device is designed for easy installation.

- The I/O device must be mounted on a solid base
- and can be prewired.

Requirements

Screw type	Explanation
Cylinder head screw M5 to ISO 1207/ISO 1580 (DIN 84/DIN85)	The minimum screw length amounts to 35 mm. Any washers you might need should conform to DIN 125.
Hexagon socket head cap screws M5 to DIN EN ISO 4762	

Tools required

Medium-sized screwdriver or 4 mm hex socket driver.

Procedure

1. Screw the I/O device onto a level surface.
   Screw the I/O device onto the panel at both mounting fixtures on the top and bottom of the front or side (torque: 3 N/m).

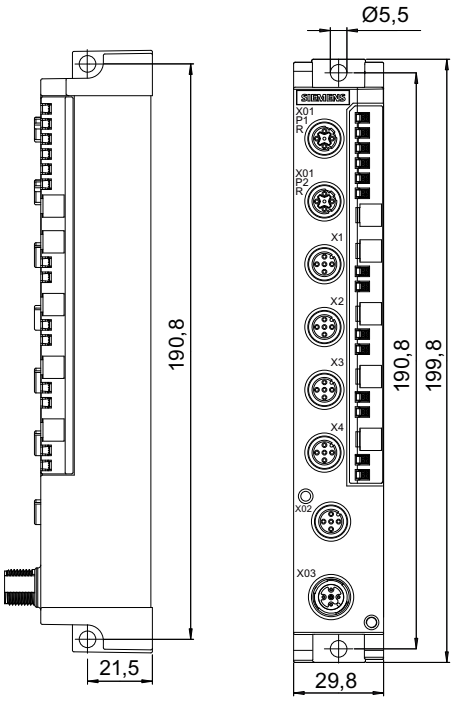


Figure 1-755 Mounting the I/O device on a panel (30 mm)

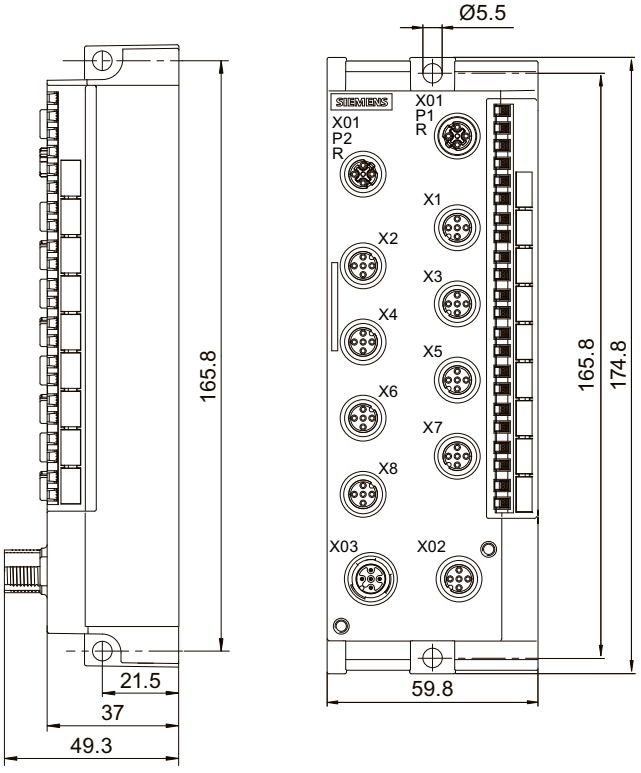


Figure 1-756 Mounting the I/O device on a panel (60 mm), for example 16 DO DC 24V/1,3A 8×M12

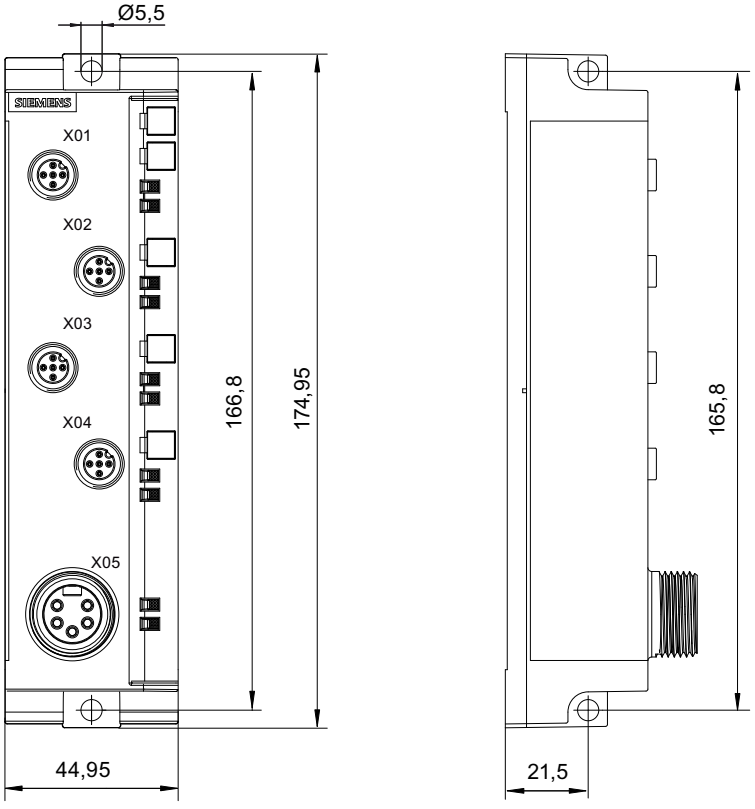


Figure 1-757 Mounting the PD DC 24V 1×7/8" 4×M12 on a panel (45 mm)

2.2 Installation with mounting rail

Version

The mounting rail is available with a length of 500 mm.

Installing the mounting rail

Cut the 500-mm rail to suit your requirements and drill mounting holes for the M8 screws. You should distribute the mounting holes evenly at a pitch of 182 mm on the rail, starting at a distance of 12 mm from the edge.

Use the rack screw to bolt the I/O devices onto the mounting rail.

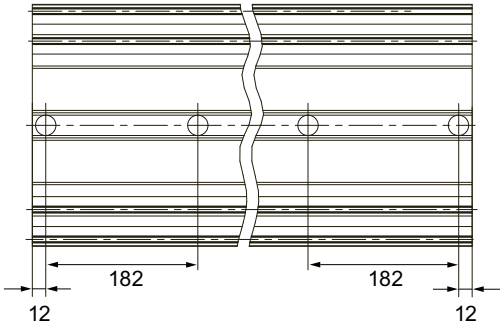


Figure 1-758 Installing the mounting rail

2.3 Mounting position, mounting dimensions

Mounting position

The ET 200eco PN can be mounted in any position.

Mounting and clearance dimensions

Table 1-1038 Mounting dimensions

	Dimensions	
	single width	**double width**
Mounting width	30 mm	60 mm
Mounting height	200 mm	175 mm
Mounting depth	49 mm	49 mm

2.4 Installing the terminal block

Properties

The terminal block connects the ET 200eco PN and supplies the I/O device with power.
The terminal block

- can be installed separately,
- or be screwed on to each I/O device.

Requirements

Note that you must wire the terminal block before you install it.

Tools required

Recessed head screwdriver, medium size

Installing the terminal block separately

You install the terminal block separately.
Remove the screws and then screw them in again at the bottom of the housing.

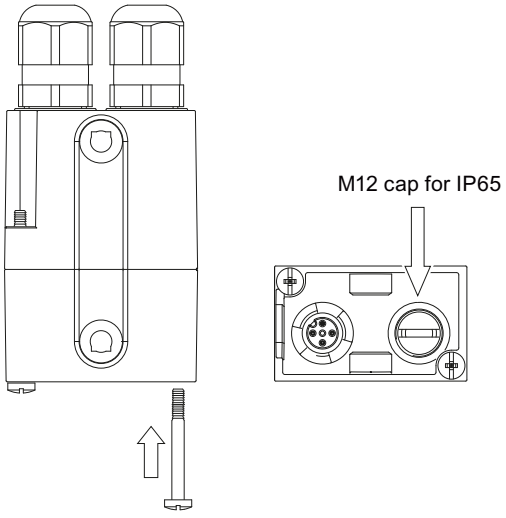


Figure 1-759 Installing the terminal block separately

Installing the terminal block on an I/O device

Install the terminal block vertically on a housing of 30 mm width, or horizontally on a housing of 60 mm width.

An M12 cap is attached to the bottom of the terminal block to implement the corresponding degree of protection. Make sure that the M12 cap is not attached to the terminal block connector and that it is mounted onto connector X02 of the I/O device. Bolt the terminal block onto the I/O device by tightening the screws.

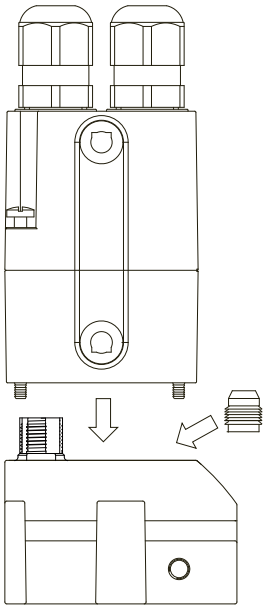


Figure 1-760 Installing the terminal block on an I/O device of 60 mm width

See also

Wiring the terminal block (Page 52)
Terminal block and voltage distributor (Page 209)

2.5 Replacing labels

Properties

You can identify the I/O device and the I/O connectors using the labels. The module is supplied with the labels already clipped into the holder.

- 1 for the I/O device
- 4 or 8 for the I/O connectors

Requirements

You can order replacement labels.

Tools required

2.5 to 4 mm slotted screwdriver

Replacing labels

1. Push the screwdriver into the small opening of the label at an angle and then lever it out.

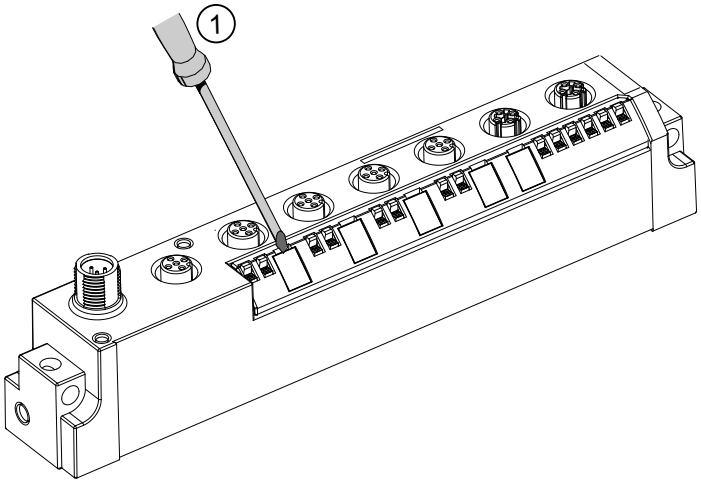


Figure 1-761 Removing labels

2. Push the new label into the holder on the device.

2.6 Removing ET 200eco PN

Procedure

The ET 200eco PN is wired up and operating.

1. Switch off the supply voltage to the ET 200eco PN.
2. Disconnect the wiring from the I/O device.
3. Remove the fixing screws from the I/O device.

NOTE

Observe the information in chapter Looping PROFINET and the supply voltage (Page 58) when replacing the I/O device.

Wiring

3

3.1 General rules and regulations for operating an ET 200eco PN

Introduction

When installing the ET 200eco PN distributed I/O device as part of a plant or system, special rules and regulations need to be adhered to depending on the area of application.

This section provides an overview of the most important rules you have to observe when integrating the ET 200eco PN distributed I/O device in a plant or system.

EMERGENCY-STOP devices

EMERGENCY-STOP devices in accordance with IEC 204 (corresponds to DIN VDE 113) must remain effective in all operating modes of the plant or system.

System startup after certain events

The table below identifies situations you must pay attention to when the system starts up after the occurrence of certain events.

If ...	then ...
Startup follows a power dip / failure The ET 200eco PN is started up after bus communication has been interrupted	Dangerous states must not result. If necessary, EMERGENCY-STOP must be enforced!
Start-up follows unlocking of the emergency stop device	An uncontrolled or undefined start up must not occur.

External fuses/switches

External fuses and switches must be installed so that they meet the standards for cable and device protection applicable to your application.

24 V DC supply

The following table identifies requirements you must observe for the 24 V DC supply.

With ...	You must take into account...	
Buildings	External lightning protection	Take lightning protection measures (for example, lightning protection elements)
24 V DC supply lines, signal lines	Internal lightning protection	
24 V DC supply	Safe (electrical) isolation of the extra-low voltage (SELV/PELV)	
Looping-through of the supply voltage	Voltage drop in the case of loop-through (see Chapter Looping PROFINET and the supply voltage (Page 58))	

Protection against external electrical influences

The table below identifies to what you must pay attention when protecting against electrical influences or faults.

With ...	You must take into account...
all plants or systems in which the ET 200eco PN is installed	The plant or system is EMC-compatible and properly grounded for the discharge of electromagnetic interference.
Supply, signal and bus lines	The wiring arrangement and installation must be correct.
Signal and bus lines	A cable or wire break must not lead to undefined states of the plant or of the system.

3.2 Operating ET 200eco PN on grounded mains

Introduction

This section provides information about the overall configuration of an ET 200eco PN distributed I/O device with a grounded power system (TN-S system). The topics covered in this section are in particular: Disconnecting devices, short-circuit and overload protection in accordance with DIN VDE 0100 and DIN EN 60204-1.

Supply voltages of the ET 200eco PN

There are 2 voltage supplies:

- 1L+: Non-switched supply voltage (electronics/encoder/load voltage supply)
- 2L+: Switched voltage supply (load voltage supply)

Definition: Grounded power supply

For grounded power supplies the neutral conductor of the supply system is grounded. A short-circuit to ground of a live conductor, or of a grounded part of the system, trips the protective devices.

Safe electrical separation (SELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with 24 V DC output voltage require safe electrical separation and voltage limiting (extra low voltage). Load power supplies/power supply modules with 24 V DC output voltage are not connected to the protective conductor. According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as SELV (Safety Extra Low Voltage).

The wiring of SELV circuits must be safely separated from the wiring of other circuits that are not SELV, or the insulation of all conductors must be dimensioned for the higher voltage.

Grounded extra-low voltage (PELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with grounded 24 V DC output voltage require safe connection to the protective conductor and voltage limiting (extra low voltage).

According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as PELV (Protective Extra Low Voltage).

Either the wiring of PELV circuits must be safely isolated from the wiring of other circuits that are not PELV, or the insulation of all wires must be dimensioned for the higher voltage.

Components and protective measures

A number of components and protective measures are prescribed for plant installations. The type of components and the degree to which the protective measures are mandatory depend on which DIN VDE regulation applies to your system configuration. The following table refers to the figure below.

Comparison ...	**Reference to figure**	**DIN VDE 0100**	**DIN EN 60204**
Disconnecting device for controller, sensors, and actuators	(1) "Grounding concept for ET 200eco PN"	... Part 460: Main switch	... Part 1: Disconnector
Short-circuit / overload protection	(2) "Grounding concept for ET 200eco PN"	... Part 725: Single-pole protection of circuits	... Part 1: With grounded secondary circuit: **Single-pole** protection
Circuit breaker		... Part 430: Protection of cables and wires against overcurrent	-

Configuring ET 200eco PN with grounded reference potential

In the configuration of the ET 200eco PN with grounded reference potential, any interference currents that occur are discharged to functional ground. The terminals must be connected externally (see the figure "Grounding concept for ET 200eco PN": Connection between 1M and FE).

Configuring ET 200eco PN with ungrounded reference potential

In the configuration of the ET 200eco PN with ungrounded reference potential, any interference currents that occur are discharged to functional ground via an internal RC network (see in the figure "Grounding concept for ET 200eco PN": **No** connection between 1M and FE).

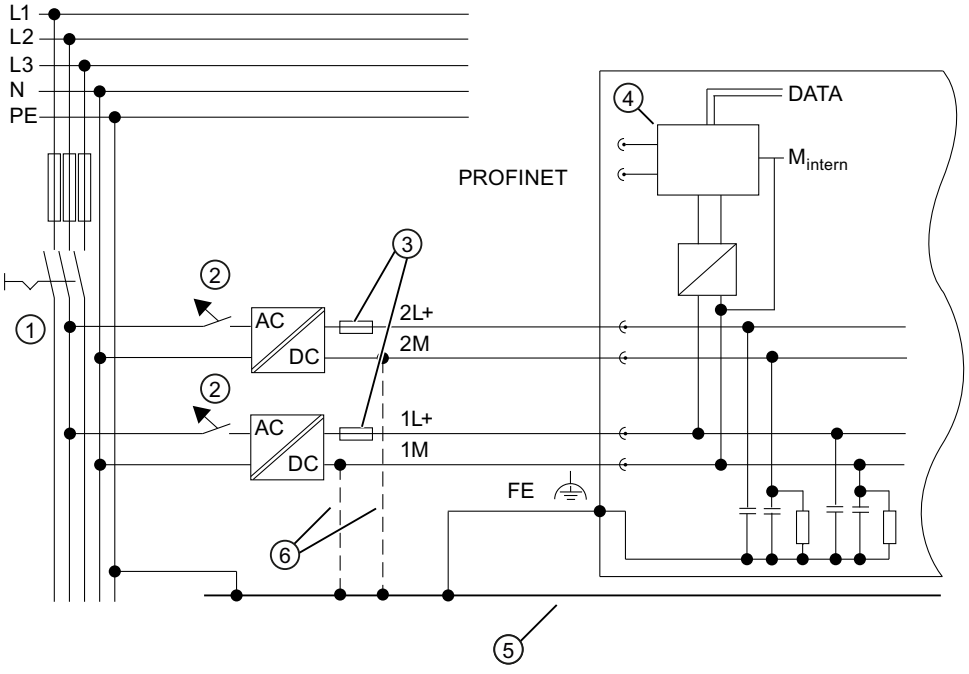
Insulation monitoring

Insulation monitoring must be provided in the following cases:

- When setting up the ET 200eco PN distributed I/O devices with non-grounded reference potential
- If dangerous system states occur due to error

ET 200eco PN in its overall configuration

The figure below shows the overall configuration of the ET 200eco PN distributed I/O device (load voltage supply and grounding concept) with supply from a TN-S system.



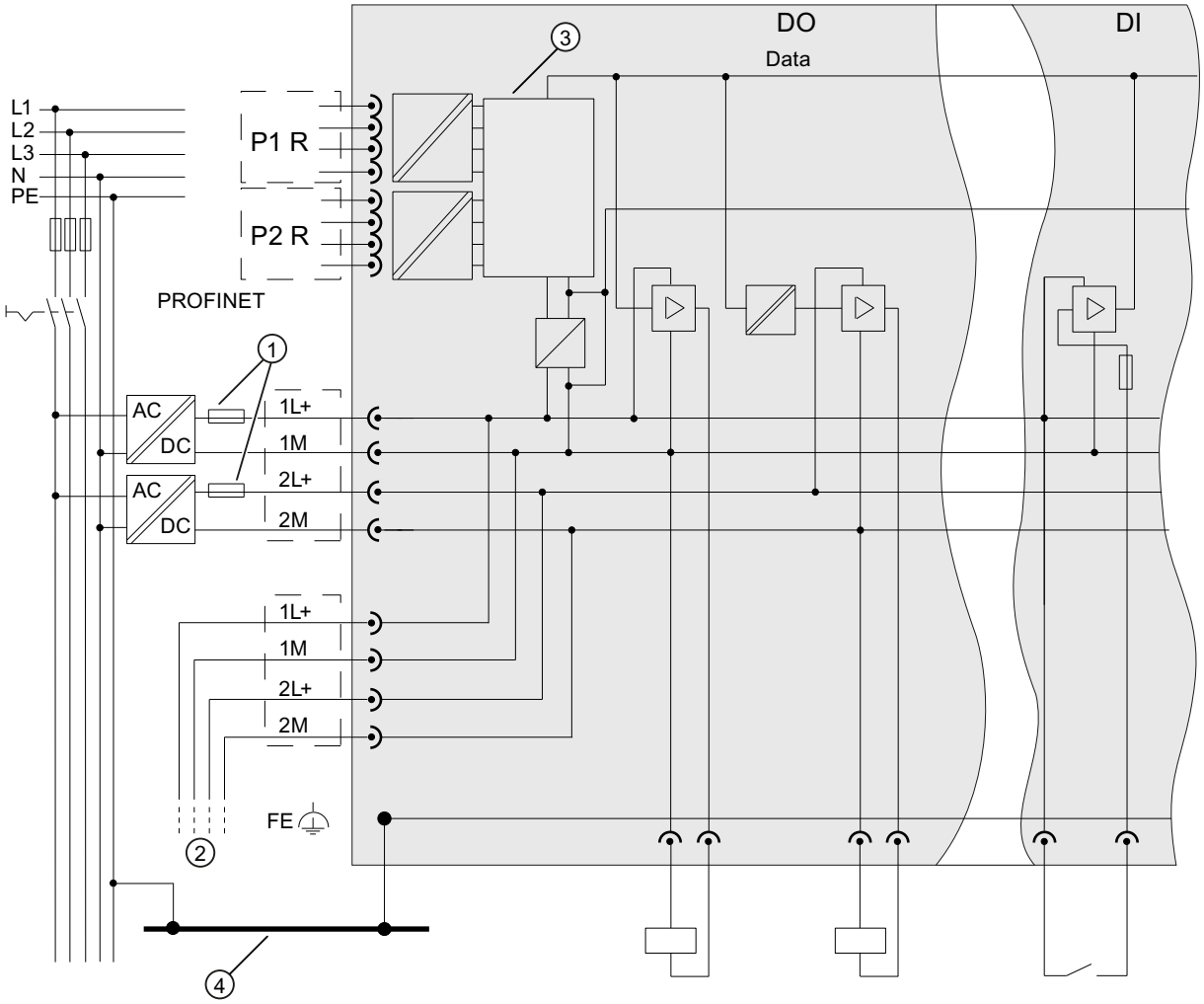
① Disconnecting device for controller, sensors, and actuators
② Short-circuit / overload protection
③ Fuses for line protection
④ Microprocessor and switch
⑤ Ground bus
⑥ When the ET 200eco PN is configured with ungrounded reference potential, the connection between 1M and FE and 2M and FE is not required

3.3 Electrical configuration of ET 200eco PN

Electrical isolation

The ET 200eco PN electrical configuration features electrical isolation between:

- 1L+ Non-switched supply voltage (electronic/sensor/load supply)
  Electrically isolated from PROFINET IO and 2L+ (load voltage supply)
- 2L+: Switched supply voltage (load voltage supply):
  Electrically isolated from all other circuit components.
  Can be shut down with influencing the 1L+.
- PROFINET IO interface:
  Electrically isolated from all other circuit components.



① Infeed of supply voltage
② Loop-through of supply voltage
③ Microprocessor and switch
④ Main ground line

Connection of a digital output to a digital input

⚠ WARNING

When a digital output is connected to a digital output, the respective potential groups have to be observed. Depending on the configuration, 1M and 2M may then be connected, resulting in elimination of the galvanic isolation between 1L+ and 2L+.

Line protection

Line protection is required in accordance with DIN VDE 0100, i.e., you must always provide external fusing.

The power supplies of the I/O device must be fused using a 24 V DC/4 A miniature circuit breaker with tripping characteristic type B or C.

The power supplies of the terminal block must be fused using a 24 V DC/10 A miniature circuit breaker with tripping characteristic type B or C.

The power supplies of the voltage distributor must be fused using a 24 VDC / 8 A miniature circuit breaker with tripping characteristic type B or C.

3.4 Technical specifications of the cables

Impact of the cable length on the supply voltage

- When you wire your configuration, you must take into account the impact of the cable length on the supply voltage of the ET 200eco PN.

  Example

  When using a 10 m cable with Ø 0.75 mm^2, the resistance is 0.5 Ω; this is equivalent to a 2 V voltage drop at 4 A.

NOTE

If you do not maintain the maximum feed current and the appropriate cable cross-sections, you will risk overheating of the cable insulation and contacts, and damage to the device.

3.5 Wiring the ET 200eco PN

3.5.1 Wiring the ET 200eco PN to functional earth (FE)

Introduction

You must connect the ET 200eco PN with the functional earth (FE).

What is functional ground?

All ET 200eco PN I/O devices have a functional earth connection. This connection is used to suppress interference but not for protective purposes. You establish a direction electrical connection to a point in your plant or a shield using the functional earth connection. EMC interference is discharged directly to earth through this connection. The interference immunity of the entire I/O device is increased by the discharge of the EMC interference.

Install ET 200eco PN I/O devices on conductive base

Requirements
Conductive base for installation of the I/O device.

Procedure
The procedure and further information about the required tools and accessories are described in the Section Installation without mounting rail (Page 19).

NOTE

Grounding with conductive base
When you fasten an I/O device of ET 200eco PN to a conductive, grounded base, the two module fixing screws create a conductive connection to the ground potential.
Make sure there is a low-impedance connection between the peripheral device and the conductive substrate and between the conductive substrate and the functional ground.

Install ET 200eco PN I/O devices on non-conductive base

Requirements
Non-conductive base for installation of the I/O device.

Tools required
You need the following tools to connect to the functional ground:

- Stripping tool
- Crimp tool
- Screwdriver

Required accessories
You need the following accessories to connect to the functional ground:

- M5 x 8 fixing screw and washers
- Grounding cable (copper braid cable) with a minimum cross-section of 4 mm^2
- Cable lug suitable for M5 screws

Installation
To connect ET 200eco PN I/O devices to functional earth with non-conductive base, follow these steps:

- Drill 2 fixing holes.
- Strip the grounding conductor and crimp on the cable lug.
- Screw the cable lug onto the I/O device and voltage distributor (M5 fixing screw) with a torque of 1.5 Nm.

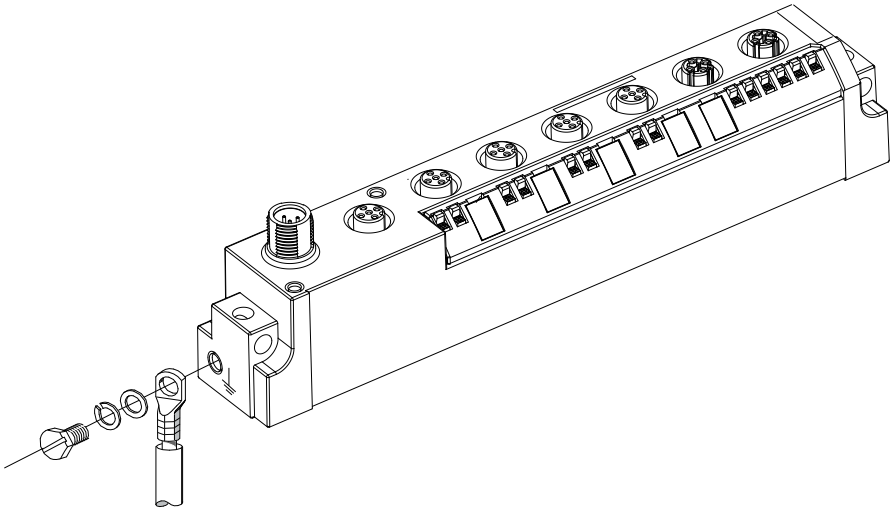


Figure 1-762 Wiring the I/O device to functional earth

Reference

For additional information on installing I/O devices, refer to the section Installing (Page 19).

3.5.2 Wiring I/O devices

Properties

Connect the sensors and actuators to the 5-pin M12 circular sockets (X1 to X4, or X1 to X8) on the front panel of the I/O device.

Requirements

Shut off the supply voltage before you wire the I/O devices.

Tools required

Stripping tool and screwdriver for wiring the M12 cable connector, if you do not use prefabricated cables.

Required accessories

- Prefabricated cable with 5-pin M12 cable connector
- or 3-, 4- or 5-wire copper cable, flexible and 5-pin M12 connector (see tables below)
- or a Y cable
- M12 sealing caps

You can find the article numbers in the appendixArticle numbers (Page 215).

Connecting the M12 connector

1. Plug the connector into the relevant circular socket connector on the I/O block. Make sure the connectors and sockets are properly interlocked (matched joint).
2. Secure the connector by tightening the knurled ring nut with a torque of 1.5 Nm.

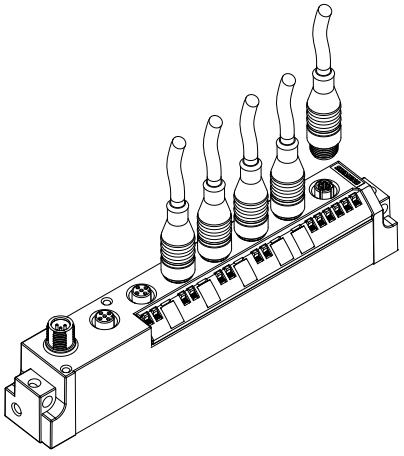


Figure 1-763 Connecting the M12 connector

Y cable

The Y cable allows you to connect two actuators or sensors to the inputs or outputs of the ET 200eco PN.

The use of the Y cable is particularly recommended when two channels are occupied for each socket of an I/O device. The Y cable distributes the channels to two circular connectors (see figure below for pin assignment).

The wiring of the Y cable is shown below.

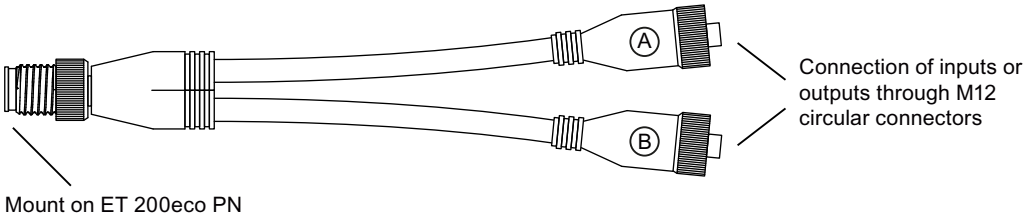
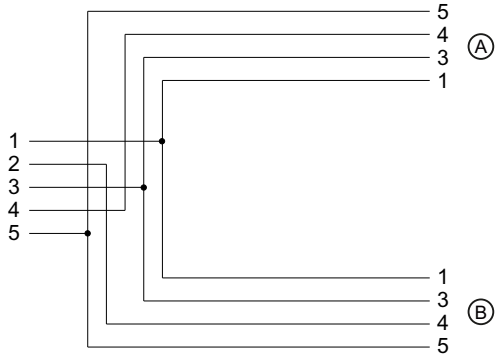


Figure 1-764 Y cable



Wiring jacks (DI/DQ) for Y cable

To connect digital inputs via a Y cable, you will need:

- A Y cable
- 2 M12 jacks
- A flexible 3-wire or 4-wire copper cable

The assignment of Pin 4 depends on which socket of the ET 200eco PN the Y cable is screwed to.

Pin assignment of the sockets for inputs/outputs

The pin assignment of the sockets for inputs/outputs can be found in the data for the individual I/O devices starting in sectionPin assignment of digital inputs (Page 38).

Wiring M12 jacks for analog inputs and analog outputs

For the connection of analog inputs and outputs, you will need:

- one 4-pin or 5-pin M12 jack
- a shielded 4-wire copper cable with a wire cross-section of ≤ 0.75 mm^2

Wire the jack according to the pin assignment of the sockets on the I/O device. You can find the pin assignment in the data for the individual I/O devices starting in Chapter Pin assignment for analog inputs (Page 47).

NOTE

Coupler plug for RTD measurement

For RTD measurements, use a coupler plug with gold-plated contacts. Other materials can create contact resistance that can result in incorrect measured values.

Sealing round sockets not in use

Always seal all unused round sockets using M12 sealing caps to achieve degree of protection IP65, IP66 or IP67.

You can find the article numbers in the appendixArticle numbers (Page 215).

Pin assignment

The pin assignment of the I/O devices is specified in the following chapters.

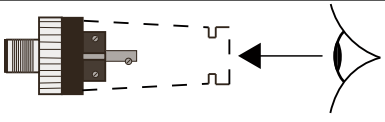
3.6 Pin assignment of connectors

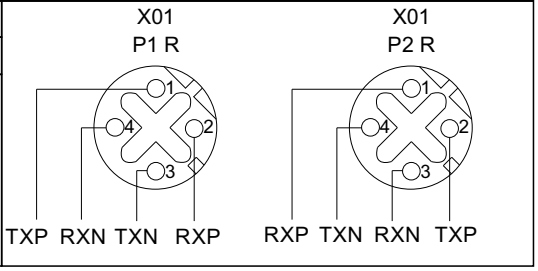
3.6.1 Pin assignment of the PROFINET connector

PROFINET connector, X01 connector, port 1 and port 2

The tables below list the pin assignment for the PROFINET connectors.

Table 1-1039 Pin assignment of the M12 cable connector for PROFINET connector, ports 1 and 2

Pin	Assignment	View of the cable connector (PROFINET), port 1 and port 2
	Assignment X01 P1 R	
1	TXP	
2	RXP	
3	TXN	
4	RXN	
Thread	Functional earth FE	
	Assignment X01 P2 R	
1	RXP	
2	TXP	

Pin	Assignment	View of the cable connector (PROFINET), port 1 and port 2
3	RXN	
4	TXN	
Thread	Functional earth FE	

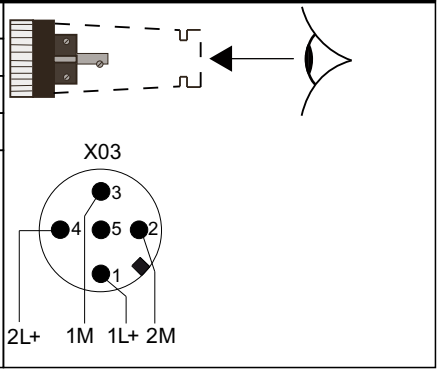
NOTE
When you deactivate the "Autonegotiation" function in *STEP 7* , you must observe the different assignment of the pins at X01 P1 R and X01 P2 R.

3.6.2 Pin assignment for feeding and looping the voltage

Cable connector for supply voltage infeed, X03 connector

The table below lists the pin assignment for the supply voltage infeed.

Table 1-1040 Pin assignment of the M12 cable connector for the supply voltage infeed

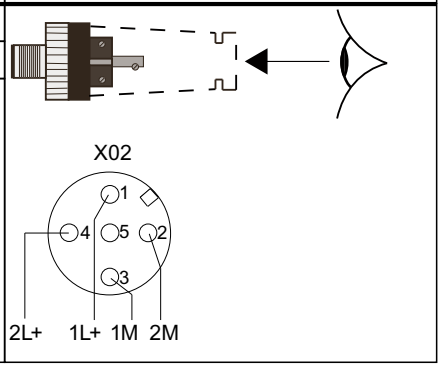
Pin	Assignment	View of the cable connector (wiring side)
1	Supply voltage 1L+ (non-switched)	
2	Ground 2M (switched)	
3	Ground 1M (non-switched)	
4	Supply voltage 2L+ (switched)	
5	Reserved	

Cable connector for loop-through of the supply voltage, X02 socket

The following table lists the supply voltage for loop-through of the supply voltage.

Table 1-1041 Pin assignment of the M12 cable connector for loop-through of the voltage

Pin	Assignment	View of the cable connector (wiring side)
1	Supply voltage 1L+ (non-switched)	
2	Ground 2M (switched)	

Pin	Assignment	View of the cable connector (wiring side)
3	Ground 1M (non-switched)	
4	Supply voltage 2L+ (switched)	
5	Reserved	

NOTE
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

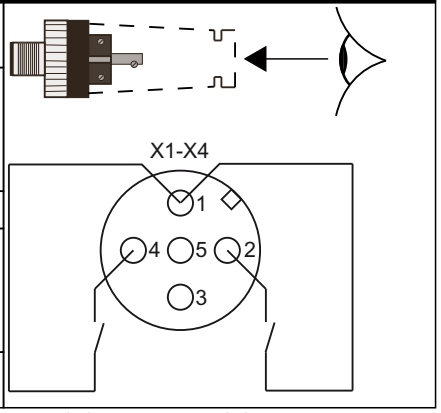
CAUTION
PROFINET IO
Modules with PROFINET interfaces may only be operated when all connected nodes are supplied with SELV/PELV voltages.

3.6.3 Pin assignment of digital inputs

I/O device 8 DI DC 24V 4×M12 (6ES7141-6BF00-0AB0)

You will find the pin assignment for the 8 DI DC 24V 4×M12 I/O device in the table below.

Table 1-1042 Pin assignment of the M12 cable connector for the 8 DI DC 24V 4×M12 I/O device

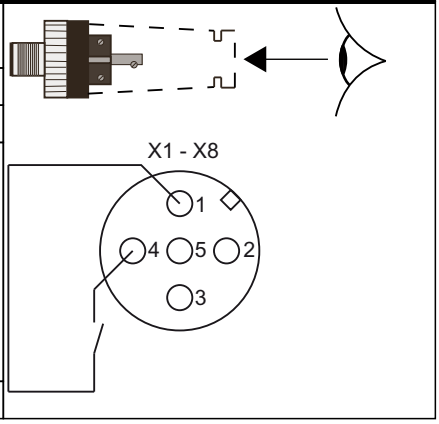
Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	
2	Input signal DI_4: Connector X1 Input signal DI_5: Connector X2 Input signal DI_6: Connector X3 Input signal DI_7: Connector X4	
3	Sensor supply ground 1M	
4	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4	
5	Functional earth FE	

When using the Y cable, pin 2 and pin 4 are assigned to pin 4 (A) and pin 4 (B).

I/O device 8 DI DC 24V 8×M12 (6ES7141-6BG00-0AB0)

You will find the pin assignment for the 8 DI DC 24V 8×M12 I/O device in the table below.

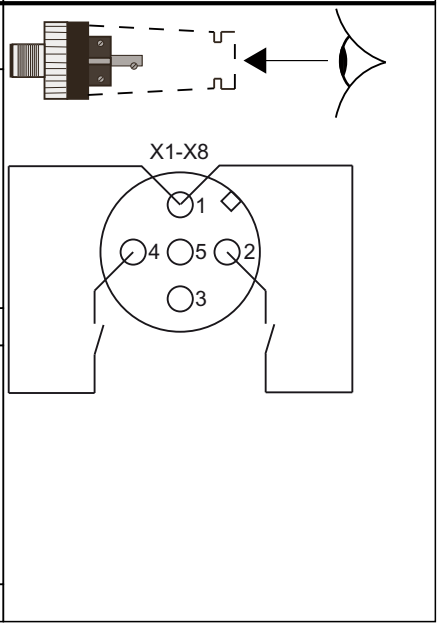
Table 1-1043 Pin assignment of the M12 cable connector for the 8 DI DC 24V 8×M12 I/O device

Pin	Assignment of X1 to X8	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	
2	Not used	
3	Sensor supply ground 1M	
4	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4 Input signal DI_4: Connector X5 Input signal DI_5: Connector X6 Input signal DI_6: Connector X7 Input signal DI_7: Connector X8	
5	Functional earth FE	

I/O device 16 DI DC 24V 8×M12 (6ES7141-6BH00-0BA0)

You will find the pin assignment for the 16 DI DC 24V 8×M12 I/O device in the table below.

Table 1-1044 Pin assignment of the M12 cable connector for the 16 DI DC 24V 8×M12 I/O device

Pin	Assignment of X1 to X8	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	
2	Input signal DI_8: Connector X1 Input signal DI_9: Connector X2 Input signal DI_{10}: Connector X3 Input signal DI_{11}: Connector X4 Input signal DI_{12}: Connector X5 Input signal DI_{13}: Connector X6 Input signal DI_{14}: Connector X7 Input signal DI_{15}: Connector X8	
3	Sensor supply ground 1M	
4	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4 Input signal DI_4: Connector X5 Input signal DI_5: Connector X6 Input signal DI_6: Connector X7 Input signal DI_7: Connector X8	
5	Functional earth FE	

When using the Y cable, pin 2 and pin 4 are assigned to pin 4 (A) and pin 4 (B).

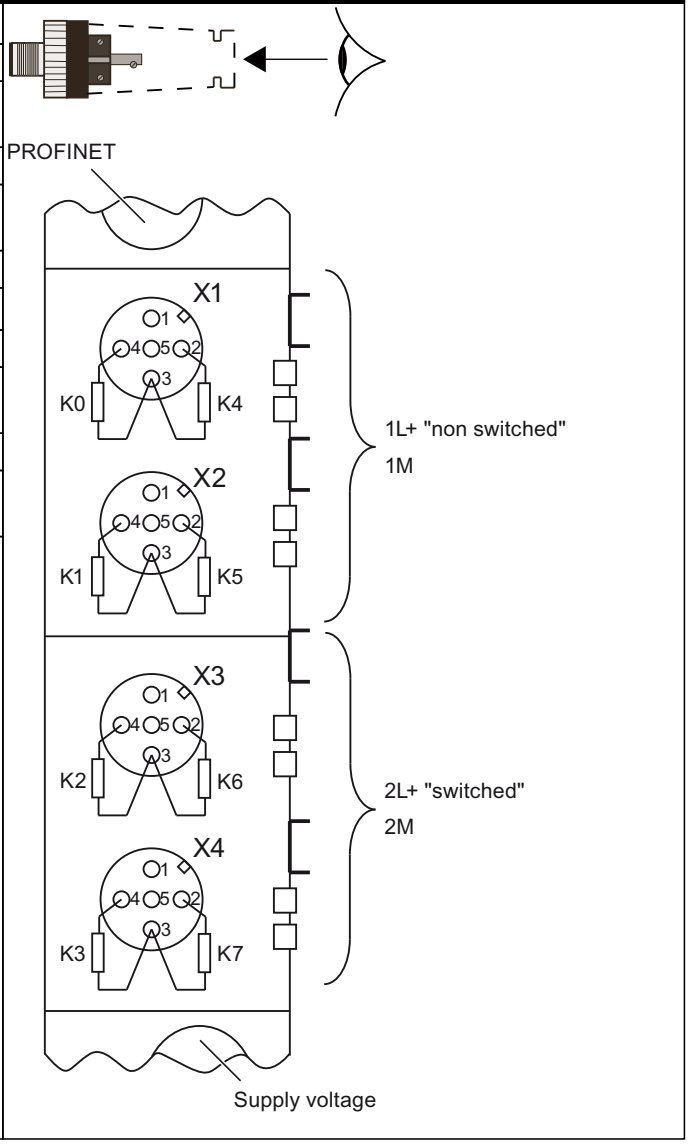
NOTE
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

3.6.4 Pin assignment of digital outputs

I/O device 8 DO DC 24V/1,3A 4×M12 (6ES7142-6BF00-0AB0)

You will find the pin assignment for the 8 DO DC 24V/1,3A 4×M12 I/O device in the table below.

Table 1-1045 Pin assignment of the M12 cable connector for the 8 DO DC 24V/1,3A 4×M12 I/O device

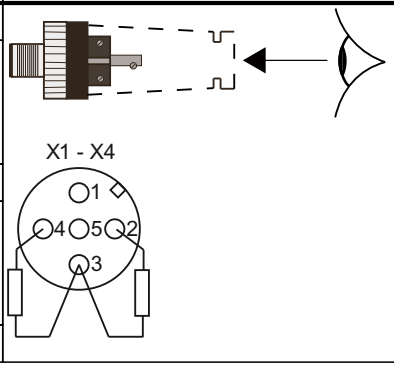
Pin	Assignment	View of the cable connector (wiring side)
	Assignment X1 and X2 (1L+ non-switched)	
1	Not used	
2	Output signal DQ_4: Connector X1 Output signal DQ_5: Connector X2	
3	Supply ground 1M	
4	Output signal DQ_0: Connector X1 Output signal DQ_1: Connector X2	
5	Functional earth FE	
	Assignment X3 and X4 (2L+ switched)	
1	Not used	
2	Output signal DQ_6: Connector X3 Output signal DQ_7: Connector X4	
3	Supply ground 2M	
4	Output signal DQ_2: Connector X3 Output signal DQ_3: Connector X4	
5	Functional earth FE	

When using the Y cable, pin 2 and pin 4 are assigned to pin 4 (B) and pin 4 (A).

I/O device 8 DO DC 24V/0,5A 4×M12 (6ES7142-6BF50-0AB0)

You will find the pin assignment for the 8 DO DC 24V/0,5A 4×M12 I/O device in the table below.

Table 1-1046 Pin assignment of the M12 cable connector for the 8 DO DC 24V/0,5A 4×M12 I/O device

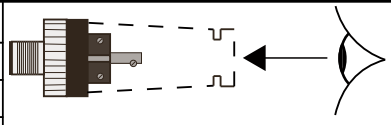
Pin	Assignment X1 to X4 (2L+ switched)	View of the cable connector (wiring side)
1	Not used	
2	Output signal DQ_4: Connector X1 Output signal DQ_5: Connector X2 Output signal DQ_6: Connector X3 Output signal DQ_7: Connector X4	
3	Supply ground 2M	
4	Output signal DQ_0: Connector X1 Output signal DQ_1: Connector X2 Output signal DQ_2: Connector X3 Output signal DQ_3: Connector X4	
5	Not used	

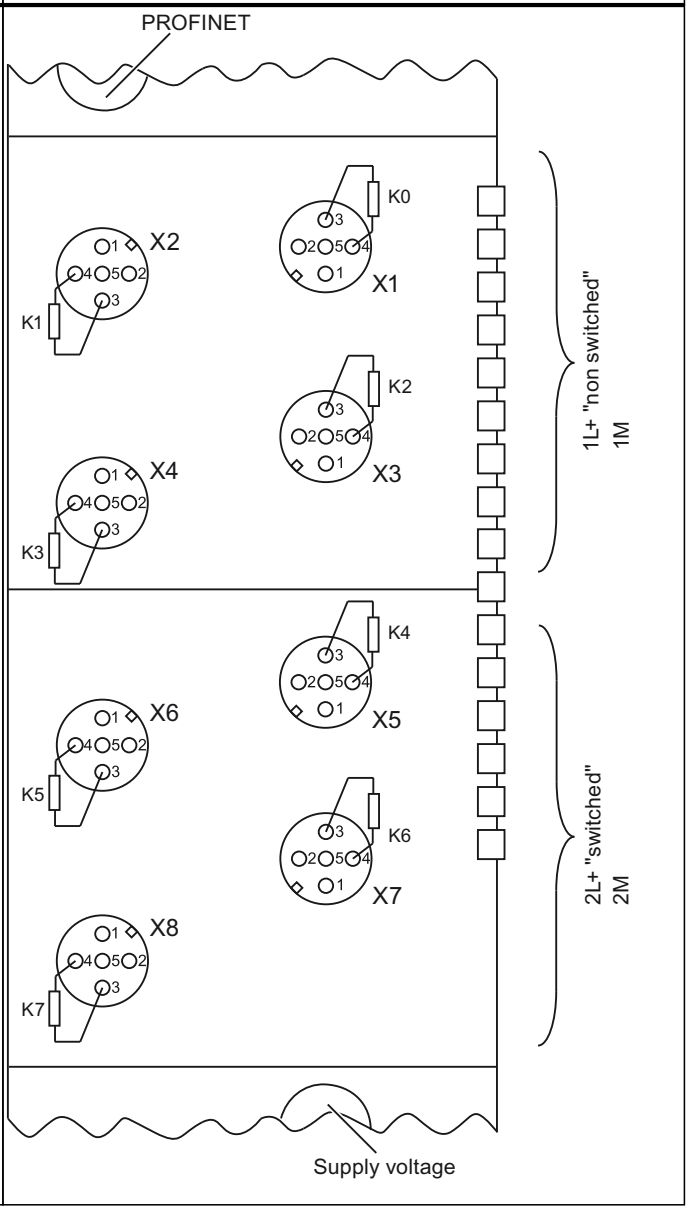
When using the Y cable, pins 2 and 4 are assigned to pin 4 (B) and pin 4 (A).

I/O device 8 DO DC 24V/1,3A 8×M12 (6ES7142-6BG00-0AB0) and 8 DO DC 24V/2,0A 8×M12 (6ES7142-6BR00-0AB0)

The table below shows the pin assignments for I/O devices 8 DO DC 24V/1,3A 8×M12 and 8 DO DC 24V/2,0A 8×M12.

Table 1-1047 Pin assignment of the M12 cable connector for I/O device 8 DO DC 24V/1,3A 8×M12 and 8 DO DC 24V/2,0A 8×M12

Pin	Assignment	View of the cable connector (wiring side)
	Assignment X1 to X4 (1L+ non-switched)	
1	Unassigned	
2	Not used	
3	Supply ground 1M	
4	Output signal DQ_0: Connector X1 Output signal DQ_1: Connector X2 Output signal DQ_2: Connector X3 Output signal DQ_3: Connector X4	
5	Functional earth FE	
	Assignment X5 to X8 (2L+ switched)	
1	Not used	
2	Not used	
3	Supply ground 2M	
4	Output signal DQ_4: Connector X5 Output signal DQ_5: Connector X6 Output signal DQ_6: Connector X7 Output signal DQ_7: Connector X8	

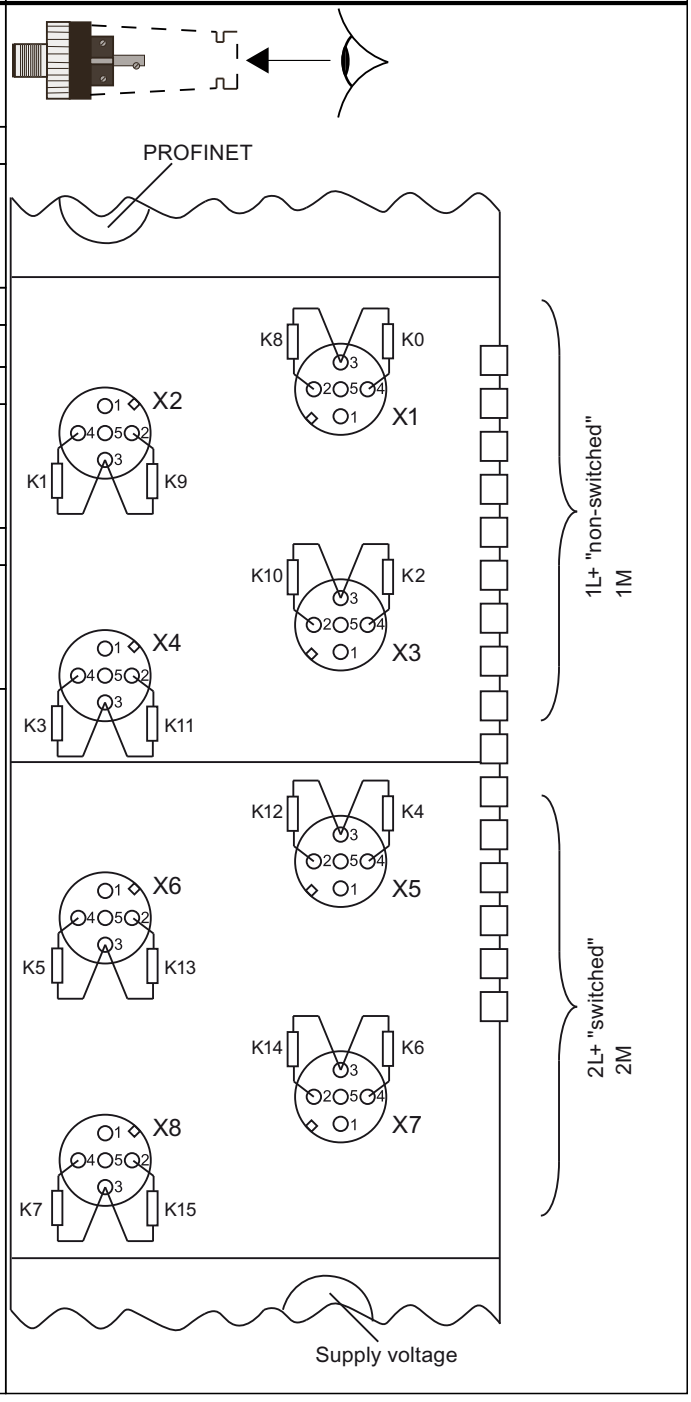
Pin	Assignment	View of the cable connector (wiring side)
5	Functional earth FE	

I/O device 16 DO DC 24V/1,3A 8×M12 (6ES7142-6BH00-0AB0)

You will find the pin assignment for the 16 DO DC 24V/1,3A 8×M12 I/O device in the table below.

Table 1-1048 Pin assignment of the M12 cable connector for the 16 DO DC 24V/1,3A 8×M12 I/O device

Pin	Assignment	View of the cable connector (wiring side)
	Assignment X1 to X4 (1L+ non-switched)	
1	Not used	

Pin	Assignment	View of the cable connector (wiring side)
2	Output signal DQ_8: Connector X1 Output signal DQ_9: Connector X2 Output signal DQ_{10}: Connector X3 Output signal DQ_{11}: Connector X4	
3	Supply ground 1M	
4	Output signal DQ_0: Connector X1 Output signal DQ_1: Connector X2 Output signal DQ_2: Connector X3 Output signal DQ_3: Connector X4	
5	Functional earth FE	
	Assignment X5 to X8 (2L+ switched)	
1	Not used	
2	Output signal DQ_{12}: Connector X5 Output signal DQ_{13}: Connector X6 Output signal DQ_{14}: Connector X7 Output signal DQ_{15}: Connector X8	
3	Supply ground 2M	
4	Output signal DQ_4: Connector X5 Output signal DQ_5: Connector X6 Output signal DQ_6: Connector X7 Output signal DQ_7: Connector X8	
5	Functional earth FE	

When using the Y cable, pin 2 and pin 4 are assigned to pin 4 (B) and pin 4 (A).

NOTE

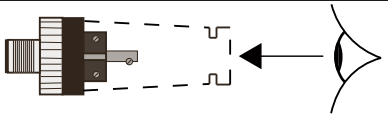
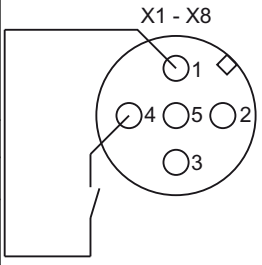
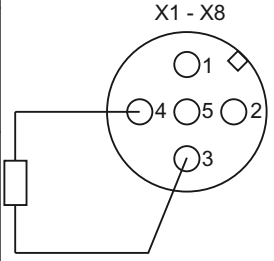
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

3.6.5 Pin assignment for parameterizable digital input/digital output

I/O device 8 DIO DC 24V/1,3A 8×M12 (6ES7147-6BG00-0AB0)

You will find the pin assignment for the 8 DIO DC 24V/1,3A 8×M12 I/O device in the table below.

Table 1-1049 Pin assignment of the M12 cable connector for the 8 DIO DC 24V/1,3A 8×M12 I/O device

Pin	Assignment	View of the cable connector (wiring side)
	Assignment X1 to X4 (1L+ non-switched)	
1*	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	
2	Not used	
3	Supply ground 1M	Input
4	Input / output signal DIQ_0: Connector X1 Input/output signal DIQ_1: Connector X2 Input/output signal DIQ_2: Connector X3 Input/output signal DIQ_3: Connector X4	
5	Functional earth FE	
	Assignment X5 to X8 (2L+ switched)	
1	24 V sensor supply $2U_S$ (derived from 2L+ switched)	
2	Not used	
3	Supply ground 2M	Output
4	Input / output signal DIQ_4: Connector X5 Input/output signal DIQ_5: Connector X6 Input/output signal DIQ_6: Connector X7 Input/output signal DIQ_7: Connector X8	
5	Functional earth FE	
* The sensor supply is only available when the corresponding channel is parameterized as an "Input".		

3.6.6 Pin assignment for IO-Link Masters

IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12 (6ES7148-6JA00-0AB0)

The following tables contain the pin assignments for the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12.

Table 1-1050 Pin assignment for IO-Link Master and digital inputs

Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	

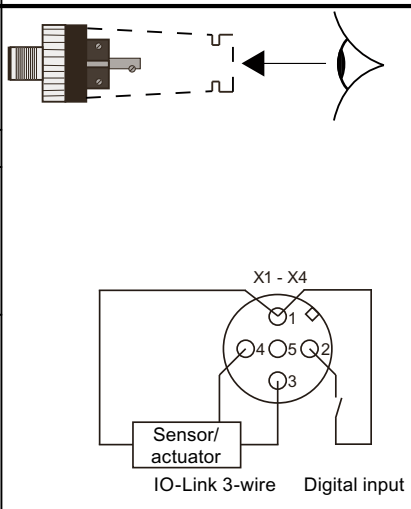
Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
2	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4	
3	Sensor supply ground 1M	
4	IO-Link Master Port 1 (C/Q): Connector X1 Port 2 (C/Q): Connector X2 Port 3 (C/Q): Connector X3 Port 4 (C/Q): Connector X4	
5	Not used	

Table 1-1051 Pin assignment for digital inputs

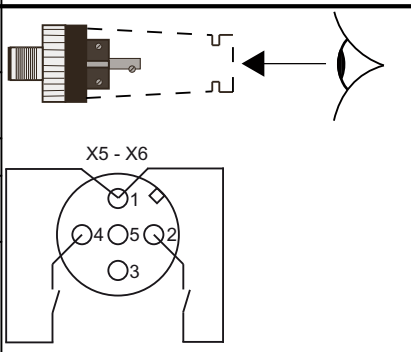
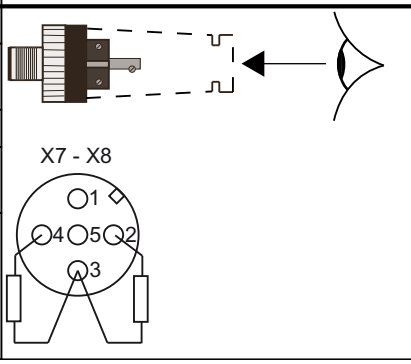
Pin	Assignment of X5 and X6	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	
2	Input signal DI_5: Connector X5 Input signal DI_7: Connector X6	
3	Sensor supply ground 1M	
4	Input signal DI_4: Connector X5 Input signal DI_6: Connector X6	
5	Functional earth FE	

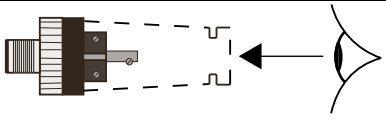
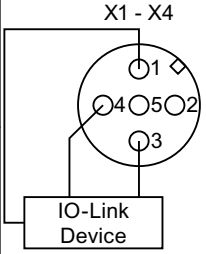
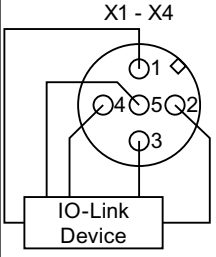
Table 1-1052 Pin assignment for digital outputs

Pin	Assignment X7 and X8 (2L+ switched)	View of the cable connector (wiring side)
1	Not used	
2	Output signal DQ_1: Connector X7 Output signal DQ_3: Connector X8	
3	Supply ground 2M	
4	Output signal DQ_0: Connector X7 Output signal DQ_2: Connector X8	
5	Functional earth FE	

IO-Link Master 4 IO-L 4×M12 (6ES7148-6JD00-0AB0)

The following tables contain the pin assignments for the IO-Link Master 4 IO-L 4×M12.

Table 1-1053 Pin assignment for IO-Link Master

Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	 Port Class A (type A)*  Port Class B (type B) 
2	24 V actuator supply $2U_A$	
3	Sensor supply ground 1M	
4	IO-Link master Port 1 (C/Q): Connector X1 Port 2 (C/Q): Connector X2 Port 3 (C/Q): Connector X3 Port 4 (C/Q): Connector X4	
5	Actuator supply ground 2M	

* If you use the sockets for IO-Link devices with Port Class A, do not place any signals on pins 2 and 5.

The M12 connectors are designed as Port Class B according to IO-Link specification. Pins 2 and 5 contain an additional power supply.

A non-interacting connection of devices of various port types (class A and class B) is possible using a 3-wire connecting cable (assignment of pins 1, 3 and 4).

NOTICE
24 V encoder supply $1U_S$ Only use the 24 V encoder supply $1U_S$ supplied by the IO-Link master to supply the devices.

3.6.7 Pin assignment for analog inputs

I/O device 8 AI 4 U/I + 4 RTD/TC 8×M12 (6ES7144-6KD00-0AB0)

You will find the pin assignment for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device in the table below.

Table 1-1054 Pin assignment for voltage and current for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

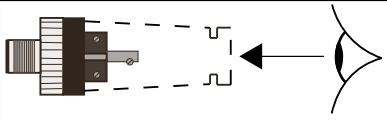
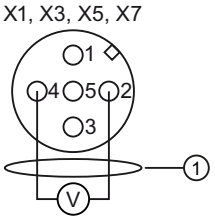
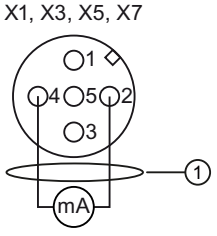
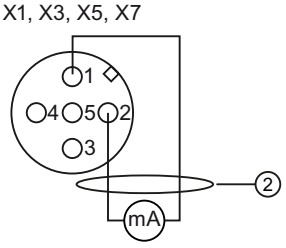
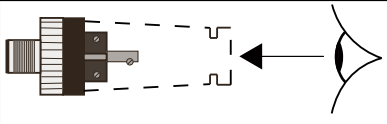
Pin	Assignment of X1, X3, X5, X7	View of the cable connector (wiring side)
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)	 Voltage  Current 4-wire transducer  2-wire transducer 
2	Connector X1: Input signal M_0+ Connector X3: Input signal M_1+ Connector X5: Input signal M_2+ Connector X7: Input signal M_3+	
3	Sensor supply ground 1M	
4	Connector X1: Input signal M_0- Connector X3: Input signal M_1- Connector X5: Input signal M_2- Connector X7: Input signal M_3-	
5	Functional earth FE	
① 4- or 5-core shielded copper cable ② 3-, 4-, or 5-core shielded copper cable		

Table 1-1055 Pin assignment for RTD for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

Pin	Assignment of X2, X4, X6, X8 (for RTD)	View of the cable connector (wiring side)
	Connector X2: Input signal 4 Connector X4: Input signal 5 Connector X6: Input signal 6 Connector X8: Input signal 7	
4-conductor		

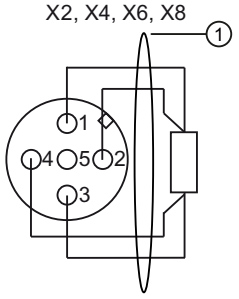
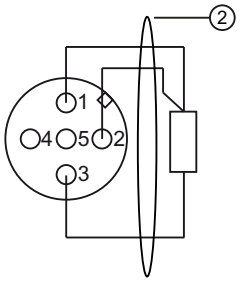
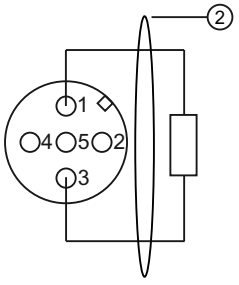
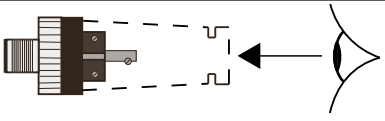
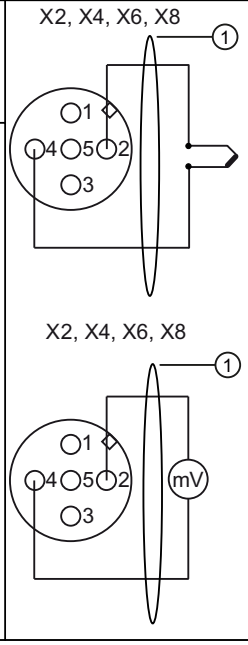
Pin	Assignment of X2, X4, X6, X8 (for RTD)	View of the cable connector (wiring side)
1	Constant current line positive I_{Cn}+	X2, X4, X6, X8 
2	Measurement cable positive M_n+	
3	Constant current line negative I_{Cn}-	
4	Measurement cable negative M_n-	
5	Functional earth FE	
3-conductor		X2, X4, X6, X8 
1	Constant current line positive I_{Cn}+	
2	Measurement cable positive M_n+	
3	Measurement cable negative M_n- and constant current line negative I_{Cn}-	
5	Functional earth FE	
2-conductor		X2, X4, X6, X8 
1	Measurement cable positive M_n+ and constant current line positive I_{Cn}+	
3	Measurement cable negative M_n- and constant current line negative I_{Cn}-	
5	Functional earth FE	
① 4- or 5-core shielded copper cable ② 3-, 4-, or 5-core shielded copper cable		

Table 1-1056 Pin assignment for thermocouple for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

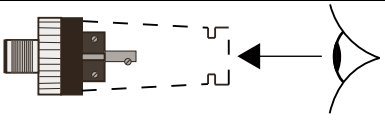
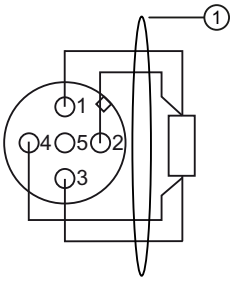
Pin	Assignment X2, X4, X6, X8 (for thermocouples and ±80 mV)	View of the cable connector (wiring side)
1	Not used	
2	Connector X2: Input signal M_4+ Connector X4: Input signal M_5+ Connector X6: Input signal M_6+ Connector X8: Input signal M_7+	
3	Not used	

Pin	Assignment X2, X4, X6, X8 (for thermocouples and ±80 mV)	View of the cable connector (wiring side)
4	Connector X2: Input signal M_4- Connector X4: Input signal M_5- Connector X6: Input signal M_6- Connector X8: Input signal M_7-	
5	Functional earth FE	
① 3-, 4-, or 5-core shielded copper cable		

I/O device 8 AI RTD/TC 8×M12 (6ES7144-6KD50-0AB0)

You will find the pin assignment for the 8 AI RTD/TC 8×M12 I/O device in the table below.

Table 1-1057 Pin assignment for RTD for the 8 AI RTD/TC 8×M12 I/O device

Pin	Assignment X1 to X8 (for RTD)	View of the cable connector (wiring side)
	Connector X1: Input signal 0 Connector X2: Input signal 4 Connector X3: Input signal 1 Connector X4: Input signal 6 Connector X5: Input signal 2 Connector X7: Input signal 6 Connector X7: Input signal 3 Connector X8: Input signal 7	
4-conductor		
1	Constant current line positive I_{Cn}+	
2	Measurement cable positive M_n+	
3	Constant current line negative I_{Cn}-	
4	Measurement cable negative M_n-	
5	Functional earth FE	
3-conductor		
1	Constant current line positive I_{Cn}+	

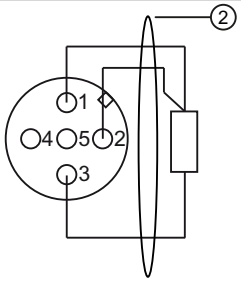
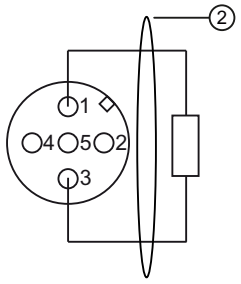
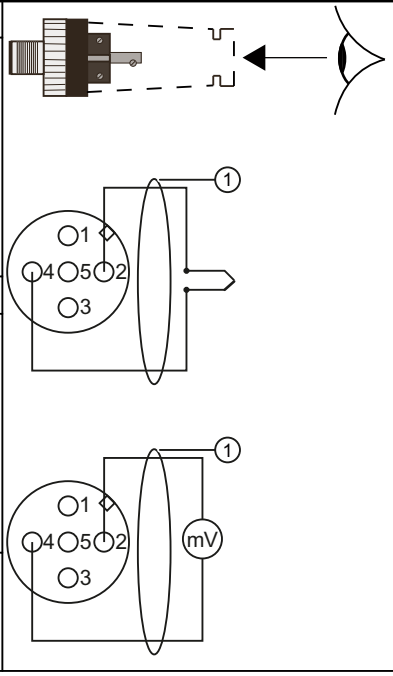
Pin	Assignment X1 to X8 (for RTD)	View of the cable connector (wiring side)
2	Measurement cable positive M_n+	
3	Measurement cable negative M_n- and constant current line negative I_{Cn}-	
5	Functional earth FE	
2-conductor		
1	Measurement cable positive M_n+ and constant current line positive I_{Cn}+	
3	Measurement cable negative M_n- and constant current line negative I_{Cn}-	
5	Functional earth FE	
① 4- or 5-core shielded copper cable ② 3-, 4-, or 5-core shielded copper cable		

Table 1-1058 Pin assignment for thermocouple for the 8 AI RTD/TC 8×M12 I/O device

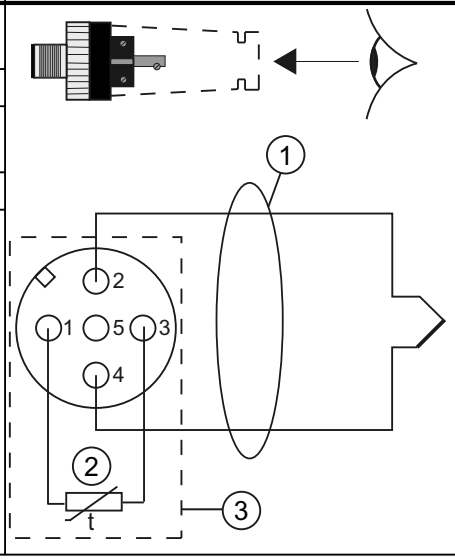
Pin	Assignment of X1 to X8 (for thermocouples and ±80 mV)	View of the cable connector (wiring side)
1	Not used	
2	Connector X1: Input signal M_0+ Connector X2: Input signal M_4+ Connector X3: Input signal M_1+ Connector X4: Input signal M_5+ Connector X5: Input signal M_2+ Connector X6: Input signal M_6+ Connector X7: Input signal M_3+ Connector X8: Input signal M_7+	
3	Not used	
4	Connector X1: Input signal M_0- Connector X2: Input signal M_4- Connector X3: Input signal M_1- Connector X4: Input signal M_5- Connector X5: Input signal M_2- Connector X6: Input signal M_6- Connector X7: Input signal M_3- Connector X8: Input signal M_7-	
5	Functional earth FE	
① 3-, 4-, or 5-core shielded copper cable		

3.6.8 Pin assignment M12 compensation connector for thermocouples

M12 compensation connectors (6ES7194-4AB00-0AA0)

You will find the pin assignment for the M12 compensation connector in the table below.

Table 1-1059 Pin assignment of the M12 compensation connector

Pin	Assignment X1	View of the M12 compensation connector
1	Measurement cable 1M+ assigned with internal Pt1000	
2	Input signal M_0+	
3	Measurement cable 1M- assigned with internal Pt1000	
4	Input signal M_0-	
5	Functional earth FE	
① Cable with cores made of thermocouple materials ② Integrated resistance thermometer Pt1000 ③ M12 compensation connector		

See also

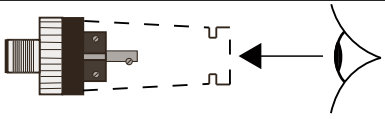
Installing (Page 19)

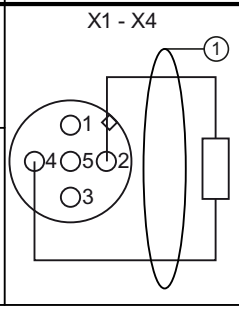
3.6.9 Pin assignment for analog output

I/O device 4 AO U/I 4×M12 (6ES7145-6HD00-0AB0)

You will find the pin assignment for the 4 AO U/I 4×M12 I/O device in the table below.

Table 1-1060 Pin assignment for voltage and current for the 4 AO U/I 4×M12 I/O device

Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
1	24 V actuator supply $1U_A$ (derived from 1L+ non-switched)	
2	Output signal Q_0+: Connector X1 Output signal Q_1+: Connector X2 Output signal Q_2+: Connector X3 Output signal Q_3+: Connector X4	
3	Actuator supply ground 1M	

Pin	Assignment of X1 to X4	View of the cable connector (wiring side)
4	Output signal Q_0-: Connector X1 Output signal Q_1-: Connector X2 Output signal Q_2-: Connector X3 Output signal Q_3-: Connector X4	
5	Functional earth FE	
① 3-, 4-, or 5-core shielded copper cable		

3.7 Wiring the terminal block

Tools required

You need a Phillips screwdriver of medium size to attach the terminal block and a slotted screwdriver to connect the wires.

Use the following cables to this purpose:

- Wires: Cables with core cross-section of 0.25 to 1.5 mm²
- Cable gland: Cables with external diameters of 4.5 to 10 mm

Wiring the connectors

Prepare the wires for connection to the terminal block.

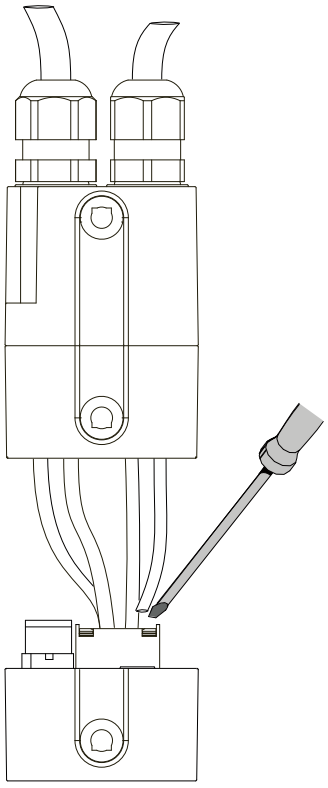


Figure 1-765 Wiring the terminal block

We'll show you an example of the separate installation of the terminal block and how to wire it to several I/O devices.

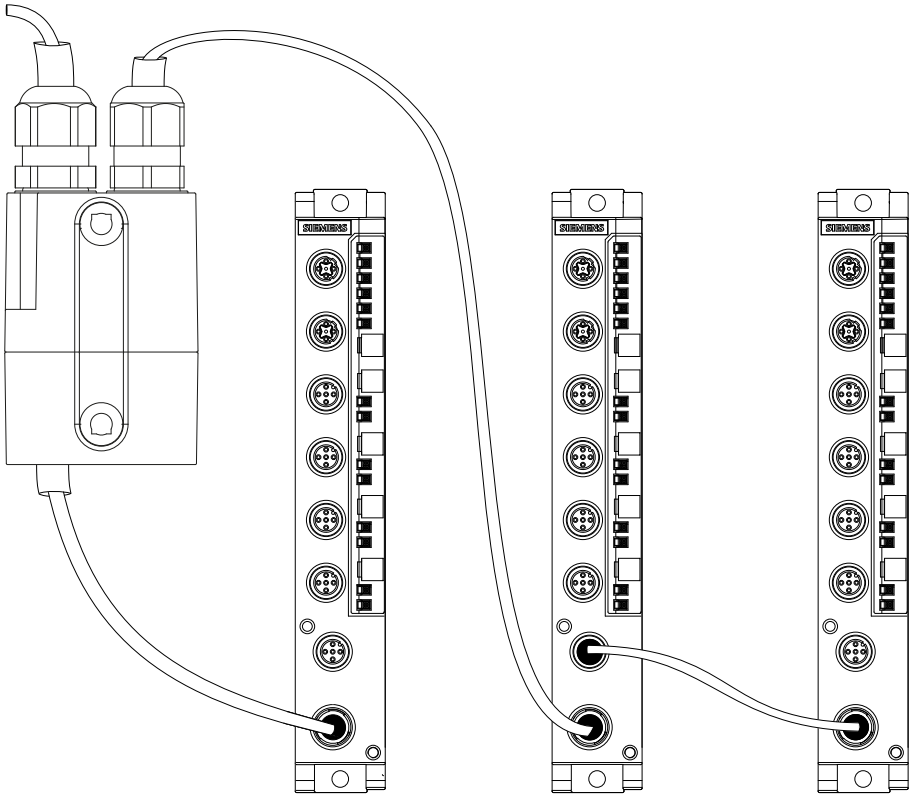


Figure 1-766 Wiring of the terminal block and of several I/O devices

You can tap a maximum load of 4 A from each supply voltage of the I/O device. You can loop-through the rest.

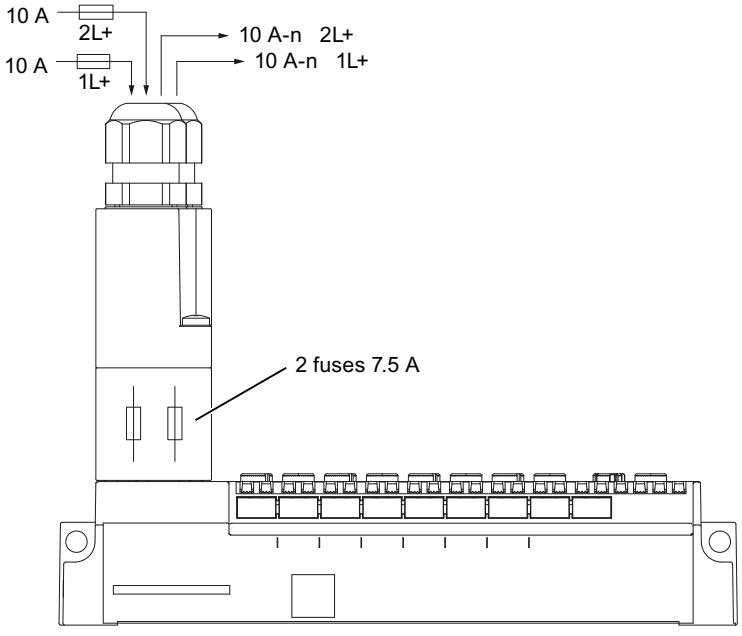


Figure 1-767 Principle of current distribution at the terminal block

Pin assignment

The tables below show the pin assignments.

Table 1-1061 Pin assignment of the insulation displacement terminal block.

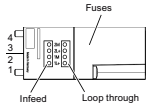
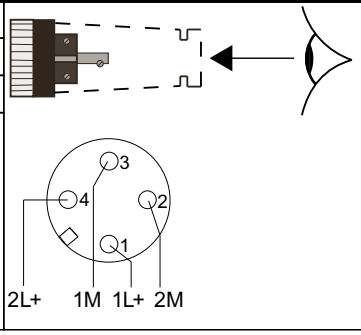
Pin	Assignment	View of the insulation displacement terminal block:
1	24 V (1L+ non-switched)	
2	Ground 1M (non-switched)	
3	24 V (2L+ switched)	
4	Ground 2M (switched)	

Table 1-1062 Pin assignment of the M12 connector

Pin	Assignment	View of the cable connector
1	24 V (1L+ non-switched)	
2	Ground 2M (switched)	
3	Ground 1M (non-switched)	
4	24 V (2L+ switched)	

Information on wiring

- If you are wiring your configuration, you must take into account the impact of cable length on the supply voltage to the ET 200eco PN (permitted tolerance).
- The maximum infeed current of the terminal block is 10 A for 1L+ non-switched and 10 A for 2L+ switched.

  Do not exceed these values.

CAUTION

Adhering to the maximum infeed currents and cable cross-sections
If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you will risk overheating the cable insulation and contacts resulting in damage to the device.

See also

Installing the terminal block (Page 23)

3.8 Wiring the voltage distributor

Wiring the connectors

We use an example to show the configuration of the PD DC 24V 1×7/8" 4×M12 voltage distributor with connected I/O devices.

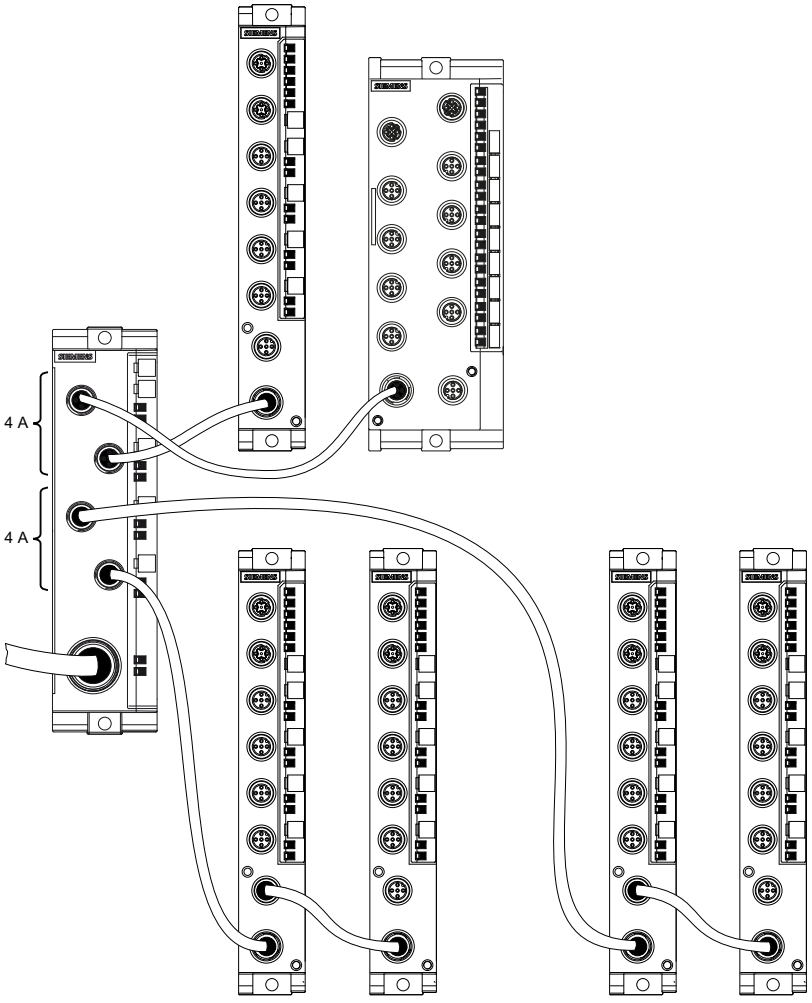


Figure 1-768 Wiring the voltage distributor

Pin assignment

The tables below show the pin assignments.

Table 1-1063 Pin assignment of the 7/8" connector at the current input of the voltage distributor

Pin	Assignment of X05	View of the 7/8" cable connector (24 V connection)
1	Ground 2M (switched)	
2	Ground 1M (non-switched)	

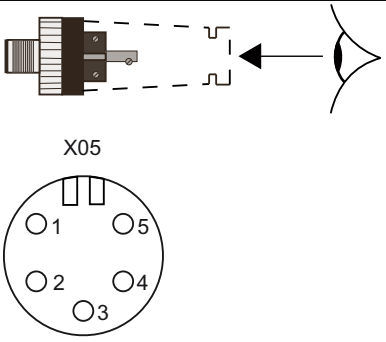
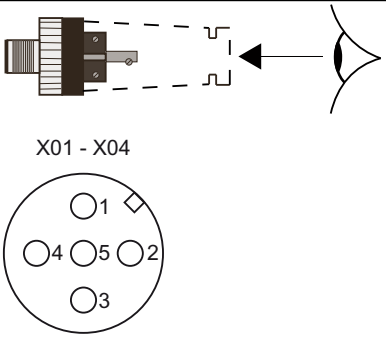
Pin	Assignment of X05	View of the 7/8" cable connector (24 V connection)
3	Functional earth FE	
4	24 V (1L+ non-switched)	
5	24 V (2L+ switched)	

Table 1-1064 Pin assignment of the M12 cable connector at the current output

Pin	Assignment of X01 to X04	View of the M12 cable connector
1	24 V (1L+ non-switched)	
2	Ground 2M (switched)	
3	Ground 1M (non-switched)	
4	24 V (2L+ switched)	
5	Not used	

Information on wiring

- If you are wiring your configuration, you must take into account the impact of cable length on the supply voltage to the ET 200eco PN (permitted tolerance).
- The maximum input current of the voltage distributor is 8 A for 1L+ non-switched and 2L+ switched.

  Do not exceed these values.

⚠ CAUTION

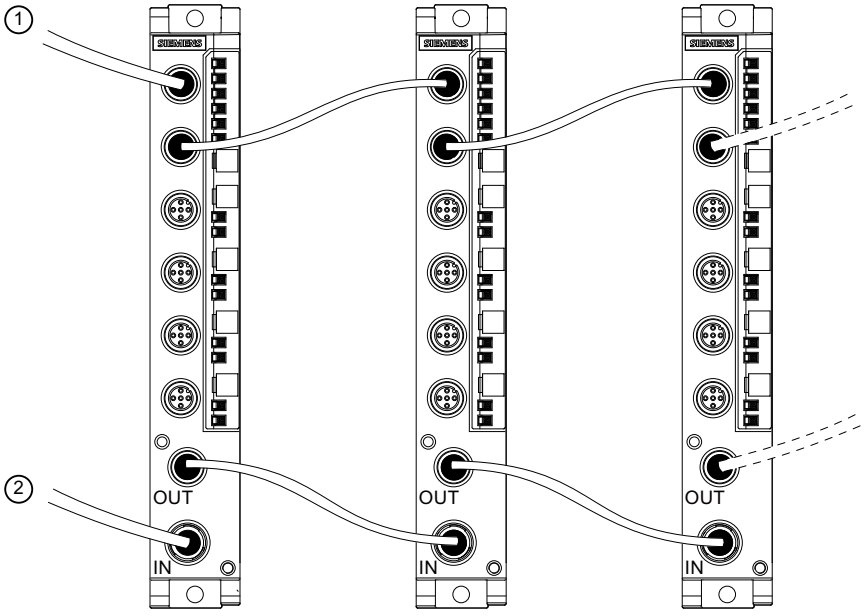
Adhering to the maximum infeed currents and cable cross-sections
If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you will risk overheating the cable insulation and contacts resulting in damage to the device.

3.9 Looping PROFINET and the supply voltage

Properties

The I/O device is equipped with one connector for the infeed and one socket for loop-through of the supply voltage. The feed connector and the socket for loop-through are interconnected internally.

Two sockets for PROFINET IO are available on the I/O device. One socket for the infeed and one socket for loop-through of the PROFINET IO.



① PROFINET
② Supply voltage

Figure 1-769 PROFINET and loop-through of supply voltage for ET 200eco PN

Information on wiring

- Always make allowances for the influence of the cable length on the supply voltage at your ET 200eco PN (permitted tolerance) when you wire your configuration.
- The maximum infeed current of the I/O module is 4 A each for 1L+ non-switched and 2L+ switched.

  These values may not be exceeded.

⚠ CAUTION
Adhering to the maximum infeed currents and cable cross-sections If you do not maintain the maximum infeed currents and the appropriate cable cross-sections, you will risk overheating of the cable insulation and contacts, and damage to the device.

Configuring

4

4.1 Configuring ET 200eco PN

Requirements

You need STEP 7 as of version V5.4, SP4 and possibly HSP.

Introduction

ET 200eco PN is included in the hardware catalog of *HW Config* after the start of STEP 7.

Procedure

1. Start SIMATIC Manager.
2. Create a new project.
3. Configure the ET 200eco PN with *HW Config*.
4. Double-click on the technology module at slot 1 of the ET 200eco PN in the configuration table and set the parameters.
5. Save the configuration, or download it to the IO Controller.

Prerequisite for the GSD file

You will need a GSD file, available for download from the Internet (http://support.automation.siemens.com/WW/view/en/19698639/133100).

ET 200eco PN family:
gsdml-v2.2-siemens-et200eco"date format yyyymmdd".xml

Configuring ET 200eco PN on PROFINET IO using STEP 7

1. Start STEP 7 and call up the **Options > Install New GSD File** menu command in *HW Config*.
2. In the next dialog box, select the GSD file to install, and confirm with "OK". Result: ET 200eco PN is displayed in the hardware catalog, PROFINET IO folder.
3. The rest of the procedure is as described in the Programming with STEP 7 (http://support.automation.siemens.com/WW/view/en/18652056) manual.

See also

For further information, refer to the STEP 7 online help.

4.2 Configuring an IO-Link master

4.2.1 Configuring the IO-Link Master 6ES7148-6JA00-0AB0

Requirements

Configuration of the IO-Link Master takes place in two steps:

1. You need STEP 7 as of version V5.4 + SP5 + HSP188 for the IO-Link Master.
2. Configure the connected IO-Link Devices, encoders, and actuators with the Port Configurator tool (S7-PCT).

Configuring the IO-Link Master with HW Config

1. Start the SIMATIC Manager and configure the project as described in the STEP 7 online help.
2. Drag the IO-Link Master from the HW catalog **PROFINET IO > ET 200eco PN > IO Link > 4 IO-L + 8 DI + 4 DO DC24V/1.3A 8×M12 V6.1.**
   You can freely choose the address space in the **Properties > Addresses** field for each slot of the IO-Link Master. Additional information on possible configurations is available in the chapter I/O address space (Page 232).
3. Assign the IO-Link Master parameters. You can assign the parameters separately for each functional unit:
   – The PROFINET IO parameters are accessed by double-clicking Slot 0.
   – The IO-Link parameters are accessed by double-clicking Slot 1.
   – The 8 digital input and 4 digital output parameters are accessed by double-clicking Slot 2.

Configuring the IO-Link Devices using "Configure IO-Link"

1. Select Slot 1 "4 IO-L" from the configuration table of the I/O device IO-Link Master.
2. Right-click and select "Configure IO-Link" in the following shortcut menu.
   Result: S7-PCT is started.
3. Now start with the parameter assignment of the IO-Link Devices, sensors, and actuators.

You can find additional information in the S7-PCT online help.

Configuring the IO-Link Master with GSD file

1. Install the GSD file in HW Config. The GSD file is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/33291771).
2. Select the IO-Link Master I/O device in the hardware catalog of HW Config.
3. You can freely choose the address space in the **Properties > Addresses** field for each slot of the IO-Link Master. In contrast to HSP configuration, the address space on Slot 1 "4 IO-L" is set permanently to 32 byte inputs and outputs. Additional information on possible configurations is available in the chapter I/O address space (Page 232).

4. Assign the IO-Link Master parameters. You can assign the parameters separately for each functional unit:
   – The PROFINET IO parameters are accessed by double-clicking Slot 0.
   – The IO-Link parameters are accessed by double-clicking Slot 1.
   – The 8 digital input and 4 digital output parameters are accessed by double-clicking Slot 2.

Configuring the IO-Link device via S7-PCT

1. Select Slot 1 "4 IO-L" from the configuration table of the I/O device IO-Link Master.
2. Right-click and select "Start Device Tool" in the following shortcut menu.
   Result: S7-PCT is started.
3. Now start with the parameter assignment of the IO-Link Devices, sensors, and actuators.

You can find additional information in the S7-PCT online help.

Response of the IO-Link Master in unparameterized state and after "Resetting the IO-Link settings" via S7-PCT

- All ports of the IO-Link Master are deactivated.
- All user data are equal to 0.
- All bits of the value status are set to "invalid."
- The maintenance data 1 to 3 are deleted.

4.2.2 Configuring the IO-Link Master 6ES7148-6JD00-0AB0

Introduction

The IO-Link Master 6ES7148-6JD00-0AB0 is configured and parameters are assigned in the user interface of the selected configuration software.

"**Configuring**" is understood to mean arranging, setting and networking of devices and modules.

"**Assigning parameters**" is understood to mean setting the properties of the components used. The parameters of the hardware and the settings for the data exchange are assigned in the process.

Configuring the submodule of the IO-Link master

Requirements

- You have configured your automation system.
- In the device configuration of the 6ES7148-6JD00-0AB0 IO-Link Master, you have selected the IO-Link port that you want to configure.

Procedure

1. You configure the operating mode of the submodule. An overview of possible operating modes is available in the chapter Configuration (Page 201).
2. When you have configured the submodule and thus defined the operating mode, make the additional settings:

- Enable the Autostart parameter (without S7-PCT)

NOTE

Changes to the port configuration
If you have assigned the parameters for the IO-Link device via Autostart (without S7-PCT), or have configured the port as digital input, digital output or disabled, you can no longer change the port configuration via S7-PCT.

- Enabling the diagnostics (only in IO-Link mode)
- Enable the parameter assignment for the hardware interrupts (only in IO-Link mode)

Response after "Resetting the IO-Link settings" via S7-PCT

- Deleting the IO-Link device data in the backup memory or the IO-Link Master
- Resetting the parameters to factory state:
  - Resetting the inspection severity and the backup behavior

NOTE

Effects on the device configuration
If you have reset the IO-Link settings via S7-PCT, you have to reload the device configuration via S7-PCT.

4.3 Device names for ET 200eco PN

Introduction

Every PROFINET IO device is assigned a unique device ID (MAC address) before it leaves the factory.

Each ET 200eco PN IO Device is addressed based on its device name during configuration and in the user program.

You will find detailed information on addressing in PROFINET IO in the the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual.

Requirements

- An online PROFINET connection from the programming device to the IO Device is required for assigning the device name to the IO Device.
- The IO device is configured and an IP address assigned in *HW Config*.

Assigning device names

1. Switch on the supply voltages for the ET 200eco PN.
2. Open the "Properties - ET 200eco PN" window in *HW Config*. Enter the device name for the IO Device and confirm your entry with "OK".
3. Select **PLC > Ethernet > Assign Device Name** in *HW Config*.
4. Click on "Assign Name" in the "Assign Device Name" window.

Result

The device name is saved internally in the ET 200eco PN.

Node flash test

The "Assign device name" dialog box displays all IO Devices used. Compare the MAC address of the device with the MAC address displayed and then select the correct IO Device.

The identification of IO Devices in a plant is facilitated by a node flash test. The flash test is activated as follows:

1. Select one of the displayed IO Devices from the "Assign device name" dialog box.
2. Select the flashing period.
3. Click the "Flash on" button.

The LINK LEDs flash on the selected IO Device.

Detailed information

For additional information, refer to the *STEP 7* Online Help and the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual.

4.4 Ports of ET 200eco PN

Introduction

The ET 200eco PN can diagnose two ports: X01 P1 R and X01 P2 R:

Requirement

- The ports must be configured in *HW Config*.
- The port diagnostics must be enabled.

Configuring the ports in *HW Config*

In HW Config, configure the two ports in the "Properties of the ET 200eco PN" dialog:

- "Addresses" tab: Diagnostic address of the respective port.
- "Topology" tab
- "Options" tab:
  To enable the port diagnostics, select the following for "Connection" under "Transmission medium / Duplex": "(Monitor) automatic settings".

See also

See the *STEP 7* online help.

4.5 Isochronous real-time communication

Isochronous real-time communication

Synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available within the send cycle for IRT IO data. The reserved bandwidth ensures that the IRT data are transmitted at reserved, synchronized intervals while remaining uninfluenced by another greater network load (for example, TCP/IP communication or additional realtime communication).

- "High performance" IRT option (not for 6ES7148-6JA00-0AB0 IO-Link Master):
  Topological configuration is required (STEP 7 V5.5 or higher).

NOTE

When using the IO controller as a Sync-Master for IRT communication with the "high performance" IRT option, the following must be observed:
Operate the IO controller as a Sync-Master if you configure the IRT communication with the "high performance" option.
Otherwise, IRT and RT configured IO devices may fail if the sync master fails.

NOTE

Using redundant Sync-Master

When using redundant Sync-Masters, a short-term failure of the 6ES7148-6JD00-0AB0 IO-Link Master can occur during the switching of the Sync-Master.

Detailed information

For additional information, refer to the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual and the Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual.

4.6 Prioritized startup

Prioritized startup

Prioritized startup denotes PROFINET functionality for accelerating the startup of IO Devices for RT and IRT communication within a PROFINET IO system.

The function reduces the time that the correspondingly configured IO Devices require to recover the cyclic exchange of user data in the following situations:

- After power has returned
- After station recovery
- After activation of IO Devices

Detailed information

For further information, see the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual and the Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual.

4.7 Device replacement without programming device

Device replacement without programming device

IO Devices having this function can be replaced easily:

- The device name does not have to be assigned using the programming device.

Instead of the programming device, the IO Controller now assigns the device name to the replacement IO Device. The IO Controller uses the configured topology and the correlations derived from the IO Devices. The configured target topology must agree with the actual topology.

IO Devices that have already been in operation must be reset to factory settings before before being put back into operation.

Detailed information

For further information, see the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual and the Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual.

4.8 Media redundancy

Media redundancy

Function for ensuring the network and system availability. Redundant transmission links (ring topology) ensures that an alternative communication path is made available if a transmission link fails (starting with STEP 7 V5.5) (not for 6ES7148-6JA00-0AB0 IO-Link Master up to firmware version 6.x).

For additional information, refer to the STEP 7 online help and the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) manual.

4.9 Reset to factory settings (PROFINET)

Reset to factory settings (PROFINET)

NOTE

The stations of a bus segment can fail during the reset to factory settings.

"Reset to factory settings" is only possible if the IO Device is not exchanging data with a controller.

SNMP parameters in non-volatile memory are reset to factory settings (*STEP 7* V5.3 SP 3 and higher) in the *HW Config* dialog **PLC > Ethernet > Edit Ethernet Nodes**, "Reset" button under "Reset to factory settings".

The following retentive data are retained during the reset:

- The MAC address,

  NOTE

  Deleting the device name

  The device name is deleted by means of the "Reset to factory settings" function.

- The I&M0 data,
- The settings configured with S7-PCT,
- The outputs take up the configured substitute value behavior.

4.10 SNMP

SNMP

The interface module supports the SNMP Ethernet service. MIB-2 (RFC1213) is supported. R/W objects can be edited using SNMP tools and are saved to module memory.

Following replacement with a brand new module, the R/W objects of the interface module are set to factory settings.

See also

SIMATIC PROFINET system description
(http://support.automation.siemens.com/WW/view/en/19292127)

Commissioning

5

5.1 Commissioning ET 200eco PN

Introduction

Your automation system is commissioned depending on the current plant configuration. The section below describes the procedure for commissioning the ET 200eco PN on an IO Controller.

Requirements for commissioning the ET 200eco PN on the PROFINET IO

Actions	Reference
ET 200eco PN installed	Chapter Installing (Page 19)
ET 200eco PN wired	Chapter Wiring (Page 26)
The IO Device was assigned a device name	Chapter Configuring (Page 59)
ET 200eco PN configured	Chapter Configuring (Page 59)
Supply voltage for the IO Controller is switched on	IO Controller manual
IO Controller switched to RUN	IO Controller manual

Commissioning ET 200eco PN

1. Switch on the voltage supply 1L+ non-switched for the ET 200eco PN.
2. Switch on the supply voltage(s) 2L+ switched as required.

Startup of the ET 200eco PN on the PROFINET IO

The schematic diagram below illustrates the startup of the ET 200eco PN on the PROFINET IO:

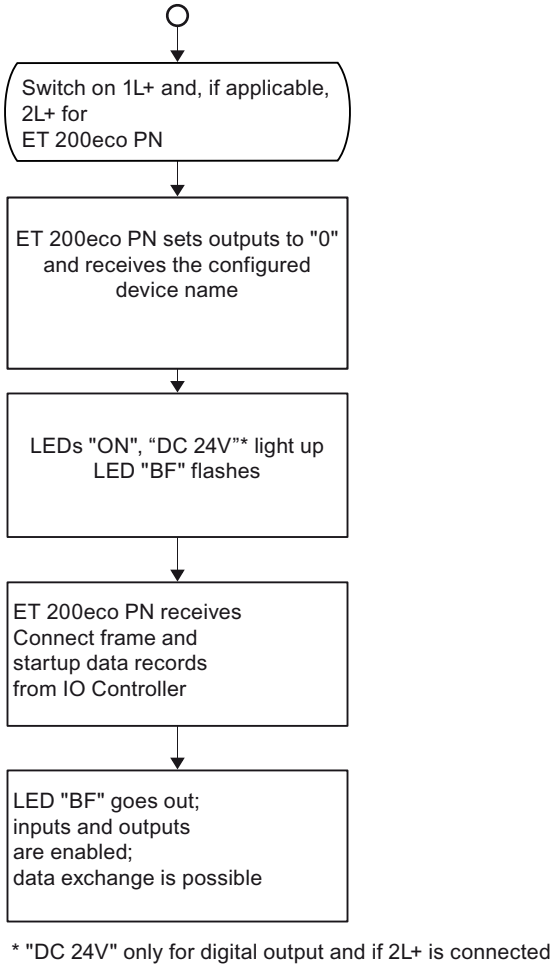


Figure 1-770 Startup of the ET 200eco PN on the PROFINET IO

Maintenance

6

6.1 Replacing the fuse

Introduction

The terminal block is equipped with replaceable fuses.
The figure below shows the fuses in the terminal block.

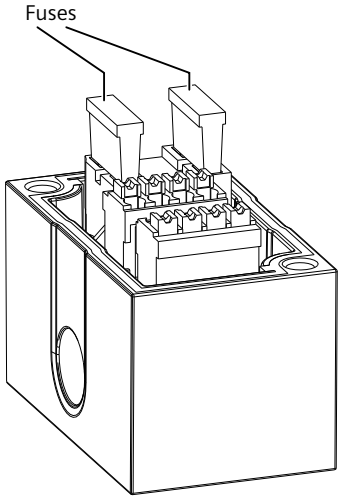


Figure 1-771 Fuses in the terminal block

Requirements

Switch off the supply voltage before you replace any fuses. Result: CPU stop of the ET 200eco PN.

Replacing a fuse of the terminal block

1. Remove the screws from the front panel of the terminal block using a crosstip screwdriver.
2. Remove the top section.
3. Remove the faulty fuse.
4. Press the new fuse (miniature copper flat fuse, type FK1, 7.5 A, fast-blow) into the fuse holder. The fuse is available as accessory.
5. Connect the terminal block and tighten the screws.
6. Switch on the supply voltage again.

6.2 Online firmware update by means of STEP 7 Manager

Introduction

To update the firmware of the ET 200eco PN including its I/O devices, you require the *.UPD files containing the current firmware version.

Requirements

- An online firmware update can be performed as of STEP 7 V5.4 + SP2.
- The I/O device of the station whose firmware is to be updated must be accessible online. The network card used must be set to "TCP/IP (Auto)" in the SIMATIC Manager under **Options > Set PG/PC Interface**.
- The files containing the current firmware versions must be available in the file system of your programming device or PC. A folder must contain the files of one firmware version only.

NOTE
The I/O device must be reset to the factory setting before the firmware update is carried out when special port parameter assignments have been carried out.

Performing a firmware update

1. Start STEP 7.
2. In the SIMATIC Manager select **PLC > Available stations**.
3. Select the I/O device.
4. Select the menu command **PLC > Update Firmware**. I/O devices without NameOfStation (NoS) are displayed with their MAC address.
   As of STEP 7 V5.4 SP5, Slot 0 must also be specified for the I/O devices. In previous versions of STEP 7 this setting is specified implicitly.
   With the ET 200eco PN, you can use the IO-Link Master 6ES7148-6JA00-0AB0 to perform the update of functional units:
   - Slot 0: PROFINET functional unit
   - Slot 1: IO-Link functional unit
   - Slot 2: 8 DI + 4 DQ functional unit
5. In the **Update Firmware** dialog, select the path to the firmware update files (*.UPD) using the "Browse" button.
6. After you have selected a file, the information in the bottom boxes of the "Update Firmware" dialog box indicates the I/O device for which the file is suitable and from which firmware version.
   If the firmware is to be loaded immediately after successful installation, select the check box "Activate firmware after download". If the check box is not selected, the firmware becomes active after the next Power Off/On.
7. Click "Run". The I/O device then automatically updates the firmware.

Result

You have updated your ET 200eco PN device online with a new firmware version.

Starting with version V6.0.0, if the ET 200eco PN I/O device was reset to the factory settings before the firmware update, the port parameter assignments are transmitted and activated again as a result of the neighborhood detection after the first connection is established between the controller and the ET 200eco PN I/O device. In previous versions, the device name had to be reassigned by selecting **PLC > Edit Ethernet Nodes ...** .

NOTE

You can also update the firmware using *HW Config*. You can find additional information in the STEP 7 online help.

6.3 Acyclic data exchange with the IO-Link library

Function blocks "LIOLink_Master" and "LIOLink_Device"

For acyclic data exchange, you can use the function blocks "LIOLink_Master" and "LIOLink_Device" for controllers of the S7-300, S7-400, S7-1200 and S7-1500 product lines.

The function blocks support the following tasks:

- Parameterization of an IO-Link device during operation
- Executing IO-Link port functions
- Diagnostics of IO-Link devices
- Backing up/restoring IO-Link device parameters

NOTE

Function blocks "LIOLink_Master" and "LIOLink_Device"

The function blocks "LIOLink_Master" and "LIOLink_Device" replace the functions of the previously available block "IOL_CALL".

The "LIOLink_Master" function block is used for all functions and accesses to the IO-Link master, and the "LIOLink_Device" function block is used for all accesses to the IO-Link devices.

Ensure for the IO-Link master 6ES7148-6JD00-0AB0 that the "LIOLink_Device" function block is only used for the configured submodules.

Reference

For an exact description of the procedure, refer to the IO-Link System functional manual on the Internet (https://support.industry.siemens.com/cs/ww/en/view/65949252).

The IO-Link block library is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/82981502).

You can find additional application examples for IO-Link block library on the Internet (https://support.industry.siemens.com/cs/ww/en/view/90529409).

6.4 Exchange object

Exchange object

With *HW Config*, the I/O devices are exchanged, for example, an 8-channel I/O device is replaced by a 16-channel I/O device. The following takes place:

With the "Exchange object" function, the device name, IP-address, etc. are taken over. The module/channel parameters are set to the "default" values.

6.5 Maintenance and repair

The components of the SIMATIC ET 200eco PN system are maintenance-free.

NOTE

Repairs to an ET 200eco PN I/O device may only be carried out by the manufacturer.

6.6 Cleaning the I/O device

When wired, ET 200eco PN I/O devices comply with degree of protection IP65/IP67 and do not require any cleaning. If you do have to clean the I/O device, then use a dry or damp cloth. Take care to comply with the conditions of degree of protection IP65/67 when cleaning with liquids.

Interrupt, error, and system messages 7

7.1 Interrupts of ET 200eco PN

Introduction

The IO Device generates interrupts as a reaction to specific error events. Interrupts are evaluated depending on the IO Controller used.

Evaluating interrupts using an IO Controller

The ET 200eco PN supports the following interrupts:

- Diagnostics interrupts
- Maintenance interrupts

In the event of an interrupt, interrupt OBs are executed automatically in the CPU of the IO Controller (refer to the System Software for S7-300/400 System and Standard Functions (http://support.automation.siemens.com/WW/view/en/1214574) Manual, chapter "Program design").

Information on the cause and class of the error is already available based on the OB number and start information.

You can obtain detailed information on the error event in the error OB by calling SFB 54 RALRM (read supplementary interrupt information).

Triggering diagnostics interrupts

After having detected an incoming or outgoing event (e.g., wire break), the device triggers a diagnostic interrupt for "Group diagnostics", if enabled, and for "Diagnostics for the relevant channel".

The CPU interrupts the processing of the user program and processes the diagnostics block OB 82. The event which led to the triggering of the interrupt is entered in the start information of OB 82.

7.2 Maintenance interrupts

Introduction

The PROFINET interfaces of the ET 200eco PN support the diagnostics concept and maintenance concept in PROFINET as defined in IEC 61158-6-10. The objective is early detection and elimination of potential disturbances.

Maintenance interrupts

The following maintenance interrupts are available for the ET 200eco PN:

- Sync mismatch (no synchronization)
- Jitter out of Boundary (jitter too high)
- Frame dropped (frames are discarded)
- I/O error (with IO-Link devices)

System alarms in *STEP 7*

The maintenance information is generated in *STEP 7* with the following system alarms:

- Maintenance required, identified by a yellow wrench icon at the relevant port.

See also

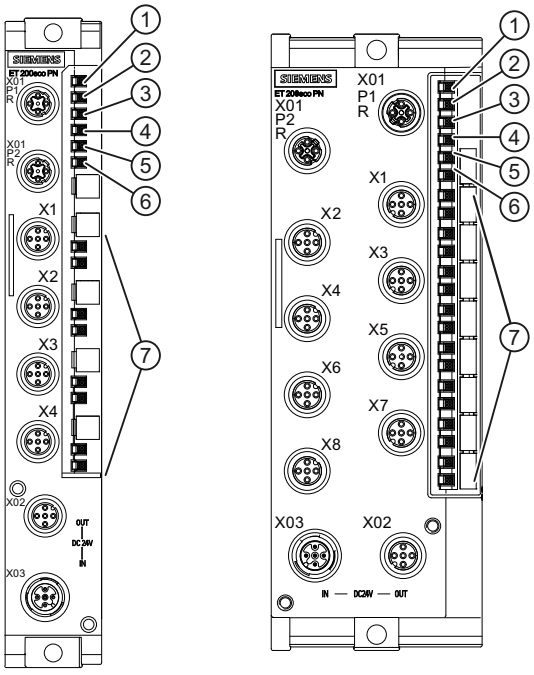
For additional information, refer to the SIMATIC PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) System Manual and the Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual.

7.3 Diagnostics by means of LED display

7.3.1 Diagnostics using the LED display on the I/O devices

LED display

The figure below shows the position and arrangement of the LED display on the ET 200eco PN I/O devices:



① SF/MT: Group fault/Maintenance (red/yellow LED)
② BF: Bus monitoring (red LED)
③ ON: Electronics/sensor/load voltage supply 1L+ non-switched (green LED)
④ DC 24V: Load voltage supply 2L+ switched (green LED); only for digital output device
⑤ P1 LK: Port1 Link (green LED)
⑥ P2 LK: Port2 Link (green LED)
⑦ Channel status, channel fault (green/red LED)

Status and error displays SF/MT, BF, ON

Table 1-1065 Status and error displays of the ET 200eco PN

LEDs			Meaning	Remedy
SF/MT	BF	ON		
Off	Off	On	IO Device is currently exchanging data with the IO Controller without errors. The IO Device is supplied with power (electronic/sensor supply).	---
Off	Off	Off	Electronic/sensor voltage missing or too low at the I/O device.	Switch on the electronic/sensor/load supply for the IO Device.
			Hardware fault.	Replace the I/O device.

LEDs			Meaning	Remedy
SF/MT	**BF**	**ON**		
*	Flashing	On	Faulty or no connect message frame - no data exchange between the IO Controller and the distributed device (IO Device), although the device is physically connected to the switch. Causes: • Incorrect device name • Error in configuration • Parameterization errors	• Check the I/O device. • Check the configuration and parameter settings. • Check the device name. • Check the IO Controller.
*	On	On	• The IO Device is not connected to a switch.	• Connect to the IO Controller. • Assign a valid device name to the I/O device. • Check the bus installation. • Check whether the M12 cable connectors are properly installed. • Check whether the bus cable to the IO Controller is interrupted.
On (red)	*	On	Fault in peripheral circuit. Incoming diagnostics	Evaluate the diagnostics interrupt.
On (yellow)	*	*	Maintenance alarm	Analyze the maintenance alarm.
* irrelevant				

Status display of the port LEDs

Table 1-1066 Status display of the port LEDs

LED		Meaning	Remedy
P1 LK	**P2 LK**		
Off	Off	No connection to the switch/IO Controller.	Check the IE cable.
On	On	Connection to switch/IO Controller.	-

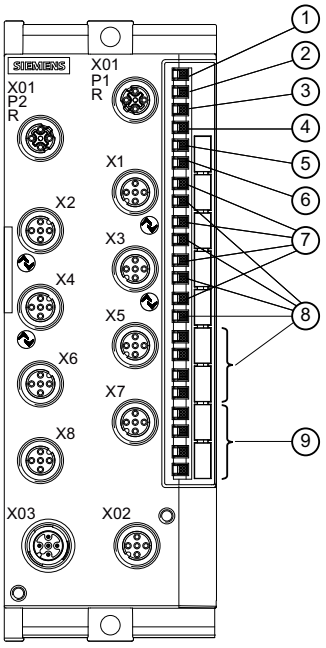
Status display DC 24V (only on I/O devices with digital outputs)

The DC 24V LED is lit in green color to indicate that you have connected the 2L+ switched load voltage supply. If the LED is not lit, check whether power is switched, or whether the fuse is okay.

7.3.2 Diagnostics using LED display on the IO-Link masters

LED display IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12 (6ES7148-6JA00-0AB0)

The figure below shows the position and arrangement of the LED display on the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12.



① SF/MT: Group fault/Maintenance (red/yellow LED)
② BF: Bus monitoring (red LED)
③ ON: Electronics/sensor/load voltage supply 1L+ non-switched (green LED)
④ DC 24V: Load voltage supply 2L+ switched (green LED); digital output
⑤ P1 LK: Port1 Link (green LED)
⑥ P2 LK: Port2 Link (green LED)
⑦ IO-L: Status display / Communications OK (green LED)
⑧ Input: Channel status, channel fault (green/red LED)
⑨ Output: Channel status, channel fault (green/red LED)

Status display of the IO-L LEDs

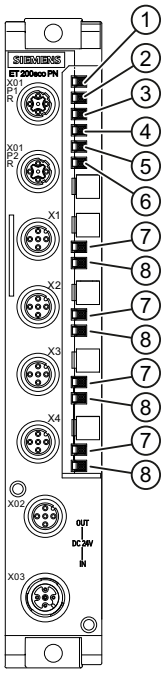
The following table displays the possible status displays of the IO-L LEDs.

Table 1-1067 Status display of the IO-L LEDs

LED IO-L	Meaning
On	• DI/DQ operating mode: Status when input or output is activated • IO-Link operating mode: When communication is running.
flashes at 2 Hz	• during startup or continuously if no operational IO-Link device as found.

LED display IO-Link Master 4 IO-L 4×M12 (6ES7148-6JD00-0AB0)

The figure below shows the position and arrangement of the LED display on the IO-Link Master 4 IO-L 4×M12.



① SF/MT: Group fault/Maintenance (red/yellow LED)
② BF: Bus monitoring (red LED)
③ ON: Electronics/sensor/load voltage supply 1L+ non-switched (green LED)
④ DC 24V: Load voltage supply 2L+ switched (green LED)
⑤ P1 LK: Port1 Link (green LED)
⑥ P2 LK: Port2 Link (green LED)
⑦ Q 1-4: Status indicator SIO mode (Green LED)
⑧ IO-L 1-4: Status display IO-Link communication / channel error (green/red LED)

LEDs Q1 to Q4

Valid for an IO-Link port that is in SIO mode.

Table 1-1068 Status displays of LEDs Q1 to Q4

LEDs Q1 to Q4	Meaning	Remedy
On	Input or output value is 1.	---
Off	Input or output value is 0 or port is deactivated.	---

LEDs IO-L 1 to IO-L 4

Valid for an IO-Link port that is in IO-Link mode.

Table 1-1069 Status displays of LEDs IO-L 1 to IO-L 4

LEDs		Meaning	Remedy
SF	**IO-L 1 to IO-L 4**		
Off	Flashes (green)	Flashes device	Check the IO-Link device used.
On	Flashes (green)	No IO-Link communication (for example, when you have activated the port but no available IO-Link device can be found.)	Check the wiring.
Off	On (green)	IO-Link communication established, **no** pending device error.	---
On	On (red)	IO-Link communication established, pending device or channel error.	Check the IO-Link device used.
Off	Off	Port deactivated	---

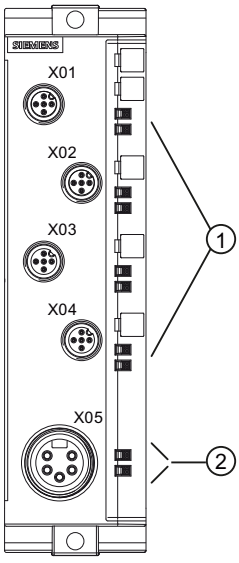
Reference

For status and error displays see section Diagnostics using the LED display on the I/O devices (Page 76).

7.3.3 Diagnostics using the LED display at the voltage distributor

LED display

The figure below shows the position and arrangement of the LED display on the voltage distributor.



① Loop-through 1L/2L (green LED)
② Infeed voltage (green LED)

Figure 1-772 LED display at voltage distributor

Table 1-1070 Status displays on the voltage distributor

LED	**Meaning**
1L/2L	
Loop-through	
On	Voltage applied
Flashing	Overload
Off	Short-circuit
Infeed voltage	
On	Voltage applied
Off	Voltage not applied

7.4 Diagnostics messages of the I/O devices

Actions after a diagnostics message

Every diagnostics message triggers the following actions:

- The SF LED (red) of the I/O device lights up.
- Several simultaneous diagnostics messages are possible.
- Diagnostics data are reported as diagnostics interrupts and can be read from data records.

- Diagnostics messages are saved to the diagnostics buffer of the I/O controller.
- OB 82 is called. If there is no OB 82, the IO Controller goes to STOP.
- Acknowledgment of the diagnostics interrupt to enable new interrupts.

7.5 Diagnostics with STEP 7

7.5.1 Reading diagnostics data

Options for reading the diagnostics data

Table 1-1071 Reading diagnostics data in STEP 7

Automation system with IO Controller	Block or register in STEP 7	Application	See ...
SIMATIC S7	For example in *HW Config* by selecting **Station > Open Online**	Device diagnostics in plain text on the STEP 7 interface (in the Quick View, Diagnostics View or Module Status windows)	"Hardware diagnostics" in the STEP 7 online help
	SFB 52 "RDREC"	Reading data records from the IO Device	SFB, see STEP 7 online help (System functions/System function blocks)
	SFB 54 "RALRM"	Receiving interrupts from the IO Device	SFB, see STEP 7 online help (System functions/System function blocks)

7.5.2 Channel diagnostics

Additional information regarding the data records for PROFINET IO

For information on the structure of diagnostics data records, including programming examples, refer to the Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) Programming Manual.

Structure of the manufacturer-specific diagnostics data records

The structure of the diagnostics data records is differentiated based on the BlockVersion. The following block versions apply to the ET 200eco PN:

ET 200eco PN	Article number	BlockVersion
8 DI DC 24V 4×M12	6ES7141-6BF00-0AB0	W#16#0101
8 DI DC 24V 8×M12	6ES7141-6BG00-0AB0	W#16#0101
16 DI DC 24V 8×M12	6ES7141-6BH00-0AB0	W#16#0101
8 DO DC 24V/1,3A 4×M12	6ES7142-6BF00-0AB0	W#16#0101
8 DO DC 24V/0,5A 4×M12	6ES7142-6BF50-0AB0	W#16#0101
8 DO DC 24V/1,3A 8×M12	6ES7142-6BG00-0AB0	W#16#0101

ET 200eco PN	Article number	BlockVersion
8 DO DC 24V/2,0A 8×M12	6ES7142-6BR00-0AB0	W#16#0101
16 DO DC 24V/1,3A 8×M12	6ES7142-6BH00-0AB0	W#16#0101
8 DIO DC 24V/1,3A 8×M12	6ES7147-6BG00-0AB0	W#16#0101
4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12	6ES7148-6JA00-0AB0	W#16#0101
4 IO-L 4×M12	6ES7148-6JD00-0AB0	W#16#0101
8 AI 4 U/I + 4 RTD/TC 8×M12	6ES7144-6KD00-0AB0	W#16#0101
8 AI RTD/TC 8×M12	6ES7144-6KD50-0AB0	W#16#0101
4 AO U/I 4×M12	6ES7145-6HD00-0AB0	W#16#0101

Manufacturer-specific diagnostics in the User Structure Identifier (USI)

- W#16#8000 channel diagnostics
- W#16#8002 extended channel diagnostics

7.5.3 Error classes for I/O devices

Error classes and remedies

The following tables show the error types for the I/O devices.

Error type for I/O devices, digital inputs/outputs, analog inputs/outputs

Table 1-1072 Overview Error types

Error class		Error text	Meaning	Remedy
00001_B	1_D	Short-circuit	• Short-circuit to M at the sensor supply line • Short-circuit at the output line • Load impedance too low	• Correct the process wiring • Check the sensor or actuator
00100_B	4_D	Thermal overload	• I/O device is overheating	• Check the process wiring • Check the ambient temperature
00110_B	6_D	Wire break	• Signal line to a sensor or actuator interrupted • Sensor or actuator failure • Load impedance too high	• Correct the process wiring • Replace the sensor or actuator • Use a sensor with lower impedance • Use an actuator with lower load impedance
00111_B	7_D	Violation of upper limit	• The value is above the overrange	• Correct the I/O device to sensor tuning • Modify measuring range by means of parameter assignment
01000_B	8_D	Violation of lower limit	• Value is below the underrange	• Correct the I/O device to sensor tuning • Modify measuring range by means of parameter assignment
01001_B	9_D	Error	• Internal I/O device error has occurred (diagnostic message on channel 0 applies to the whole I/O device).	• Replacement of I/O device

Error class		Error text	Meaning	Remedy
10000_B	16_D	Parameter assignment errors	• I/O device is incorrectly parameterized	• Correct the parameter assignment
10001_B	17_D	1L+ or 2L+ is missing	• Supply voltages missing or too low • Load voltage supply missing or too low	• Check the supply voltages • Check the load voltage supply • Correct the process wiring
10101_B	21_D	Reference channel fault	• Measurement cable for compensation interrupted • Data record DS2 incorrect • Timeout for "Dynamic ref. Temp."	• Correct the process wiring • Check the data record DS2. • Send DS2

Error classes for IO-Link Master (6ES7148-6JA00-0AB0), Slot 1

Table 1-1073 Overview Error types Slot 1

Error class		Error text	Meaning	IO-Link Master	IO-Link Device
00001_B	1_D	Short-circuit	Short circuit at the process cables of the IO-Link device (0x5151)		X
00010_B	2_D	Undervoltage	Supply voltage too low (0x5110 to 0x5119)		X
00100_B	4_D	Overload	Overload of the output stage of the IO-Link Devices (0x5410)		X
00101_B	5_D	Overtemperature	• Ambient temperature too high (0x4110) • IO-Link Device too hot (0x4210) • IO temperature exceeded (0x4310)		X
00110_B	6_D	Wire break	• No IO-Link Device connected • Incorrect IO-Link Device connected • Signal cable to IO-Link Device interrupted • Signal cable to IO-Link Device short-circuited • Short-circuit of supply voltage at sensor • IO-Link Device addressed with too short communication cycle time • IO-Link Device cannot communicate due to another error (0xFF10)	X	
00111_B	7_D	Overflow	• Process variable range exceeded (0x8C10) • Measuring range exceeded (0x8C20)		X
01000_B	8_D	Underflow	Process variable range too small (0x8C30)		X
01001_B	9_D	Error	All the IO-Link error codes not listed here will be mapped to this PROFINET IO error.		X
			Hardware error at IO-Link Master detected	X	
10000_B	16_D	Parameter assignment errors	IO-Link Master could not be parameterized	X	
			Event code of the IO-Link Device (0x6230 to 0x6340)		X
10010_B	18_D	Fuse defective	Event code of the IO-Link Device (0x5450 to 0x5459)		X
11010_B	26_D	External error	IO-Link Device cannot be set to desired mode	X	

Errors types IO-Link Master (6ES7148-6JD00-0AB0)

IO-Link devices diagnostics

The IO-Link master generates PROFINET channel diagnostics (CET, ECET) from the IO-Link events of an IO-Link devices according to the following mapping rules:

The IO-Link event codes of the area 0x0000 – $0x7FFF_H$ are displayed directly in the "IO-Link Device Diagnostics - Page 1" (CET $0x9500_H$):
$ECET_H$ = IO-Link Event $Code_H$

The IO-Link event codes of the area 0x8000 – $0xFFFF_H$ are displayed directly in the "IO-Link Device Diagnostics - Page 2" (CET $0x9501_H$) via the following rule:
$ECET_H$ = (IO-Link Event $Code_H$ – $0x8000_H$)

Table 1-1074 Overview Error types IO-Link Device Diagnostics

IO-Link Event Code	Error type (CET)	Expanded error type (ECET)	Error text	Meaning
0x0000 - $0x7FFF_H$	$0x9500_H$ (38144_D)	0x0000 - $0x7FFF_H$ (0 - 32767_D)	Error / Warning	See manual of the IO-Link devices or IODD file used.
0x8000 - $0xFFFF_H$	$0x9501_H$ (38134_D)	0x0000 - $0x7FFF_H$ (0 - 32767_D)	Error / Warning	See manual of the IO-Link devices or IODD file used.

Example of Display of IO-Link Event Codes:

An IO-Link device supports the event codes $0x4000_H$ and $0x8CA0_H$.
The channel diagnostics result from the event codes:

- CET: $0x9500_H$, ECET: $0x4000_H$
  Diagnostic alarm "IO-Link Device Diagnostics - Page 1, Temperature fault - Overload", generates Event Code $0x4000_H$ from the IO-Link.
- CET: $0x9501_H$, ECET: $0xCA0_H$
  Diagnostic alarm "IO-Link Device Diagnostics - Page 2, Ambient light interference, generates Event Code $0x8CA0_H$ from the IO-Link.

IO-Link Port Diagnostics

The IO-Link master generates channel diagnostics for each port. The port-specific channel diagnostics are display in the port diagnostics (CET $0x9502_H$).
The following table provides an overview of the possible diagnostics events and their meaning.

Table 1-1075 Overview Error types IO-Link Port Diagnostics

Error type (CET)	Expanded error type (ECET)	Error text	Meaning
$0x9502_H$ (38136_D)	$0x1883_H$ (6275_D)	S7-PCT configuration errors	Wrong or inconsistent parameter assignment
	$0x1888_H$ (6280_D)	Module defective	Replace module
	$0x7F22_H$ (32546_D)	Device not available	Communication aborted
	$0x1801_H$ (6145_D)	Parameter assignment error during startup	Check the parameterization
	$0x1802_H$ (6146_D)	Wrong device	Check device
	$0x1803_H$ (6147_D)	Nonconformance of process data	Check submodule configuration
	$0x1804_H$ (6148_D)	Short circuit at C/Q	Check port connection

Error type (CET)	Expanded error type (ECET)	Error text	Meaning
$0x9502_H$ (38136_D)	$0x1805_H$ (6149_D)	IO-Link PHY overtemperature	
	$0x1806_H$ (6150_D)	Short circuit at L+	Check port connection
	$0x1807_H$ (6151_D)	Undervoltage at L+	Check port connection
	$0x1808_H$ (6152_D)	Event overflow at device	
	$0x1809_H$ (6153_D)	Backup failed	Memory outside of the area 2k
	$0x180A_H$ (6154_D)	Backup inconsistent	Data storage index not available
	$0x180B_H$ (6155_D)	Backup invalid	Length of the data storage index is invalid
	$0x7F23_H$ (32547_D)	Backup invalid	Nonconformance in identification of data storage
	$0x7F25_H$ (32549_D)	Backup invalid	Access to data storage denied
	$0x180E_H$ (6158_D)	No P24 (Class B) or undervoltage	Check power supply (for example, 2L+)
	$0x180F_H$ (6159_D)	Short circuit at P24 (Class B)	Check port connection
	$0x6000_H$ (24576_D)	Invalid cycle time	Check cycle time
	$0x6001_H$ (24577_D)	Revision error	Incomplete protocol version
	$0x6002_H$ (24578_D)	Implausible device	

See also

For more information please refer to the STEP 7 online help and to the programming manual Migration from PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930).

7.5.4 STOP of the IO Controller and recovery of the IO Device

Diagnostics events triggered after a STOP of the IO Controller

Diagnostics frames received from the IO Device while the IO Controller is in STOP do not trigger the start of corresponding OBs after the restart of the IO Controller. You must explicitly read the diagnostics data from OB 100 to obtain an overview of the device state.

Diagnostics after recovery of the IO Device

You must explicitly read data record $E00C_H$ by calling SFB 52 after recovery of an IO Device. This record contains all diagnostics data for the device slots assigned to an IO Controller

General technical data

8

8.1 Standards and certifications

Introduction

The ET 200eco PN distributed I/O system satisfies the requirements and criteria of IEC 61131-2.

NOTE

Information on the nameplate
You will find the currently valid labels and approvals on the type plate of the respective product.

PROFINET IO

PROFINET IO is an open transmission protocol with real-time functionality defined in PROFINET.

CE marking

CE

Our products fulfill the requirements and safety objectives of the following EU Directives and comply with the harmonized European standards (EN) published for programmable logic controllers in the official journals of the European Union:

- 2014/30/EU "Electromagnetic compatibility" (EMC Guidelines)
- 2014/34/EU "Equipment and protective systems for use in hazardous areas" (Explosion protection directive)
- EU Directive 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic devices" (RoHS Directive)

The EU Declarations of Conformity are available to the relevant authorities at the following address:

Siemens AG
Digital Industries
Factory Automation
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg

These files are also available for download on the Customer Support Internet pages, under "Declaration of Conformity".

UKCA mark

The ET 200eco PN distributed I/O system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The ET 200eco PN distributed I/O system meets the requirements and protection targets of the following regulations and related amendments:

- Electromagnetic Compatibility Regulations 2016 (EMC)
- Equipment and Protective Systems Intended for use in Potentially Explosive Atmospheres Regulations 2016 (Explosion Protection)
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (RoHS).

UK declarations of conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
DI FA TI COS TT
P.O. Box 1963
D-92209 Amberg

The UK declarations of conformity are also available for download from the Siemens Industry Online Support website, under the keyword "Declaration of Conformity".

ATEX approval

According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Type of protection "n"), EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and EN 60079-31 (Equipment dust ignition protection by enclosure "t").

II 3 G Ex nA IIC T4 Gc
II 3 D Ex tc IIIC T90°C Dc
DEKRA 12ATEX0220 X

OR

According to EN 60079-7 + A1 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and EN 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").

II 3 G Ex ec IIC T4 Gc
II 3 D Ex tc IIIC T90°C Dc
DEKRA 20ATEX0119 X

Special conditions in hazardous areas:

Install the device so that there is a minimal risk of mechanical danger.

To prevent electrostatic charging, wipe the housing surface only with a wet cloth.

Use the device only in an environment that is protected from UV light.

The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the device in an area with a degree of pollution 2 according to EN 60664-1.
- Provisions must be taken to prevent the rated voltage from being exceeded by transient disturbance voltages of more than 119 V.

UKEX approval



According to EN 60079-7 + A1 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and EN 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").

II 3 G Ex ec IIC T4 Gc
II 3 D Ex tc IIIC T90°C Dc
DEKRA 21UKEX0015 X

Special conditions in hazardous areas:
Install the device so that there is a minimal risk of mechanical danger.

To prevent electrostatic charging, wipe the housing surface only with a wet cloth.

The following additional conditions apply when using the devices in an area that requires EPL Gc:

- Only use the device in an area with a degree of pollution 2 according to EN 60664-1.
- Provisions must be taken to prevent the rated voltage from being exceeded by transient disturbance voltages of more than 119 V.

IECEx approval



According to IEC 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e"), IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements) and IEC 60079-31 (Electrical apparatus for potentially explosive atmospheres – Part 31: dust ignition protection by enclosure "t").

Ex ec IIC T4 Gc
Ex tc IIIC T90°C Dc
IECEx DEK 20.0070 X

Special conditions in hazardous areas:
Install the device so that there is a minimal risk of mechanical danger.

To prevent electrostatic charging, wipe the housing surface only with a wet cloth.

Use the device only in an environment that is protected from UV light.

When using the devices in an area that requires devices with EPL Gc:

- Only use the device in an area with a degree of pollution 2 according to IEC 60664-1.
- Provisions must be taken to prevent the rated voltage from being exceeded by transient disturbance voltages of more than 119 V.

CCCEx approval



In accordance with GB/T 3836.3 (Explosive atmospheres - Part 3: Equipment protection by type of protection "e"), GB/T 3836.31 (Explosive atmospheres - Part 31: Equipment protection by type of protection "t") and GB/T 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements).

Ex ec IIC T4 Gc

Ex tc IIIC T90 °C Dc

Special conditions in hazardous areas:
Install the device so that there is a minimal risk of mechanical danger.

To prevent electrostatic charging, wipe the housing surface only with a wet cloth.

Use the device only in an environment that is protected from UV light.

When using the devices in an area that requires devices with EPL Gc:

- Only use the device in an area with a degree of pollution 2 according to GB/T 16935.1.
- Provisions must be taken to prevent the rated voltage from being exceeded by transient disturbance voltages of more than 119 V.

RCM (C-Tick) Declaration of conformity for Australia/New Zealand



The ET 200eco PN distributed I/O system fulfills the requirements of the standard EN 61000-6-4 Generic standards - Emission standard for industrial environments.

Korea Certificate KCC-REM-S49-ET200



Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Marking for the Eurasian Customs Union



EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU).

cULus approval



Underwriters Laboratories Inc. in accordance with

- UL 508 (Industrial Control Equipment)
- UL50 Enclosure Type 4X, indoor use only, watertight
- CAN/CSA C22.2 No. 142 (Process Control Equipment)

NOTE

Class 2 power supply unit
The components must be supplied with a class 2 power supply unit.

Industrial applications

The ET 200eco PN distributed I/O system is designed for operation in industrial environments. It conforms to the following standards:

- Requirements for emissions EN 61000-6-4: 2007 + A1: 2011
- Requirements for immunity EN 61000-6-2: 2005

Usage in mixed-use zone
Under certain circumstances, you can use the ET 200eco PN distributed I/O system in a mixed-use zone. A mixed-use zone is used for housing and commercial operations that do not have a significant impact on residents.

When you use the ET 200eco PN distributed I/O system in a mixed-use zone, you must ensure that the limits of the generic standard EN 61000-6-3 regarding emission of radio frequency interference are observed. Suitable measures for achieving these limits for use in a mixed-use zone include:

- Installation of the ET 200eco PN distributed I/O system in grounded control cabinets / boxes.
- Use of noise filters in the supply lines

Individual acceptance is required.

Usage in residential area

NOTE

ET 200eco PN distributed I/O system not intended for use in residential area
The ET 200eco PN distributed I/O system is not intended for use in residential areas. Operation of the ET 200eco PN distributed I/O system in residential areas can have a negative influence on radio or TV reception.

Marine approval

Classification authorities:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- CCS (China Classification Society)
- DNVGL (Det Norske Veritas / Germanischer Lloyd)
- KR (Korean Register of Shipping)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)

The article numbers of the approved I/O devices for the respective classification society can be found here (https://support.industry.siemens.com/cs/ww/en/ps/14244/cert?ct=446).

See also

PI explosion protection use ecoPN
(https://support.industry.siemens.com/cs/ww/en/view/80484830)

8.2 EMC compatibility, shipping and storage conditions

Definition

Electromagnetic compatibility is the ability of an electrical device to function in its electromagnetic environment in a satisfactory manner without affecting this environment.

The ET 200eco PN distributed I/O device also meets the requirements of the EMC law of the European Single Market. Prerequisite is compliance of the electrical configuration of the ET 200eco PN distributed I/O device with specifications and directives.

Pulse-shaped disturbances

The table below shows the electromagnetic compatibility of the ET 200eco PN distributed I/O device with respect to pulse-shaped disturbances.

Pulse-shaped disturbance	Test voltage	corresponds with degree of severity
Electrostatic discharge to IEC 61000-4-2	8 kV 6 kV	3 (air discharge) 3 (contact discharge)
Burst pulses (high-speed transient disturbances) according to IEC 61000-4-4.	2 kV (power supply line) 2 kV (signal line)	3 4
High-energy single pulse (surge) according to IEC 61000-4-5 *		3
• Asymmetric coupling • Symmetric coupling	2 kV (power supply line) 2 kV (signal / data line) 1 kV (power supply line) 1 kV (signal / data line)	
* On DC 24 V supply only with protective element		

Sinusoidal disturbance variables

The table below shows the electromagnetic compatibility of the ET 200eco PN distributed I/O device with respect to sinusoidal disturbances.

HF radiation according to IEC 61000-4-3 Electromagnetic HF field	HF coupling according to IEC 61000-4-6
Amplitude modulated	
80 to 1000 MHz; 1.4 to 2 GHz	0.15 MHz to 80 MHz
10 V/m 80% AM (1 kHz)	10 V_{rms} unmodulated
2 to 2.7 GHz	80 % AM (1 kHz)
1 V/m at 80 % AM (1 kHz)	150 Ω source impedance

Emission of radio interference

Interference emission of electromagnetic fields in accordance with EN 61000-4-6: (measured at a distance of 10 m).

Frequency	Noise emission
30 MHz to 230 MHz	< 40 dB (µV/m)Q
230 MHz to 1000 MHz	<47 dB (µV/m) Q

Shipping and storage conditions

The ET 200eco PN distributed I/O device surpasses the requirements according to IEC 61131-2 for transport and storage conditions. The following information applies to modules transported or stored in their original packaging.

Type of condition	Permissible range
Free fall	≤ 0.3 m
Temperature	from -40 °C to +70 °C
Temperature change	20 K/h
Air pressure	From 1140 hPa to 660 hPa (corresponds with an altitude of -1000 m to 3500 m)
Relative humidity	From 5% to 95%, without condensation

8.3 Mechanical and climatic environmental conditions

Climatic environmental conditions

Applicable climatic environmental conditions:

Environmental conditions	Fields of application	Remarks
Temperature	from 0 °C to 55 °C	All mounting positions
Temperature change	10 K/h	-
Relative humidity	5 % to max. 100 %	With condensation
Air pressure	From 1140 hPa to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

Operating temperature range for the devices

The following devices can be used in different temperature ranges (indoor use only):

Designation	Article number	Fields of application			From product version
		-25 °C to 55 °C	-25 °C to 60 °C	-40 °C to 60 °C	
8 DI DC 24V 4×M12	6ES7141-6BF00-0AB0	X	X		1
		X	X	X	4
8 DI DC 24V 8×M12	6ES7141-6BG00-0AB0	X	X		1
		X	X	X	4
16 DI DC 24V 8×M12	6ES7141-6BH00-0AB0	X	X		1
		X	X	X	4
8 DO DC 24V/1,3A 4×M12	6ES7142-6BF00-0AB0	X	X		1
		X	X	X	4
8 DO DC 24V/0,5A 4×M12	6ES7142-6BF50-0AB0	X	X		1
		X	X	X	4
8 DO DC 24V/1,3A 8×M12	6ES7142-6BG00-0AB0	X	X		1
		X	X	X	4
8 DO DC 24V/2,0A 8×M12	6ES7142-6BR00-0AB0	X	X		1
		X	X	X	4
16 DO DC 24V/1,3A 8×M12	6ES7142-6BH00-0AB0	X	X		1
		X	X	X	4
8 DIO DC 24 V/1,3A 8×M12	6ES7147-6BG00-0AB0	X	X		1
		X	X	X	4
8 AI 4 U/I + 4 RTD/TC 8×M12	6ES7144-6KD00-0AB0	X	X		1
		X	X	X	4
8 AI RTD/TC 8×M12	6ES7144-6KD50-0AB0	X	X	X	1
4 AO U/I 4×M12	6ES7145-6HD00-0AB0	X	X		1

Designation	Article number	Fields of application			From product version
		-25 °C to 55 °C	-25 °C to 60 °C	-40 °C to 60 °C	
4 AO U/I 4×M12	6ES7145-6HD00-0AB0	X	X	X	4
4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12	6ES7148-6JA00-0AB0	X	X		1
4 IO-L 4×M12	6ES7148-6JD00-0AB0	X	X	X	1
PD DC 24V 1×7/8" 4×M12	6ES7148-6CB00-0AA0	X			1
Terminal block	6ES7194-6CA00-0AA0	X			1
Mounting rail	6ES7194-6GA00-0AA0	X	X	X	1

Mechanical environmental conditions

The table below shows the mechanical environmental conditions in the form of sinusoidal oscillation.

Devices	Frequency band	Continuous	Tested at ...
Without mounting rail	10 ≤ f ≤ 58 Hz	1.5 mm amplitude	3 mm amplitude
	58 ≤ f ≤ 150 Hz	20 g constant acceleration	40 g constant acceleration
With mounting rail	5 ≤ f ≤ 8 Hz	15 mm amplitude	-
	8 ≤ f ≤ 150 Hz	5 g constant acceleration	10 g constant acceleration

Compatibility test, mechanical environmental conditions

The table below provides information about the type and scope of the tests of mechanical environmental conditions.

Test ...	Test standard	Terminal and I/O devices	
Vibration	Vibration test according to IEC 60068-2-6	Without mounting rail With mounting rail	Type of vibration: Frequency sweeps at a rate of change of 1 octave/minute. 10 Hz ≤ f ≤ 58 Hz, constant amplitude 3 mm 58 Hz ≤ f ≤ 150 Hz, constant acceleration 40 g 5 Hz ≤ f ≤ 12 Hz, constant amplitude 15 mm 12 Hz ≤ f ≤ 150 Hz, constant acceleration 10 g Duration of vibration: 10 frequency sweeps per axis in each of three perpendicular axes
Shock	Shock, tested in accordance with IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 30 g peak value, 18 ms duration Direction of shock: 3 shocks in each +/- direction at each of the three vertically aligned axes	
Continuous shock		Type of shock: Half-sine Shock intensity: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks in each +/- direction at each of the three vertically aligned axes	

Extended environmental conditions for outdoor use

The table below provides information about the type and scope of the tests for extended environmental conditions for outdoor use.

Test ...	Test standard	Conditions/Comments
Salt spray	IEC 60068-2-52	Severity level 1 for products used at sea or close to the ocean: 4 cycles each with: • 2 h with 5 % NaCl at 35 °C • 7 days at 40 °C/93 % rel. humidity
UV resistance		Chamber with glass: Sun test CPS plus Fa. Atlas Duration: 12 weeks • Irradiance (E): 550 W/m² • Black standard temperature (BST): 55 °C
Condensation changing climate	DIN EN ISO 6270-2	Condensation climate with alternating humidity and air temperature (AHT): 84 cycles each with: • 8 h at 40 °C +3 °C with 100% relative humidity (condensation) • 16 h at 18 °C to 28 °C with 100% relative humidity
Thermal shock test	IEC 60068-2-14 Na	Temperature: -40 °C/+125 °C Duration: 500 cycles (500 h) Device is switched off
Hot storage	IEC 60068-2-2 Bb	Temperature: 100 °C Duration: 1 year

Devices for operating range of extended environmental conditions in outdoor use

The following devices can be used for extended environmental conditions in outdoor use:

Designation	Article number	From product version
8 DI DC 24V 4×M12	6ES7141-6BF00-0AB0	4
8 DI DC 24V 8×M12	6ES7141-6BG00-0AB0	4
16 DI DC 24V 8×M12	6ES7141-6BH00-0AB0	4
8 DO DC 24V/1,3A 4×M12	6ES7142-6BF00-0AB0	4
8 DO DC 24V/0,5A 4×M12	6ES7142-6BF50-0AB0	4
8 DO DC 24V/1,3A 8×M12	6ES7142-6BG00-0AB0	4
8 DO DC 24V/2,0A 8×M12	6ES7142-6BR00-0AB0	4
16 DO DC 24V/1,3A 8×M12	6ES7142-6BH00-0AB0	4
8 DIO DC 24 V/1,3A 8×M12	6ES7147-6BG00-0AB0	4
8 AI 4 U/I + 4 RTD/TC 8×M12	6ES7144-6KD00-0AB0	4
8 AI RTD/TC 8×M12	6ES5144-6KD50-0AB0	1
4 AO U/I 4×M12	6ES7145-6HD00-0AB0	4

8.4 Specification of dielectric tests, protection class, degree of protection, and rated voltage of ET 200eco PN

Insulation

The insulation is designed in accordance with the requirements of EN 61131-2: 2007.

NOTE
In the case of modules with supply voltage 24 V DC (SELV/PELV) electrical isolation with DC 707 V (type test) are tested.

Severity for voltage interruption

The distributed I/O devices of the ET 200eco PN meet the severity class PS1 for voltage interruptions (1 ms).

Degree of protection IP65

Degree of protection according to IEC 60529:

- Protection against the ingress of dust and full touch protection
- Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.

Degree of protection IP66 and IP67

Degree of protection according to IEC 60529:

- Protection against the ingress of dust and full touch protection
- IP66: Protection against water from heavy seas or water projected in powerful jets (water must not enter the enclosure in harmful quantities)
- IP67: Protection against water when enclosure is immersed at specified pressures over a specified time period (water must not enter the enclosure in any harmful amount)

Rated voltage for operation

The ET 200eco PN distributed I/O device operates at the following rated voltage and corresponding tolerances.

Rated voltage	Tolerance range
DC 24 V	20.4 to 28.8 V DC

8.5 Safety-relevant symbols for the ET 200eco PN distributed I/O system

The following table contains a declaration of the systems than can be located on the modules of the ET 200ecoPN distributed I/O system, on their packaging or on the accompanying documentation.

Symbol	Meaning
	General warning sign **Caution/Notice** You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
 ONLY EX MODULES	The assigned safety symbols apply to devices **with Ex approval**. You must read the product documentation. The product documentation contains information about the type of potential hazard and enables you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by an electrically skilled person. IEC 60417 No. 6182
 CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
 EMC	Note that the device must be constructed and connected in accordance with EMC regulations.
 230V MODULES	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2
 24V MODULES	Note that a device of Protection Class III must only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
 INDOOR USE ONLY INDUSTRIAL USE ONLY	If you use the ET 200ecoPN in accordance with the UL standard, take into account that the device is only approved for industrial field and only for the interior.

8.6 Use of the ET 200eco PN in zone 2/zone 22 hazardous areas

Approved ET 200eco PN distributed I/O devices

You can find the EC type examination certificate with the approved ET 200eco PN I/O devices on the Internet at the following link: Type test (http://support.automation.siemens.com/WW/view/de/71748103)

Approval

The approval is available in the section Standards and certifications (Page 88).

⚠ WARNING

Risk of personal injury and damage to property.
In hazardous areas, personal injury or damage to property may occur if you disconnect any plug connections during operation of an ET 200eco PN.
In hazardous areas, always switch off the power to the ET 200eco PN when disconnecting plug connections.

Special conditions

1. The I/O devices should be set up in such a way that the risk of mechanical danger is low.
2. The technical specifications of the I/O devices specified in the EC type examination certification must be adhered to:
   - Supply voltage of ET 200eco PN
   - Input and output currents
   - Ambient temperatures
3. M12 connectors (for PROFINET, supply voltage, encoders and actuators) must never be connected or disconnected with the power on.
4. Use the following cables with even connector outlets to wire the different M12 interfaces:
   - PROFINET: SIEMENS, order number 6XV1 870-8A or 6XV1 871-5T
   - Supply voltage: SIEMENS, order number 6XV1 801-5D
   - Encoders and actuators: SIEMENS, Y-cable, order number 6ES7194-6KA00-0XA0; PHOENIX CONTACT *, product designation SAC-3P-M12MS

5. All M12 connectors must be protected against unauthorized opening, for example with safety clips. Suitable safety clips are available with PHOENIX CONTACT *, product designation SAC-M12-EXCLIP-F or SAC-M12-EXCLIP-M.

SAC-M12-EXCLIP-F



SAC-M12-EXCLIP-M



6. All unoccupied M12 circular sockets should be closed using sealing caps in such a way that the caps cannot be loosened by hand (torque: 0.6 Nm). Suitable sealing caps are available from: Binder GmbH + Co. **, item no. 08 2769 000 000.



* PHOENIX CONTACT GmbH & Co. KG, Flachsmarktstr. 8, D-32825 D-Blomberg, http://www.phoenixcontact.com (http://www.phoenixcontact.com)

** Fa. Binder GmbH & Co., Elektrische Bauelemente KG, Rötelstr. 7, D-74148 Neckarlsulm, http://www.binder-connector.com (http://www.binder-connector.com)

I/O device digital inputs/digital outputs

9

9.1 I/O device digital inputs

9.1.1 I/O device 8 DI DC 24 V 4xM12

Article number

6ES7141-6BF00-0AB0

Properties

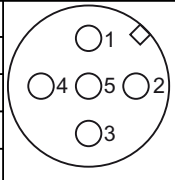
The 8 DI DC 24V 4×M12 I/O device has the following properties:

- 8 digital inputs
- Dimensions 30 x 200 mm, dual assignment of the sockets
- Rated input voltage DC 24 V
- Suitable for switches and proximity switches
- Diagnostics
  - "Missing 1L+" for the I/O device
  - "Short-circuit to M at sensor supply", per channel group
  - "Wire break", per channel
- Prioritized startup
- Media redundancy

Pin assignment of the DI sockets

The table below shows the pin assignment of the four sockets for connecting the digital inputs

Table 1-1076 Pin assignment of the digital input sockets X1 to X4

Pin	Assignment				View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)				
2	Input signal				
	DI_4	DI_5	DI_6	DI_7	
3	Sensor supply ground 1M				
4	Input signal				
	DI_0	DI_1	DI_2	DI_3	
5	Functional earth FE				

Block diagram

The block diagram below shows the 8 DI DC 24V 4×M12 I/O device.

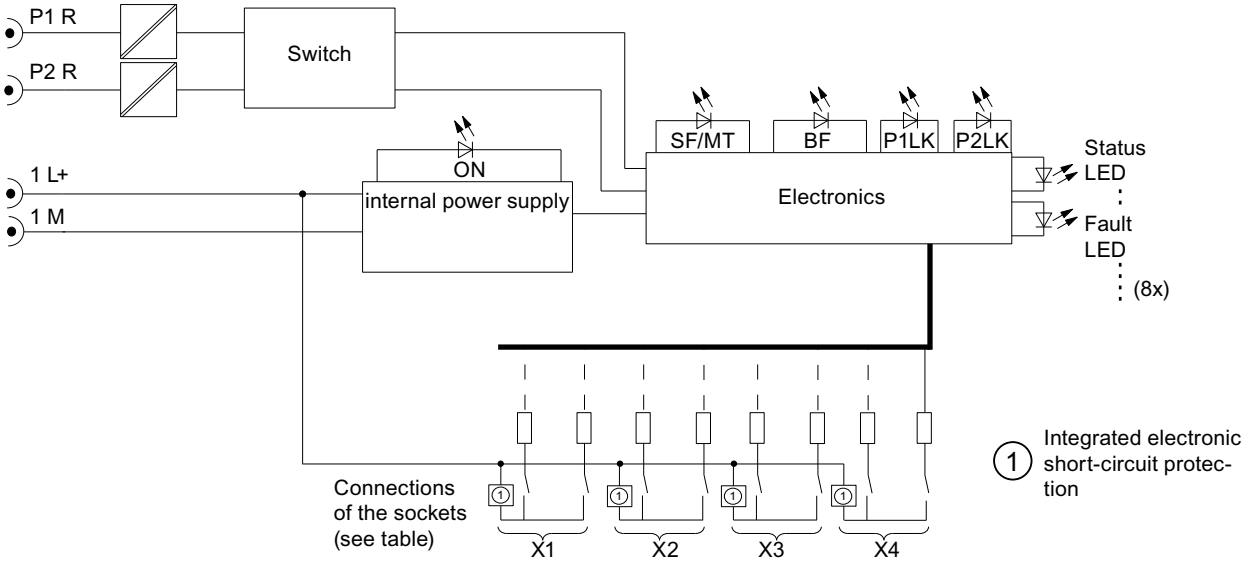


Figure 1-773 Block diagram of the 8 DI DC 24V 4×M12 I/O device

Technical data of the 8 DI DC 24V 4×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	30 x 200 x 49
Weight	Approx. 550 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
Power loss of the device	Typ. 5.5 W
Digital inputs	
Number of inputs	8
Number of inputs that can be controlled simultaneously	8, in all mounting positions
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No

Technical data	
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital input	Green LED
• Fault at digital input	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Short-circuit	Yes, per channel group
• Wire break	Input current < 0.3 mA, per channel
• Missing sensor supply	Yes
Sensor supply	
Number of sensor supplies	4
Load current	100 mA per output
Short-circuit protection	Yes, electronic
Sensor selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Input voltage	
• Nominal value	DC 24 V
• For signal "1"	11 to 30 V
• For signal "0"	-3 to +5 V
Input current	
• At signal "1"	Typ. 7 mA
Input delay	
• At "0" to "1"	Typ. 3 ms
• At "1" to "0"	Typ. 3 ms
Input characteristic	According to IEC 61131, Type 3
Connection of 2-wire proximity switches	Supported
• Permitted quiescent current	Max. 1.5 mA

9.1.2 I/O device 8 DI DC 24 V 8xM12

Article number

6ES7141-6BG00-0AB0

Properties

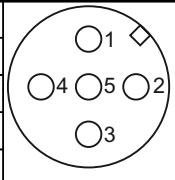
The 8 DI DC 24V 8×M12 I/O device has the following properties:

- 8 digital inputs
- Dimensions 60 x 175 mm, single assignment of the sockets
- Rated input voltage DC 24 V
- Suitable for switches and proximity switches
- Diagnostics
  - "Missing 1L+" for the I/O device
  - "Short-circuit to M at sensor supply" per channel
  - "Wire break", per channel
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the eight sockets for connecting the digital inputs.

Table 1-1077 Pin assignment of sockets X1 to X8 for digital inputs

Pin	Assignment								View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	**Socket X5**	**Socket X6**	**Socket X7**	**Socket X8**	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)								
2	Not used								
3	Sensor supply ground 1M								
4	Input signal								
	DI_0	DI_1	DI_2	DI_3	DI_4	DI_5	DI_6	DI_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 8 DI DC 24V 8×M12 I/O device.

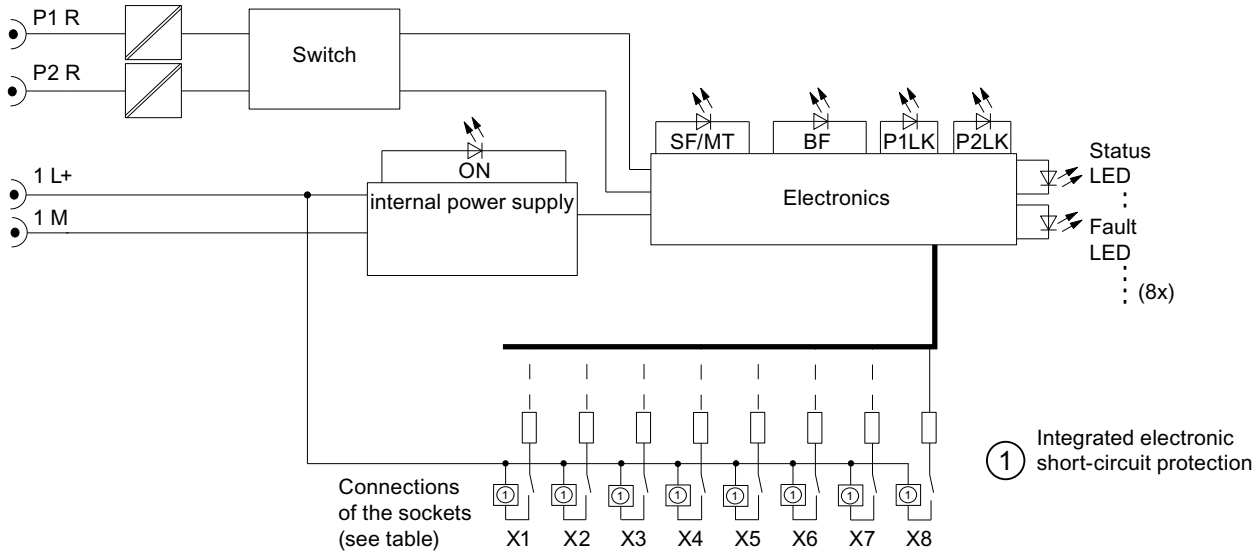


Figure 1-774 Block diagram of the 8 DI DC 24V 8×M12 I/O device

Technical data of the 8 DI DC 24V 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	0 mA
Power loss of the device	4.5 W, typical
Digital inputs	
Number of inputs	8
Number of inputs that can be controlled simultaneously	8, in all mounting positions
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes

Technical data	
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital input	Green LED
• Fault at digital input	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Short-circuit	Yes, per channel
• Wire break	Input current < 0.3 mA, per channel
• Missing sensor supply	Yes
Sensor supply	
Number of sensor supplies	8
Load current	100 mA per output
Short-circuit protection	Yes, electronic
Sensor selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Input voltage	
• Nominal value	DC 24 V
• For signal "1"	11 to 30 V
• For signal "0"	-3 to +5 V
Input current	
• At signal "1"	Typ. 7 mA
Input delay	
• At "0" to "1"	Typ. 3 ms
• At "1" to "0"	Typ. 3 ms
Input characteristic	According to IEC 61131, Type 3
Connection of 2-wire proximity switches	Supported
• Permitted quiescent current	Max. 1.5 mA

9.1.3 I/O device 16 DI DC 24 V 8xM12

Article number

6ES7141-6BH00-0AB0

Properties

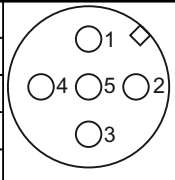
The 16 DI DC 24V 8×M12 I/O device has the following properties:

- 16 digital inputs
- Dimensions 60 x 175 mm, dual assignment of the sockets
- Rated input voltage DC 24 V
- Suitable for switches and proximity switches
- Diagnostics
  - "Missing 1L+" for the I/O device
  - "Short-circuit to M at sensor supply", per channel group
  - "Wire break", per channel
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the eight sockets for connecting the digital inputs.

Table 1-1078 Pin assignment of sockets X1 to X8 for digital inputs

Pin	Assignment								View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	**Socket X5**	**Socket X6**	**Socket X7**	**Socket X8**	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)								
2	Input signal								
	DI_8	DI_9	DI_{10}	DI_{11}	DI_{12}	DI_{13}	DI_{14}	DI_{15}	
3	Sensor supply ground 1M								
4	Input signal								
	DI_0	DI_1	DI_2	DI_3	DI_4	DI_5	DI_6	DI_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 16 DI DC 24V 8×M12 I/O device.

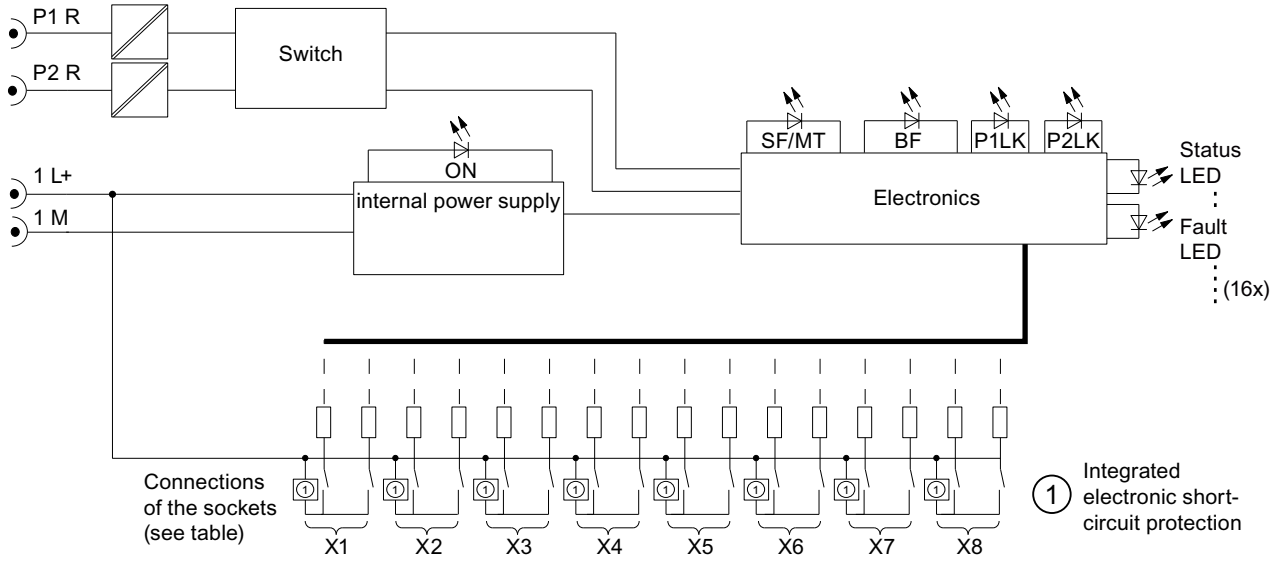


Figure 1-775 Block diagram of the 16 DI DC 24V 8×M12 I/O device

Technical data of the 16 DI DC 24V 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	0 mA
Power loss of the device	6.5 W, typical
Digital inputs	
Number of inputs	16
Number of inputs that can be controlled simultaneously	16 at all mounting positions
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes

Technical data	
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital input	Green LED
• Fault at digital input	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Short-circuit	Yes, per channel group
• Wire break	Input current < 0.3 mA, per channel
• Missing sensor supply	Yes
Sensor supply	
Number of sensor supplies	8
Load current	100 mA per output
Short-circuit protection	Yes, electronic
Sensor selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Input voltage	
• Nominal value	DC 24 V
• For signal "1"	11 to 30 V
• For signal "0"	-3 to +5 V
Input current	
• At signal "1"	Typ. 7 mA
Input delay	
• At "0" to "1"	Typ. 3 ms
• At "1" to "0"	Typ. 3 ms
Input characteristic	According to IEC 61131, Type 3
Connection of 2-wire proximity switches	Supported
• Permitted quiescent current	Max. 1.5 mA

9.1.4 Parameter overview digital inputs

Parameters for 8 DI DC 24V 4×M12 (6ES7141-6BF00-0AB0) and for 8 DI DC 24V 8×M12 (6ES7141-6BG00-0AB0)

Parameter	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 1L+	• Disable • Enable	Disable	Device
Diagnostics: Wire break at inputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel
Diagnostics: Short-circuit to M, inputs 0,4/1,5/2,6/3,7 (channels 0,4/1,5/2,6/3,7)	• Disable • Enable	Disable	Channel group

Parameters for 16 DI DC 24V 8×M12 (6ES7141-6BH00-0AB0)

Parameter	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 1L+	• Disable • Enable	Disable	Device
Diagnostics: Wire break at inputs 0 to 15 (channels 0 to 15)	• Disable • Enable	Disable	Channel
Diagnostics: Short-circuit to M, inputs 0,8/1,9/2,10/3,11/4,12/5,13/6,14/7,15 (channels 0,8/1,9/2,10/3,11/4,12/5,13/6,14/7,15)	• Disable • Enable	Disable	Channel group

9.2 I/O device digital outputs

9.2.1 I/O device 8 DO DC 24 V/1.3A 4xM12

Article number

6ES7142-6BF00-0AB0

Properties

The 8 DO DC 24V/1,3A 4×M12 I/O device has the following properties:

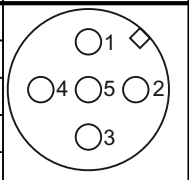
- 8 digital outputs
- Dimensions 30 x 200 mm and duplicate assignment of the sockets
- Output current: 1.3 A per output
- Rated load voltage DC 24 V
- Suitable for solenoid valves, DC contactors, and indicator lights

- Diagnostics
  - "Missing 1L+ or 2L+" for the I/O device
  - "Wire break at outputs" per channel
  - "Short-circuit to M at outputs" per channel
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

Pin assignment of the sockets for digital outputs

The table below shows the pin assignment of the four sockets for connecting digital outputs.

Table 1-1079 Pin assignment of sockets X1 to X4 for digital outputs

Pin	Assignment				View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	
	24 V (1L+ non-switched)		**24 V (2L+ switched)**		
1	Not used				
2	Output signal				
	DQ_4	DQ_5	DQ_6	DQ_7	
3	Ground 1M		Ground 2M		
4	Output signal				
	DQ_0	DQ_1	DQ_2	DQ_3	
5	Functional earth FE				

Block diagram

The block diagram below shows the 8 DO DC 24V/1,3A 4×M12 I/O device.

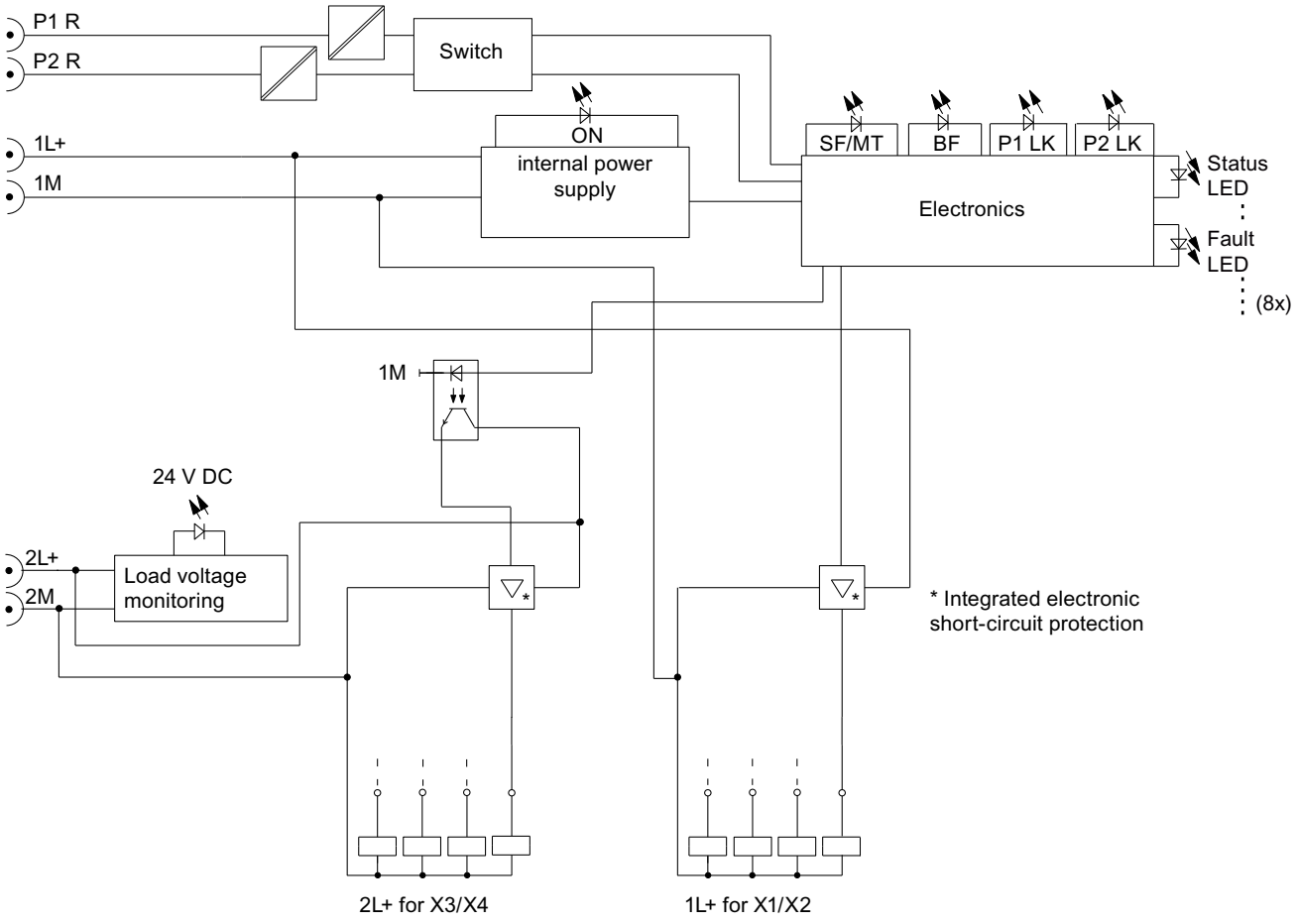


Figure 1-776 Block diagram of the 8 DO DC 24V/1,3A 4×M12 I/O device

Technical specifications of the 8 DO DC 24V/1,3A 4×M12 I/O device

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	30 x 200 x 49
Weight	Approx. 550 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"

Technical specifications	
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs *	
• All mounting positions to 55°C	3.9 A per 1L+ and 2L+
• All mounting positions to 60°C	2.6 A per 1L+ and 2L+
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
Power loss of the device	Typ. 5.5 W
Digital outputs	
Number of outputs	8
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Monitoring of supply voltage 2L+	Green "DC24V" LED

Technical specifications	
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Short-circuit	Yes
• Wire break	Yes, in the off state, per channel
• Failure of 1L+ and 2L+	Yes
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	Max. 1.3 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	22 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Controlling of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 1.8 A (per channel)
* Make allowances for the maximum total current when configuring the module.	

9.2.2 I/O device 8 DO DC 24 V/0.5A 4xM12

Article number

6ES7142-6BF50-0AB0

Properties

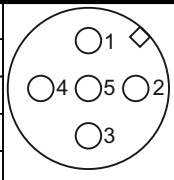
The 8 DO DC 24V/0,5A 4×M12 I/O device has the following properties:

- 8 digital outputs
- Dimensions 30 x 200 mm, dual assignment of the sockets
- Output current: 0.5 A per output
- Rated load voltage DC 24 V
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostics
  - "Missing 1L+ or 2L+" for the I/O device
  - "Wire break at outputs" per channel
  - "Short-circuit to M at outputs" per channel
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the four sockets for connecting digital outputs.

Table 1-1080 Pin assignment of sockets X1 to X4 for digital outputs

Pin	Assignment				View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	
1	Not used				
2	Output signal				
	DQ_4	DQ_5	DQ_6	DQ_7	
3	Ground 2M				
4	Output signal				
	DQ_0	DQ_1	DQ_2	DQ_3	
5	Functional earth FE				

Block diagram

The block diagram below shows the 8 DO DC 24V/0,5A 4×M12 I/O device.

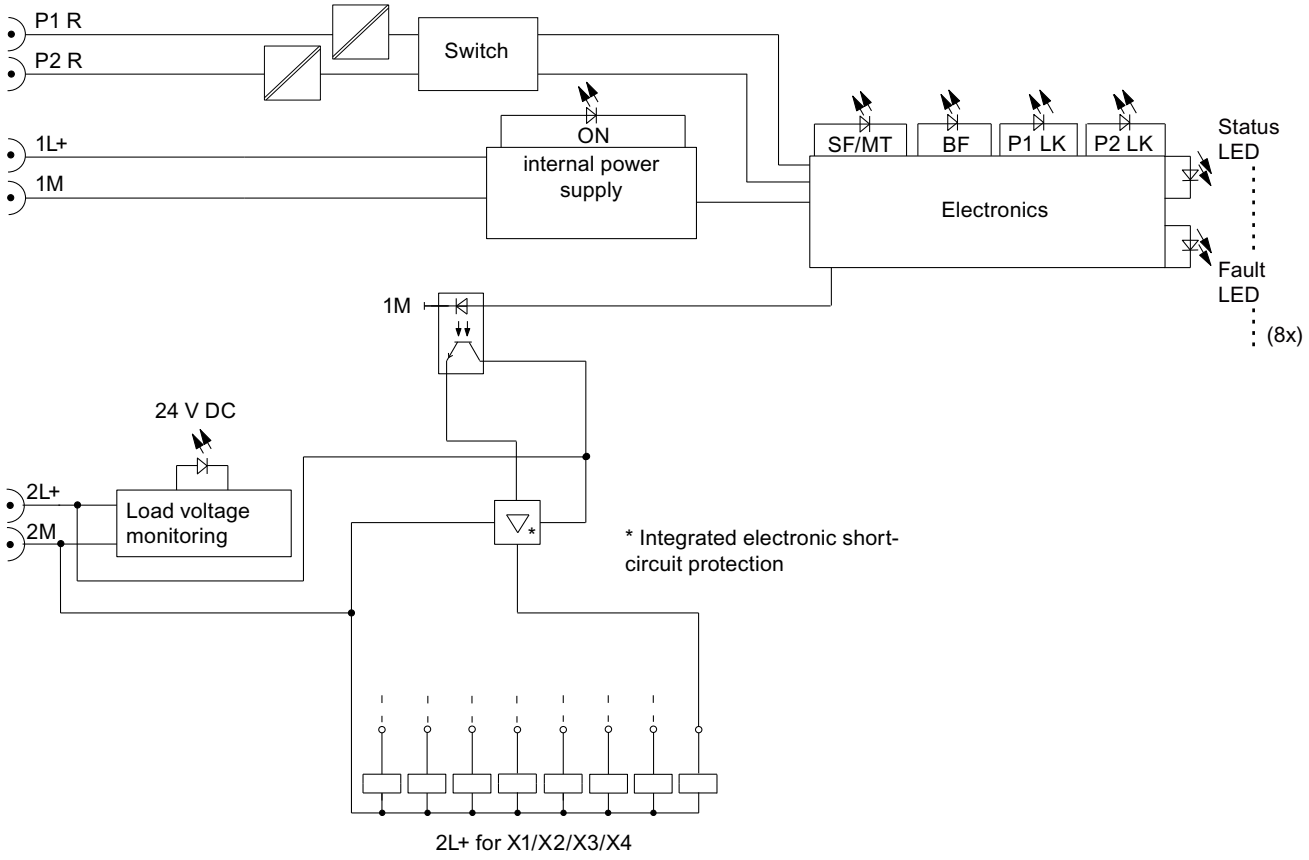


Figure 1-777 Block diagram of the 8 DO DC 24V/0,5 A 4×M12 I/O device

Technical data of the 8 DO DC 24V/0,5A 4×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	30 x 200 x 49
Weight	Approx. 550 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"

Technical data	
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs	
• All mounting positions to 60°C	Max. 4 A (only 2L+)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Current consumption	
• From supply voltage (1L+)	Typ. 100 mA
• From supply voltage (2L+)	Typ. 5 mA
Power loss of the device	Typ. 3 W
Digital outputs	
Number of outputs	8
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED

Technical data	
• Monitoring of supply voltage 2L+	Green "DC24V" LED
• Existing connection to network	Green LED "P1 LK" and "P2 LK";
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Failures of 2L+	Yes
• Short-circuit	Yes
• Wire break	Yes, in the off state, per channel
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	0.5 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	48 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Control of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 0.7 A (per channel)

9.2.3 I/O device 8 DO DC 24 V/1.3A 8xM12

Article number

6ES7142-6BG00-0AB0

Properties

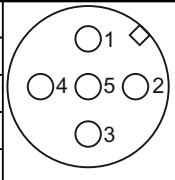
The 8 DO DC 24V/1,3A 8×M12 I/O device has the following properties:

- 8 digital outputs
- Dimensions 60 x 175 mm, single assignment of the sockets
- Output current: 1.3 A per output
- Rated load voltage DC 24 V
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostics
  - "Missing 1L+ or 2L+" for the I/O device
  - "Wire break at outputs" per channel
  - "Short-circuit to M at outputs" per channel
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the eight sockets for connecting digital outputs.

Table 1-1081 Pin assignment of sockets X1 to X8 for digital outputs

Pin	Assignment								View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	**Socket X5**	**Socket X6**	**Socket X7**	**Socket X8**	
	24 V (1L+ non-switched)				**24 V (2L+ switched)**				
1	Not used								
2	Not used								
3	Ground 1M				Ground 2M				
4	Output signal								
	DQ_0	DQ_1	DQ_2	DQ_3	DQ_4	DQ_5	DQ_6	DQ_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 8 DO DC 24V/1,3A 8×M12 I/O device.

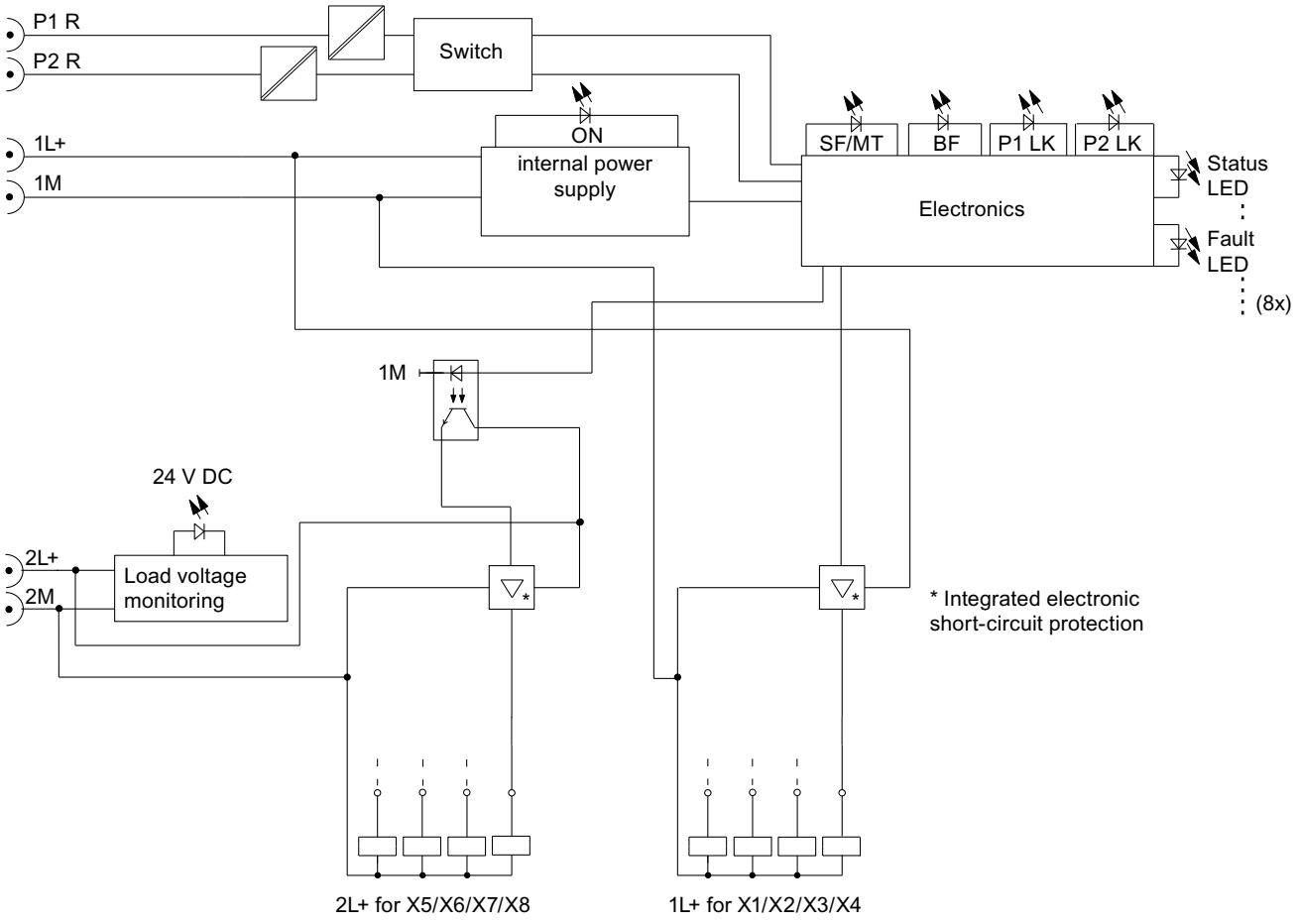


Figure 1-778 Block diagram of the 8 DO DC 24V/1,3A 8×M12 I/O device

Technical data of the 8 DO DC 24V/1,3A 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"

Technical data	
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs *	
• All mounting positions to 60°C	Max. 3.9 A per 1L+ and 2L+
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	Typ. 5 mA
Power loss of the device	Typ. 5.5 W
Digital outputs	
Number of outputs	8
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Monitoring of supply voltage 2L+	Green "DC24V" LED

Technical data	
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Failure of 1L+ and 2L+	Yes
• Short-circuit	Yes, per channel
• Wire break	Yes, in the off state, per channel
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	Max. 1.3 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	22 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Control of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 1.8 A (per channel)
* Make allowances for the maximum total current when configuring the module.	

9.2.4 I/O device 8 DO DC 24V/2.0A 8xM12

Article number

6ES7142-6BR00-0AB0

Properties

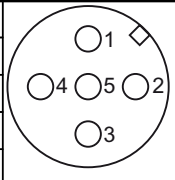
The 8 DO DC 24V/2,0A 8×M12 I/O device has the following properties:

- 8 digital outputs
- Dimensions 60 x 175 mm, single assignment of the sockets
- Output current: 2.0 A per output
- Rated load voltage DC 24 V
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostics
  - "Missing 1L+ or 2L+" for the I/O device
  - "Wire break at outputs" per channel
  - "Short-circuit to M at outputs" per channel
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the eight sockets for connecting digital outputs.

Table 1-1082 Pin assignment of sockets X1 to X8 for digital outputs

Pin	Assignment								View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	**Socket X5**	**Socket X6**	**Socket X7**	**Socket X8**	
	24 V (1L+ non-switched)				**24 V (2L+ switched)**				
1	Not used								
2	Not used								
3	Ground 1M				Ground 2M				
4	Output signal								
	DQ_0	DQ_1	DQ_2	DQ_3	DQ_4	DQ_5	DQ_6	DQ_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 8 DO DC 24V/2,0A 8×M12 I/O device.

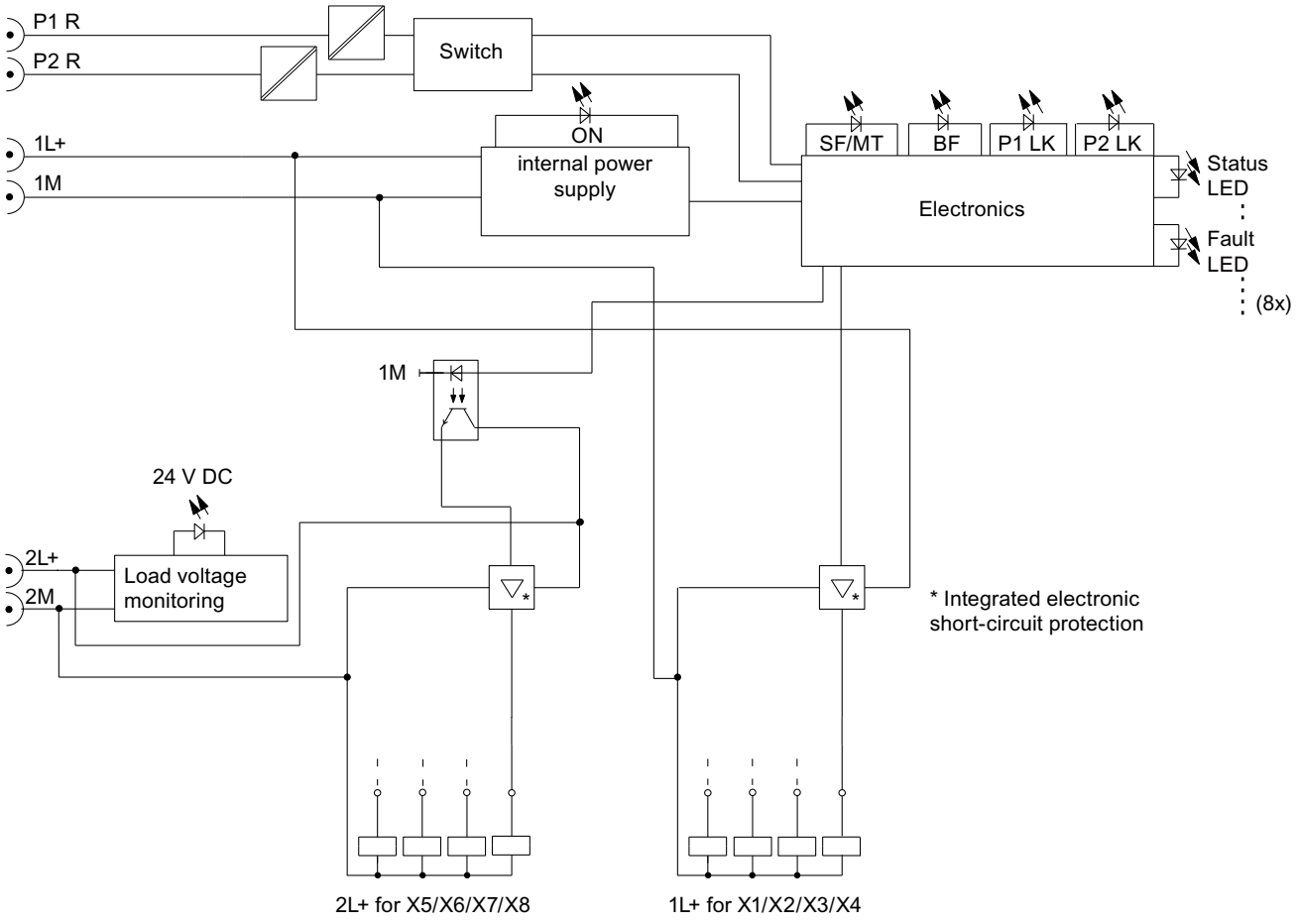


Figure 1-779 Block diagram of the 8 DO DC 24V/2,0A 8×M12 I/O device

Technical data of the 8 DO DC 24V/2,0A 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"

Technical data	
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs *	
• All mounting positions to 60°C	Max. 3.9 A 1L+ and max. 4 A 2L+
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	Typ. 5 mA
Power loss of the device	Typ. 5 W
Digital outputs	
Number of outputs	8
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Monitoring of supply voltage 2L+	Green "DC24V" LED

Technical data	
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Failure of 1L+ and 2L+	Yes
• Short-circuit	Yes, per channel
• Wire break	Yes, in the off state, per channel
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	2.0 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	12 Ω to 3.3 kΩ
Lamp load	Max. 10 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Control of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 2.8 A (per channel)
* Make allowances for the maximum total current when configuring the module.	

9.2.5 I/O device 16 DO DC 24 V/1.3A 8xM12

Article number

6ES7142-6BH00-0AB0

Properties

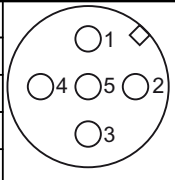
The 16 DO DC 24V/1,3A 8×M12 I/O device has the following properties:

- 16 digital outputs
- Dimensions 60 x 175 mm, dual assignment of the sockets
- Output current: 1.3 A per output
- Rated load voltage DC 24 V
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostics
  - "Missing 1L+ and 2L+" for the I/O device
  - "Wire break at outputs" per channel
  - "Short-circuit to M at outputs" per channel
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

Pin assignment of the sockets

The table below shows the pin assignment of the eight sockets for connecting digital outputs.

Table 1-1083 Pin assignment of sockets X1 to X8 for digital outputs

Pin	Assignment								View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	**Socket X5**	**Socket X6**	**Socket X7**	**Socket X8**	
	24 V (1L+ non-switched)				**24 V (2L+ switched)**				
1	Not used								
2	Output signal								
	DQ_8	DQ_9	DQ_{10}	DQ_{11}	DQ_{12}	DQ_{13}	DQ_{14}	DQ_{15}	
3	Ground 1M				Ground 2M				
4	Output signal								
	DQ_0	DQ_1	DQ_2	DQ_3	DQ_4	DQ_5	DQ_6	DQ_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 16 DO DC 24V/1,3A 8×M12 I/O device.

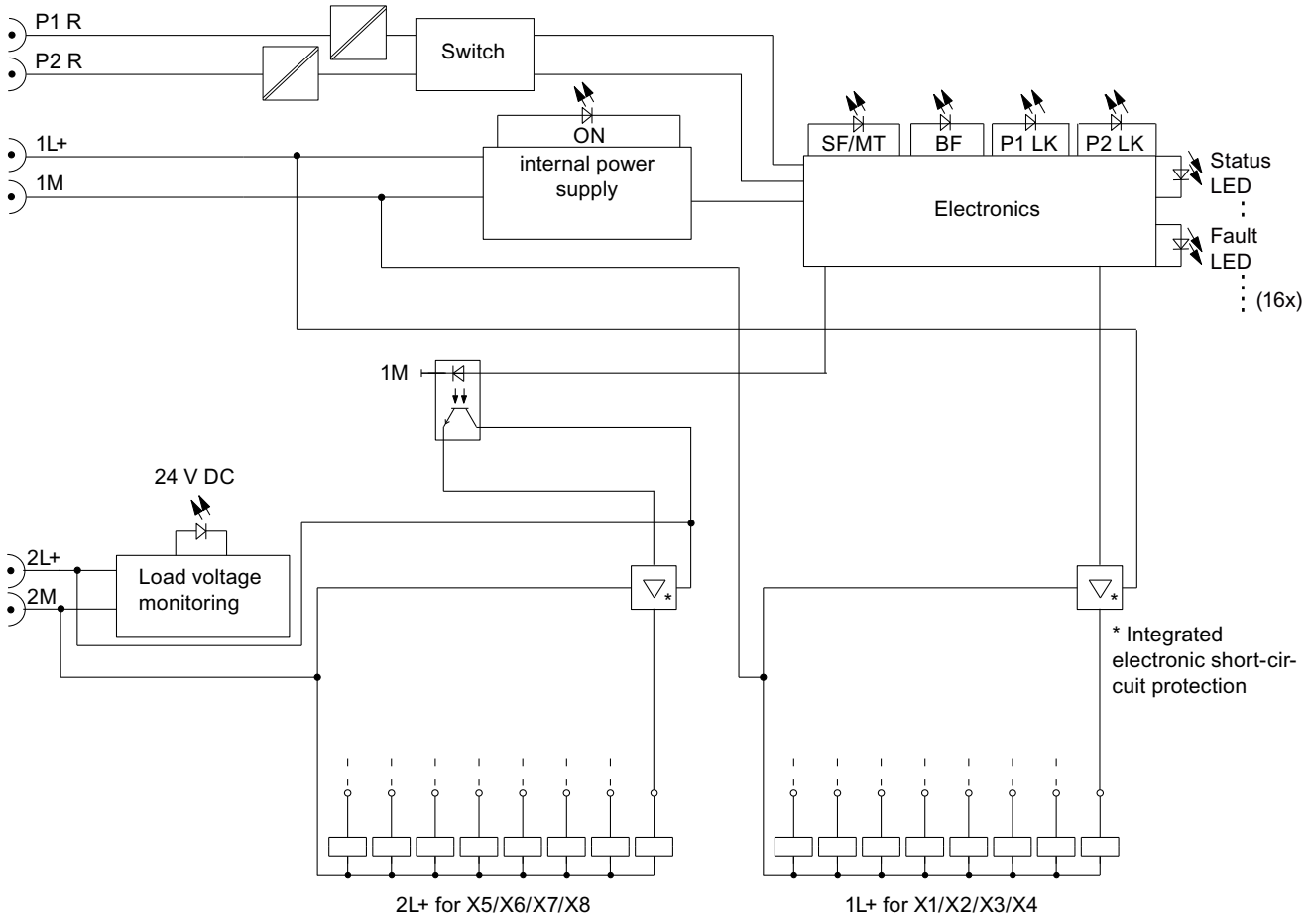


Figure 1-780 Block diagram of the 16 DO DC 24V/1,3A 8×M12 I/O device

Technical data of the 16 DO DC 24V/1,3A 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"

Technical data	
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs *	
• All mounting positions to 60°C	Max. 3.9 A per 1L+ and 2L+
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	Typ. 5 mA
Power loss of the device	Typ. 5.5 W
Digital outputs	
Number of outputs	16
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Monitoring of supply voltage 2L+	Green "DC24V" LED

Technical data	
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Failure of 1L+ and 2L+	Yes
• Short-circuit	Yes, per channel
• Wire break	Yes, in the off state, per channel
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	Max. 1.3 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	22 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Control of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 1.8 A (per channel)
* Make allowances for the maximum total current when configuring the module.	

9.2.6 Parameter overview digital outputs

Parameters for

- 8 DO DC 24V/1,3A 4×M12 (6ES7142-6BF00-0AB0)
- 8 DO DC 24V/1,3A 8×M12 (6ES7142-6BG00-0AB0)
- 8 DO DC 24V/2,0A 8×M12 (6ES7142-6BR00-0AB0)

Parameter	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 1L+ or 2L+	• Disable • Enable	Disable	Channel group
Response to CPU/Master STOP	• Shut down • Retain last value	Shut down	Device
Diagnostics: Wire break at outputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel
Diagnostics: Short circuit to M, outputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel

Parameters for 8 DO DC 24V/0,5A 4×M12 (6ES7142-6BF50-0AB0)

Parameter	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 2L+	• Disable • Enable	Disable	Device
Response to CPU/Master STOP	• Shut down • Retain last value	Shut down	Device
Diagnostics: Wire break at outputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel
Diagnostics: Short circuit to M, outputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel

Parameters for 16 DO DC 24V/1,3A 8×M12 (6ES7142-6BH00-0AB0)

Parameter	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 1L+ or 2L+	• Disable • Enable	Disable	Channel group
Response to CPU/Master STOP	• Shut down • Retain last value	Shut down	Device
Diagnostics: Wire break at outputs 0 to 15 (channels 0 to 15)	• Disable • Enable	Disable	Channel
Diagnostics: Short circuit to M, outputs 0 to 15 (channels 0 to 15)	• Disable • Enable	Disable	Channel

9.3 I/O device digital inputs/digital outputs

9.3.1 I/O device 8 DIO DC 24V/1.3A 8xM12

Article number

6ES7147-6BG00-0AB0

Properties

The 8 DIO DC 24V/1,3A 8×M12 I/O device has the following properties:

- 8 freely parameterizable digital inputs/outputs
- Prioritized startup
- Media redundancy
- Dimensions 60 x 175 mm, single assignment of the sockets
- Digital inputs
  - Rated input voltage DC 24 V
  - Suitable for switches and proximity switches
  - Diagnostics
    "Missing 1L+ or 2L+" for the I/O device
    "Short-circuit to M at sensor supply", per channel group
    "Wire break", per channel
- Digital outputs
  - Rated load voltage DC 24 V
  - Output current: 1.3 A per output
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Diagnostics
    "Missing 1L+ or 2L+" for the I/O device
    "Wire break at outputs" per channel
    "Short-circuit to M at outputs" per channel
  - Parameterizable response to CPU/Master STOP for I/O device

Pin assignment of the DIO sockets

The table below shows the pin assignment of the eight sockets for connecting digital inputs and digital outputs.

Table 1-1084 Pin assignment of sockets X1 to X8 for digital inputs/digital outputs

Pin	Assignment								View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	Socket X5	Socket X6	Socket X7	Socket X8	
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)				24 V sensor supply $2U_S$ (derived from 2L+ switched)				
2	Not used								
3	Supply ground 1M				Supply ground 2M				

Pin	Assignment								View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	Socket X5	Socket X6	Socket X7	Socket X8	
4	Input/output signal								X01 - X04
	DIQ_0	DIQ_1	DIQ_2	DIQ_3	DIQ_4	DIQ_5	DIQ_6	DIQ_7	
5	Functional earth FE								

Block diagram

The block diagram below shows the 8 DIO DC 24V/1,3A 8×M12 I/O device.

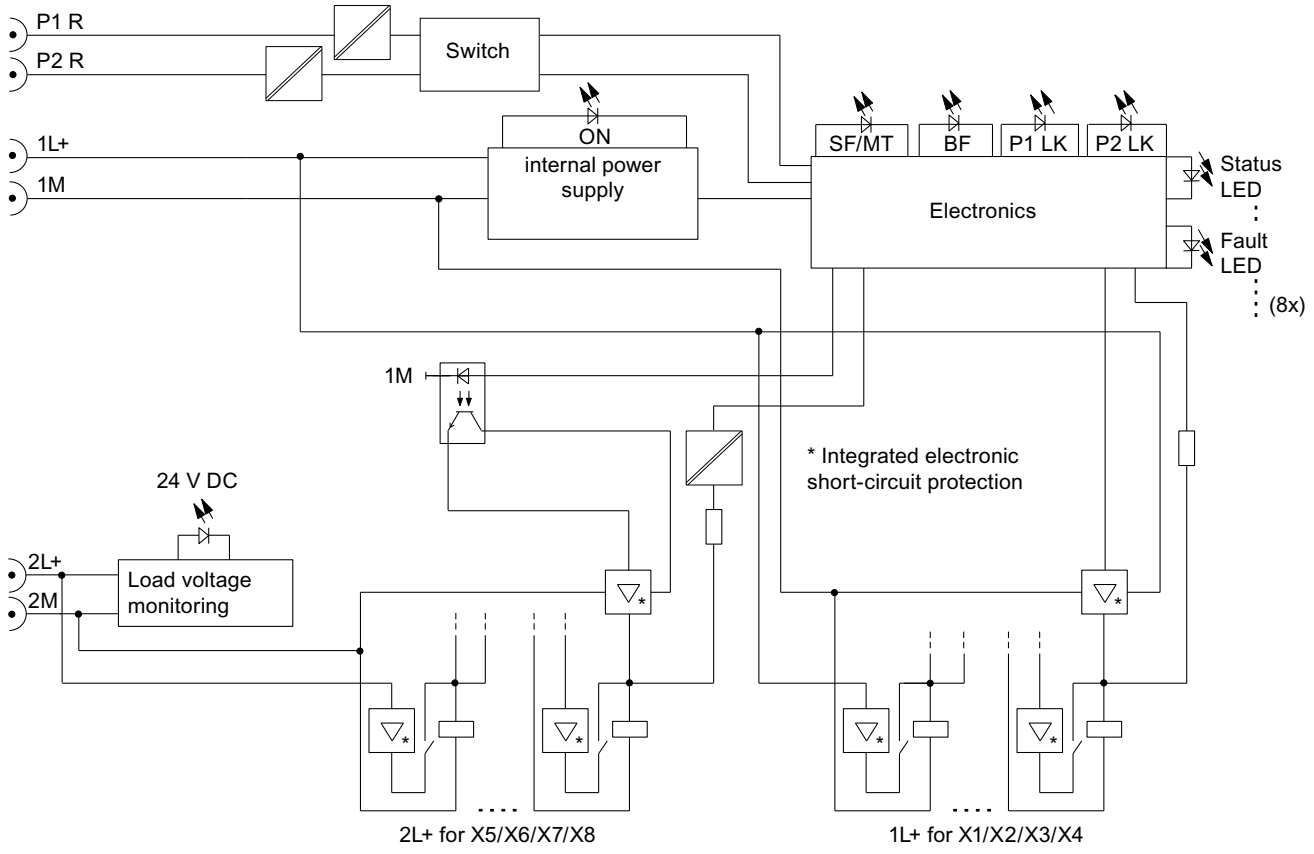


Figure 1-781 Block diagram of the 8 DIO DC 24V/1,3A 8×M12 I/O device

Technical data of the 8 DIO DC 24V/1,3A 8×M12 I/O device

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Current consumption	
From supply voltage (1L+)	Typ. 100 mA (no digital output activated)
From supply voltage (2L+)	Typ. 5 mA (no digital output activated)
Power loss of the device	type 4.5 W (if all channels are set as digital input) type 6.5 W (if all channels are set as digital output)
Total current of the outputs	
• All mounting positions to 60°C	Max. 3.9 A per 1L+ and 2L+
Digital inputs/digital outputs	
Number of configurable inputs/outputs	8
Number of inputs that can be controlled simultaneously	8, in all mounting positions
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)

Technical data	
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red/yellow "SF/MT" LED
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• Digital input	Green LED
• Fault at digital input	Red LED
• Digital output	Green LED
• Fault at digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Failure of 1L+ and 2L+	Yes
• Sensor supply short-circuit	Yes, per channel
• Digital output short-circuit	Yes, per channel
• Digital input wire break	Yes, input current < 0.3 mA, per channel
• Digital output wire break	Yes, in the off state, per channel
Sensor supply	
Number of sensor supplies	8, 4×1L+ and 4×2L+ Note: The sensor supply is only available when the corresponding channel is parameterized as an "Input".
Load current	100 mA per output
Short-circuit protection	Yes, electronic
Sensor selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Input voltage	
• Nominal value	24 V DC
• For signal "1"	11 to 30 V
• For signal "0"	-3 to +5 V
Input current	
• At signal "1"	Typ. 7 mA
Input delay	
• At "0" to "1"	Typ. 3 ms

Technical data	
• At "1" to "0"	Typ. 3 ms
Input characteristic	According to IEC 61131, Type 3
Connection of 2-wire proximity switches	Supported
• Permitted quiescent current	Max. 1.5 mA
Actuator selection data	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	24 V DC
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	Max. 1.3 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	22 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Control of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 1.8 A (per channel)

9.3.2 Parameter overview digital inputs/digital outputs

Parameters for 8 DIO DC 24V/1,3A 8×M12 (6ES7147-6BG00-0AB0)

Parameters	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics: Missing 1L+ or 2L+	• Disable • Enable	Disable	Channel group
Diagnostics: Wire break at inputs 0 to 7 (channels 0 to 7)	• Disable • Enable	Disable	Channel
Diagnostics: Short-circuit to M, inputs 0 to 7	• Disable • Enable	Disable	Channel
Response to CPU/Master STOP	• Shut down • Retain last value	Shut down	Device

Parameters	Range of values	Default setting	Range of effectiveness
Diagnostics: Wire break outputs 0 to 7	• Disable • Enable	Disable	Channel
Diagnostics: Short-circuit to M, outputs 0 to 7	• Disable • Enable	Disable	Channel
Freely parameterizable	• Digital input • Digital output	Digital input	Channel

I/O device analog input/analog output

10

10.1 I/O device analog input

10.1.1 I/O device 8 AI 4 U/I + 4 RTD/TC 8xM12

Article number

6ES7144-6KD00-0AB0

Properties

- 4 inputs for voltage and current measurement (2-wire and 4-wire transducers)
- 4 inputs for resistance (2-/3-/4-wire transducer), thermal resistor (2-/3-/4-conductor connection system), thermocouple or ±80 mV
- Input ranges:
  - ±10 V, resolution 15 bits + sign
  - ±80 mV, resolution 15 bps + sign
  - 0 to 10 V, resolution 15 bits
  - 1 to 5 V, resolution 15 bits
  - ±20 mA, resolution 15 bits + sign
  - 0 to 20 mA, resolution 15 bps + sign
  - 4 to 20 mA, resolution 15 bits
  - 150, 300, 600, 3000 Ω, resolution 15 bps
  - Ni100, Ni1000, Ni120, Ni200, Ni500, Pt100, Pt1000, Pt200, Pt500, resolution 15 bps + sign
  - E, J, K, N, resolution 15 bps + sign
- Dimensions 60 x 175 mm
- Diagnostics
  - "No 1L+" supply voltage
  - "Sensor supply short-circuit"
  - "Wire break"
  - "Underflow"
  - "Overflow"
- Permitted common-mode voltage AC $10V_{PP}$

- Prioritized startup
- Media redundancy

NOTE

During startup
As long as no parameters are assigned for the I/O device, the I/O device supplies the process values 0x7FFF.

Pin assignment

The tables below show the pin assignment for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device.

Table 1-1085 Pin assignment for voltage and current for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

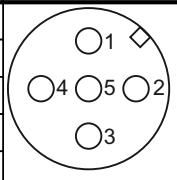
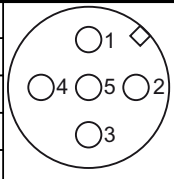
Pin	Assignment for U/I				View of socket (front view)
	Socket X1 (Channel 0)	Socket X3 (Channel 1)	Socket X5 (Channel 2)	Socket X7 (Channel 3)	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)				
2	Input signal				
	M_0+	M_1+	M_2+	M_3+	
3	Sensor supply ground 1M				
4	Input signal				
	M_0-	M_1-	M_2-	M_3-	
5	Functional earth FE				

Table 1-1086 Pin assignment for RTD for the 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

Pin	Assignment for RTD				View of socket (front view)
	Socket X2 (Channel 4)	Socket X4 (Channel 5)	Socket X6 (Channel 6)	Socket X8 (Channel 7)	
4-conductor					
1	Constant current line				
	I_{C4}+	I_{C5}+	I_{C6}+	I_{C7}+	
2	Measurement cable				
	M_4+	M_5+	M_6+	M_7+	
3	Constant current line				
	I_{C4}-	I_{C5}-	I_{C6}-	I_{C7}-	
4	Measurement cable				
	M_4-	M_5-	M_6-	M_7-	
5	Functional earth FE				
3-conductor					
1	Constant current line				
	I_{C4}+	I_{C5}+	I_{C6}+	I_{C7}+	
2	Measurement cable				
	M_4+	M_5+	M_6+	M_7+	
3	Constant current line and measurement cable				

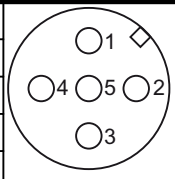
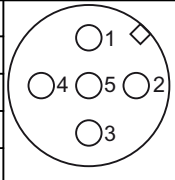
Pin	Assignment for RTD				View of socket (front view)
	Socket X2 (Channel 4)	**Socket X4 (Channel 5)**	**Socket X6 (Channel 6)**	**Socket X8 (Channel 7)**	
3	I_{C4}-, M_4-	I_{C5}-, M_5-	I_{C6}-, M_6-	I_{C7}-, M_7-	
4	Not used				
5	Functional earth FE				
2-conductor					
1	Constant current line and measurement cable				
	I_{C4}+, M_4+	I_{C5}+, M_5+	I_{C6}+, M_6+	I_{C7}+, M_7+	
2	Not used				
3	Constant current line and measurement cable				
	I_{C4}-, M_4-	I_{C5}-, M_5-	I_{C6}-, M_6-	I_{C7}-, M_7-	
4	Not used				
5	Functional earth FE				

Table 1-1087 Pin assignment for thermocouple and voltage ±80 mV for 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

Pin	Assignment for thermocouples and ±80 mV				View of socket (front view)
	Socket X2 (Channel 4)	**Socket X4 (Channel 5)**	**Socket X6 (Channel 6)**	**Socket X8 (Channel 7)**	
1	Not used				
2	Input signal				
	M_4+	M_5+	M_6+	M_7+	
3	Not used				
4	Input signal				
	M_4-	M_5-	M_6-	M_7-	
5	Functional earth FE				

Block diagram

The block diagram below shows the 8 AI 4 U/I + 4 RTD/TC 8×M12.

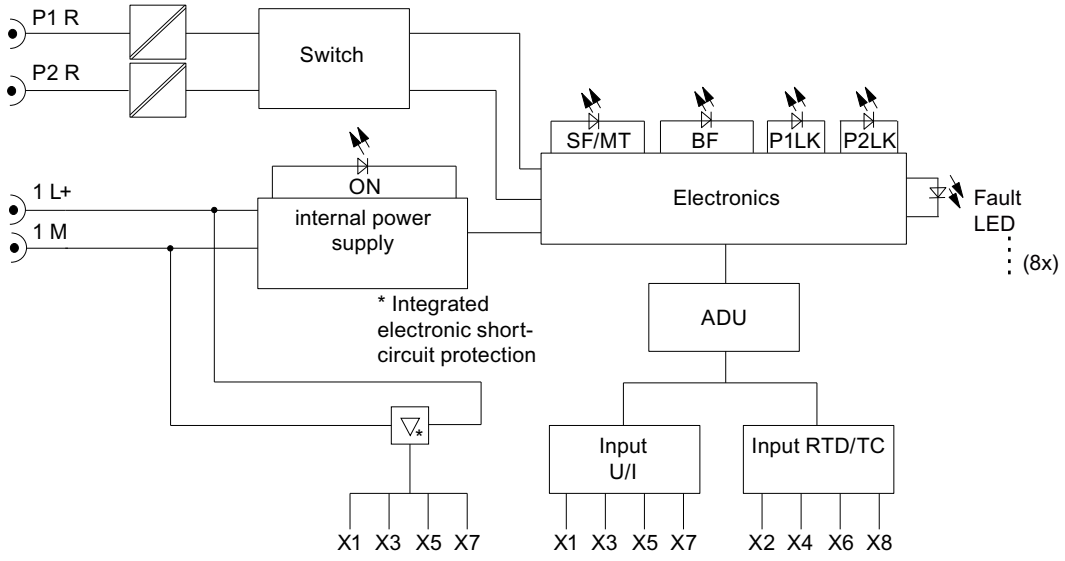


Figure 1-782 Block diagram 8 AI 4 U/I + 4 RTD/TC 8×M12

Technical specifications

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 930 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy

Technical specifications	
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes; if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
• From supply voltage 1L+	Typ. 110 mA
• From supply voltage 2L+	0 mA
Power loss of the device	Typ. 2.8 W, without sensor current
Analog inputs	
Number of inputs	8 (4 for U or I, 4 for RTD or thermocouple)
Cable length, shielded	Max. 30 m
Sensor supply	
Number of sensor supplies	4
Total current	Max. 1 A
Short-circuit protection	Yes; electronic, for each module, to ground
• Response threshold	Min. 1.4 A
Sensor selection data	
Input ranges (Rated value)/input resistance or input voltage	
• Voltage	±80 mV/10 MΩ ±10 V/100 kΩ 0 to 10 V/100 kΩ 1 to 5 V/100 kΩ
• Current	±20 mA/17 V for 2-wire transducer, 3.5 V for 4-wire transducer 0 to 20 mA/17 V for 2-wire transducer, 3.5 V for 4-wire transducer 4 to 20 mA/17 V for 2-wire transducer, 3.5 V for 4-wire transducer

Technical specifications		
• Resistor and thermal resistor		150 Ω/10 MΩ 300 Ω/10 MΩ 600 Ω/10 MΩ 3000 Ω/10 MΩ Ni100/10 MΩ Ni1000/10 MΩ Ni120/10 MΩ Ni200/10 MΩ Ni500/10 MΩ Pt100/10 MΩ Pt1000/10 MΩ Pt200/10 MΩ Pt500/10 MΩ
• Thermocouple		Types E, J, K, N
Permitted input voltage for voltage input (destruction limit)		28.8 V continuous, 35 V for max. duration of 500 ms
Connection of sensors for voltage measurement		Yes
Connection of sensors for current measurement		Yes (as 2-wire/4-wire transducer)
Connection of sensors for RTD		Yes (with 2-/3-/4-conductor connection)
Connection of sensors for thermocouples		Yes
Temperature compensation for thermocouples [1]		
• Internal temperature compensation		Yes, parameterizable
• External temperature compensation		Yes, parameterizable
Technical unit for temperature measurement		°C, °F, K
Formation of analog values		
Measuring principle		Integrating
Integration time and conversion time/resolution (per channel)		
• Integration time parameterizable		Yes
• Interference frequency suppression in Hz		500/60/50/10
• Integration time in ms		2.0/16.667/20/100
• Conversion time in ms (per channel) [2]		4/19/22/102
• Resolution for voltage (including overrange)		±80 mV/15 bps + sign ±10 V/15 bps + sign 0 to 10 V/15 bps 1 to 5 V/15 bps
• Resolution for current (including overrange)		±20 mA/15 bps + sign 0 to 20 mA/15 bps 4 to 20 mA/15 bps
• Resolution for RTD (including overrange)		150 Ω, 300 Ω, 600 Ω, 3000 Ω/15 bps, Ni100, Ni1000, Ni120, Ni200; Ni500, Pt100, Pt1000, Pt200, Pt500/15 bps + sign
• Resolution for thermocouples (including overrange)		Types E, J, K, N/15 bps + sign
Measured value smoothing		Yes, parameterizable in 4 levels
	Level None Weak Medium Strong	**Time constant** 1 x cycle time 4 x cycle time 16 x cycle time 64 x cycle time

Technical specifications				
Interference suppression, error limits				
Interference suppression for f = n x (f1 ± 0.5%), (f1 = interference frequency)	46 dB			
• Common-mode interference (interference voltage < 5 V)	70 dB			
• Series-mode interference (peak value of interference < Rated value of input range)	46 dB			
Crosstalk between inputs	< -85 dB			
Operational limit (across temperature range, relative to input range)		Ambient temperature		
		positive	negative (0 °C to -25 °C)	negative (-25 °C to -40 °C)
	U	0.15%	0.2%	0.35%
	I	0.2%	0.25%	0.4%
	R, RTD	0.1%	0.15%	0.3%
	TC	0.2%	0.25%	0.4%
Basic error limit (operational limit at 25 °C, relative to input range) [3]	U	0.1%		
	I	0.1%		
	R, RTD	0.05%		
	TC	0.1%		
Temperature error (relative to input range)		Ambient temperature		
		positive	negative	
	U	0.0035%/K	0.007%/K	
	I	0.006%/K	0.007%/K	
	R, RTD	0.0005%/K	0.001%/K	
	TC	0.0035%/K	0.007%/K	
Linearity error (relative to input range)	±0.01%			
Repeat accuracy (in steady-state condition at 25°C, relative to input range)	±0.008%			
Operational limit for internal temperature sensor	±3 °C			
Basic error limit for internal temperature sensor	±2 °C			
Status, interrupts, diagnostics				
Interrupts	Yes			
Diagnostics functions				
• Group error/maintenance	Red/yellow "SF/MT" LED			
• Bus monitoring PROFINET IO	Red "BF" LED			
• Monitoring of supply voltage 1L+	Green "ON" LED			
• Existing connection to bus	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through			
• Analog input error	Red LED			
• Diagnostic information can be read	Yes			
Monitoring for				
• Sensor supply short-circuit	Yes, only if channel is enabled			
• Wire break	4 to 20 mA, 1 to 5 V, resistors and thermoresistors			
• Underflow and overflow	Yes			

Technical specifications	
• Supply voltage 1L+	Yes
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Standards, approvals, certificates	
Suitable for applications according to AMS 2750	Yes; Declaration of Conformity, see online support entry 109757262
Suitable for applications according to CQI-9	Yes; based on AMS 2750 E
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes

[1] "No temperature compensation" is always run when using the measuring type ±80 mV regardless of the configured temperature compensation.
[2] With 3-wire resistance measurement (and thermal resistor) the measuring resistances and the line resistances are updated in alternating cycles. Rapid changes in the measuring resistance therefore impair the accuracy.
[3] For thermocouples, the information refers to the temperature range from -100 °C to nominal value

NOTE

The accuracy information is valid for static thermal states and changes in ambient temperature < 1 K/h.
The I/O device achieves the highest accuracy with the 4-wire connection system (see technical specifications above).
Although the 3-wire connection system compensates for the missing wire, the accuracy is impaired. With the 2-wire connection system, the line resistances considerably impair the accuracy.
In the last two cases this impairment is not determinable.

NOTE

With the 3-wire connection system, the compensation of the missing cable is only ensured if all three cores in the cable have the same length and cross-section.

See also

Response times for analog input device and output device (Page 240)

10.1.2 8 AI RTD/TC 8×M12 I/O device

Article number

6ES7144-6KD50-0AB0

Properties

The electronic module 8 AI RTD/TC 8×M12 has the properties listed below:

- 8 freely parameterizable inputs:
  - Resistance (2-/3-/4-wire transmitter)
  - Thermoresistor (2-/3-/4-conductor connection system)
  - Thermocouple or ±80 mV
- Input ranges:
  - Voltage measurement: ±80 mV; resolution 15 bit + sign
  - Resistance measurement: 150 Ω, 300 Ω, 600 Ω, 3000 Ω; resolution 15 bits
  - Resistance thermometer: Pt100, Ni100, Ni120, Pt200, Ni200, Pt500, Ni500, Pt1000, Ni1000; resolution 15 bits + sign
  - Thermocouple elements: E, J, K, N; resolution 15 bits + sign
- Dimensions 60 x 175 mm
- Diagnostics
  - "No 1L+" supply voltage
  - "Wire break"
  - "Underflow"
  - "Overflow"
- Permitted common-mode voltage AC $10V_{PP}$
- Prioritized startup
- Media redundancy

NOTE
During startup
As long as no parameters are assigned for the I/O device, the I/O device supplies the process values $7FFF_H$.

Pin assignment

The tables below show the pin assignment for the 8 AI RTD/TC 8xM12 electronic module.

Table 1-1088 Pin assignment for RTD for the 8 AI RTD/TC 8xM12 electronic module

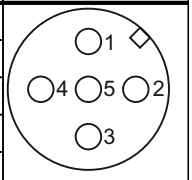
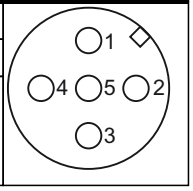
Pin	Assignment for RTD								View of socket (front view)
	Socket X1 (Channel 0)	**Socket X2 (Channel 4)**	**Socket X3 (Channel 1)**	**Socket X4 (Channel 5)**	**Socket X5 (Channel 2)**	**Socket X6 (Channel 6)**	**Socket X7 (Channel 3)**	**Socket X8 (Channel 7)**	
4-conductor									
1	Constant current line								
	I_{C0}+	I_{C4}+	I_{C1}+	I_{C5}+	I_{C2}+	I_{C6}+	I_{C3}+	I_{C7}+	
2	Measurement cable								
	M_0+	M_4+	M_1+	M_5+	M_2+	M_6+	M_3+	M_7+	
3	Constant current line								
	I_{C0}-	I_{C4}-	I_{C1}-	I_{C5}-	I_{C2}-	I_{C6}-	I_{C3}-	I_{C7}-	
4	Measurement cable								
	M_0-	M_4-	M_1-	M_5-	M_2-	M_6-	M_3-	M_7-	
5	Functional earth FE								
3-conductor									
1	Constant current line								
	I_{C0}+	I_{C4}+	I_{C1}+	I_{C5}+	I_{C2}+	I_{C6}+	I_{C3}+	I_{C7}+	
2	Measurement cable								
	M_0+	M_4+	M_1+	M_5+	M_2+	M_6+	M_3+	M_7+	
3	Constant current line and measurement cable								
	I_{C0}-, M_0-	I_{C4}-, M_4-	I_{C1}-, M_1-	I_{C5}-, M_5-	I_{C2}-, M_2-	I_{C6}-, M_6-	I_{C3}-, M_3-	I_{C7}-, M_7-	
4	Not used								
5	Functional earth FE								
2-conductor									
1	Constant current line and measurement cable								
	I_{C0}+, M_0+	I_{C4}+, M_4+	I_{C1}+, M_1+	I_{C5}+, M_5+	I_{C2}+, M_2+	I_{C6}+, M_6+	I_{C3}+, M_3+	I_{C7}+, M_7+	
2	Not used								
3	Constant current line and measurement cable								
	I_{C0}-, M_0-	I_{C4}-, M_4-	I_{C1}-, M_1-	I_{C5}-, M_5-	I_{C2}-, M_2-	I_{C6}-, M_6-	I_{C3}-, M_3-	I_{C7}-, M_7-	
4	Not used								
5	Functional earth FE								

Table 1-1089 Pin assignment for thermocouples with 8 AI RTD/TC 8xM12 electronic module

Pin	Assignment for thermocouples and ±80 mV								View of socket (front view)
	Socket X1 (Channel 0)	**Socket X2 (Channel 4)**	**Socket X3 (Channel 1)**	**Socket X4 (Channel 5)**	**Socket X5 (Channel 2)**	**Socket X6 (Channel 6)**	**Socket X7 (Channel 3)**	**Socket X8 (Channel 7)**	
1	Not used								
2	Input signal								
	M_0+	M_4+	M_1+	M_5+	M_2+	M_6+	M_3+	M_7+	
3	Not used								

Pin	Assignment for thermocouples and ±80 mV								View of socket (front view)
	Socket X1 (Channel 0)	**Socket X2 (Channel 4)**	**Socket X3 (Channel 1)**	**Socket X4 (Channel 5)**	**Socket X5 (Channel 2)**	**Socket X6 (Channel 6)**	**Socket X7 (Channel 3)**	**Socket X8 (Channel 7)**	
4	Input signal								
	M_0-	M_4-	M_1-	M_5-	M_2-	M_6-	M_3-	M_7-	
5	Functional earth FE								

Block diagram

The figure below shows the block diagram of the 8 AI RTD/TC 8xM12 electronic module.

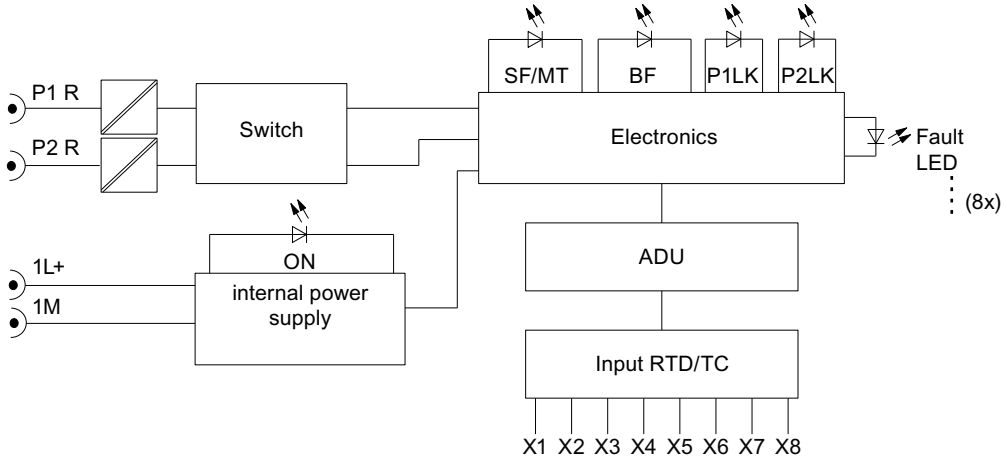


Figure 1-783 Block diagram 8 AI RTD/TC 8xM12

Technical specifications

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 930 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100 BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes; if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
• From supply voltage 1L+	Typ. 110 mA
• From supply voltage 2L+	0 mA
Power loss of the device	Typ. 2.8 W, without sensor current
Analog inputs	
Number of inputs	8, for RTD or thermocouple
Cable length, shielded	Max. 30 m
Sensor selection data	
Input ranges (Rated value)/input resistance or input voltage	
• Voltage	±80 mV
• Resistance	150 Ω/10 MΩ 300 Ω/10 MΩ 600 Ω/10 MΩ 3000 Ω/10 MΩ

Technical specifications		
• Thermoresistor		Pt100/10 MΩ Pt200/10 MΩ Pt500/10 MΩ Pt1000/10 MΩ Ni100/10 MΩ Ni120/10 MΩ Ni200/10 MΩ Ni500/10 MΩ Ni1000/10 MΩ
• Thermocouple		Types N, E, J, K
Permitted input voltage for voltage input (destruction limit)		28.8 V continuous, 35 V for max. duration of 500 ms
Connection of sensors for RTD		Yes (with 2-/3-/4-conductor connection)
Connection of sensors for thermocouples		Yes
Temperature compensation [1]		
• None		Yes, parameterizable
• Internal		Yes, parameterizable
• RTD (0)		Yes, parameterizable
• Dynamic reference temperature		Yes, parameterizable
• Fixed reference temperature		Yes, parameterizable
Technical unit for temperature measurement		°C, °F, K
Formation of analog values		
Measuring principle		Integrating
Integration time and conversion time/resolution (per channel)		
• Integration time parameterizable		Yes
• Interference frequency suppression in Hz		500/60/50/10
• Integration time in ms		2.0/16.667/20/100
• Conversion time in ms (per channel) [2]		4/19/22/102
• Resolution for RTD (including overrange)		150 Ω, 300 Ω, 600 Ω, 3000 Ω/15 bits Pt100, Pt200, Pt500, Pt1000, Ni100, Ni120, Ni200, Ni500, Ni1000/15 bits + sign
• Resolution for thermocouples (including overrange)		Types N, E, J, K/15 bits + sign
Measured value smoothing		Yes, parameterizable in 4 levels
	Level None Weak Medium Strong	**Time constant** 1 x cycle time 4 x cycle time 16 x cycle time 64 x cycle time
Interference suppression, error limits		
Interference suppression for f = n x (f1 ± 0.5%), (f1 = interference frequency)		46 dB
• Common-mode interference (interference voltage < 5 V)		70 dB
• Series-mode interference (peak value of interference < Rated value of input range)		46 dB
Crosstalk between inputs		< -85 dB
Operational limit (across temperature range, relat-		Ambient temperature

Technical specifications				
ive to input range)		positive	negative (0 °C to -25 °C)	negative (-25 °C to -40 °C)
	R, RTD	0.1%	0.15%	0.3%
	TC	0.2%	0.25%	0.4%
Basic error limit (operational limit at 25 °C, relative to input range) [3]	R, RTD	0.05%		
	TC	0.1%		
Temperature error (relative to input range)		Ambient temperature		
		positive	negative	
	R, RTD	0.0005%/K	0.001%/K	
	TC	0.0035%/K	0.007%/K	
Linearity error (relative to input range)	±0.01%			
Repeat accuracy (in steady-state condition at 25°C, relative to input range)	±0.008%			
Operational limits (relative to internal temperature sensor)	±3 °C			
Basic error limits (relative to internal temperature sensor)	±2 °C			
Status, interrupts, diagnostics				
Interrupts	Yes			
Diagnostics functions				
• Group error/maintenance	Red/yellow "SF/MT" LED			
• Bus monitoring PROFINET IO	Red "BF" LED			
• Monitoring of supply voltage 1L+	Green "ON" LED			
• Existing connection to bus	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through			
• Analog input error	Red LED			
• Diagnostic information can be read	Yes			
Monitoring for				
• Wire break	Resistors and thermoresistors			
• Underflow and overflow	Yes			
• Supply voltage 1L+	Yes			
Insulation				
Insulation test voltage				
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)			
• All other circuit elements	707 V DC (type test)			
Standards, approvals, certificates				
Suitable for applications according to AMS 2750	Yes; Declaration of Conformity, see online support entry 109757262			
Suitable for applications according to CQI-9	Yes; based on AMS 2750 E			
Electrical isolation				
• Between 1L+ and 2L+	Yes			
• Between 1L+, channels and all other circuit elements	No			

Technical specifications	
• Between channels	No
• Between Ethernet and all other circuit elements	Yes

[1] "No temperature compensation" is always run when using the measuring type ±80 mV regardless of the configured temperature compensation.
[2] With 3-wire resistance measurement (and thermal resistor) the measuring resistances and the line resistances are updated in alternating cycles. Rapid changes in the measuring resistance therefore impair the accuracy.
[3] For thermocouples, the information refers to the temperature range from -100 °C to nominal value.

NOTE

The accuracy information is valid for static thermal states and changes in ambient temperature < 1 K/h.
The I/O device achieves the highest accuracy with the 4-wire connection system (see technical specifications above).
Although the 3-wire connection system compensates for the missing wire, the accuracy is impaired. With the 2-wire connection system, the line resistances considerably impair the accuracy.
In the last two cases this impairment is not determinable.

NOTE

With the 3-wire connection system, the compensation of the missing cable is only ensured if all three cores in the cable have the same length and cross-section.

10.1.3 Parameter overview analog input

Parameters for analog input 8 AI 4 U/I + 4 RTD/TC 8xM12 (6ES7144-6KD00-0AB0)

Parameters	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics, missing 1L+	• Disable • Enable	Disable	Device
Diagnostics, sensor supply short-circuit	• Disable • Enable	Disable	Device
Interference frequency suppression	• Off (Fast Mode) • 60 Hz • 50 Hz • 10 Hz	50 Hz	Device
Temperature unit	• Celsius • Fahrenheit • Kelvin	Celsius	Channel groups 4 to 7
Reference temperature for TC	• -145.0 to 155.0 (Celsius) • -229.0 to 311.0 (Fahrenheit) • 128.2 to 428.2 (Kelvin)	0.0	Device

Parameters	Range of values	Default setting	Range of effectiveness
Measurement type, channels 0 to 3	• Disabled • Voltage • Current (4-wire transducer) • Current (2-wire transducer)	Voltage	Channel
Measurement type, channels 4 to 7	• Disabled • Resistance (4-wire connection) • Resistance (3-wire connection) • Resistance (2-wire connection) • Thermoresistor (linear, 4-conductor connection) • Thermoresistor (linear, 3-conductor connection) • Thermoresistor (linear, 2-conductor connection) • Thermocouple elements • Voltage +/-80 mV	Thermoresistor Pt100 (4-conductor connection)	Channel
Measurement range, channels 0 to 3	• 1 to 5 V • 0 to 10 V • +/-10 V • 0 to 20 mA • 4 to 20 mA • ±20 mA	±10 V	Channel
Measuring range, channels 4 to 7	• +/-80 mV • 150 Ω • 300 Ω • 600 Ω • 3000 Ω • Pt100 Climatic range • Pt100 Standard range • Pt200 Climatic range • Pt200 Standard range • Pt500 Climatic range • Pt500 Standard range • Pt1000 Climatic range • Pt1000 Standard range • Ni100 Climatic range • Ni100 Standard range • Ni120 Climatic range • Ni120 Standard range • Ni200 Climatic range • Ni200 Standard range • Ni500 Climatic range • Ni500 Standard range • Ni1000 Climatic range • Ni1000 Standard range • TC_EL Typ_N_[NiCrSi_NiSi] • TC_EL Typ_E_[NiCr_CuNi] • TC_EL Typ_J_[Fe_CuNi] • TC_EL Typ_K_[NiCr_Ni]	Pt100 Standard range	Channel
Reference junction for thermoresistor (TC)	• Internal • External	Internal	Channel
Temperature coefficient	• Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.003851[1] • Ni 0.00618 • Ni 0.00672 • Ni 0.005000	Pt 0.003851[1]	Channel

Parameters	Range of values	Default setting	Range of effectiveness
Smoothing	• None • Weak • Medium • Strong	None	Channel
Diagnostics, wire break	• Disable • Enable	Disable	Channel
Diagnostics, underflow	• Disable • Enable	Disable	Channel
Diagnostics, overflow	• Disable • Enable	Disable	Channel
[1]This value can also be shown as α = 0.00385055 in the parameter assignment.			

Parameters for analog input 8 AI RTD/TC 8xM12 (6ES7144-6KD50-0AB0)

Parameters	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics, missing 1L+	• Disable • Enable	Disable	Device
Interference frequency suppression	• Off (Fast Mode) • 60 Hz • 50 Hz • 10 Hz	50 Hz	Device
Temperature unit	• Celsius • Fahrenheit • Kelvin	Celsius	Device
Reference temperature for TC	• -145.0 to 155.0 (Celsius) • -229.0 to 311.0 (Fahrenheit) • 128.2 to 428.2 (Kelvin)	0.0	Device
Measurement type, channels 0 to 7	• Disabled • Voltage +/-80 mV • Resistance (4-wire connection) • Resistance (3-wire connection) • Resistance (2-wire connection) • Thermoresistor (linear, 4-conductor connection) • Thermoresistor (linear, 3-conductor connection) • Thermoresistor (linear, 2-conductor connection) • Thermocouple elements	Thermoresistor Pt100 (4-conductor connection)	Channel
Measuring range, channels 0 to 7	• +/-80 mV • 150 Ω • 300 Ω • 600 Ω • 3000 Ω • Pt100 Climatic range • Pt100 Standard range • Pt200 Climatic range • Pt200 Standard range • Pt500 Climatic range • Pt500 Standard range	Pt100 Standard range	Channel

Parameters	Range of values	Default setting	Range of effectiveness
	• Pt1000 Climatic range • Pt1000 Standard range • Ni100 Climatic range • Ni100 Standard range • Ni120 Climatic range • Ni120 Standard range • Ni200 Climatic range • Ni200 Standard range • Ni500 Climatic range • Ni500 Standard range • Ni1000 Climatic range • Ni1000 Standard range • TC_EL Typ_N_[NiCrSi_NiSi] • TC_EL Typ_E_[NiCr_CuNi] • TC_EL Typ_J_[Fe_CuNi] • TC_EL Typ_K_[NiCr_Ni]		
Reference junction for thermoresistor (TC)	• None • Internal • RTD (0) • Dynamic Ref. Temp. • Fixed Ref. Temp.	Internal	Channel
Temperature coefficient	• Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.003851[1] • Ni 0.00618 • Ni 0.00672 • Ni 0.005000	Pt 0.003851[1]	Channel
Smoothing	• None • Weak • Medium • Strong	None	Channel
Diagnostics, wire break	• Disable • Enable	Disable	Channel
Diagnostics, underflow	• Disable • Enable	Disable	Channel
Diagnostics, overflow	• Disable • Enable	Disable	Channel
[1]This value can also be shown as α = 0.00385055 in the parameter assignment.			

Measuring type with 8 AI RTD

The following table lists the temperature coefficients and measuring ranges you can assign for each measurement type:

Measurement type	Temperature coefficient	Measuring range
Thermoresistor 4-conductor Thermoresistor 3-conductor Thermoresistor 2-conductor	Pt 0.003851[1, 2]/ Pt 0.003916/ Pt 0.003902/ Pt 0.003920	Pt100 Climatic range / Pt100 Standard range / Pt200 Climatic range / Pt200 Standard range / Pt500 Climatic range / Pt500 Standard range /

Measurement type	Temperature coefficient	Measuring range
Thermoresistor 4-conductor Thermoresistor 3-conductor Thermoresistor 2-conductor		Pt1000 Climatic range / Pt1000 Standard range
	Ni 0.006180[1]/ Ni 0.006720/ Ni 0.005[3]	Ni100 Climatic range / Ni100 Standard range / Ni120 Climatic range / Ni120 Standard range / Ni200 Climatic range / Ni200 Standard range / Ni500 Climatic range / Ni500 Standard range / Ni1000 Climatic range / Ni1000 Standard range
[1] The default settings for the temperature coefficients apply according to the standard EN60751. [2]This value can also be shown as α = 0.00385055 in the parameter assignment. [3] The thermoresistor LG-Ni1000 corresponds to the thermoresistor Ni1000 with the temperature coefficient 0.005		

NOTE

For a thermoresistor, the climatic type is only possible with temperature units Celsius (°C) and Fahrenheit (°F).

10.1.4 Parameter description analog input

Group diagnostics

You can generally enable and disable the diagnostics function of the device with this parameter.

The "Fault" and "Parameter assignment error" diagnostics functions are always independent of the group diagnostics.

Diagnostics: Missing 1L+

If you enable this parameter, the check for missing supply voltage is enabled.

Diagnostics: Short-circuit sensor supply

If you enable this parameter, a diagnostics event is generated if a short-circuit of the sensor supply to ground is detected and the channel is enabled. The sensor supply is monitored for connectors X1, X3, X5, and X7. No differentiation is made as to the connector where the sensor short-circuit occurred.

Interference frequency suppression

With this parameter, you set the integration time of the device, based on the selected interference frequency. Select the frequency of the supply voltage used. Interference frequency suppression "Off (Fast Mode)" means 500 Hz, which corresponds to an integration time of 2 ms for a measurement channel.

Temperature unit

This parameter is used to select the unit in which the temperature is detected.

Reference temperature for TC

The reference temperature applies to all channels at which "Fix Ref. Temp." was selected at "Reference junction". Information about the value range of the reference temperature is available in the table Reference temperature for TC.

Measurement type (channel-wise)

Click the field to have the available measurement types displayed and select them.

Possible measurement types:

- Voltage ±80 mV
- Resistor (4-wire connection)
- Resistor (3-wire connection)
- Resistor (2-wire connection)
- Thermal resistor (linear, 4-wire connection)
- Thermal resistor (linear, 3-wire connection)
- Thermal resistor (linear, 2-wire connection)
- Thermocouple

This parameter is used to set the measuring method, for example voltage. For any unused channels, you must select the **disabled** setting. For a disabled channel, the conversion time and integration time of the channel = 0 s, and the overall cycle time of the device is reduced.

Measuring range

With this parameter, you set the measuring range of the selected measurement type.

Temperature coefficient (for RTD, thermoresistor)

The correction factor for the temperature coefficient (α-value) specifies the extent to which the resistance of a certain material changes when the temperature is raised by 1 °C.

The α-values conform to EN 60751, GOST 6651, JIS C 1604, and ASTM E-1137.

The temperature coefficient depends on the chemical composition of the material.

Smoothing

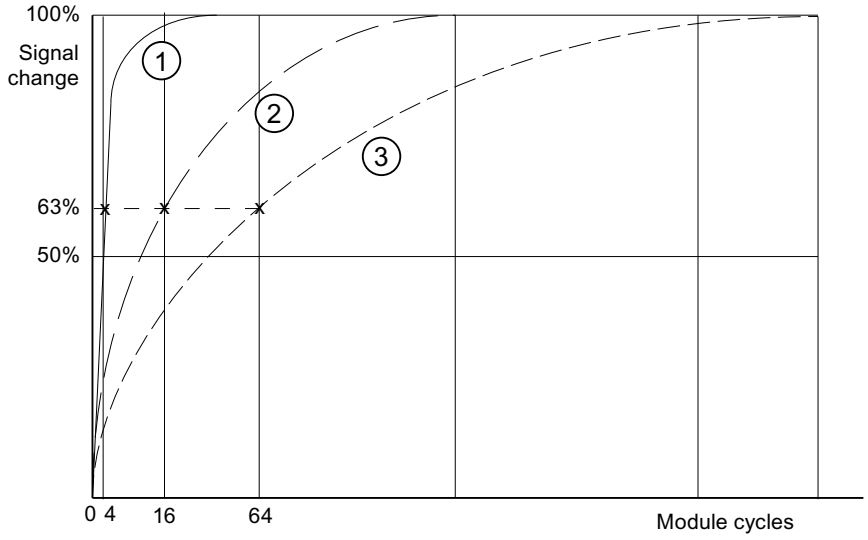
Smoothing of the analog values produces a stable analog signal for further processing. The smoothing of analog values is useful when handling wanted signals (measured values) with a slow rate of change, for example, temperature measurements.

The measured values are smoothed by digital filtering. To achieve smoothing, the device generates a mean value from a specified number of converted (digitized) analog values.

You assign a maximum of four levels for the smoothing (none, weak, medium, strong). The level determines the number of module cycles, from which the mean value is generated.

The stronger the smoothing, the more precisely the smoothed analog value reaches the setpoint value. The time interval until the smoothed analog value is applied after a signal change is also prolonged.

The figure below shows the number of cycles a module requires to apply the smoothed analog value at almost 100% after a step response, based on the smoothing function settings. The figure applies to all signal changes at the analog input. The smoothing value defines the number of cycles a module requires to reach 63% of the end value of the changed signal.



① Smoothing, weak
② Smoothing, medium
③ Smoothing, strong

Diagnostics: Wire break

When this parameter is enabled, the **Wire break** diagnostics event is generated when a wire break is detected.

Observe the rules outlined below to handle a wire break in the 1 V to 5 V and 4 mA to 20 mA measuring ranges:

Parameters	Event	Measured value	Explanation
Enable wire break[1]	Wire break	$7FFF_H$	Diagnostics, **wire break**
Wire break disabled[1] Underflow enabled	Wire break	8000_H	Measured value after leaving the undershoot range Diagnostic message **Lower limit value undershot**
Wire break disabled[1] Underflow disabled	Wire break	8000_H	Measured value after leaving the undershoot range

[1] Measuring range limits for wire break detection and measuring range undershoot detection:
- 1 V to 5 V: At 0.296 V
- 4 mA to 20 mA: At 1.185 mA

Diagnostics at 8AI RTD/TC

Take the following diagnostics into account:

Diagnostics, wire break	Diagnostics, overflow	Diagnostics, underflow	Event	Process data	Diagnostic message per channel:
Activated	Deactivated	Deactivated	Wire break	0x7FFF	Wire break
Deactivated	Deactivated	Activated	Wire break	0x8000	Low limit violated
Deactivated	Activated	Deactivated	Wire break	0x7FFF	High limit violated
Deactivated	Activated	Activated	Wire break	0x8000	Low limit violated
Deactivated	Deactivated	Deactivated	Wire break	0x7FFF	

Diagnostics: Underflow

If the measured value reaches the underflow range and you enable this parameter, the **Underflow** diagnostics event is generated.

Diagnostics: Overflow

If the measured value reaches the overflow range and you enable this parameter, the **Overflow** diagnostics event is generated.

Reference junction for thermoresistor (TC)

A difference in temperature between the measuring point and the free ends of the thermocouple (terminal point) generates a voltage between the free ends, namely the thermoelectric voltage. The value of this thermoelectric voltage is determined by the temperature difference between the measuring point and the free ends, and by the type of material combination of the thermocouple. Since a thermocouple always measures a temperature difference, the free ends at the reference junction must be maintained at a known temperature in order to determine the temperature of the measuring point.

In the case of the I/O device 8 AI 4 U/I + 4 RTD/TC 8×M12 and 8 AI RTD/TC 8xM12, the following compensation settings are possible:

- No / external compensation: The reference junction temperature is measured outside the module, e.g., via a compensation slot.

  With this compensation type, the reference junction temperature of the thermocouples is measured outside the two I/O devices. For this purpose you can, for example, connect a compensation slot to the thermocouple.

  With this compensation type, the temperature of the reference junction is specified at 0 °C .

  The temperature of 0 °C is reached when a compensation slot is used. One compensation slot is required per thermocouple.
- Internal: The temperature of the measuring point is measured in the housing of the I/O device.

  With this type of compensation the reference junction temperature is determined with an internal temperature sensor. One temperature sensor is integrated into each I/O device.

  The reference junction temperature is detected by an internal temperature sensor.

  The same reference junction temperature is assigned to all the channels of the I/O devices that you selected for this type of compensation.

With the I/O device 8 AI RTD/TC 8xM12, the following compensation settings are also possible :

- RTD (0): The reference junction temperature is determined by means of a thermal resistor (Pt1000).

  With this compensation the reference junction temperature is determined by measuring the resistance value of a Pt1000 at the terminal point of the M12 compensation connector. The resistance measurement may only be carried out on the round socket X1 (Channel 0).

  The reference junction temperature is determined by the resistance value Pt1000.

  The same reference junction temperature is assigned to all the channels of the I/O device 8 AI RTD/TC 8xM12 that you selected for this type of compensation.

  The cycle time increases by 1 x the conversion time.

  If the compensation RTD (0) is selected on a channel of the I/O device 8 AI RTD/TC 8xM12, the measurement type for Channel 0 (X1) is limited; that is, only the measurement types "Thermocouple" or "±80 mV" are possible.

  A wire break at Pt1000 cannot be detected and is reported with the diagnosis "Reference channel error".
- The M12 compensation connector is provided for the temperature compensation "RTD (0)" (prerequisite: "Reference junction" parameter set to "RTD (0)". For all other temperature compensations, no M12 compensation connector is required.

  The M12 compensation connector has an integrated resistance thermometer Pt1000 (with α = 0.003851) for compensating the reference junction temperature of the

thermocouples. The α value conforms to the standards EN 60751, GOST 6651, JIS C 1604 and ASTM E-1137.

The M12 compensation connector is delivered unassembled. You can connect a thermocouple by using terminals 2 and 4 of the M12 compensation connector.

The M12 compensation connector is bolted to the round socket X1 on the connection module CM IO 4 x M12 (torque: 1.5 Nm). The procedure is identical to the M12 connector (see section Mounting (Page 19)).

NOTE

The M12 compensation connector is only designed for the electronic module 8 AI RTD/TC 8xM12. Operation without a cable is not permitted in order to comply with degree of protection IP67.

- Dynamic Ref. Temp.: The reference junction temperature is measured via a module on a different station.

  With this type of compensation the reference junction temperature (compensation voltage) is measured by means of an external module on another station.

  The reference junction temperature is transferred from the CPU to the I/O device 8 AI RTD/TC 8xM12 by means of the data record DS2 using the SFB 53.

  An separate reference junction temperature can be assigned by means of the the user program to each channel for which you select this type of compensation.
- Fixed Ref. Temp.: The reference temperature is specified permanently.

  With this type of compensation, the reference junction temperature is stored as a parameter.

  The reference junction temperature is specified in the parameter "Reference temperature for TC".

  The possible value range is listed in the table Reference temperature for TC.

  The parameterized reference junction temperature is valid for all the channels of the I/O device for which you have selected this type of compensation.

10.1.5 Analog value representation for measuring ranges with SIMATIC S7

Representation of analog values

With the same nominal range, the digitized analog value is the same for input and output values. Analog values are represented in two's complement.

The following table shows the representation of analog values of the analog input.

Table 1-1090 Representation of analog values (SIMATIC S7 format)

Resolution	**Analog value**															
Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Significance of the bits	Sign	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Sign

The sign (S) of the analog value is always in bit number 15:

- "0" → +
- "1" → -

10.1.6 Measuring ranges of the analog input device in S7 format

Voltage measuring ranges: Measuring range 1 to 5 V

Measuring range 1 to 5 V	Units		Range
	Decimal	Hexadecimal	
> 5.704 V	32767	$7FFF_H$	Overflow
5.704 V	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
5 V	27648	$6C00_H$	Nominal range
4 V	20736	5100_H	
1 V + 144.7 µV	1	0001_H	
1 V	0	0000_H	
	-1	$FFFF_H$	Underrange
0.296 V	-4864	$ED00_H$	
< 0.296 V	32767	$7FFF_H$	Wire break
	- 32768	8000_H	Underflow

Voltage measuring ranges: Measuring range 0 to 10 V

Measuring range 0 to 10 V	Units		Range
	Decimal	Hexadecimal	
> 11.759 V	32767	$7FFF_H$	Overflow
11.759 V	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
10 V	27648	$6C00_H$	Nominal range
7.5 V	20736	5100_H	
0 V + 361.7 µV	1	0001_H	
0 V	0	0000_H	
	-1	$FFFF_H$	Underrange
-1.759 V	-4864	$ED00_H$	
< -1.759 V	- 32768	8000_H	Underflow

Measuring ranges for voltage: ±10 mV

Measuring range ±10 V	Units		Range
	Decimal	Hexadecimal	
> 11.759 V	32767	$7FFF_H$	Overflow
11.759 V	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
10 V	27648	$6C00_H$	Nominal range
7.5 V	20736	5100_H	
361.7 µV	1	0001_H	
0 V	0	0000_H	
	-1	$FFFF_H$	
- 7.5 V	-20736	$AF00_H$	
-10 V	-27648	9400_H	
	-27649	$93FF_H$	
-11.759 V	-32512	8100_H	Underrange
< -11.759 V	-32768	8000_H	Underflow

Current measuring range: 0 to 20 mA

Measuring range 0 to 20 mA	Units		Range
	Decimal	Hexadecimal	
> 23.52 mA	32767	$7FFF_H$	Overflow
23.52 mA	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
20 mA	27648	$6C00_H$	Nominal range
15 mA	20736	5100_H	
723.4 nA	1	0001_H	
0 mA	0	0000_H	
	1	$FFFF_H$	Underrange
-3.52 mA	-4864	$ED00_H$	
< -3.52 mA	32768	8000_H	Underflow

Current measuring range: 4 to 20 mA

Measuring range 4 to 20 mA	Units		Range
	Decimal	Hexadecimal	
> 22.81 mA	32767	$7FFF_H$	Overflow
22.81 mA	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	

Measuring range 4 to 20 mA	Units		Range
	Decimal	Hexadecimal	
20 mA	27648	$6C00_H$	Nominal range
16 mA	20736	5100_H	
4 mA + 578.7 nA	1	0001_H	
4 mA	0	0000_H	
	1	$FFFF_H$	Underrange
1.185 mA	-4864	$ED00_H$	
< 1.185 mA	32767	$7FFF_H$	Wire break
	-32768	8000_H	Underflow

Measuring range for current: ±20 mA

Measuring range ±20 mA	Units		Range
	Decimal	Hexadecimal	
> 23.52 mA	32767	$7FFF_H$	Overflow
23.52 mA	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
20 mA	27648	$6C00_H$	Nominal range
15 mA	20736	5100_H	
723.4 nA	1	0001_H	
0 mA	0	0000_H	
	-1	$FFFF_H$	
-15 mA	-20736	$AF00_H$	
-20 mA	-27648	9400_H	
	-27649	$93FF_H$	Underrange
-23.52 mA	-32512	8100_H	
< -23.52 mA	-32768	8000_H	Underflow

Measuring range for voltage: ±80 mV

Measuring range ±80 mV	Units		Range
	Decimal	Hexadecimal	
> 94.1 mV	32767	$7FFF_H$	Overflow
94.1 mV	32511	$7EFF_H$	Overrange
	27649	$6C01_H$	
80 mV	27648	$6C00_H$	Nominal range
60 mV	20736	5100_H	
2.89 µV	1	0001_H	

Measuring range ±80 mV	Units		Range
	Decimal	Hexadecimal	
0 mV	0	0000_H	Nominal range
	-1	$FFFF_H$	
-60 mV	-20736	$AF00_H$	
-80 mV	-27648	9400_H	
	-27649	$93FF_H$	Underrange
-94.1 mV	-32512	8100_H	
< -94.1 mV	-32768	8000_H	Underflow

Measuring ranges for resistance-based sensor: 150 Ω, 300 Ω, 600 Ω, 3000 Ω

Measuring range				Units		Range
150 Ω	300 Ω	600 Ω	3 kΩ	Decimal	Hexadecimal	
> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3.53 kΩ	32767	$7FFF_H$	Overflow
176.38 Ω	352.77 Ω	705.53 Ω	3.53 kΩ	32511	$7EFF_H$	Overrange
				27649	$6C01_H$	
150 Ω	300 Ω	600 Ω	3 kΩ	27648	$6C00_H$	Nominal range
112.5 Ω	225 Ω	450 Ω	2.25 kΩ	20736	5100_H	
5.43 mΩ	10.85 mΩ	21.70 mΩ	108.05 mΩ	1	0001_H	
0 Ω	0 Ω	0 Ω	0 Ω	0	0000_H	
Negative values are physically impossible						

Measuring ranges for Pt x00 standard thermal resistor

Pt x00 Standard in °C (1 digit = 0.1°C)	Units		Pt x00 Standard in °F (1 digit = 0.1°F)	Units		Pt x00 Standard in K (1 digit = 0.1 K)	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 1000.0	32767	$7FFF_H$	> 1832.0	32767	$7FFF_H$	> 1273.2	32767	$7FFF_H$	Overflow
1000.0 : 850.1	10000 : 8501	2710_H : 2135_H	1832.0 : 1562.1	18320 : 15621	4790_H : $3D05_H$	1273.2 : 1123.3	12732 : 11233	$31BC_H$: $2BE1_H$	Overrange
850.0 : -200.0	8500 : -2000	2134_H : $F830_H$	1562.0 : -328.0	15620 : -3280	$3D04_H$: $F330_H$	1123.2 : 73.2	11232 : 732	$2BE0_H$: $2DC_H$	Nominal range
-200.1 : -243.0	-2001 : -2430	$F82F_H$: $F682_H$	-328.1 : -405.4	-3281 : -4054	$F32F_H$: $F02A_H$	73.1 : 30.2	731 : 302	$2DB_H$: $12E_H$	Underrange
< -243.0	-32768	8000_H	< -405.4	-32768	8000_H	< 30.2	32768	8000_H	Underflow

Measuring ranges for Pt x00 climatic thermal resistor

Pt x00 Climatic in °C (1 digit = 0.01 °C)	Units		Pt x00 Climatic in °F (1 digit = 0.01 °F)	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 155.00	32767	$7FFF_H$	> 311.00	32767	$7FFF_H$	Overflow
155.00 : 130.01	15500 : 13001	$3C8C_H$: $32C9_H$	311.00 : 266.01	31100 : 26601	$797C_H$: $67E9_H$	Overrange
130.00 : -120.00	13000 : -12000	$32C8_H$: $D120_H$	266.00 : -184.00	26600 : -18400	$67E8_H$: $B820_H$	Nominal range
-120.01 : -145.00	-12001 : -14500	$D11F_H$: $C75C_H$	-184.01 : -229.00	-18401 : -22900	$B81F_H$: $A68C_H$	Underrange
< -145.00	-32768	8000_H	< -229.00	-32768	8000_H	Underflow

Measuring ranges for Ni x00 Standard thermal resistor

Ni x00 Standard in °C (1 digit = 0.1°C)	Units		Ni x00 Standard in °F (1 digit = 0.1°F)	Units		Ni x00 Standard in K (1 digit = 0.1 K)	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 295.0	32767	$7FFF_H$	> 563.0	32767	$7FFF_H$	> 568.2	32767	$7FFF_H$	Overflow
295.0 : 250.1	2950 : 2501	$B86_H$: $9C5_H$	563.0 : 482.1	5630 : 4821	$15FE_H$: $12D5_H$	568.2 : 523.3	5682 : 5233	1632_H : 1471_H	Overrange
250.0 : -60.0	2500 : -600	$9C4_H$: $FDA8_H$	482.0 : -76.0	4820 : -760	$12D4_H$: $FD08_H$	523.2 : 213.2	5232 : 2132	1470_H : 854_H	Nominal range
-60.1 : -105.0	-601 : -1050	$FDA7_H$: $FBE6_H$	-76.1 : -157.0	-761 : -1570	$FD07_H$: $F9DE_H$	213.1 : 168.2	2131 : 1682	853_H : 692_H	Underrange
< -105.0	-32768	8000_H	< -157.0	-32768	8000_H	< 168.2	32768	8000_H	Underflow

Measuring ranges for Ni x00 climatic thermal resistor

Ni x00 Climatic in °C (1 digit = 0.01 °C)	Units		Ni x00 Climatic in °F (1 digit = 0.01 °F)	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
> 155.00	32767	$7FFF_H$	> 311.00	32767	$7FFF_H$	Overflow
155.00 : 130.01	15500 : 13001	$3C8C_H$: $32C9_H$	311.00 : 266.01	31100 : 26601	$797C_H$: $67E9_H$	Overrange

Ni x00 Climatic in °C (1 digit = 0.01 °C)	Units		Ni x00 Climatic in °F (1 digit = 0.01 °F)	Units		Range
	Decimal	Hexadecimal		Decimal	Hexadecimal	
130.00 : -60.00	13000 : -6000	$32C8_H$: $E890_H$	266.00 : -76.00	26600 : -7600	$67E8_H$: $E250_H$	Nominal range
-60.01 : -105.00	-6001 : -10500	$E88F_H$: $D6FC_H$	-76.01 : -157.00	-7601 : -15700	$E24F_H$: $C2AC_H$	Underrange
< -105.00	-32768	8000_H	< -157.00	-32768	8000_H	Underflow

Representation of analog values for thermocouple type E

Type E in °C	Units		Type E in °F	Units		Type E in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 1200.0	32767	$7FFF_H$	> 2192.0	32767	$7FFF_H$	> 1473.2	32767	$7FFF_H$	Overflow
1200.0 : 1000.1	12000 : 10001	$2EE0_H$: 2711_H	2192.0 : 1832.1	21920 : 18321	$55A0_H$: 4791_H	1473.2 : 1273.3	14732 : 12733	$398C_H$: $31BD_H$	Overrange
1000.0 : -270.0	10000 : -2700	2710_H : $F574_H$	1832.0 : -454.0	18320 : -4540	4790_H : $EE44_H$	1273.2 : 3.2	12732 : 32	$31BC_H$: 0020_H	Nominal range
< -270.0	-32768	8000_H	< -454.0	-32768	8000_H	< 3.2	-32768	8000_H	Underflow

Measuring ranges for thermocouple Type N

Type N in °C	Units		Type N in °F	Units		Type N in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 1550.0	32767	$7FFF_H$	> 2822.0	32767	$7FFF_H$	> 1823.2	32767	$7FFF_H$	Overflow
1550.0 : 1300.1	15500 : 13001	$3C8C_H$: $32C9_H$	2822.0 : 2372.1	28220 : 23721	$6E3C_H$: $5CA9_H$	1823.2 : 1573.3	18232 : 15733	4738_H : $3D75_H$	Overrange
1300.0 : -270.0	13000 : -2700	$32C8_H$: $F574_H$	2372.0 : -454.0	23720 : -4540	$5CA8_H$: $EE44_H$	1573.2 : 3.2	15732 : 32	$3D74_H$: 0020_H	Nominal range
< -270.0	-32768	8000_H	< -454.0	<-32768	8000_H	< 3.2	-32768	8000_H	Underflow

Representation of analog values for thermocouple type J

Type J in °C	Units		Type J in °F	Units		Type J in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 1450.0	32767	$7FFF_H$	> 2642.0	32767	$7FFF_H$	> 1723.2	32767	$7FFF_H$	Overflow
1450.0 : 1200.1	14500 : 12001	$38A4_H$: $2EE1_H$	2642.0 : 2192.1	26420 : 21921	6734_H : $55A1_H$	1723.2 : 1473.3	17232 : 14733	4350_H : $398D_H$	Overrange
1200.0 : -210.0	12000 : -2100	$2EE0_H$: $F7CC_H$	2192.0 : -346.0	21920 : -3460	$55A0_H$: $F27C_H$	1473.2 : 63.2	14732 : 632	$398C_H$: 0278_H	Nominal range
< -210.0	-32768	$<8000_H$	< -346.0	-32768	8000_H	< 63.2	-32768	8000_H	Underflow

Representation of analog values for thermocouple type K

Type K in °C	Units		Type K in °F	Units		Type K in K	Units		Range
	Decimal	Hexa-decimal		Decimal	Hexa-decimal		Decimal	Hexa-decimal	
> 1622.0	32767	$7FFF_H$	> 2951.6	32767	$7FFF_H$	> 1895.2	32767	$7FFF_H$	Overflow
1622.0 : 1372.1	16220 : 13721	$3F5C_H$: 3599_H	2951.6 : 2501.7	29516 : 25017	$734C_H$: $61B9_H$	1895.2 : 1645.3	18952 : 16453	$4A08_H$: 4045_H	Overrange
1372.0 : -270.0	13720 : -2700	3598_H : $F574_H$	2501.6 : -454.0	25016 : -4540	$61B8_H$: $EE44_H$	1645.2 : 3.2	16452 : 32	4044_H : 0000_H	Nominal range
< -270.0	-32768	8000_H	< -454.0	-32768	8000_H	< 3.2	-32768	8000_H	Underflow

10.1.7 Dynamic reference temperature with module 8 AI RTD/TC 8xM12

Properties

You can measure the reference junction temperature of the measuring point by using the I/O device 8 AI RTD/TC 8xM12 or an external module from another station when you use the compensation type "Dynamic reference temperature". To do so, the reference temperature is transmitted with SFB 53 "WRREC" using the data record DS2 to the I/O device 8 AI RTD/TC 8xM12.

Requirements

- Standard function block SFB 53 "WRREC"
- User program

Programming

Observe the following notes on the user program:

- The permitted value range of the reference junction temperature in standard resolution corresponds to the temperature range Pt100 Climatic for platinum RTDs.
- If a reference junction temperature is received in data record DS2 that is outside the permitted value range, a diagnostic interrupt "Reference channel fault" is signaled if the "Group diagnostics" parameter has been enabled.
- All inputs signal overflow (32767) when you start the I/O device 8 AI RTD/TC 8xM12. After receiving a compensation value by means of the data record DS2, the I/O device starts reading the TC inputs and signals correct data.
- The I/O device 8 AI RTD/TC 8xM12 has a watchdog set to 5 minutes that is reset after a new compensation value was received by means of DS2. If the I/O device in standard operation does not receive DS2 data within the 5-minute interval of the watchdog, a diagnostic interrupt "Reference channel fault" is signaled if the "Group diagnostics" parameter has been enabled.
- When you use ET 200eco PN modules or other modules for measuring the reference junction temperature, the RTD module parameters/module parameters for the output structure and measuring accuracy must be represented in the DS2 by bytes 0 and 1. The figure below "Structure of data record DS2" illustrates this setting.

Structure of data record DS2

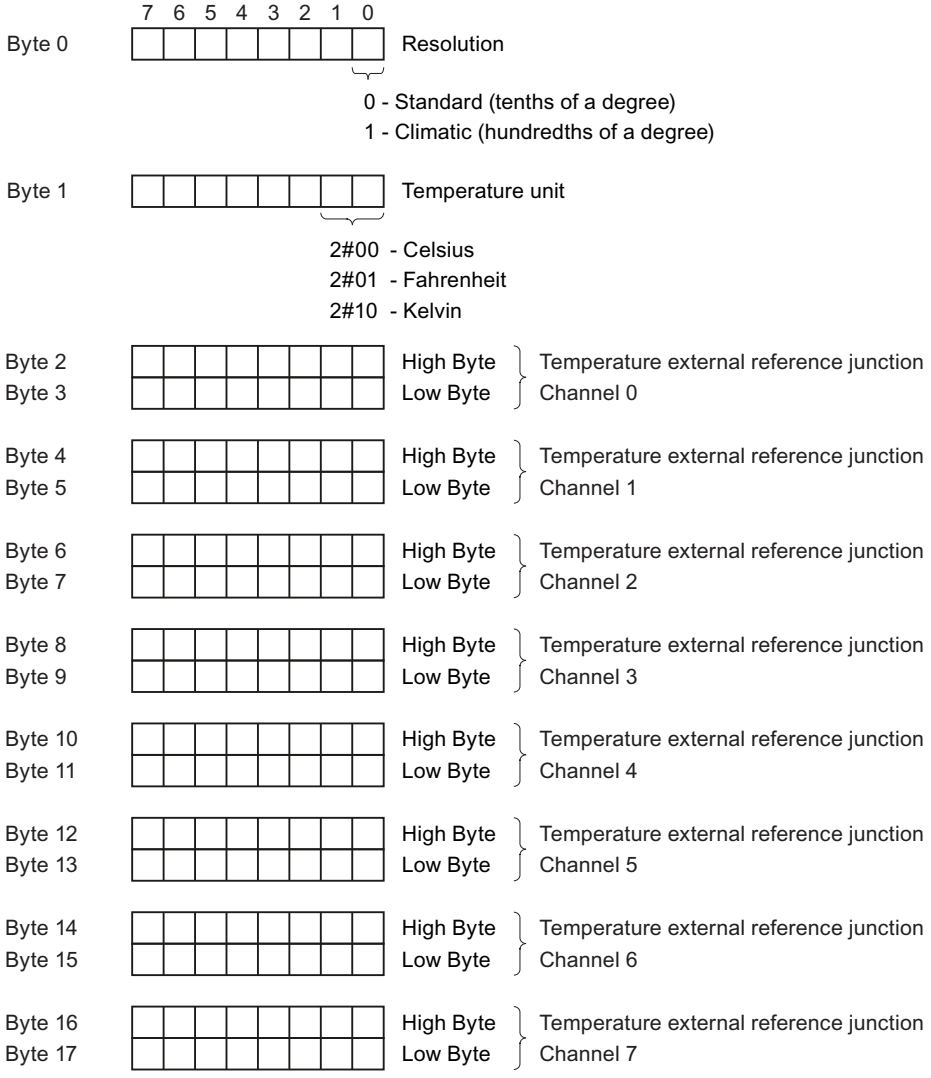


Figure 1-784 Structure of data record DS2

Table 1-1091 Reference temperature for TC

Temperature unit	Decimal	Hexadecimal
Standard temperature unit		
Celsius	-1450 to 1550	$FA56_H$ to $60E_H$
Fahrenheit	-2290 to 3110	$F70E_H$ to $C26_H$
Kelvin	1282 to 4282	502_H to $10BA_H$
Climatic temperature unit		
Celsius	-14500 to 15500	$C75C_H$ to $3C8C_H$
Fahrenheit	-22900 to 31100	$A68C_H$ to $797C_H$
Kelvin	12815 to 32760	$320F_H$ to $7FF8_H$

NOTE

You can use a separate reference junction for each channel due to the flexible structure of the data record DS2. You can also combine channels with the user program so that they use the same reference junction. All channels that operate with the same reference junction temperature must have the same temperature value in the DS2.

User program

The following user program shows an example for the compensation type "Dynamic reference temperature" of channels 0 to 7 of the I/O device 8 AI RTD/TC 8xM12 of an RTD module. The reference junction temperature of the RTD module applies to all channels of the I/O device 8 AI RTD/TC 8xM12.

Requirements:

- Input address of the I/O device 8 AI RTD/TC 8xM12: 120 (module address)
- Input address of the RTD module: 136 (channel address)
- Request bit for SFB "WRREC": M 20.0
- Busy bit for SFB "WRREC": M 20.1
- Memory for data transmission: MW 0 to MW 16

```
STL                                 Explanation
UN M 20.0                           Checking the request: New Dynamic Ref. Temp.
UN M 20.1                           Checking if WRREC is "Busy"
SPB END                             skip if no transmission is required
U M 20.1                            Checking if WRREC is "Busy"
SPB WRT
// Create memory for data transmission
L B#16#1                            Transmit temperature in hundredths of a degree (Pt100 Climatic)
T MB 0
L B#16#0                            Transmit temperature in Celsius
T MB 1
L PIW 136                           Read in reference junction temperature of an RTD module in the plant
T MW 2                              for channel 0 of the 4 AI RTD/TC
T MW 4                              for channel 1 of the 4 AI RTD/TC
```

```
STL                                 Explanation
T MW 6                              for channel 2 of the 4 AI RTD/TC
T MW 8                              for channel 3 of the 4 AI RTD/TC
T MW 10                             for channel 4 of the 4 AI RTD/TC
T MW 12                             for channel 5 of the 4 AI RTD/TC
T MW 14                             for channel 6 of the 4 AI RTD/TC
T MW 16                             for channel 7 of the 4 AI RTD/TC
// Transmit the reference junction temperature to the RTD/TC
WRT :CALL "WRREC", DB53
REQ :=M20.0                         Request bit for data transmission
ID :=DW#16#78                       Input address 120 of the 8 AI RTD/TC
INDEX :=2                           Data record number must be set to 2
LEN :=18                            Length 18 bytes
DONE :=
BUSY :=M20.1                        Busy bit from SFB "WRREC"
ERROR :=
STATUS :=MD24
RECORD :=P#M0.0 BYTE 18             Pointer to memory for data transmission, length 18 bytes
U M 20.1                            Checking if WRREC is "Busy"
SPB END
CLR
= M 20.0                            Reset request for Dynamic Ref. Temp.
END :NOP 0
```

This is only an example. The logic and memory assignment have to be adapted to the structure of the used PLC program.

Addition information on SFB 53 "WRREC" is available in the System Software for S7-300/400 System and Standard Functions manual.

10.2 I/O device analog output

10.2.1 I/O device 4 AO U/I 4xM12

Article number

6ES7145-6HD00-0AB0

Properties

- 4 outputs for voltage or current output
- Output ranges:
  - ±10 V, resolution 15 bits + sign
  - 1 to 5 V, resolution 15 bits
  - 0 to 10 V, resolution 15 bits
  - ±20 mA, resolution 15 bits + sign
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
- Supply voltage DC 24 V
- Dimensions 60 x 175 mm
- Diagnostics
  - "Missing 1L+" supply voltage
  - "Sensor supply short-circuit"
  - "Wire break"
  - "Short-circuit"
  - "Overload"
- Parameterizable response to CPU/Master STOP
- Prioritized startup
- Media redundancy

NOTE

Incorrect intermediate values at the output are possible when supply voltage 1L+ is switched on and off.

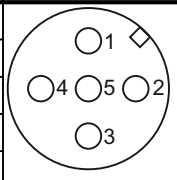
NOTE

The outputs are in voltage mode and supply a signal 0 V until the parameter assignment becomes effective after switching on.

Pin assignment

You will find the pin assignment for the 4 AO U/I 4×M12 I/O device in the table below.

Table 1-1092 Pin assignment for voltage and current for the 4 AO U/I 4×M12 I/O device

Pin	Assignment for U/I				View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	
1	24 V actuator supply $1U_A$(derived from 1L+ non-switched)				
2	Output signal				
	Q_0+	Q_1+	Q_2+	Q_3+	
3	Actuator supply ground 1M				
4	Output signal				
	Q_0-	Q_1-	Q_2-	Q_3-	
5	Functional earth FE				

Block diagram

The block diagram below shows the 4 AO U/I 4×M12.

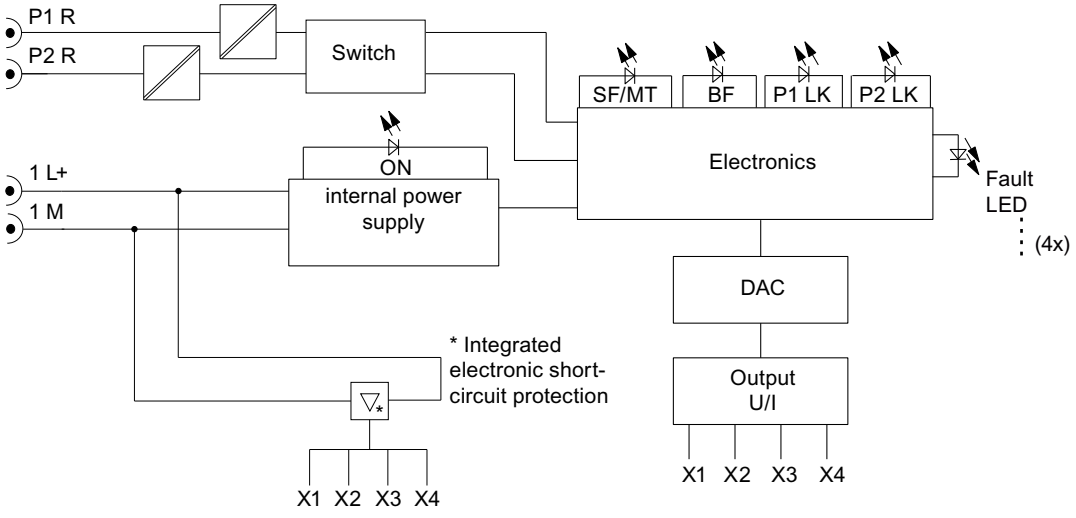


Figure 1-785 Block diagram 4 AO U/I 4xM12

Technical specifications

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 930 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility" • IRT with the option "high performance"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy
PROFINET interface	
• Connection socket	2 x M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes, if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Infeed current 2L+	Max. 4 A
Current consumption	
• From supply voltage (1L+)	Typ. 280 mA
• From supply voltage (2L+)	0 A
Power loss of the device	Typ. 5.5 W
Analog outputs	
Number of outputs	4
Cable length, shielded	Max. 30 m
Voltage	
• Short-circuit protection	Yes, electronic, to ground
• Short-circuit current	Max. 30 mA
Current	
• No-load voltage	Max. 20 V
Actuator supplies	
Number of actuator supplies	4

Technical specifications				
Total current	Max. 1 A			
Short-circuit protection	Yes, electronic			
• Response threshold	Min. 1.4 A			
Actuator selection data				
Output ranges (Rated value)				
Voltage	±10 V 1 V to 5 V 0 V to 10 V			
Current	±20 mA 4 to 20 mA 0 to 20 mA			
Load resistance (in the Rated range of the output)				
• For voltage outputs	Min. 1 kΩ			
• For voltage outputs, capacitive load	Max. 1 µF			
• For current outputs	Max. 0.6 kΩ			
• For current outputs, inductive load	Max. 1 mH			
Permissible input voltage at the output (destruction limit)	28.8 V continuous, 35 V for 500 ms			
Connection of actuators				
• For voltage output, 2-wire connection	Yes			
• For current output, 2-wire connection	Yes			
Formation of analog values				
Conversion principle	Resistor network			
• Conversion time per channel, in ms	1 ms			
• Voltage resolution (including overrange)	±10 V/15 bits + sign 1 to 5 V/15 bits 0 to 10 V/15 bits			
• Current resolution (including overrange)	±20 mA/15 bits + sign 4 to 20 mA/15 bits 0 to 20 mA/15 bits			
Settling time	U	I		
• For resistive load	1.3 ms	2 ms		
• For capacitive load	1.8 ms	-		
• For inductive load	-	2 ms		
Ability to switch to substitute values	Yes			
Interference suppression, error limits				
Crosstalk between outputs	Min. 70 dB			
Operational limit (across the temperature range, relative to output range)		Ambient temperature		
		positive	negative (0 °C to -25 °C)	negative (-25 °C to -40 °C)
	U	0.1%	0.15%	0.3%
	I	0.15%	0.25%	0.4%
Basic error limit (operational limit at 25°C, relative to output range)	U	0.08%		
	I	0.1%		
Temperature error (relative to output range)		Ambient temperature		

Technical specifications			
Temperature error (relative to output range)		positive	negative
	U	0.001%/K	0.003%/K
	I	0.0025%/K	0.005%/K
Linearity error (relative to output range)	± 0.02%		
Repeat accuracy (in steady-state condition at 25°C, relative to output range)	±0.008%		
Output ripple (relative to output range, bandwidth 0 to 50 kHz	U	±0.6 mVrms	
	I	±0.4 nArms	
Status, interrupts, diagnostics			
Interrupts	Yes		
Diagnostics functions			
• Group error/maintenance	Red/yellow "SF/MT" LED		
• Bus monitoring PROFINET IO	Red "BF" LED		
• Monitoring of supply voltage 1L+	Green "ON" LED		
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through		
• Fault at analog output	Red LED		
• Diagnostic information can be read	Yes		
Monitoring for			
• Supply voltage 1L+	Yes		
• Sensor supply short-circuit	Yes		
• Short-circuit	Yes; channel (voltage)		
• Wire break	Yes; channel (current)		
• Thermal overload at output	Yes; channel		
Insulation			
Insulation test voltage			
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)		
• All other circuit elements	707 V DC (type test)		
Electrical isolation			
• Between 1L+ and 2L+	Yes		
• Between 1L+, channels and all other circuit elements	No		
• Between channels	No		
• Between Ethernet and all other circuit elements	Yes		

See also

Response times for analog input device and output device (Page 240)

10.2.2 Parameter overview analog output

Parameters for analog output 4 AO U/I 4xM12 (6ES7145-6HD00-0AB0)

Parameters	Range of values	Default setting	Range of effectiveness
Group diagnostics	• Disable • Enable	Disable	Device
Diagnostics, missing 1L+	• Disable • Enable	Disable	Device
Diagnostics, sensor supply short-circuit	• Disable • Enable	Disable	Device
Response to CPU/Master STOP	• Output has no current or voltage • Retain last value • Switch to substitute values	Output has no current or voltage	Device
Type of output	• Disabled • Voltage • Current	Voltage	Channel
Output range	• 1 to 5 V • 0 to 10 V • ±10 V • 0 to 20 mA • 4 to 20 mA • ±20 mA	±10 V	Channel
Diagnostics, wire break at outputs	• Disable • Enable	Disable	Channel
Diagnostics, short-circuit at outputs	• Disable • Enable	Disable	Channel
Diagnostics, overload	• Disable • Enable	Disable	Channel
Substitute value	Each value in the nominal range, overrange, and underrange	0	Channel

Output range	Permitted substitute value
1 to 5 V	0.000 V to 5.704 V
0 to 10 V	0.000 V to 11.759 V
±10 V	-11.759 V to 11.759 V
0 to 20 mA	0.000 mA to 23.518 mA
4 to 20 mA	0.000 mA to 22.814 mA
±20 mA	-23.519 mA to 23.518 mA

10.2.3 Parameter description analog output

Group diagnostics

You can generally enable and disable the diagnostics function of the device with this parameter.

The "Fault" and "Parameter assignment error" diagnostics functions are always independent of the group diagnostics.

Diagnostics, missing 1L+

If you enable this parameter, the check for missing supply voltage is enabled.

Diagnostics, sensor supply short circuit

When this parameter is enabled, the system generates a diagnostics event if it detects a short-circuit of the sensor supply to ground. This diagnostics function is activated when the group diagnostics function is enabled.

Response to CPU/Master STOP

Select how the module's outputs will respond to a CPU STOP:

- Shut down
  The I/O device goes to the safe state. The process image output is deleted (=0).
- Keep last value
  The I/O device retains the last value to be output before STOP.
- Substitute value
  The I/O device outputs the value for the channel set beforehand.

NOTE

Make sure that the plant is always in a safe state if "Keep last value" is selected.

Type of output

With this parameter, you set the output type, for example, voltage. For any unused channels, select the **disabled** setting. For a disabled channel, the conversion time and integration time of the channel = 0 s, and the cycle time is optimized.

Output range

With this parameter, you set the output range of the selected output type.

Diagnostics, wire break (in current mode)

When this parameter is enabled, the **Wire break** diagnostics event is generated when a wire break is detected. This diagnostics event cannot be detected in the zero range.

Diagnostics, short circuit (in voltage mode)

If you enable this parameter, a diagnostics event is generated in the event of a short circuit in the output line. This diagnostics event cannot be detected in the zero range.

Diagnostics, overload

If you enable this parameter, the diagnostics event is generated in the event of an overload.

Substitute values

With this parameter, you enter a substitute value that the module is to output in CPU-STOP mode. The substitute value must be in the nominal range, overrange, or underrange.

10.2.4 Output ranges of analog output device

Output ranges for voltage and current: ±10 V; ±20 mA

Output range ±10 V	Output range ±20 mA	Units		Range
		Decimal	Hexadecimal	
0.00 V	0.00 mA	32767	$7FFF_H$	Overflow
		32512	$7F00_H$	
11.76 V	23.52 mA	32511	$7EFF_H$	Overrange
		27649	$6C01_H$	
10 V	20 mA	27648	$6C00_H$	Nominal range
7.5 V	15 mA	20736	5100_H	
361.7 µV	723.4 nA	1	0001_H	
0 V	0 mA	0	0000_H	
-361.7 µV	-723.4 nA	-1	$FFFF_H$	
-7.5 V	-15 mA	-20736	$AF00_H$	
-10 V	-20 mA	-27648	9400_H	
		-27649	$93FF_H$	Underrange
-11.76 V	-23.52 mA	-32512	8100_H	
		-32513	$80FF_H$	Underflow
0.00 V	0.00 mA	-32768	8000_H	

Output ranges for voltage and current: 1 to 5 V; 4 to 20 mA

Output range 1 to 5 V	Output range 4 to 20 mA	Units		Range
		Decimal	Hexadecimal	
0.00 V	0.00 mA	32767	$7FFF_H$	Overflow
		32512	$7F00_H$	
5.70 V	22.81 mA	32511	$7EFF_H$	Overrange
		27649	$6C01_H$	
5 V	20 mA	27648	$6C00_H$	Nominal range
4 V	16 mA	20736	5100_H	
1 V + 144.7 µV	4 mA + 578.7 nA	1	0001_H	
1 V	4 mA	0	0000_H	
		-1	$FFFF_H$	Underrange
0 V	0 mA	-6912	$E500_H$	
		-6913	$E4FF_H$	Underflow
0.00 V	0.00 mA	-32768	8000_H	

Output ranges for voltage and current: 0 to 10 V; 0 to 20 mA

Output range 0 to 10 V	Output range 0 to 20 mA	Units		Range
		Decimal	Hexadecimal	
0.00 V	0.00 mA	32767	$7FFF_H$	Overflow
		32512	$7F00_H$	
11.76 V	23.52 mA	32511	$7EFF_H$	Overrange
		27649	$6C01_H$	
10 V	20 mA	27648	$6C00_H$	Nominal range
7.5 V	15 mA	20736	5100_H	
361.7 µV	723.4 nA	1	0001_H	
0 V	0 mA	0	0000_H	
		-1	$FFFF_H$	Underflow
0.00 V	0.00 mA	-32768	8000_H	

10.3 Influence of the range of values

Influence of analog signal on input value

The response of the I/O devices with analog inputs depends on the position of the input values within the range of values. The table below shows this dependency.

The measured value lies	Result	SF LED	Diagnostics data range of device	Interrupt
Within the nominal range	Measured value	-	-	-
Within the overrange/underrange	Measured value	-	-	-
Within the overflow	$7FFF_H$	On	Entry[1]	Diagnostic interrupt[1]

The measured value lies	Result	SF LED	Diagnostics data range of device	Interrupt
Within the underflow	8000_H	On	Entry[1]	Diagnostic interrupt[1]
Before parameter assignment	$7FFF_H$	-	-	-
Within an incorrect parameter assignment[2]	Measured value	On	Entry	Diagnostic interrupt
Within an incorrect initial parameter assignment	$7FFF_H$	On	Entry	Diagnostic interrupt
[1] If the the **group diagnostics** and **measuring range** parameters are enabled for the input device. [2] If a channel was previously parameterized correctly, it continues running with the last parameters.				

Influence of output value on analog output

The response of I/O devices with analog outputs depends on the position of the input values within the range of values. The table below shows this dependency.

The output value lies	Result	SF LED	Diagnostics data range of device	Interrupt
Within the nominal range	Value from the IO Controller	-	-	-
Within the overrange/underrange	Value from the IO Controller	-	-	-
Within the overflow	0 signal	-	-	-
Within the underflow	0 signal	-	-	-
Before parameter assignment	0 signal	-	-	-
Within an incorrect parameter assignment[1]	Value from the IO Controller	On	Entry	Diagnostic interrupt
Within an incorrect initial parameter assignment	0 signal	On	Entry	Diagnostic interrupt
[1] If a channel was previously parameterized correctly, it continues running with the last parameters.				

IO-Link Master

11

11.1 IO-Link Master (6ES7148-6JA00-0AB0)

Article number

6ES7148-6JA00-0AB0

Properties

The IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12 has the following technical specifications:

- IO-Link Master according to IO-Link specification V1.0
- Dimensions 60 x 175 mm
- Double assignment of the sockets
- 4 IO-Link ports (Port Class A)
- IO-Link ports can be used optionally as:
  - 4 IO-Link devices as 3-conductor connection
  - 4 standard actuators/encoders (SIO mode)
- 8 digital inputs and 4 digital outputs
- Digital inputs
  - Rated input voltage DC 24 V
  - Suitable for switches and proximity switches
  - Diagnostics
    "Missing 2L+" for the I/O device
    "Short-circuit to M at sensor supply", per channel group
    "Wire break", per channel
  - Channels 4 to 7 are diagnostics-capable, Channels 0 to 3 do not have diagnostics.
- Digital outputs
  - Rated load voltage DC 24 V
  - Output current: 1.3 A per output
  - Suitable for solenoid valves, DC contactors, and indicator lights
  - Diagnostics
    "Missing 2L+" for the I/O device
    "Wire break at outputs" per channel
    "Short-circuit to M at outputs" per channel
  - Parameterizable response to CPU/Master STOP
- Data transfer rates COM1 (4.8 kBaud), COM2 (38.4 kBaud)

The module supports the following functions:

- Prioritized startup
- Media redundancy (as of firmware V7.0)

General pin assignment

Table 1-1093 Pin assignment of sockets X1 to X4 for IO-Link Master and digital inputs

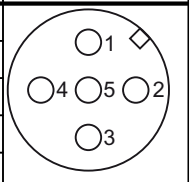
Pin	Assignment				View of socket (front view)
	Socket X1	**Socket X2**	**Socket X3**	**Socket X4**	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)				
2	Input signal				
	DI_0	DI_1	DI_2	DI_3	
3	Sensor supply ground 1M				
4	IO-Link port 1	IO-Link port 2	IO-Link port 3	IO-Link port 4	
5	Not used				

Table 1-1094 Pin assignment of the sockets X5 to X6 for digital inputs

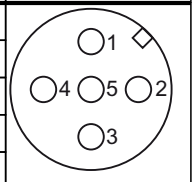
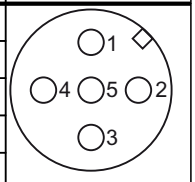
Pin	Assignment		View of socket (front view)
	Socket X5	**Socket X6**	
1	24 V sensor supply $1U_S$(derived from 1L+ non-switched)		
2	Input signal		
	DI_5	DI_7	
3	Sensor supply ground 1M		
4	Input signal		
	DI_4	DI_6	
5	Functional earth FE		

Table 1-1095 Pin assignment of sockets X7 and X8 for digital outputs

Pin	Assignment		View of socket (front view)
	Socket X7 (2L+ switched)	**Socket X8 (2L+ switched)**	
1	Not used		
2	Output signal		
	DQ_1	DQ_3	
3	Supply ground 2M		
4	Output signal		
	DQ_0	DQ_2	
5	Functional earth FE		

Block diagram

The figure below shows the block diagram of the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12.

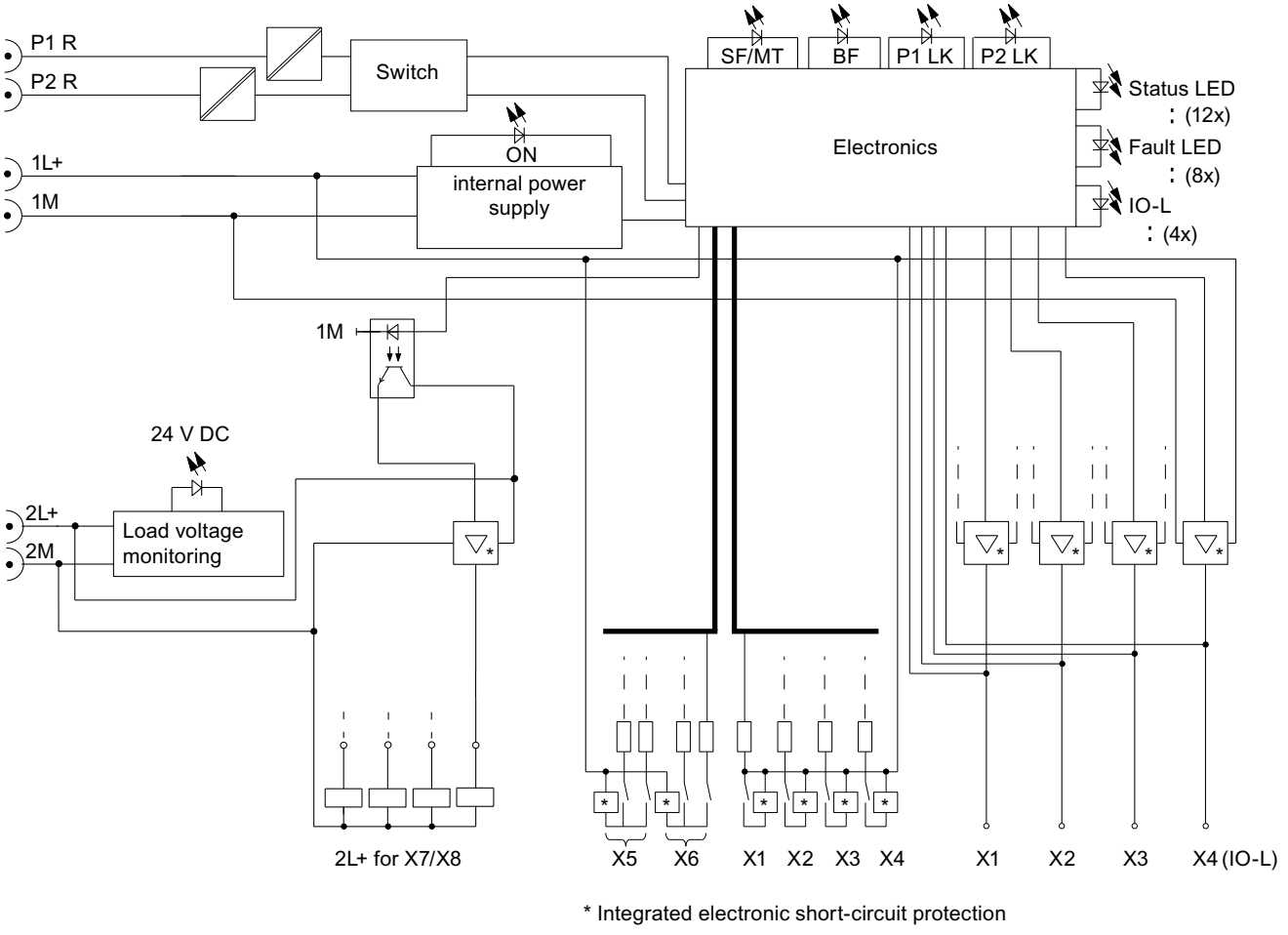


Figure 1-786 Block diagram of the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12

Technical data of the IO-Link Master

Technical data	
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight	Approx. 910 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX

Technical data	
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT with the option "high flexibility"
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Prioritized startup • Media redundancy (as of firmware V7.0)
PROFINET interface	
• Connection socket	2 × M12 d-coded
• Switch function	Yes, internal
• Auto-crossover	Yes; if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction
• Infeed current 1L+	Max. 4 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Total current of the outputs	
• All mounting positions to 60°C	3.9 A
Current consumption	
From supply voltage (1L+)	Typ. 200 mA
From supply voltage (2L+)	Typ. 5 mA
Power loss of the device	Typ. 8 W
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
• Between 1L+, channels and all other circuit elements	No
• Between channels	No
• Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
Diagnostics function	Yes
• Group error/maintenance	Red LED / yellow LED "SF/MT"
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED

Technical data	
• Monitoring of supply voltage 2L+	Green "24 V DC" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED; LED for PROFINET IO infeed and loop-through
• IO-Link port	Green LED "IO-L"
• Digital input/digital output	Green LED
• Fault at digital input/digital output	Red LED
• Diagnostic information can be read	Yes
Monitoring for	
• Missing 2L+	Yes
• Short-circuit of the sensor supply to M	Yes, for Channels 4 to 7, per channel group
• Short-circuit at output (Channel 0 to 3)	Yes, per channel
• Wire break at input	Input current < 0.3 mA per channel
• Wire break at output (Channel 0 to 3)	Yes, in the off state, per channel
Sensor supply	
Number of sensor supplies	6 (X1-X4 (IO-LINK/DI) and X5-X6 (DI))
Load current	200 mA per output to X1-X4 (IO-LINK/DI) 100 mA per output to X5-X6 (DI)
Short-circuit protection	Yes, electronic
IO-Link port	
Number of ports	4
Number of ports that can be controlled simultaneously	4, in all mounting positions
IO-Link protocol 1.0	Yes
IO-Link protocol 1.1	No
Transmission rate	4.8 kBaud (COM1), 38.4 kBaud (COM2)
Size of the process data, input per port	32 bytes
Size of the process data, input per module	32 bytes
Size of the process data, output per port	32 bytes
Size of the process data, output per module	32 bytes
Digital inputs	
Number of inputs	8
Number of inputs that can be controlled simultaneously	8, in all mounting positions
Digital outputs	
Number of outputs	4
IO-Link Device selection data (Port 1 to 4)	
Cable length, unshielded	Max. 20 m
Connection of IO-Link devices	
Port type A	Yes; with 3-wire cable
Operating modes	
IO-Link	Yes
DI	Yes
DQ	Yes
Sensor selection data (input signals 0 to 7 only)	
Cable length, shielded	Max. 30 m

Technical data	
Cable length, unshielded	Max. 30 m
Input voltage	
• Nominal value	DC 24 V
• For signal "1"	11 to 30 V
• For signal "0"	-3 to 5 V
Input current	
• At signal "1"	Typ. 7 mA
Input delay	
• At "0" to "1"	Typ. 3 ms
• At "1" to "0"	Typ. 3 ms
Input characteristic	According to IEC 61131, Type 3
Connection of 2-wire proximity switches	Supported
• Permitted quiescent current	Max. 1.5 mA
Actuator selection data (output signals 0 to 3 only)	
Cable length, shielded	Max. 30 m
Cable length, unshielded	Max. 30 m
Output voltage	
• Nominal value	DC 24 V
• For signal "1"	Min. 1L+/2L+ (-0.8 V)
Output current	
• At signal "1"	Max. 1.3 A
• For "0" signal (residual current)	Max. 1.5 mA
Load resistance range	22 Ω to 3.3 kΩ
Lamp load	Max. 5 W
Parallel wiring of two outputs	
• To increase performance	No
• For redundant control of a load	Supported
Controlling of a digital input	Yes
Switching frequency	
• With resistive load	Max. 100 Hz
• With inductive load	Max. 0.5 Hz
• With lamp load	Max. 1 Hz
Limiting of the inductive shutdown voltage to lamp load	Typ. 1L+/2L+ (-47 V)
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 1.8 A (per channel)

11.1.1 Parameters for IO-Link Master

Parameters for the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12

Parameters		Range of values	Default setting	Range of effectiveness
Slot 1 "4 IO-L"				
Group diagnostics		• Disable • Enable	Disable	Slot 1
Diagnostics enable for Ports 1		• Disable • Enable	Disable	Channel
Diagnostics enable for Port 2		• Disable • Enable	Disable	Channel
Diagnostics enable for Port 3		• Disable • Enable	Disable	Channel
Diagnostics enable for Port 4		• Disable • Enable	Disable	Channel
Slot 2 "8 DI + 4 DO DC 24V/1,3A 8×M12"				
Group diagnostics		• Disable • Enable	Disable	Slot 2
Diagnostics: Missing 2L+		• Disable • Enable	Disable	Channel group
Response to CPU/Master STOP		• Shut down • Retain last value	Shut down	Slot 2
Inputs				
Channel 4	Diagnostics: Short-circuit of the sensor supply to M	• Disable • Enable	Disable	Channel group*
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 5	Diagnostics: Short-circuit of the sensor supply to M	• Disable • Enable	Disable	Channel group*
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 6	Diagnostics: Short-circuit of the sensor supply to M	• Disable • Enable	Disable	Channel group*
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 7	Diagnostics: Short-circuit of the sensor supply to M	• Disable • Enable	Disable	Channel group*
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Outputs				
Channel 0	Diagnostics: Short-circuit of outputs to M	• Disable • Enable	Disable	Channel
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 1	Diagnostics: Short-circuit of outputs to M	• Disable • Enable	Disable	Channel
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 2	Diagnostics: Short-circuit of outputs to M	• Disable • Enable	Disable	Channel

Parameters		Range of values	Default setting	Range of effectiveness
Channel 2	Diagnostics: Wire break	• Disable • Enable	Disable	Channel
Channel 3	Diagnostics: Short-circuit of outputs to M	• Disable • Enable	Disable	Channel
	Diagnostics: Wire break	• Disable • Enable	Disable	Channel

* Channel group is defined by the digital inputs of the M12 socket. Example:
- Channel 4 and Channel 5 form the channel group of connection socket X5.
- Channel 6 and Channel 7 form the channel group of connection socket X7.

Generally short-circuit monitoring of the M12 digital input socket is only carried once via Pin 1 (1L+) and Pin 3 (1M). The short-circuit parameterization can be used to select which channel of the M12 socket reports the short-circuit or whether both channels report the short-circuit.

11.1.2 Functions

Introduction

You can select one of the following operating modes for each of the four ports of the IO-Link Master:

- IO-Link
- DI
- DQ
- Disabled

You make the selection in the Port Configurator tool during parameterization. If no parameters have been assigned, the ports will be disabled.

NOTE

Value status
The value status (PortQualifier) is relevant in IO-Link mode only.

Value status

Each port has a value status display (PortQualifier) per device. The value status shows if the process data is valid or invalid.

By default, the value status (PortQualifier) is disabled.

IO-Link

In IO-Link mode, the port is in IO-Link communication. There are two data transmission rates in this operating mode. COM1 with 4.8 kBaud; COM2 with 38.4 kBaud. The data transmission rate depends on the IO-Link Device used. The IO-Link Master and the IO-Link Device used automatically negotiate the maximum data transmission rate at startup.

DI

In DI mode, a port of the IO-Link Master behaves like a standard DI.

DQ

In DQ mode, a port of the IO-Link Master behaves like a standard DQ.

Disabled

The respective port of the IO-Link Master is disabled in Disabled mode. The ports are disabled if the IO-Link Master has not yet been parameterized with *S7-PCT* (default setting).

Consistency width of 8 byte

The IO-Link Master has a consistency width of 8 byte. In addition to the upper limit of 32 byte input and 32 byte output for the entire IO-Link Master, there are other upper limits of 8 byte input and 8 byte output per IO-Link Device (per port).

11.2 IO-Link Master (6ES7148-6JD00-0AB0)

Article number

6ES7148-6JD00-0AB0

Properties

The IO-Link Master 4 IO-L 4×M12 has the following technical specifications:

- IO-Link Master according to IO-Link specification V1.1
- Dimensions 30 x 200 mm
- 4 IO-Link ports (Port Class B)
- IO-Link ports can be used optionally as:
  - 4 IO-Link devices (Port Class A oder Class B) with variable address area up to 32 byte inputs/32 byte outputs per port
  - 4 standard actuators/encoders (SIO mode)
- Data transfer rates COM1 (4.8 kBaud), COM2 (38.4 kBaud), COM3 (230.4 kBaud)
- Identification and maintenance data I&M0 to I&M3
- Media redundancy
- Configurable diagnostics can be set per port (in IO-Link mode)
- Hardware interrupts (in IO-Link mode)

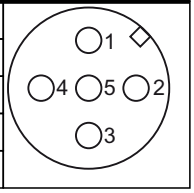
The module supports the following functions:

Table 1-1096 Version dependencies of the functions of the module

Function	Firmware version of the module
Master backup with function block "LIOLink_Master"	As of V1.0
Port Qualifier Information (PQI)	As of V1.0
IO-Link port configuration with S7-PCT (as of V3.4)	As of V1.0
IO-Link port configuration without S7-PCT • IO-Link auto start • IO-Link manual	 As of V1.0 As of V1.1

General pin assignment

Table 1-1097 Pin assignment of sockets X1 to X4 for IO-Link master

Pin	Assignment				View of socket (front view)
	Socket X1	Socket X2	Socket X3	Socket X4	
1	24 V sensor supply $1U_S$ (derived from 1L+ non-switched)				
2	24 V actuator supply $2U_A$ (derived from 2L+ switched)				
3	Sensor supply ground 1M				
4	IO-Link port 1	IO-Link port 2	IO-Link port 3	IO-Link port 4	
5	Actuator supply ground 2M				

Additional information on pin assignment including wiring examples for the 3- and 5-conductor connection (Port Class A or Class B) is available in the chapter Pin assignment for IO-Link Masters (Page 44).

Block diagram

The figure below shows the block diagram of the IO-Link master 4 IO-L 4×M12.

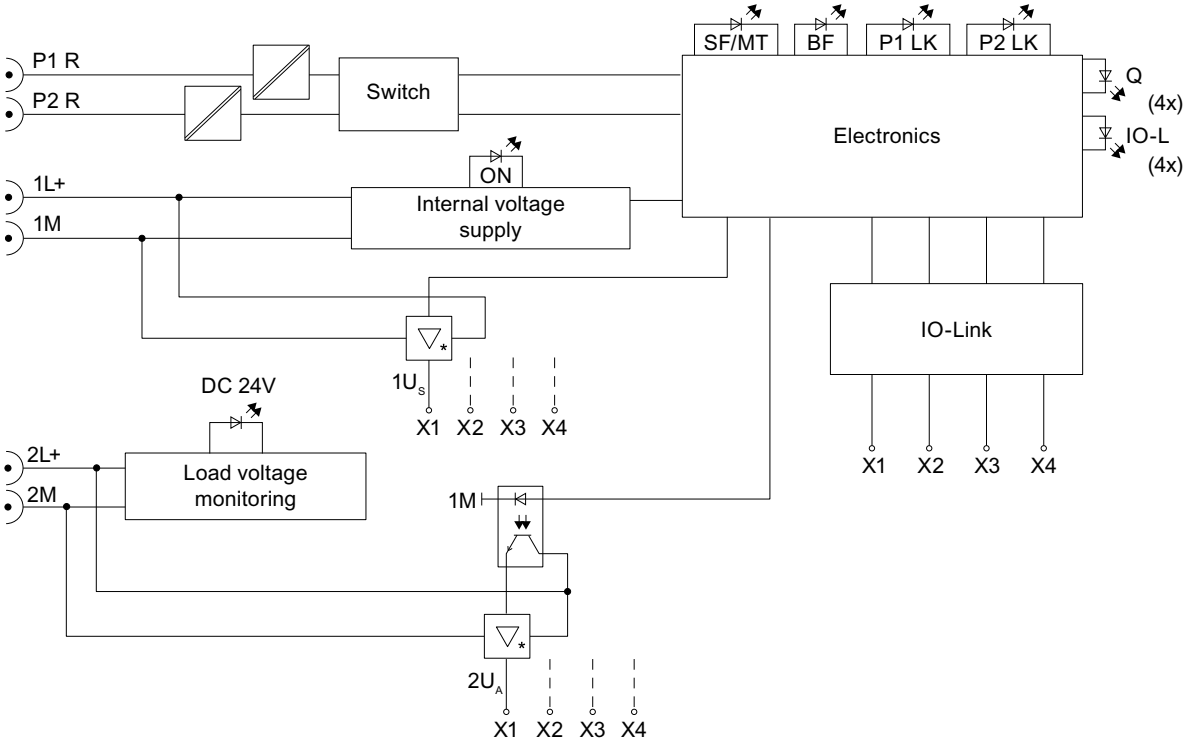


Figure 1-787 Block diagram of the IO-Link Master 4 IO-L 4×M12

Technical specifications of the IO-Link Master

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	30 x 200 x 49
Weight	Approx. 550 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes
Bus protocol	PROFINET IO • IRT
Supported Ethernet services	PROFINET IO (Device) • ping • arp • LLDP • Network diagnostics (SNMP) • DCP • Media redundancy

Technical specifications	
PROFINET interface	
• Connection socket	2 × M12 d-coded
• Switch function	Yes, internal
• Autocrossing	Yes; if autonegotiation is enabled
Manufacturer ID (Vendor ID)	$002A_H$
Device ID (DeviceID)	0306_H
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes
• Infeed current 1L+	Max. 4 A
Load voltage 2L+	DC 24 V
• Reverse polarity protection	Yes, against destruction, loads are activated
• Infeed current 2L+	Max. 4 A
Current consumption	
From supply voltage (1L+)	Typ. 100 mA
From supply voltage (2L+)	Typ. 15 mA
Power loss of the device	Typ. 4.8 W
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• between 1L+ and 2L+	Yes
• between 1L+, channels and all other switching parts	No
• Between channels	No
• between Ethernet and all other switching parts	Yes
Status, interrupts, diagnostics	
Interrupts	Yes
• Hardware interrupt (device notification)	Yes
Diagnostics function	Yes
• Group error/maintenance	Yes; red/yellow LED "SF/MT"
• Bus monitoring PROFINET IO	Red "BF" LED
• Monitoring of supply voltage 1L+	Green "ON" LED
• Monitoring of supply voltage 2L+	Green "24 V DC" LED
• Existing connection to network	Green "P1 LK" and "P2 LK" LED for PROFINET IO infeed and loop-through
• IO-Link port – Port in IO-Link mode – Port in SIO mode	 green/red LED "IO-L" Green LED "Q"
• Diagnostic information can be read	Yes
Monitoring for	
• Missing 2L+	Yes
• Sensor supply short-circuit	Yes; device supply to ground

Technical specifications	
Sensor supply	
Number of outputs	4
Load current	500 mA per output
Short-circuit protection	Yes, electronic
IO-Link port	
Number of ports	4
Number of ports that can be controlled simultaneously	4, in all mounting positions
IO-Link protocol 1.0	Yes
IO-Link protocol 1.1	Yes
Transmission rate	4.8 kBaud (COM1), 38.4 kBaud (COM2), 230.4 kBaud (COM3)
Size of the process data, input per port	32 bytes + 1 byte PQI
Size of the process data, input per module	128 bytes + 4 bytes PQI
Size of the process data, output per port	32 bytes
Size of the process data, output per module	128 bytes
Memory size for device parameters	2 Kbytes; for each port
Master backup	possible; with function block LIOLink_Master
Configuration without S7-PCT	supported; autostart function
Data for selection of an IO-Link device	
Cable length, unshielded	Max. 20 m
Connection of IO-Link devices	
Port type A	Yes; with 3-wire cable
Port type B	Yes; additional device supply: Max. 2 A per Port, max. 4 A per module
Operating modes	
IO-Link	Yes
DI	Yes
DQ	Yes; max. 100 mA

11.2.1 Configuration

Introduction

The IO-Link Master 4 IO-L 4×M12 has four ports. Each port is represented by a submodule.

Configuration of the IO-Link port of the IO-Link Master 4 IO-L 4×M12

You specify the various operating modes of each IO-Link port by configuring a relevant submodule:

- as digital input by configuring a digital input submodule,
- as digital output by configuring a digital output submodule,
- as IO-Link device by configuring an IO-Link submodule.
- Port deactivated:
  - In STEP 7 V5.5 and higher and with GSD: By deleting the submodule,
  - in STEP 7 (TIA Portal): By deactivating the port enable.

The IO-Link ports are preconfigured as 2I + PQI.

When configuring IO-Link submodules, you can select address spaces for I/O data in the following byte scales:

- 1 I/1 O + PQI
- 2 I + PQI
- 2 I/2 O + PQI
- 4 I/4 O + PQI
- 8 I/8 O + PQI
- 16 I/16 O + PQI
- 32 I/32 O + PQI

NOTE

Port Qualifier Information (PQI)

The Port Qualifier Information (PQI) with the size of 1 byte is always transferred together with the input data of the IO-Link device. The PQI cannot be deactivated.

Additional information on the structure of the PQI byte is available in the appendix I/O address space (Page 232).

Various parameters are available depending on the operating mode.

More information on the parameters is available in the chapter Parameter (Page 202).

11.2.2 Parameter

Port parameters for the IO-Link Master 4 IO-L 4×M12

The following tables show the parameters that you can set for each submodule (each port) of the 4 IO-L 4×M12 IO-Link Master.

Table 1-1098 Diagnostics

Parameters	Range of values	Default setting
Diag: Missing 2L+	• Disable • Enable	Disable
Diag: Port	• Disable • Enable	Disable
Hardware interrupt (device notification)	• Disable • Enable	Disable

The following table shows the port parameters for 4 IO-L 4×M12 the IO-Link Master with firmware as of V1.1.

Table 1-1099 Port parameter

Parameter	Range of values	Default setting
Port configuration without S7-PCT	• Disable • Enable	Disable
Operating mode	• IO-Link auto start • IO-Link manual	IO-Link auto start
VendorID*	Manufacturer ID of the connected IO-Link device	0
DeviceID*	Device ID of the connected IO-Link device	0
Test accuracy / data backup*	• Same type (V1.0) without backup & restore • Type compatible (V1.1) without backup & restore • Type compatible (V1.1) with backup & restore • Type compatible (V1.1) with restore	Type compatible (V1.1) with backup & restore

* Only effective if you use the port mode "IO-Link Manual".

11.2.3 Explanation of the parameters

Diag: Missing 2L+

Enabling of diagnostics in the case of missing or insufficient load voltage 2L+.

Diag: Port

Enabling of the diagnostics for the selected port.
A distinction is made between error and maintenance interrupts during the diagnostics. The possible diagnostics depend IO-Link device used. More information on the diagnostic interrupts is available in the description of the IO-Link device that is used.

Hardware interrupt (device notification)

Enabling of hardware interrupts for the selected port.
The possible hardware interrupts depend on the IO-Link device that is used. More information on the hardware interrupts is available in the description of the IO-Link device that is used.

NOTE

Configuration as digital input or output
Please not that you cannot activate any port parameters or diagnostic alarms in SIO mode.

Port configuration without S7-PCT

This parameter enables the port configuration without S7-PCT for the module.

NOTE

Changes to the port configuration
If you have assigned the parameters for the IO-Link device via port configuration without S7-PCT, or have configured the port as digital input, digital output or disabled, you can no longer change the port configuration via S7-PCT.

Operating mode

This parameter specifies the mode in which the selected port is to be operated.
The following options are available for selection:

- IO-Link auto start
- IO-Link manual

IO-Link auto start

The connected IO-Link device starts automatically (Plug & Play functionality) The IO-Link device is operational and immediately available to you.

IO-Link manual

The connected IO-Link Device is **not** started automatically.
You have to store the VendorID and DeviceID of the connected IO-Link Device in STEP 7.
In addition, you can select the test accuracy for data storage:

- Same type (V1.0) without backup & restore
- Type compatible (V1.1) without backup & restore
- Type compatible (V1.1) with backup & restore
- Type compatible (V1.1) with restore

You can find the VendorID and DeviceID on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748852).

See also

I/O address space (Page 232)

11.2.4 Functions

Introduction

A brief overview of the functions of the 4 IO-L 4×M12 IO-Link Master is presented below.

Master backup

The "LIOLink_Master" function block is used to read all relevant IO-Link device and IO-Link master parameters. These an be stored retentively at a central location, for example, in a data block in the IO controller.

The status of the IO-Link devices or IO-Link ports stored in the IO-Link master can be restored with the "LIOLink_Master" function block.
As a result, the IO-Link ports and the IO-Link master are configured with the values stored in the master backup.

A typical use case is restoring the parameters after the exchange of the IO-Link master.

NOTE

Availability
Note that the Master Backup function is only available for IO-Link devices that are specified for the IO-Link standard as of V1.1.

More information on the use of the function blocks for the master backup and master restore is available in the chapter Acyclic data exchange with the IO-Link library (Page 72).

More information on Master Backup and Master Restore is available in the Master Backup section of the Integration in the Automation System chapter of the IO-Link System (https://support.industry.siemens.com/cs/ww/en/view/65949252) function manual.

Identification and maintenance data

The identification and maintenance data (I&M data) is information that is saved as read-only (I data) or read/write (M data) on the module.

Identification data (I&M0): Manufacturer information on the module to which you only have read access and some of which may be printed on the module housing, for example, article number and serial number.
Maintenance data (I&M1, 2, 3): Plant dependent information, such as installation location.

The identification data I&M support you in the following tasks:

- Checking the plant configuration
- Locating hardware modifications in a plant
- Correcting errors in a plant

Modules are uniquely identifiable online with the I&M identification data.

In addition, you can read the identification data contained in the IO-Link device as I&M0 via the associated submodule.

Port Qualifier Information (PQI)

Each port has a PortQualifierInformation (PQI). This PQI provides information on the port and IO-Link device status. The PQI is transferred cyclically with the process data. The PQI cannot be deactivated.

The structure of the PQI byte is available in the appendix I/O address space (Page 232).

Port configuration

With a 4 IO-L 4×M12 IO-Link Master as of firmware version V1.1 you can commission the IO-Link submodules (ports) of the IO-Link Masters or the connected IO-Link Devices in two different ways:

- Port configuration without S7-PCT
- Port configuration with S7-PCT

Port configuration without S7-PCT

Requirement

You have activated the "Port configuration with S7-PCT" check box at the configuration of the IO-Link Master submodules in STEP 7.

Procedure

You carry out the configuration of the IO-Link Master submodules directly in STEP 7:

- Activating diagnostics
- Port mode:
  - Operation in "IO-Link auto start" mode (pre-selected)
  - Operation in "IO-Link manual" mode

NOTE

Changing settings of IO-Link devices

If in the further course of the project you want to carry out settings at the connected IO-Link Devices with S7-PCT, you require S7-PCT as of V3.5 with Hotfix 1.

Port configuration with S7-PCT

Requirement

You have **de**activated (default) the "Port configuration without S7-PCT" check box for the configuration of all the IO-Link Master submodules in STEP 7.

Procedure

You carry out the port configuration of the IO-Link Master via the Port Configuration Tool S7-PCT as of V3.2.

You can find more detailed information on the submodule configuration in the section "Configuration (Page 201)".

11.2.5 Interrupts

Introduction

According to IEC 61131-9, IO-Link devices are able to generate events of the types error, warning and notification. These events are mapped directly to the interrupts of the assigned submodule.

Evaluating interrupts with IO controller

The IO-Link Master 4 IO-L 4×M12 supports the following interrupts:

- Diagnostic interrupts (at IO-Link Master / at submodule port)
- Hardware interrupts (at submodule port)
- Pull/plug interrupts (at submodule port)
- Maintenance events (at submodule port)

In the case of an interrupt, the CPU of the IO controller automatically calls the interrupt OBs. The OB number and the start information provide you with information about the cause and class of the error.

You can obtain detailed information on the error event in the error OB with the "RALRM" instruction (read supplementary interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller CPU S7-1500) and ET 200eco PN (IO device). Alarms are made available on the display of the S7-1500 CPU, the CPU Web server and the HMI device.

More information on system diagnostics is available in the Diagnostics function manual on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59192926).

11.2.5.1 Triggering of a diagnostic interrupt

Introduction

All IO-Link events of the type error, which the IO-Link Device generates, as well as problems and errors at the IO-Link port (for example Diag: Missing 2L+), are mapped to the diagnostic interrupts for the assigned submodule.

Triggering of a diagnostic interrupt

If you have assigned the parameters for the IO-Link master accordingly, this triggers a diagnostic interrupt for an incoming or outgoing event of the IO-Link device.

The CPU interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82). The event that led to the triggering of the interrupt is entered in the start information of the diagnostic interrupt OB.

11.2.5.2 Triggering a hardware interrupt

Introduction

All IO-Link events of the type notification which the IO-Link device generates are mapped to the hardware interrupts of the assigned submodule.

Triggering a hardware interrupt

In the event of a hardware interrupt the CPU interrupts the processing of the user program and processes the hardware interrupt OB (for example, OB 40). The event that led to the triggering of the interrupt is entered in the start information of the hardware interrupt OB.

11.2.5.3 Triggering of a pull/plug interrupt

Introduction

If your remove an IO-Link device or interrupt communication, a pull interrupt is generated by the assigned submodule.
A plug interrupt is triggered as soon as the IO-Link device is plugged in again or IO-Link communication re-established.

Triggering of a pull/plug interrupt

In the case of a pull/plug interrupt, the CPU interrupts the processing of the user program and process the pull/plug OB (OB 83). The event that led to the triggering of the interrupt is entered in the start information of the pull/plug OB.

11.2.6 Maintenance events

Introduction

All IO-Link events of the type warning which the IO-Link device generates are mapped to the maintenance interrupts of the assigned submodule. The objective is early detection and elimination of potential disturbances.
With the IO-Link master, maintenance events indicate to the user when a check or an exchange of network components is required.

The CPU interrupts processing of the user program and processes the diagnostics block OB82. The event which led to the triggering of the maintenance event is entered in the start information of the OB82.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system alarms:

- Maintenance demanded - symbolized for each port by a wrench (on a yellow background)  in the device view or in the hardware configuration.

You can find additional information in the STEP 7 online help.

Terminal block and voltage distributor 12

12.1 Terminal block

Article number

6ES7194-6CA00-0AA0

Properties

The terminal block has the following properties:

- The terminal block can be inserted and screw-mounted on any I/O device
- It can also be used separately.
- It distributes 10 A per supply voltage 1L+ and 2L+ to the I/O devices. You can tap a maximum load of 4 A from each supply voltage of the I/O device. The voltages are protected with two 7.5 A fuses.

Pin assignment

The tables below show the pin assignments.

Table 1-1100 Pin assignment of the terminal block

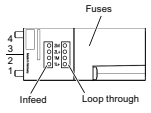
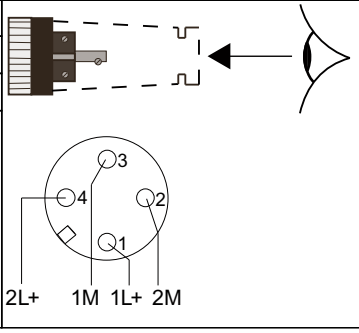
Pin	Assignment	View of the insulation displacement terminal block:
1	24 V (1L+ non-switched)	
2	Ground 1M (non-switched)	
3	24 V (2L+ switched)	
4	Ground 2M (switched)	

Table 1-1101 Pin assignment of the M12 connector

Pin	Assignment	View of the cable connector
1	24 V (1L+ non-switched)	
2	Ground 2M (switched)	
3	Ground 1M (non-switched)	
4	24 V (2L+ switched)	

Block diagram

The block diagram below shows the terminal block.

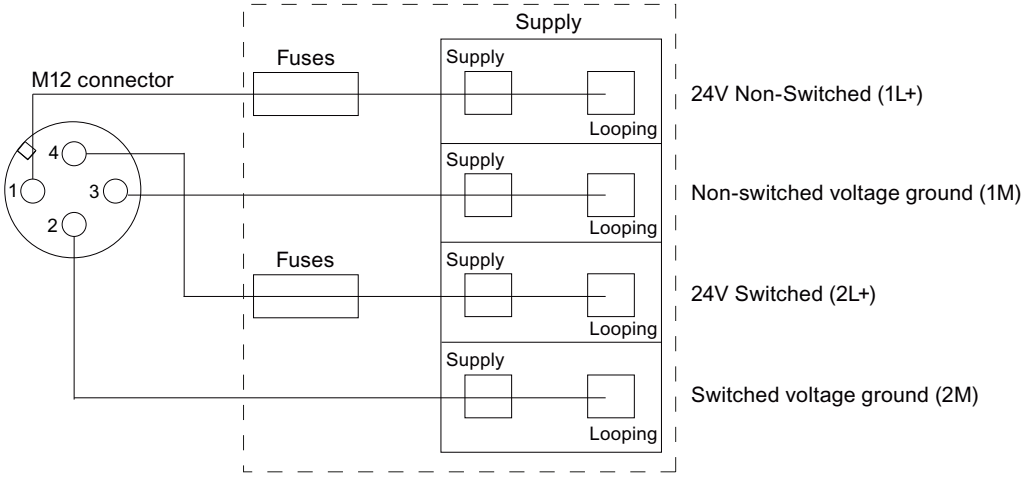


Figure 1-788 Block diagram of the terminal block

Technical specifications

Dimensions and Weight	
Dimensions W x H x D (mm)	30 x 50 x 98
Weight	Approx. 90 g
Current	
Infeed current 1L+ and 2L+	Max. 10 A per 1L+ and 2L+
Output current via the M12 connector	Max. 4 A per 1L+ and 2L+
Power loss	
Power loss of the terminal block	1 W, typical

See also

Installing the terminal block (Page 23)

12.2 Voltage distributor

Article number

6ES7148-6CB00-0AA0

Properties

The voltage distributor PD DC 24V 1×7/8" 4×M12 has the following properties:

- It distributes the centrally fed supply voltage (7/8") to 4 connectors (M12).
- Integrated electronic short-circuit protection
- Direct connection of up to 4 I/O devices
- Distribution of 1L+ and 2L+

Pin assignment

The tables below show the pin assignments.

Table 1-1102 Pin assignment of the 7/8" connector as current input

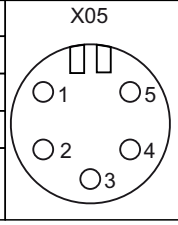
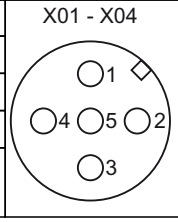
Pin	Assignment	View of the 7/8" cable connector, 24 V connection
1	Ground 2M (switched)	
2	Ground 1M (non-switched)	
3	Functional earth FE	
4	24 V (1L+ non-switched)	
5	24 V (2L+ switched)	

Table 1-1103 Pin assignment of the M12 connector as current output

Pin	Assignment	View of the M12 connection plug (front view)
1	24 V (1L+ non-switched)	
2	Ground 2M (switched)	
3	Ground 1M (non-switched)	
4	24 V (2L+ switched)	
5	Not used	

Block diagram

The figure below shows the block diagram of the voltage distributor PD DC 24V 1×7/8" 4×M12.

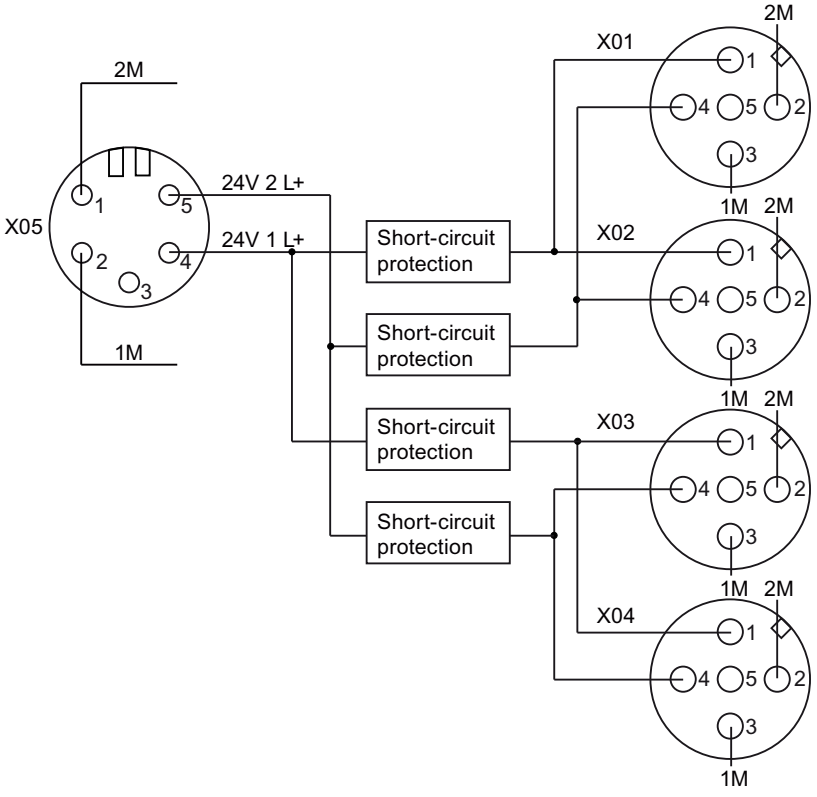


Figure 1-789 Block diagram of the voltage distributor PD DC 24V 1×7/8" 4×M12

Technical specifications

Dimensions and Weight	
Dimensions W x H x D (mm)	45 x 175 x 49
Weight	Approx. 590 g
Voltages and currents	
Supply voltage 1L+	DC 24 V
• Reverse polarity protection	Yes; against destruction (continuously without load)
• Infeed current 1L+	8 A
Supply voltage 2L+	DC 24 V
• Reverse polarity protection	Yes; against destruction (continuously without load)
• Infeed current 2L+	8 A
Total current of the outputs	

Dimensions and Weight	
• All mounting positions to 45 °C	for X1 and X2 in total max. 4 A for 1L+ for X1 and X2 in total max. 4 A for 2L+ for X3 and X4 in total max. 4 A for 1L+ for X3 and X4 in total max. 4 A for 2L+
• All mounting positions to 55 °C	for X1 and X2 in total max. 3 A for 1L+ for X1 and X2 in total max. 3 A for 2L+ for X3 and X4 in total max. 3 A for 1L+ for X3 and X4 in total max. 3 A for 2L+
• Number of outputs	4, with 1L+ and 2L+ each
Input voltage/loop-through	Green LED "1L+" and "2L+"
• Nominal value	DC 24 V
Short-circuit protection of the output	Yes, electronic
• Response threshold	Typ. 4.5 A
Power loss of the voltage distributor	Typ. 3.5 W
Insulation	
Insulation test voltage	
• Ethernet interface	1500 V_{rms} (IEEE802.3, Type Test)
• All other circuit elements	707 V DC (type test)
Electrical isolation	
• Between 1L+ and 2L+	Yes
Status, interrupts, diagnostics	
Diagnostics functions	
• Input/output voltage	Green LED "1L" and "2L"

Signal names

A

A.1 Signal names

Signal names of the I/O devices

Table 1-1104 Signal names of the digital inputs and digital outputs (DI/DQ)

Signal name	Meaning
xL+	Input external auxiliary voltage DC (x: load group)
xM	Ground external auxiliary voltage DC (x: load group)
DI_{xUs}	Digital input (x: load group)
DQ_{xUs}	Digital output (x: load group)
DIQ_{xUs}	Digital input/digital output (x: load group)
U_{Sn}	Sensor supply voltage, channel n
$1U_S$	24 V sensor supply $1U_S$(derived from 1L+ non-switched)

Table 1-1105 Signal names of the analog inputs (AI)

Signal name	Meaning
xL+	Input external auxiliary voltage (x: load group)
xM	Ground external auxiliary voltage (x: load group)
M_n+	Measuring input channel n (voltage, current, RTD, TC, etc.)
M_n-	Measuring input channel n (voltage, current, RTD, TC, etc.)
I_{Cn}+	Power output power supply RTD channel n
I_{Cn}-	Power output power supply RTD channel n
U_{Vn}+	Infeed voltage for 2DMU
U_{Sn}	Sensor supply voltage, channel n
$1U_S$	24 V sensor supply $1U_S$(derived from 1L+ non-switched)

Table 1-1106 Signal names of the analog outputs (AQ)

Signal name	Meaning
xL+	Input external auxiliary voltage (x: load group)
xM	Ground external auxiliary voltage (x: load group)
Q_n+	Output channel n (current or voltage)
Q_n-	Output channel n (current or voltage)
U_{An}	Actuator supply voltage, channel n

Article numbers

B

I/O devices

Table 1-1107 I/O devices: Article numbers

Designation	Article number
Digital input devices	
8 DI DC 24V 4×M12	6ES7141-6BF00-0AB0
8 DI DC 24V 8×M12	6ES7141-6BG00-0AB0
16 DI DC 24V 8×M12	6ES7141-6BH00-0AB0
Digital output devices	
8 DO DC 24V/1,3A 4×M12	6ES7142-6BF00-0AB0
8 DO DC 24V/0,5A 4×M12	6ES7142-6BF50-0AB0
8 DO DC 24V/1,3A 8×M12	6ES7142-6BG00-0AB0
8 DO DC 24V/2,0A 8×M12	6ES7142-6BR00-0AB0
16 DO DC 24V/1,3A 8×M12	6ES7142-6BH00-0AB0
Digital input/digital output device	
8 DIO DC 24V/1,3A 8×M12	6ES7147-6BG00-0AB0
Analog input device	
8 AI 4 U/I + 4 RTD/TC 8×M12	6ES7144-6KD00-0AB0
8 AI RTD/TC 8×M12	6ES7144-6KD50-0AB0
Analog output device	
4 AO U/I 4×M12	6ES7145-6HD00-0AB0
IO-Link master	
4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12	6ES7148-6JA00-0AB0
4 IO-L 4×M12	6ES7148-6JD00-0AB0

Accessories for I/O devices

Table 1-1108 Accessories for I/O devices: Article numbers

Designation	Article number
Accessories	
Voltage distributor PD DC 24V 1x7/8" 4×M12	6ES7148-6CB00-0AA0
Terminal block	6ES7194-6CA00-0AA0
Mounting rail, 500 mm	6ES7194-6GA00-0AA0
Profile screws, 50 items	6ES7194-6MA00-0AA0
M12 cover caps 10 items/package, 10 items	3RX9802-0AA00
M12 cover caps AS-Interface 10 items/package, 10 items	3RK1901-1KA00

Designation		Article number
Labels 10 x 7 mm, pale turquoise, 816 items per pack		3RT1900-1SB10
Accessories for the interface "PROFINET M12 connector X1 P1 R or X1 P2 R LAN"		
Raw cables and connectors		
PROFINET M12 connector d coded with FastConnect connection system, 180°	1 item per pack	6GK1901-0DB10-6AA0
	8 items per pack	6GK1901-0DB10-6AA8
PROFINET M12 connector d-coded with FastConnect connection system, 180°	1 item per pack	6GK1901-0DB20-6AA0
	8 items per pack	6GK1901-0DB20-6AA8
PROFINET M12 connector d-coded, angled		3RK1902-2DA00
PROFINET FC cable		
• FC TP Standard Cable		6XV1840-2AH10
• FC TP Trailing Cable		6XV1840-3AH10
• FC TP Trailing Cable GP		6XV1870-2D
• FC TP Marine Cable		6XV1840-4AH10
• FC TP Torsion Cable		6XV1870-2F
• FC TP Flexible Cable GP		6XV1870-2B
• FC TP FRNC Cable		6XV1871-2F
• FC TP Food Cable		6XV1871-2L
• FC TP Festoon Cable GP		6XV1871-2S
Preassembled cable		
PROFINET M12 connecting cable Trailable cable • Preassembled with M12 connectors 180°, fixed lengths, 1 unit	0.3 m	6XV1870-8AE30
	0.5 m	6XV1870-8AE50
	1.0 m	6XV1870-8AH10
	1.5 m	6XV1870-8AH15
	2.0 m	6XV1870-8AH20
	3.0 m	6XV1870-8AH30
	5.0 m	6XV1870-8AH50
	10.0 m	6XV1870-8AN10
	15.0 m	6XV1870-8AN15
PROFINET M12 connecting cable Trailable cable • Preassembled with M12 connectors, angled, fixed lengths, 1 unit	0.3 m	6XV1870-8GE30
	0.5 m	6XV1870-8GE50
	1.0 m	6XV1870-8GH10
	1.5 m	6XV1870-8GH15
	2.0 m	6XV1870-8GH20
	3.0 m	6XV1870-8GH30
	5.0 m	6XV1870-8GH50
	10.0 m	6XV1870-8GN10
	15.0 m	6XV1870-8GN15

Designation		Article number
PROFINET M12 connecting cable Trailable cable • Preassembled with M12 connector at one end (one end with pin, one end open), fixed lengths, 1 item:	3.0 m	3RK1902-2HB30
	3.0 m	3RK1902-2HB50
	10.0 m	3RK1902-2HC10
PROFINET M12 connecting cable Trailable cable • Preassembled at one end with M12 connector 180° (pin), other side with RJ45 plug 145°, fixed lengths, 1 item	2.0 m	6XV1871-5TH20
	3.0 m	6XV1871-5TH30
	5.0 m	6XV1871-5TH50
	10.0 m	6XV1871-5TN10
	15.0 m	6XV1871-5TN15
IE FC Robust Food Cable GP 2×2 • Preassembled at both ends with M12 connectors (d-coded), 1 unit	1.0 m	6XV1881-5AH10
	2.0 m	6XV1881-5AH20
	3.0 m	6XV1881-5AH30
	5.0 m	6XV1881-5AH50
Y-cable for connection of two I/Os, 5-pole M12, 200 mm		6ES7194-6KA00-0XA0
Accessory for the interface "M12-socket X1 to X4/X8"		
Non-converted connector		
M12 connector, 5-pole, screw-type terminal, max. 0.75 mm², A-coded, max. 4 A, 1 unit		3RK1902-4BA00-5AA0
M12 connector angled, 5-pole, screw-type terminal, max. 0.75 mm², A-coded, max. 4 A, 1 unit		3RK1902-4DA00-5AA0
M12 plug-in cables, shielded, for connecting digital and analog sensors and actuators		(on request)
Preassembled cables and connectors		
Connecting cable M12-M12, 3-pin, PUR cable, 3 × 0.34 mm², Type E, L, IP67, NO, straight female connector M12 to straight male connector M12	1.5 m	3RK19024PB15-3AA0
M12 connecting cables (PUR sheath), A-coded, max. 4 A • Preassembled at both ends, 3 x 0.34 mm², fixed lengths, 1 item	1.5 m	3RK1902-4PB15-3AA0
	5.0 m	6GT2891-4MH50
	10.0 m	6GT2891-4MH10
M12 connecting cables (PUR sheath), A-coded, max. 4 A • Preassembled with M12 connector at one end, angled (one end with socket, one end open), 5 x 0.35 mm², fixed lengths, 1 item	1.5 m	3RK1902-4HB15-5AA0
	5 m	3RK1902-4HB50-5AA0
	10 m	3RK1902-4HC01-5AA0
M12 compensation connector for thermocouples		6ES7194-4AB00-0AA0
Accessories for the interface "DC 24 V IN/OUT M12 (X02/X03)"		
Raw cables and connectors		
IE Power M12 Cable Connector PRO, plug-in connector for connection to PS791-1PRO power supply for 24 V DC supply voltage with mounting instructions, 4-pin, A-coded, 3 units		6GK1907-0DB10-6AA3
IE Power M12 Cable Connector Pro, connection socket for connecting SCALANCE W-700/X208PRO for 24 V DC supply voltage with mounting instructions, 4-pin, A-coded, 3 items		6GK1907-0DC10-6AA3
Power M12 connector angled, 4-pole, screw-type terminal, max. 0.75 mm², A-coded, max. 4 A, 1 unit		3RK1902-4CA00-4AA0
Power M12 connector angled, 5-pole, screw-type terminal, max. 0.75 mm², A-coded, max. 4 A, 1 unit		3RK1902-4DA00-5AA0
Preassembled cables and connectors		
Power Connecting Cable M12-180/M12-180 for power sup-	0.3 m	6XV1801-5DE30

Designation		Article number
ply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.5 m	6XV1801-5DE50
	1.0 m	6XV1801-5DH10
	1.5 m	6XV1801-5DH15
	2.0 m	6XV1801-5DH20
	3.0 m	6XV1801-5DH30
	5.0 m	6XV1801-5DH50
	10.0 m	6XV1801-5DN10
	15.0 m	6XV1801-5DN15
Power Connecting Cable M12-90/M12-90 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.3 m	6XV1801-5GE30
	0.5 m	6XV1801-5GE50
	1.0 m	6XV1801-5GH10
	1.5 m	6XV1801-5GH15
	2.0 m	6XV1801-5GH20
	3.0 m	6XV1801-5GH30
	5.0 m	6XV1801-5GH50
	10.0 m	6XV1801-5GN10
	15.0 m	6XV1801-5GN15
Robust Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	1.0 m	6XV1801-5AH10
	2.0 m	6XV1801-5AH20
	3.0 m	6XV1801-5AH30
	5.0 m	6XV1801-5AH50

Accessories for voltage distributors

Table 1-1109 Accessories for voltage distributors: Article numbers

Designation		Article number
Accessories for the interface "DC 24V IN 7/8" (X05)"		
Raw cables and connectors		
7/8" connector with axial cable exit for field assembly ET 200, socket insert		6KG1905-0FB00
7/8" connector (screw mechanism), angled, socket insert, 5 items/package		3RK1902-3DA00
Energy Cable Trailable power cable, 5 x 1.5 mm^2 Sold by meter, min. ordering quantity 20 m, Delivery unit max. 1000 m, 1 m		6XV1830-8AH10
Preassembled cables and connectors		
Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.3 m	6XV1801-5DE30
	0.5 m	6XV1801-5DE50
	1.0 m	6XV1801-5DH10
	1.5 m	6XV1801-5DH15
	2.0 m	6XV1801-5DH20
	3.0 m	6XV1801-5DH30
	5.0 m	6XV1801-5DH50

* Order via Org-ID 10001539

Designation		Article number
Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	10.0 m	6XV1801-5DN10
	15.0 m	6XV1801-5DN15
Power Connecting Cable M12-90/M12-90 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.3 m	6XV1801-5GE30
	0.5 m	6XV1801-5GE50
	1.0 m	6XV1801-5GH10
	1.5 m	6XV1801-5GH15
	2.0 m	6XV1801-5GH20
	3.0 m	6XV1801-5GH30
	5.0 m	6XV1801-5GH50
	10.0 m	6XV1801-5GN10
	15.0 m	6XV1801-5GN15
Robust Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	1.0 m	6XV1801-5AH10
	2.0 m	6XV1801-5AH20
	3.0 m	6XV1801-5AH30
	5.0 m	6XV1801-5AH50
7/8" connecting cable for power supply of the ET 200, preassembled cable with 7/8" connectors 180° at both sides (one side female connector, one side male connector), 5-pole	0.3 m	6XV1822-5BE30
	0.5 m	6XV1822-5BE50
	1.0 m	6XV1822-5BH10
	1.5 m	6XV1822-5BH15
	2.0 m	6XV1822-5BH20
	3.0 m	6XV1822-5BH30
	5.0 m	6XV1822-5BH50
	10.0 m	6XV1822-5BN10
	15.0 m	6XV1822-5BN15
7/8" connecting cable for power supply of the ET 200, preassembled cable with 7/8" connectors angled at both sides (one side female connector, one side male connector), 5-pole	1.5 m	6XV1822-5BH15-0SB0*
	2.0 m	6XV1822-5BH20-0SB0*
	3.0 m	3RK1902-3NB30
	5.0 m	3RK1902-3NB50
	10.0 m	3RK1902-3NC10
	15.0 m	6XV1822-5BN15-0SB0*
7/8" connecting cable for power supply of the ET 200, preassembled at one side with 7/8" connector angled (one side female connector, one side male connector), 5-pole	3.0 m	3RK1902-3GB30
	5.0 m	3RK1902-3GB50
	10.0 m	3RK1902-3GC10

* Order via Org-ID 10001539

Spare parts

Table 1-1110 Spare parts: Article numbers

Designation	Article number
Spare fuses for terminal block (Miniature copper flat fuse, type FK1, 7.5 A, fast-blow), 10 pieces	6ES7194-6HB00-0AA0

PROFINET IO

Technical book	Contents	Article number
Automating with PROFINET - Industrial Communication based on Industrial Ethernet	This book provides an introduction to the new PROFINET technology	Commercial book number: ISBN 3-89578-244-0

SIMATIC Manual Collection

Designation	Contents	Article number
SIMATIC Manual Collection	Contains all SIMATIC manuals in electronic format	6ES7998-8XC01-8YE0

Technical Product Data - CD ROM

Designation	Contents	Article number
Technical Product Data for CAx Applications	Contains the following technical product data for CAD/CAE systems: • Technical specifications according to ECAD component standard V1.2 • Graphical data (drawings) • Circuit-diagram macros	6ES7991-0CC00-0YX0

Dimensional drawings

C

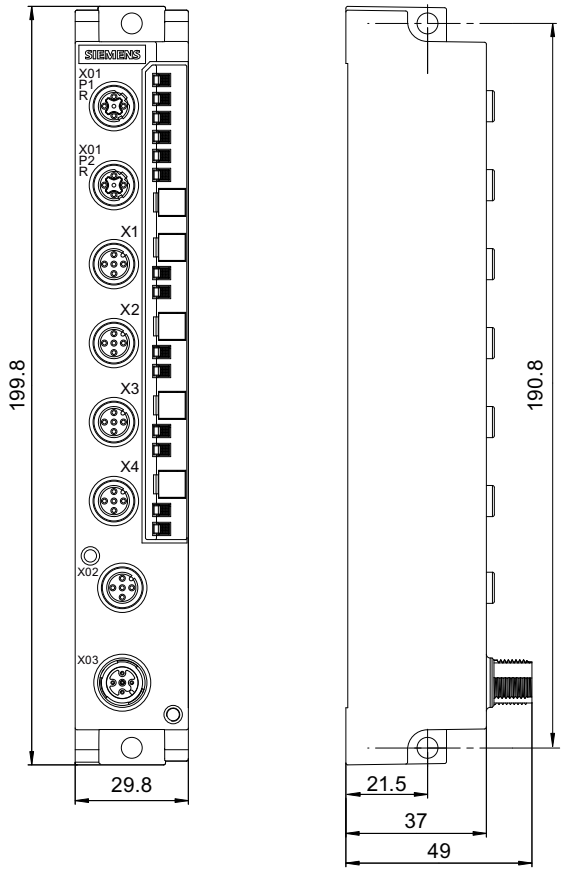
C.1 Dimensional drawings

Dimensional drawing of the I/O devices of 30 mm width

The figure shows the dimensional drawing of the I/O devices:

- 8 DI DC 24V 4×M12
- 8 DO DC 24V/1,3A 4×M12
- 8 DO DC 24V/0,5A 4×M12

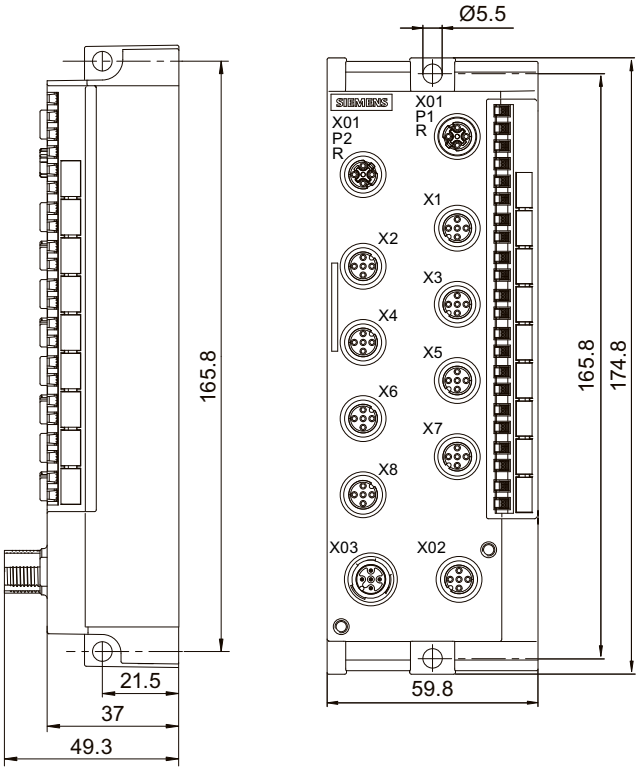
- 4 IO-L 4×M12


SIEMENS
X01
P1
R
X01
P2
R
X1
X2
X3
X4
X02
X03
199.8
29.8
190.8
21.5
37
49

Dimensional drawing of the I/O devices of 60 mm width

The figure shows the dimensional drawing of the I/O devices:

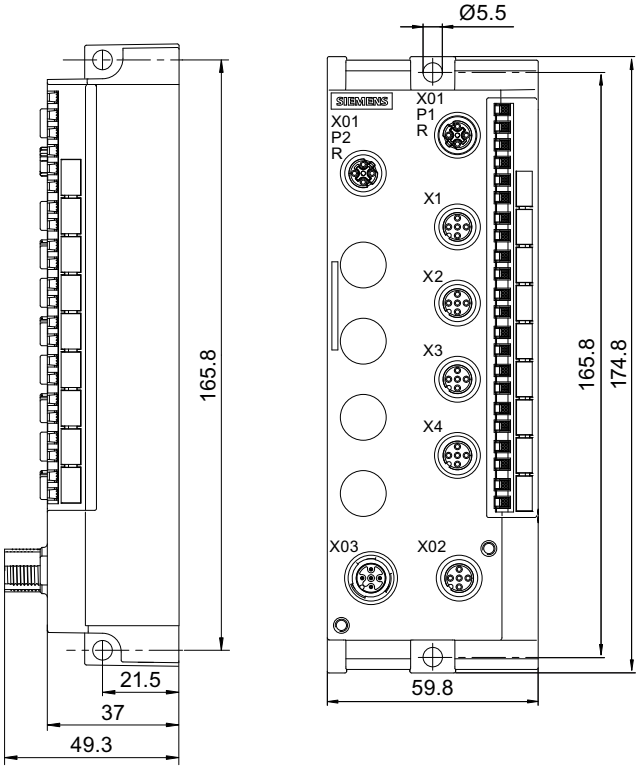
- 8 DI DC 24V 8×M12 (current figure)
- 16 DI DC 24V 8×M12
- 8 DO DC 24V/1,3A 8×M12
- 8 DO DC 24V/2,0A 8×M12
- 16 DO DC 24V/1,3A 8×M12
- 8 DIO DC 24V/1,3A 8×M12
- 8 AI 4 U/I + 4 RTD/TC 8×M12
- 8 AI RTD/TC 8×M12
- 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12



Dimensional drawing of the I/O devices of 60 mm width (with 4 I/O connectors)

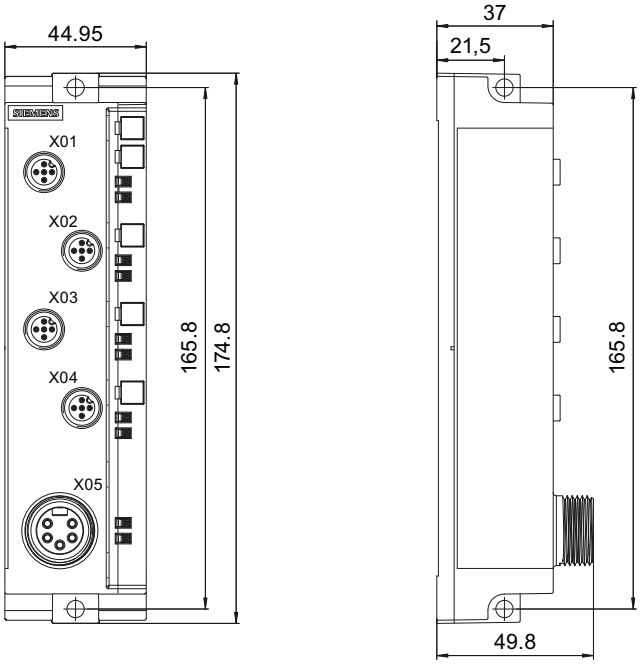
The figure shows the dimensional drawing of the I/O devices:

- 4 AO U/I 4×M12



Dimensional drawing of the voltage distributor

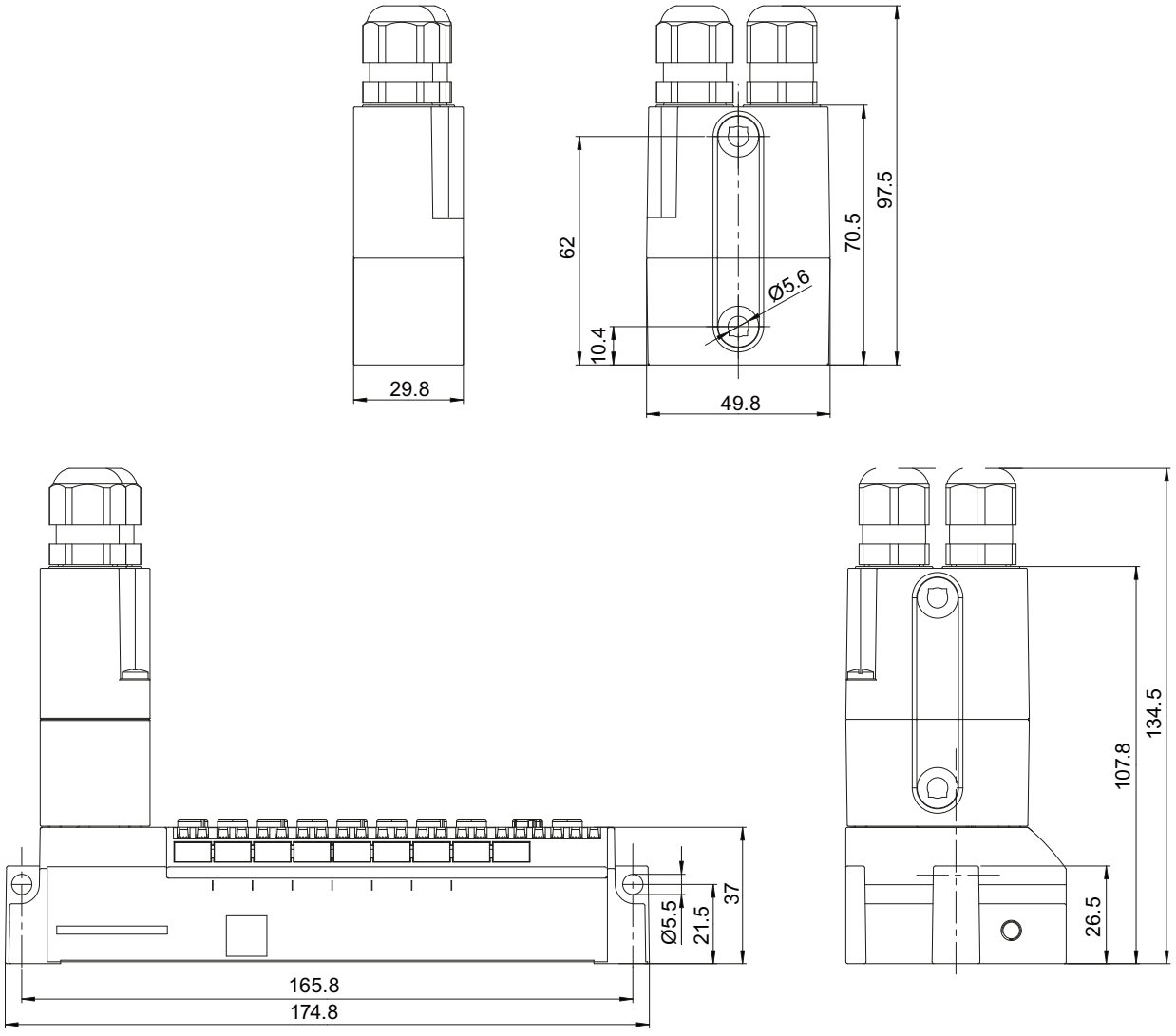
The figure shows the dimensional drawing of the voltage distributor PD DC 24V 1×7/8" 4×M12



Dimensional drawing of the terminal block

The figure shows the dimensional drawing of the terminal block:

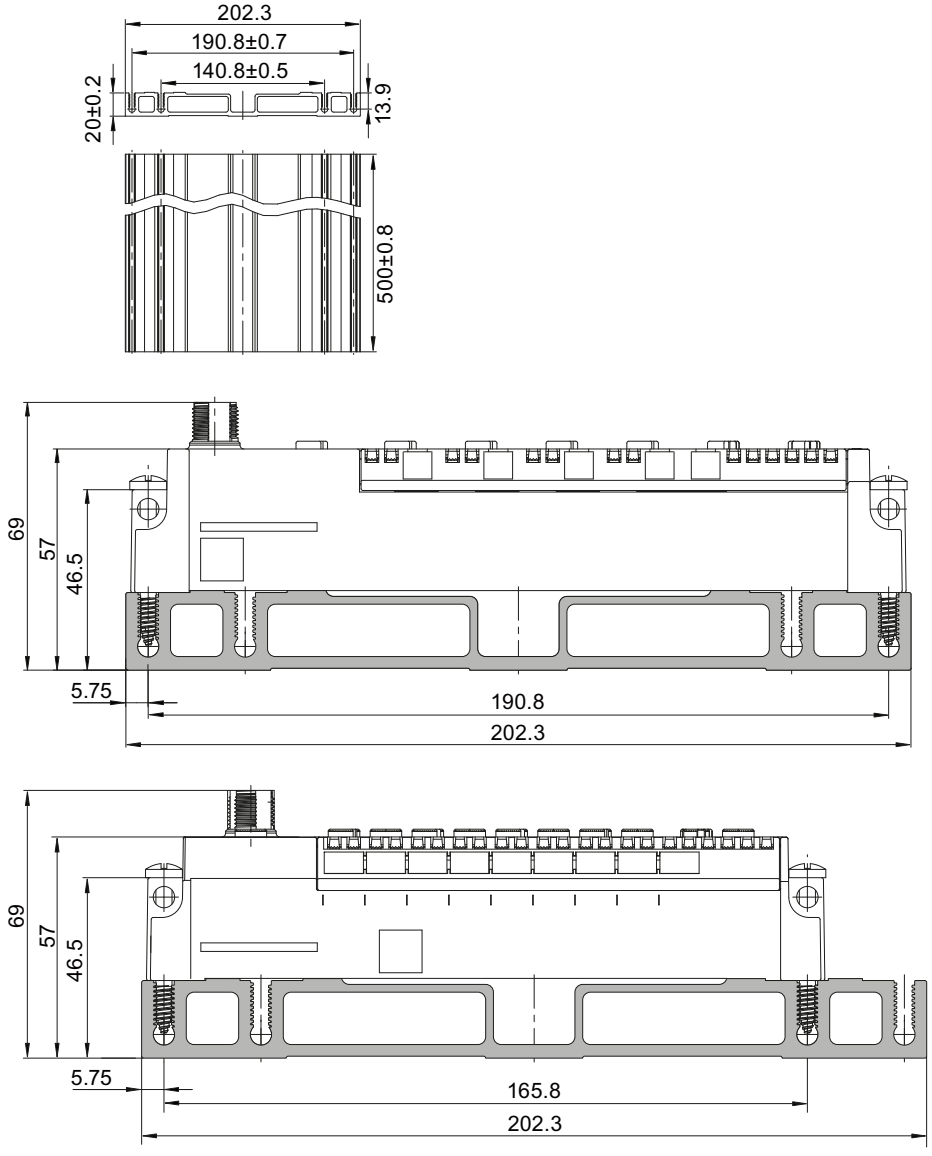
- Separately
- Installed on an I/O device



Dimensional drawing of the mounting rail

The figure shows the dimensional drawing of the mounting rail:

- Separately
- with an I/O device of 30 mm width
- with an I/O device of 60 mm width



Connection examples

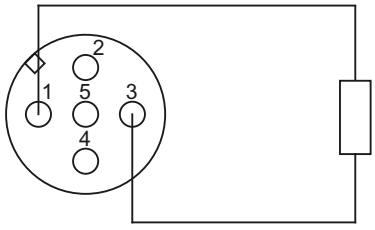
D

D.1 Connection of resistance thermometers to the analog inputs

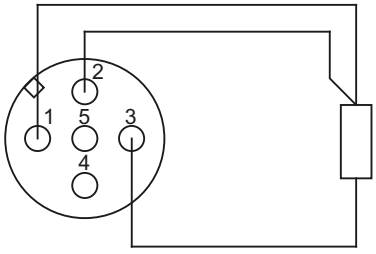
Connection example 8 AI RTD/TC 8xM12

The figure below shows connection examples for 2-, 3- and 4-conductor connections.

2-conductor



3-conductor



4-conductor

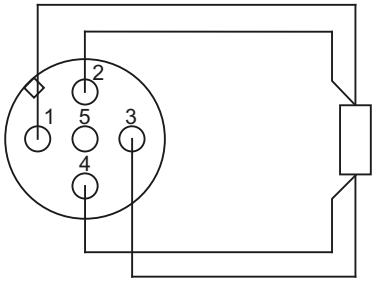


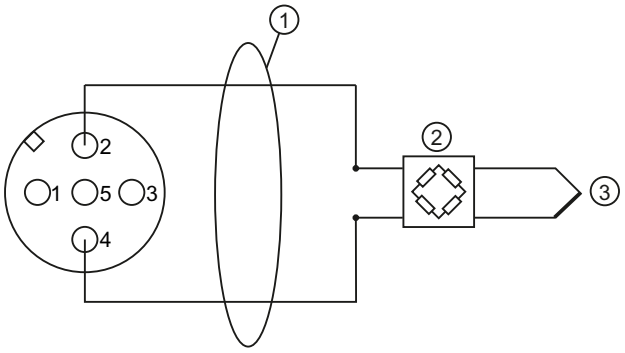
Figure 1-790 Connection examples: 2-, 3- and 4-conductor

D.2 Connection of thermocouples to the analog inputs

Introduction

Different options are available for the analog I/O device 8 AI RTD/TC 8xM12 for compensation of the reference junction temperature. The corresponding connection examples are shown below. In practice, different connection variants may be possible due to the conditions on site.

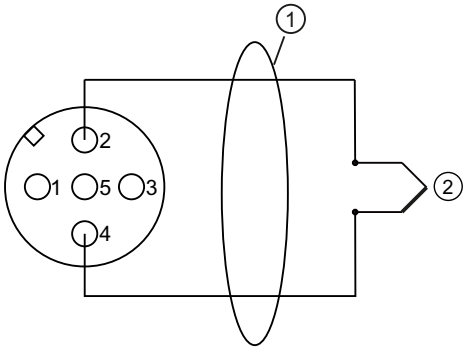
Connection example "No" compensation as reference junction



① Copper cables
② e. g. compensating box (per channel); thermocouple type B does not need a compensating box
③ Thermocouple

Figure 1-791 Connection example "No" compensation as reference junction

Connection example "Internal" compensation or "Fixed reference temperature" as reference junction

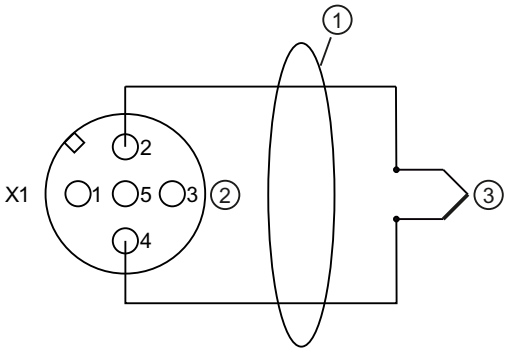


① Direct connection of the thermocouple or with compensating lines
② Thermocouple

Figure 1-792 Connection example "Internal" compensation or "Fixed reference temperature" as reference junction

Connection example "RTD (0)" as reference junction

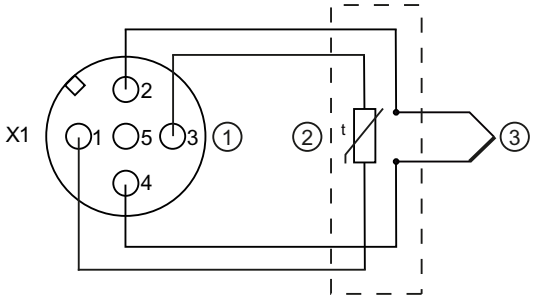
- With M12 compensation connector (integrated resistance thermometer Pt1000)



① Direct connection of the thermocouple or with compensating lines
② M12 compensation connector (terminals 1 and 3 assigned with internal Pt1000) only on round socket X1. The comparison value of the M12 compensation connector at round socket X1 also applies to thermocouples at X2, X3, X4, X5, X6, X7 and X8.
③ Thermocouple

Figure 1-793 Connection example "RTD (0)" as reference junction in M12 compensation connector

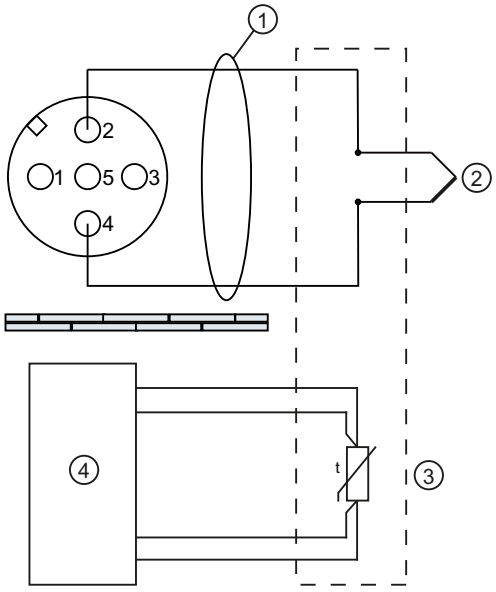
- With external resistance thermometer Pt1000



① M12 connector only on round socket X1
② External Pt1000 (α = 0.003851) in the area of the reference junction with copper cables at terminals 1 and 3. The comparison value of the external Pt1000 at round socket X1 also applies to thermocouples at X2, X3, X4, X5, X6, X7 and X8.
③ Thermocouple

Figure 1-794 Connection example "RTD (0)" as reference junction with external Pt1000

Connection example "Dynamic reference temperature" as reference junction



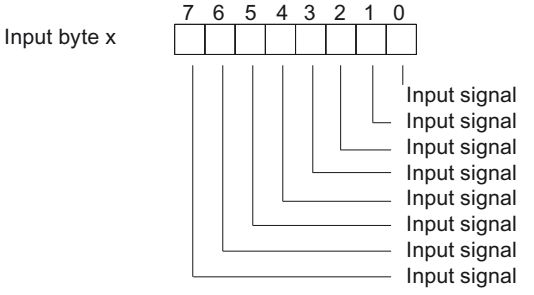
① Copper cables
② Thermocouple at 8 AI RTD/TC 8xM12
③ e. g. Pt100 in the area of the reference junction
④ RTD module of another station

Figure 1-795 Connection example "Dynamic reference temperature" as reference junction

I/O address space

I/O device 8 DI DC 24V 4×M12

Assignment in the process image inputs per device:

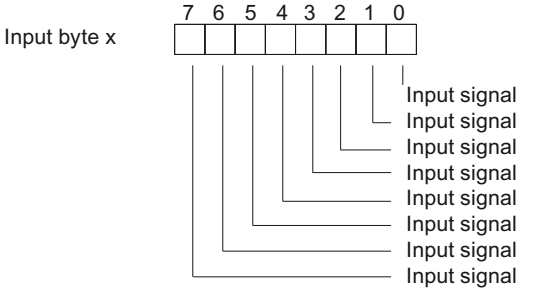


8 DI DC 24V 4xM12	Channel
X1 at pin 4	0
X2 at pin 4	1
X3 at pin 4	2
X4 at pin 4	3
X1 at pin 2	4
X2 at pin 2	5
X3 at pin 2	6
X4 at pin 2	7

Figure 1-796 Address space of 8 DI DC 24V 4×M12 I/O device

I/O device 8 DI DC 24V 8×M12

Assignment in the process image inputs per device:

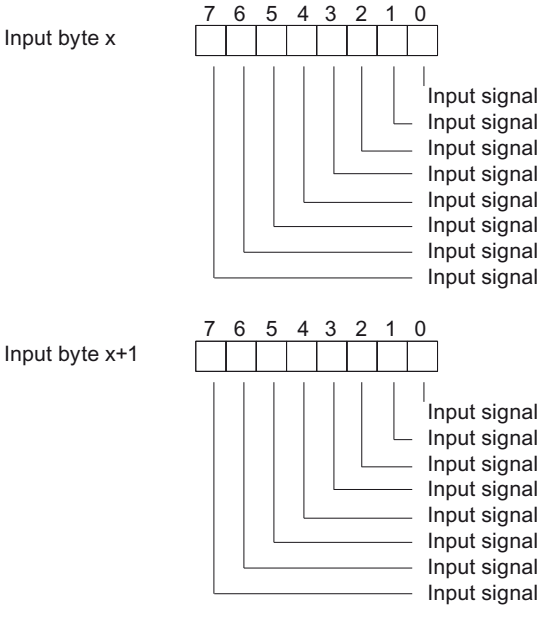


8 DI DC 24V 8xM12	Channel
X1 at pin 4	0
X2 at pin 4	1
X3 at pin 4	2
X4 at pin 4	3
X5 at pin 4	4
X6 at pin 4	5
X7 at pin 4	6
X8 at pin 4	7

Figure 1-797 Address space of 8DI DC 24V 8×M12 I/O device

I/O device 16 DI DC 24V 8×M12

Assignment in the process image inputs per device:

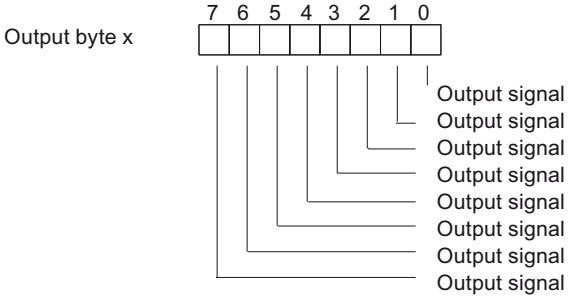


16 DI DC 24V 8xM12	Channel
X1 at pin 4	0
X2 at pin 4	1
X3 at pin 4	2
X4 at pin 4	3
X5 at pin 4	4
X6 at pin 4	5
X7 at pin 4	6
X8 at pin 4	7
X1 at pin 2	8
X2 at pin 2	9
X3 at pin 2	10
X4 at pin 2	11
X5 at pin 2	12
X6 at pin 2	13
X7 at pin 2	14
X8 at pin 2	15

Figure 1-798 Address space of 16 DI DC 24V 8×M12 I/O device

I/O device 8 DO DC 24V/1,3A 4×M12

Assignment in the process image output per device:

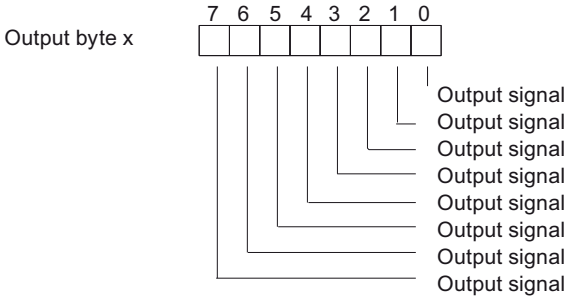


8 DO DC 24V/1,3A 4xM12	Channel	Supply voltage
X1 at pin 4	0	1L+
X2 at pin 4	1	
X3 at pin 4	2	2L+
X4 at pin 4	3	
X1 at pin 2	4	1L+
X2 at pin 2	5	
X3 at pin 2	6	2L+
X4 at pin 2	7	

Figure 1-799 Address space of 8 DO DC 24V/1,3A 4×M12 I/O device

I/O device 8 DO DC 24V/0,5A 4×M12

Assignment in the process image output per device:

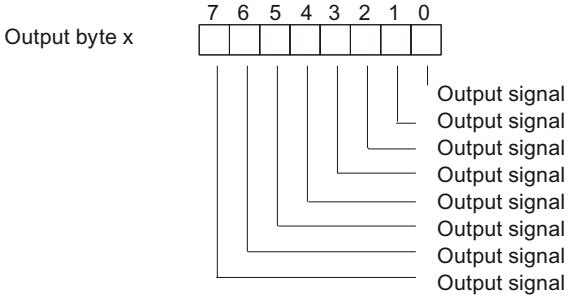


8 DO DC 24V/0,5A 4xM12	Channel	Supply voltage
X1 at pin 4	0	2L+
X2 at pin 4	1	
X3 at pin 4	2	
X4 at pin 4	3	
X1 at pin 2	4	
X2 at pin 2	5	
X3 at pin 2	6	
X4 at pin 2	7	

Figure 1-800 Address space of 8 DO DC 24V/0,5A 4×M12 I/O device

I/O device 8 DO DC 24V/1,3A 8×M12 and 8 DO DC 24V/2,0A 8×M12

Assignment in the process image output per device:

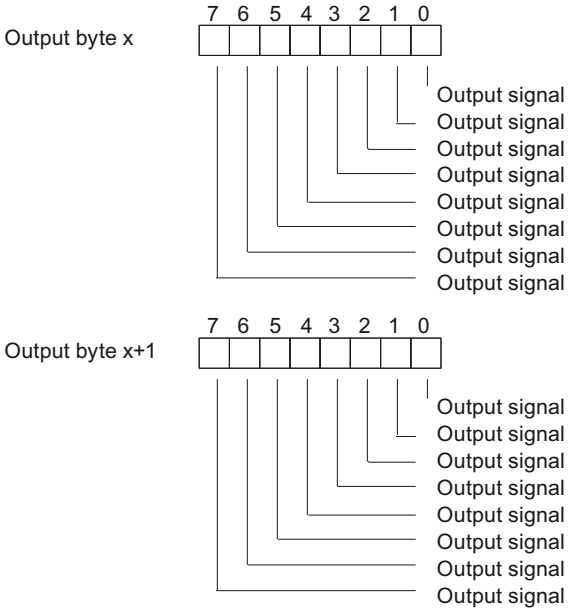


8 DO DC 24V/1,3A 8xM12	Channel	Supply voltage
X1 at pin 4	0	1L+
X2 at pin 4	1	
X3 at pin 4	2	
X4 at pin 4	3	
X5 at pin 4	4	2L+
X6 at pin 4	5	
X7 at pin 4	6	
X8 at pin 4	7	

Figure 1-801 Address space of I/O device 8 DO DC 24V/1,3A 8×M12 and 8 DO DC 24V/2,0A 8×M12

I/O device 16 DO DC 24V/1,3A 8×M12

Assignment in the process image output per device:

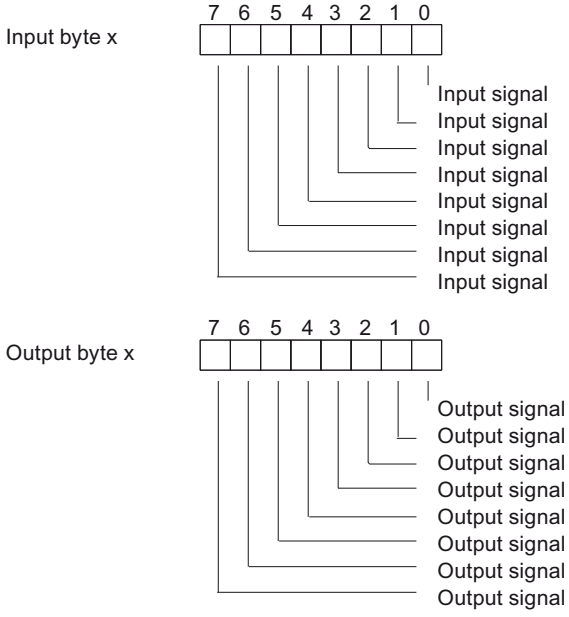


16 DO DC 24V/1,3A 4xM12	Channel	Supply voltage
X1 at pin 4	0	1L+
X2 at pin 4	1	
X3 at pin 4	2	
X4 at pin 4	3	
X5 at pin 4	4	2L+
X6 at pin 4	5	
X7 at pin 4	6	
X8 at pin 4	7	
X1 at pin 2	8	1L+
X2 at pin 2	9	
X3 at pin 2	10	
X4 at pin 2	11	
X5 at pin 2	12	2L+
X6 at pin 2	13	
X7 at pin 2	14	
X8 at pin 2	15	

Figure 1-802 Address space of 16 DO DC 24V/1,3A 8×M12 I/O device

I/O device 8 DIO DC 24V/1,3A 8×M12

Assignment in the process image inputs per device:



8 DIO DC 24V/1,3A 8xM12	Channel	Supply voltage
X1 at Pin 4	0	1L+
X2 at Pin 4	1	
X3 at Pin 4	2	
X4 at Pin 4	3	
X5 at Pin 4	4	2L+
X6 at Pin 4	5	
X7 at Pin 4	6	
X8 at Pin 4	7	
X1 at Pin 4	0	1L+
X2 at Pin 4	1	
X3 at Pin 4	2	
X4 at Pin 4	3	
X5 at Pin 4	4	2L+
X6 at Pin 4	5	
X7 at Pin 4	6	
X8 at Pin 4	7	

Figure 1-803 Address space of 8 DIO DC 24V/1,3A 8×M12 I/O device

I/O device 8 AI 4 U/I + 4 RTD/TC 8×M12

Assignment in the process image inputs per device:

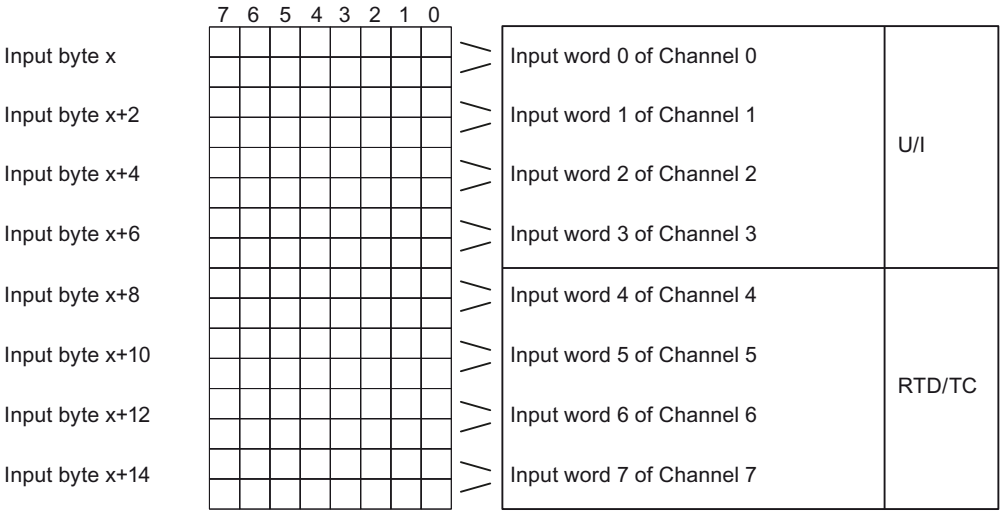


Figure 1-804 Address space of 8 AI 4 U/I + 4 RTD/TC 8×M12 I/O device

I/O device 8 AI RTD/TC 8×M12

Assignment in the process image inputs per device:

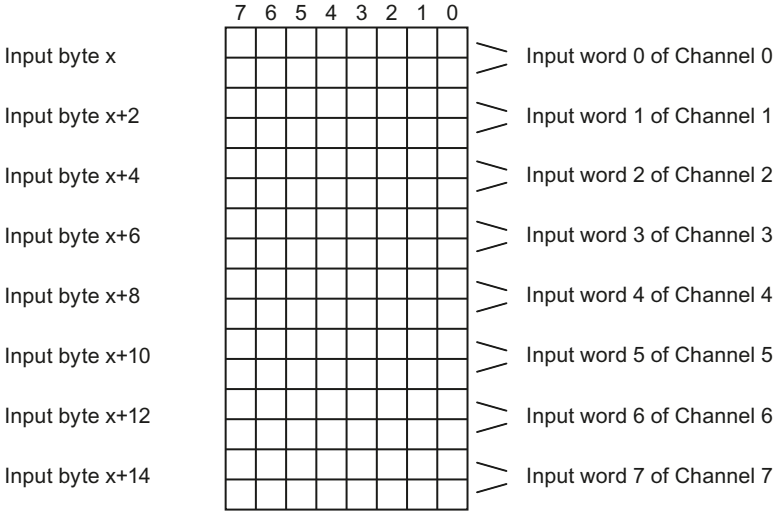


Figure 1-805 Address space of 8 AI RTD/TC 8×M12 I/O device

I/O device 4 AO U/I 4×M12

Assignment in the process image output per device:

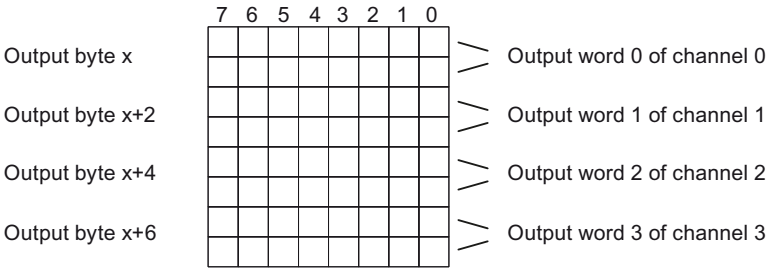


Figure 1-806 Address space of 4 AO U/I 4×M12 I/O device

IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12

During the STEP 7 configuration, you can select the address space according to use.

During GSD configuration, Slot 1 "4 IO-L" has fixed 32 bytes input and 32 bytes output. Addressing of the input and output data can be selected freely using *S7-PCT*.

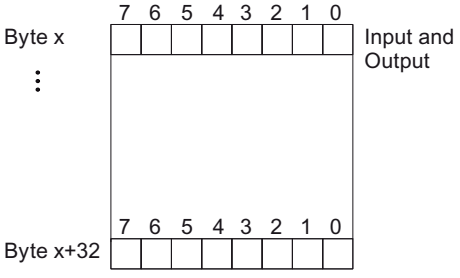
NOTE

Value status (PortQualifier)

The value status (PortQualifier) is disabled by default. An active value status (PortQualifier) is generally at byte x, bit 0 to bit 3. It can also be placed freely within the address space (byte x to x+32).

Assignment of the inputs and IO-Link channels as an example:

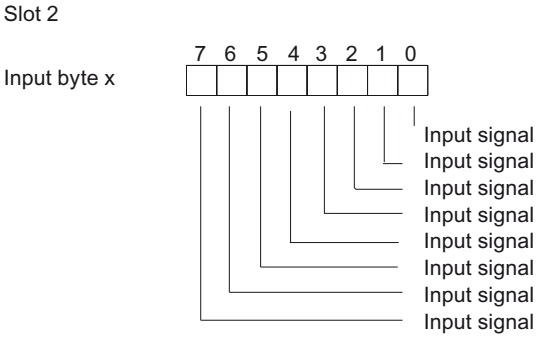
Slot 1



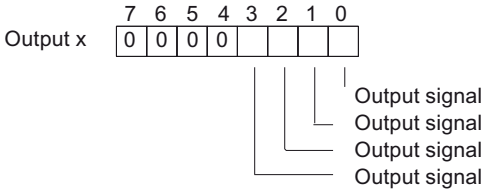
4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8xM12	Input signal	Diagnostic channel	Comment
X1 at Pin 4 X2 at Pin 4 X3 at Pin 4 X4 at Pin 4	1 2 3 4	1 2 3 4	The PCT-Tool takes over the partitioning of the IO-link-channels in the process image of the inputs and outputs and also the addressing of the value status (port qualifier)

Figure 1-807 Address space of the IO-Link channels of the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12

Slot "8 DI + 4DO" has its own address space. The scope amounts to one byte inputs and one byte outputs.



8 DI + 4 DO	Input signal	Diagnostic channel
X1 at Pin 2	0	No diagnostics
X2 at Pin 2	1	
X3 at Pin 2	2	
X4 at Pin 2	3	
X5 at Pin 4	4	4
X5 at Pin 2	5	5
X6 at Pin 4	6	6
X6 at Pin 2	7	7



4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8xM12	Output signal	Diagnostic channel	Supply voltage
X7 at Pin 4	0	0	2L+
X7 at Pin 2	1	1	
X8 at Pin 4	2	2	
X8 at Pin 2	3	3	

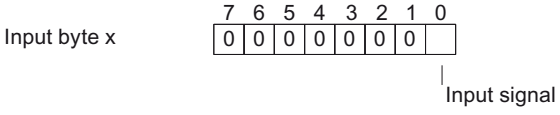
Figure 1-808 Address space of the inputs and outputs of the IO-Link Master 4 IO-L + 8 DI + 4 DO DC 24V/1,3A 8×M12

IO-Link Master 4 IO-L 4×M12

During the configuration, you can select the address space according to use.

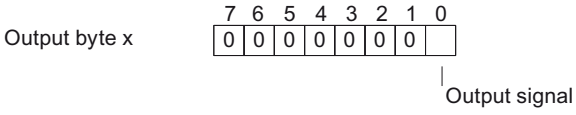
SIO mode

The following figures show the assignment of the address spaces of a submodule/port with the IO-Link Master 4 IO-L 4×M12, if you have configured the port as digital input or digital output in SIO mode.



4 IO-L 4xM12	Port
X1 at Pin 4	0
X2 at Pin 4	1
X3 at Pin 4	2
X4 at Pin 4	3

Figure 1-809 Address space of the inputs of the IO-Link Master 4 IO-L 4×M12 in SIO mode

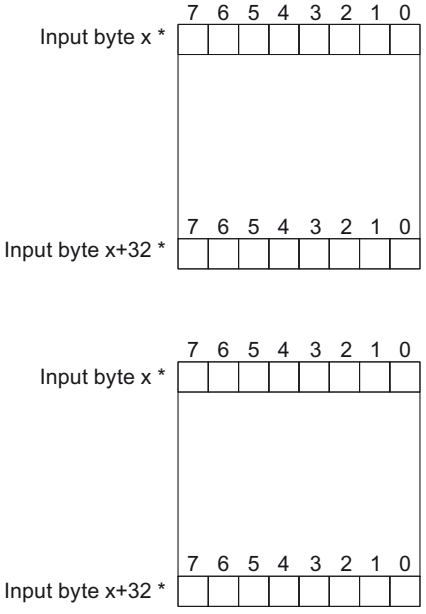


4 IO-L 4xM12	Port
X1 at Pin 4	0
X2 at Pin 4	1
X3 at Pin 4	2
X4 at Pin 4	3

Figure 1-810 Address space of the outputs of the IO-Link Master 4 IO-L 4×M12 in the SIO mode

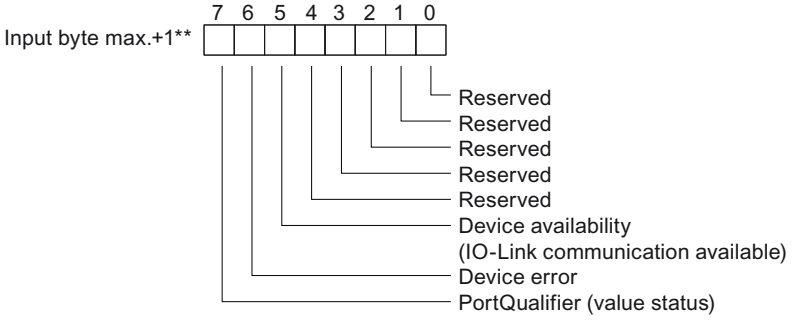
IO-Link mode

The following figure shows the assignment of the address spaces of a submodule/port with the IO-Link Master 4 IO-L 4×M12, if you have configured the port in IO-Link mode.



4 IO-L 4xM12	Channel
X1 at Pin 4	0
X2 at Pin 4	1
X3 at Pin 4	2
X4 at Pin 4	3

Port Qualifier Information (PQI)



* Detailed information on the assignment of the input and output bytes is available in the description of the IO-Link devices that are used.
** The PQI byte is always located behind the last input byte of the port. Depending on the configuration, the PQI byte is thus at byte 2, 3, 5, 9, 17 or 33 in the process input image.

Figure 1-811 Address space of the inputs and outputs and of the PQI byte of the IO-Link Master 4 IO-L 4×M12 in IO-Link mode

Response times for analog input device and output device

F

F.1 Response times for analog input device

Conversion time

The basic conversion time depends directly on the conversion method of the analog input channel (integrating method, instantaneous value conversion). For the integrating conversion method, the integration time is included directly in the conversion time. The integration time depends on the interference frequency suppression.

For information on the basic conversion times and additional processing times of the individual analog devices, refer to the technical data of the corresponding analog I/O device.

Cycle time

The analog-digital conversion and the transfer of the digitized measured values to memory or to the backplane bus take place sequentially. In other words, the analog input channels are converted one after the other. The cycle time, that is, the time until an analog input value is converted again, is the sum of the conversion times of all the activated analog input channels of the analog input devices. You should deactivate unused analog input channels during parameter assignment in order to reduce the cycle time. The conversion and integration time for a deactivated channel is 0.

The figure below provides an overview of the cycle time elements of an n-channel analog input device.

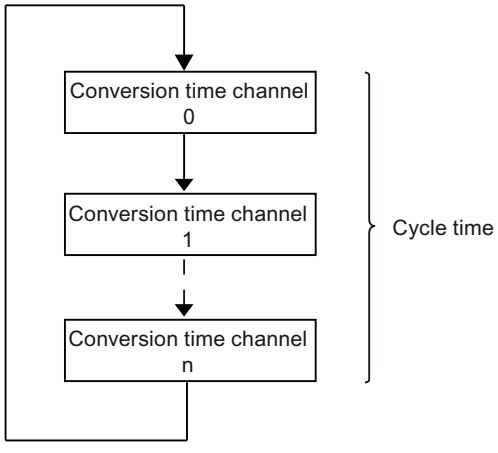


Figure 1-812 Cycle time for analog input devices

Settling time

See *Smoothing*.

F.2 Response times for analog output device

Conversion time

The conversion time of the analog output channels includes the transfer of digitized output values from internal memory, and their digital-to-analog conversion.

Cycle time

The analog output channels are converted for the device with an execution time plus the sequential conversion time for channels 0, 1, 2, and 3.

The cycle time, i.e., the time until an analog output value is converted again, is the sum of the conversion times of all the activated analog output channels and of the processing time of the analog output device. You should deactivate unused analog output channels during parameter assignment in order to reduce the cycle time. The conversion time for a deactivated channel is 0 ms.

The following figure provides you with an overview of the cycle time elements for an analog output device.

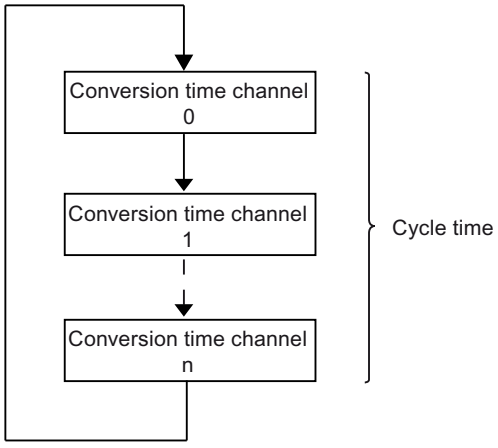


Figure 1-813 Cycle time of analog output modules

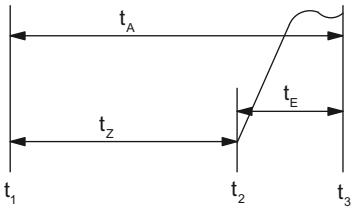
Settling time

The settling time (t_2 to t_3)—that is, the time from the application of the converted value until the specified value is reached at the analog output—depends on the load. We therefore distinguish between resistive, capacitive, and inductive loads.

Response time

The response time (t_1 to t_3)—that is, the time from the application of the digital output values in internal memory until the specified value is reached at the analog output—is, in the most unfavorable case, the sum of the cycle time and the settling time. The worst case scenario is when the analog channel has been converted immediately before a new output value is transferred and is not converted again until all other channels have been converted (cycle time).

This figure shows the response time of an analog output channel:



t_A Response time

t_Z Cycle time, corresponding to the processing time of the device and the conversion time of the channel

t_E Settling time

t_1 New digital output value applied

t_2 Output value transferred and converted

t_3 Specified output value obtained

Figure 1-814 Response time of an analog output channel

Fail-safe shutdown of ET 200eco PN standard modules

G

G.1 Back-up oriented shutdown of ET 200eco PN standard modules

Introduction

The following structure describes how to perform a fail-safe shutdown of ET 200eco PN standard modules.

In the configuration shown in the diagram below (e.g. with the safety shutdown device 3SK1), all digital outputs that are connected to the 2L+ and 2M supply (24 V switched) of the ET 200eco PN standard modules are switched to the safe OFF state. This step achieves the safety class SIL2/category 3/PL d.

Principle of operation

The higher-level safety shutdown device (e.g. 3SK1) disconnects the supply 2L+ and 2M switched. The digital outputs of the ET 200eco PN standard modules operated at the 2L+ and 2M (24 V switched) supply are switched to the safe state. The digital outputs connected to the supply 1L+ and 1M (24 V non-switched) are not intended for switching under normal operating conditions and cannot be safely shutdown.

There is no opposite influence of the outputs.

⚠ WARNING

Pay attention to the potential groups

When a digital output is connected to a digital input, pay attention to the respective potential groups. Depending on the configuration, 1M and 2M can then be connected, resulting in elimination of the electrical isolation between 1L+ and 2L+. In this case, a safety-oriented shutdown is not possible.

Block diagram

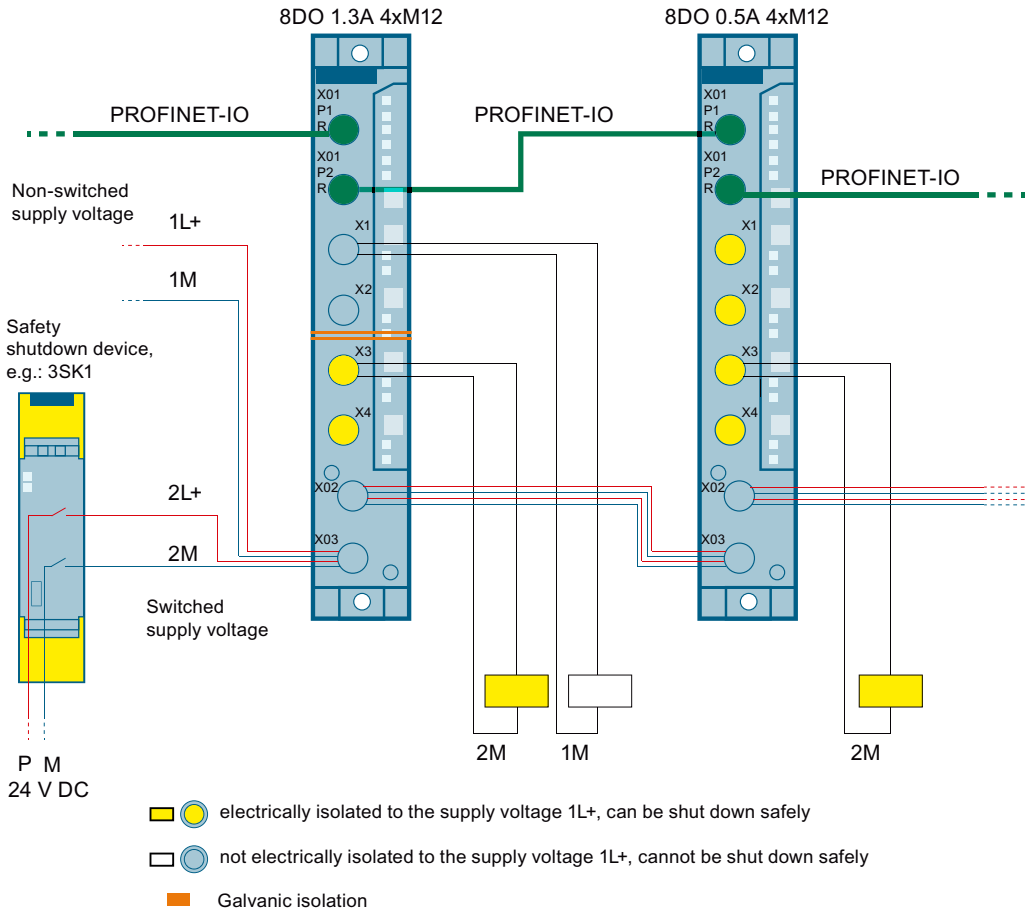


Figure 1-815 Higher-level safety shutdown of the outputs

WARNING

When you use a pp-switching safety shutdown device, the power supply cable for connection of the ET 200eco PN modules must be routed cross-circuit proof.
Note the requirements of the standard EN 60204-1, "Cross-circuit proof routing".

NOTE

Maintain safe electrical isolation for voltages higher than SELV/PELV.

Limits of the higher-level safety circuit

The ET 200eco PN standard modules do not fulfill any safety functions. Safety functions are performed by the safety relay or the F-switch to bring the system into a safe state.
Adjust the operation inspection interval of the safety relay with relay output according to the safety class.
Take the following measures if energy that is not provided by the higher-level safety circuit is used to control the safety function.

Cover critical errors in the safety function that are not detected by the higher-level safety circuit (e.g. 3SK1, F-switch etc.) with suitable safety measures. The "diagnostics" must be performed indirectly via the controlled process.

Specifications for safety-relevant process data:

- Functionally safe
- Read via fail-safe inputs (e.g. F-DI)
- Fail-safe processing unit (e.g. F-CPU) for issuing commands
- Output through fail-safe outputs (e.g. F-DQ) to control the safety function

Requirements on the power supply

Operation requires a SELV/PELV power supply to limit overvoltages to L+ and M (24 V). This measure prevents possible errors from the power supply side at the same time.

Select the power supply according to the requirements of the respective operating instructions for the shutdown device or for the ET 200eco PN system.

You can find more information on safe SELV/PELV in the data sheets of the power supplies used.

FAQ

Read the latest information on safety-related shutdown in the FAQ (https://support.industry.siemens.com/cs/ww/en/view/39198632).

In this FAQ, you will find the SIMATIC standard modules that are suitable for safety-related shutdown.

Request German Technical Inspectorate report (Report no. SN95432T)

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SIMATIC

ET 200eco PN M12-L F-DI 4x24VDC + F-DQ 2x24VDC/2A PM + DIQ 4x24VDC + CM 1xIO-Link, M12-L, 7xM12 (6ES7146-6FF00-0BB0)

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Introduction

1

1.1 General information ET 200eco PN Master

Purpose of the documentation

This equipment manual supplements the ET 200eco PN M12-L Distributed I/O System manual (https://support.industry.siemens.com/cs/us/en/view/109778292). Functions that relate in general to the distributed I/O devices ET 200eco PN M12-L are described in the system manual.

The information provided in this equipment manual, in the system manual, and in the functional manuals supports you in commissioning ET 200eco PN M12-L F distributed I/O devices.

Conventions

For the sake of readability, this manual refers to the module as the "ET 200eco PN M12-L F".

ID link for the digital nameplate



The ID link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product.

The figure shows an example of an ID link for the ET 200eco PN M12-L F.

You can recognize the ID link by the frame with a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Access the ID link.

In the digital nameplate, you can find product data, manuals, declarations of conformity, certificates and other helpful information about your product.

⚠ WARNING

Risks when using a cellular phone in close proximity to an ET 200eco PN M12-L F module

Using a cellular phone in close proximity to an ET 200eco PN M12-L F module with cellular and Wi-Fi communications active can cause unpredictable behavior.

To reduce any influence of a cellular phone on the ET 200eco PN M12-L F module, and to ensure proper operation of your devices, place the phone in "Airplane mode" to disable cellular and Wi-Fi before bringing the phone into proximity (<10 cm) of the device.

Failure to comply with these guidelines can cause damage or unpredictable operation, which could result in death, severe personal injury, and/or property damage.

Industry Mall

The Industry Mall is the catalog and order system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

Certifications and approvals

Refer to the technical specifications (Page 110)for details on certifications and approvals.

Glossary

The definitions in the glossary provide an easy first reference for understanding the terms in this manual. Some terms have detailed formal definitions in IEC 61508, EN ISO 13849, IEC 61784-3-3, and associated standards. These terms refer to broad safety concepts, for which the standards provide specific details.

1.2 Documentation guide

Basic information

The *SIMATIC ET 200eco PN Distributed I/O system ET 200eco PN M12-L System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109778292) describes in detail the configuration, installation, wiring, and commissioning of the SIMATIC ET 200eco PN M12-L distributed I/O system. The TIA Portal Information System supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics, and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200eco PN M12-L distributed I/O system; for example, diagnostics, communication, Motion Control, and Web server.

Manual Collection ET 200eco PN M12-L

The Manual Collection (https://support.industry.siemens.com/cs/us/en/view/109781058) contains the complete documentation on the SIMATIC ET 200eco PN M12-L distributed I/O system gathered together in one file.

TIA Selection Tool

With the TIA Selection Tool (https://support.industry.siemens.com/cs/us/en/view/109767888), you can select, configure, and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) to perform commissioning and maintenance activities on various SIMATIC devices as operations independent of TIA Portal. The supported devices are listed in the SIMATIC Automation Tool Device Catalog within the SIMATIC Automation Tool.

For more information, refer to the SIMATIC Automation Tool user guide (https://support.industry.siemens.com/cs/ww/en/view/109827741).

PRONETA

SIEMENS PRONETA (https://support.industry.siemens.com/cs/ww/en/view/67460624) (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks.

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used.

SINETPLAN

SINETPLAN (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html), the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

Safety technology support

Siemens provides the following online comprehensive support for your use of safety technology:

- Safety Evaluation Tool (https://support.industry.siemens.com/cs/us/en/view/109767888) - assists you in determining required safety levels.
- Siemens training (SITRAIN) classes (https://www.siemens.com/global/en/products/services/digital-enterprise-services/training-services/sitrain.html?gclid=EAIaIQobChMIlvun-NDEhgMVHYVaBR2NkQM0EAAYASAAEgLFe_D_BwE&acz=1&gad_source=1) - offers training in safety standards and products.
- SIMATIC STEP 7 Safety Advance F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT_calculator) (https://support.industry.siemens.com/cs/ww/en/view/58856512) - assists you in calculating your maximum system response time.

1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:



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Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 S7 Port Configuration Tool (S7-PCT)

The S7 Port Configuration Tool (S7-PCT) is a PC-based software for the parameter assignment of Siemens IO-Link Master modules and IO-Link devices from any manufacturer.

You integrate IO-Link (https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html) devices using the standardized device description, which you get from the device manufacturer. S7-PCT supports V1.0 and V1.1 of the IO-Link Device Description (IODD).

The hardware configuration of the IO-Link Master in STEP 7 calls the S7-PCT. When STEP 7 is not used, or the IO-Link Master is not operated on a SIMATIC controller, "standalone" operation is not possible.

1.5 S7 Fail-safe Configuration Tool (S7-FCT)

The SIMATIC S7 Fail-safe Configuration Tool (S7-FCT)
(https://support.industry.siemens.com/cs/us/en/view/109762827) allows you to use selected functionally fail-safe SIMATIC I/O devices and the SIRIUS ACT PROFINET interface from SIEMENS in an engineering system from a third-party manufacturer.

You can assign the F-source and F-destination address of a fail-safe SIMATIC I/O device and support the calculation and provision of the F_iPar_CRC in STEP 7.

For more information on using the S7-FCT, refer to "Configuring ET 200eco PN F-IO M12-L Fail-safe modules with a GSDML file".
(https://support.industry.siemens.com/cs/ww/en/view/109976831)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the SIMATIC ET 200eco PN Distributed I/O system ET 200eco PN M12-L (https://support.industry.siemens.com/cs/us/en/view/109778292) System Manual for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
The security "Defense in Depth" strategy for the product to support installation, operation, and maintenance	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Guidelines for performing security hardening during installation and maintenance of the product	This information can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Security properties of the product	
Access protection	Note the information on the topic of access protection in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications (https://support.industry.siemens.com/cs/ww/en/view/109994978/188110615563). You can find detailed information on supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols, and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925). Note exceptions outlined in the Communication protocols and ports Appendix (Page 128).
Secure operation	
Recommendations for safe operation	Information on the safe operation of the module can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).

Topics with cybersecurity-relevant information	Reference
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://www.siemens.com/global/en/products/services/cert.html) web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Account management guidelines	You can find Information on access control, user rights, and default accounts in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Security events	You can find a list of all events in Fault types, causes, and corrective measures (Page 67).
Security update notifications	You can find Information on security patches for dependent components and operating systems and how to install them in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292).
Integrity	
Integrity of documentation and other important files	You can find information on how to verify the integrity of documentation and file downloads like firmware updates using checksums on the SiePortal (https://support.industry.siemens.com/cs/ww/en/view/109483101) website.

Product overview

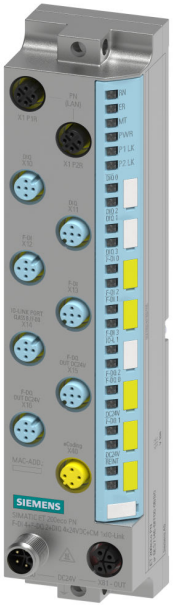
3

3.1 Properties

Article Number

6ES7146-6FF00-0BB0

View of the Module



Properties

The ET 200eco PN M12-L F module is a PROFINET device that combines different I/O architectures into a single module. The module incorporates fail-safe I/O, standard I/O, and IO-Link ports. It includes built-in distributed PROFINET device capability which does not require the presence of a head-module. The ET 200eco PN M12-L F module is IP65 and IP67 compliant and is capable of being installed independently from typical IP20 control cabinetry.

The module has the following technical properties:

- Two M12-L module voltage ports, which contain both logic and input power (1L+) and output power (2L+) and can provide power to the next module by means of a daisy chain
- Two PROFINET M12 communication ports

- Eight M12 connector ports
  - Two connectors for fail-safe inputs, supporting four 1oo1 (1 out of 1) inputs or two 1oo2 (1 out of 2) inputs
  - Two connectors for fail-safe outputs, supporting two PM outputs with optional provision of 1L+ power to support safety shutdown applications
  - Two connectors for standard I/O, supporting four DIQ points
  - One connector for an IO-Link Class B port with optional provision for safety shutdown or optional safety PM output
  - One connector for a specialized eCoding plug whose purpose is safety address storage

Accessories

The module package includes the following components:

- Identification labels (yellow and white)
- eCoding plug (used to store the application's PROFIsafe addresses)

Other components

You can order the following components as spare parts:

- Identification labels (yellow and white)
- eCoding plug

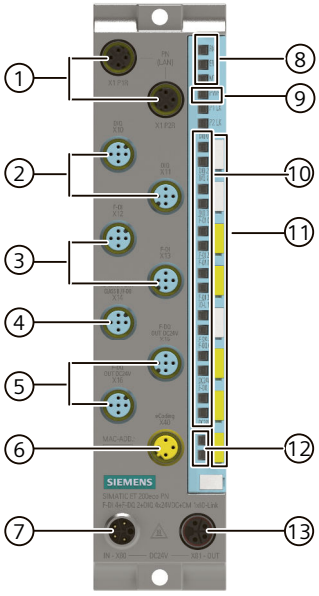
You can order the following components as accessories:

- Mounting rail
- Connectors and cables
- M12 sealing cap

You can find more information on accessories in "Accessories/spare parts" in the *SIMATIC ET 200eco PN Distributed I/O system ET 200eco PN M12-L system manual* (https://support.industry.siemens.com/cs/us/en/view/109778292).

3.2 Operator controls and display elements

The figure below shows the operator controls and display elements of the ET 200eco PN M12-L F module:



① X1 P1R / X1 P2R: Connector for PROFINET I/O
② X10 / X11: Connector for standard DIQ x2 (each)
③ X12 / X13: Connector for F-DI and sensor supply x2 (each)
④ X14: Connector for IO-Link Class B or F-DQ
⑤ X15 / X16: Connector for F-DQ on 2L+ and 1L+ switch (each)
⑥ X40: Connector for eCoding Plug
⑦ X80: Socket for voltage infeed
⑧ LED indicators for module status/fault (RUN, ERROR, MAINT)
⑨ PWR: LED status for load voltage 2L+
⑩ LED status for channel status/fault
⑪ Removable I/O labels (yellow = fail-safe I/O, white = standard I/O)
⑫ Reintegration LED
⑬ X81: Socket for loop-through of the voltage

Figure 1-816 Operator controls and display elements

3.3 Functions

The module supports the following functions:

Module

- PROFINET device
- Shared device
- Firmware update
- Identification and maintenance data I&M0 to I&M3

Fail-safe

- Fail-safe digital inputs
- Fail-safe digital outputs
- Embedded safety functions
- Safety shutdown of standard outputs

Standard

- IO-Link
- Standard digital inputs/outputs

3.3.1 Hardware and software components

Fail-safe CPUs

You can use any of the following fail-safe CPUs with the ET 200eco PN M12-L F module:

- S7-1200 F/S7-1200 G2 F
- S7-1500 F
- ET 200SP F

A fail-safe system requires a fail-safe CPU with fail-safe central I/O and/or fail-safe distributed I/O.

Required software components

You require a STEP 7 V20 Basic / Professional license, which includes STEP 7 Safety Basic as an integral product.

STEP 7 V20 is the configuration and programming software for the SIMATIC Safety fail-safe system. STEP 7 V20 includes the following:

- Support for configuring the fail-safe CPUs and I/O in the hardware and network editor of the TIA Portal
- Support for creating the safety program using LAD and FBD to integrate error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD

You also require a Hardware Support Package (HSP) which corresponds with used devices and their firmware versions.

3.3.2 Fail-safe functions

3.3.2.1 Fail-safe digital inputs

The fail-safe digital inputs of the ET 200eco PN M12-L F module are rated for connection to 24 V DC sensors/switches and 3/4-wire proximity switches (for example, BEROs: no-touch sensors) and have an EN61131-2 Type 3 input rating.

The fail-safe module has four sensor supply outputs that can power external sensors (inputs). You can configure each fail-safe input channel to provide 24 V sensor power from the module or to provide external 24 V sensor power.

You can integrate these sensors directly as inputs into safety functions, which are embedded within this F-module to control F-outputs. By configuring the F-inputs in this way, you can achieve faster reaction times when the Emergency Stop and/or Internal Evaluation safety functions use these sensors.

Inputs and test circuit

The fail-safe digital inputs consist of four input channels (F-DI x.0 to x.3). You can configure these inputs as four 1 out of 1 (1oo1) inputs (SIL 2/Cat. 3/PL d), two 1 out of 2 (1oo2) inputs (SIL 3/Cat. 3 or Cat. 4/PL e), or combinations of 1oo1 and 1oo2 inputs.

Connections	Input channel pairs
X12	0 and 2
X13	1 and 3

One microcontroller monitors inputs 0 and 1, and the other microcontroller monitors inputs 2 and 3. The corresponding channels (0, 2) and (1, 3) each form a 1oo2 channel group. The first of the two fail-safe inputs conveys the signal in a 1oo2 configuration. For example, if you wire x.0 and x.2 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal appears at only the x.0 input when you close or open the circuit for both. This also applies to the channel quality.

When you configure a channel group as 1oo2, the two microcontrollers must sense an appropriate input change within a configured time. Otherwise, the module reports a discrepancy error.

If you use a sensor supply output to provide power to a sensor, you can enable short-circuit testing. The short-circuit test checks for shorts to 24 V DC on your inputs by periodically pulsing the sensor output off and verifying that the associated input is off. The sensor supply can also detect shorts to 24 V DC and ground on the sensor supply itself, as well as cross-connected shorts between sensor supplies and inputs.

3.3.2.2 Fail-safe digital outputs

The fail-safe digital outputs of the ET 200eco PN M12-L F are for use in fail-safe applications and are suitable for various actuators including solenoid valves, DC contactors, and indicator LEDs. The two fail-safe digital outputs have P- and M-switching that are rated for connections to 24 V DC actuators with up to a 2.0 A rating, and a third additional PM output is optionally configurable. The fail-safe digital outputs use the supply voltage 2L+.

The fail-safe digital outputs consist of three output channels (F-DQ x.0, x.1, and, optionally, x.2). The fail-safe output F-DQ x.2 is shared with the IO-Link Class B port and can be configured to operate solely as an F-DQ for a third fail-safe digital output. You can use each

output for SIL 3 applications; however, F-DQ x.2 must be configured to "Operate as F-DQ only" for these applications.

Connections	Output channel
X14	IO-Link Class B / 2
X15	0
X16	1

Each output consists of two switches:

- A P-switch connects 24 V DC positive (L+) through the load.
- An M-switch connects the load to M or 24 V DC return.

When you enable an output, both switches are turned ON, which allows current to flow through the load.

The fail-safe digital outputs use two microcontrollers to implement the safety function. One microcontroller controls the P-switch while the other microcontroller controls the M-switch. There is feedback from the P-switch output to the other microcontroller that is controlling the M-switch. Likewise, there is feedback from the M-switch output to the other microcontroller that is controlling the P-switch. The feedback verifies that the output switches are operating properly and in the commanded state.

You can configure a "Maximum readback time" in STEP 7 device configuration that specifies the maximum amount of time that the output channel waits for the voltage to respond when the process value changes. The higher the capacitance of the connected load is, the higher your set value for "Maximum readback time" must be.

The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. Your configured "Maximum readback time" sets the duration of the "OFF" test pulse. Your configured "Maximum readback time switch on test" sets the duration of the "ON" test pulse. Choose short enough durations to not affect your load. You can disable the "OFF" test pulse during this switch test with the "Disable dark test" parameter.

The module can detect a broken wire or missing load only when the output PV is "OFF" and the load is wired in PM mode.

The module provides overload protection through current measurement of the P-outputs when the output is ON. M-outputs are short-circuit protected, but are not monitored for over-current.

Safety shutdown

You can configure outputs F-DQ x.0 and x.1 to operate in the following fail-safe modes:

- "Operate as F-DQ only"
- "Operate as F-DQ with Safety shutdown"

You can configure output F-DQ x.2 to operate in the following fail-safe mode:

- "Operate as F-DQ only"

Configuring one of these outputs as "Operate as F-DQ only" provides switchable 2L+ 24 V DC power, while configuring as "Operate as F-DQ with Safety shutdown" provides switchable 2L+ 24 V DC power, as well as non-switchable 1L+ 24 V DC power. See Pin assignment of connectors (Page 36).

Output F-DQ x.2 can also operate in Safety shutdown mode, but it cannot simultaneously operate as an F-DQ if you select this mode.

⚠ WARNING

IO-Link port safety ratings
F-DQ x.2 is only rated for safety applications when you configure its "Channel operating Mode" as "Operate as F-DQ only".
You must ensure that F-DQ x.2 is configured appropriately for your intended application.
Attempting to use F-DQ x.2 as a fail-safe output configured for Class B operation could result in death, severe personal injury, and/or property damage.

NOTE

Parameterization of the IO-Link port
Because the IO-Link port can also serve as an F-DQ channel, when you change the parameter "Operating mode" under "IO-Link > Port 1 > Port configuration", the safety program always treats it as a safety parameter. Regardless of whether the port is currently configured as an F-DQ or as an IO-Link, the safety program requires that you input the safety program password.
In the absence of parameterization, such as in the case of CPU factory reset or upon module power up, the operating mode of the FDQ2 / IO-Link port operates as an IO-Link port.

3.3.2.3 Requirements for sensors and actuators for fail-safe modules

When using sensors and actuators in safety-related applications, observe the following general requirements:

⚠ WARNING

Safety-related responsibility
Instrumentation with sensors and actuators bears a considerable safety responsibility. Also bear in mind that sensors and actuators generally require proof-test intervals that are more frequent than the service life of Siemens products, which is generally 20 years.
The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. You can find a listing of values achieved by each F-module in its respective technical specifications.
To achieve the required safety class, suitably qualified sensors and actuators are necessary.
Failure to use suitably qualified sensors and actuators can result in death, severe personal injury, and/or property damage.

Additional sensor requirements

Generally, to achieve SIL 3/Cat. 3/PL e, a single-channel sensor is adequate. However, with a single-channel sensor, the sensor itself must be SIL 3/Cat. 3/PL e capable. Otherwise, two sensors must be used. To achieve SIL 3/Cat. 3/PL e, sensors must be connected to the module using two input channels.

⚠ WARNING

Additional sensor requirements
In the case of fail-safe input channels, the value "0" is output to the F-CPU after detection of faults. You need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.
Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).
Failure to ensure that sensors are implemented to ensure reliable reaction of the safety program can result in death, severe personal injury, and/or property damage.

Duration requirements for sensor signals

⚠ WARNING

Duration requirements for sensor signals
To ensure the correct detection of the sensor signals by fail-safe modules with input channels, you need to make sure that the sensor signals are output for a minimum duration.
For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.
Failure to ensure that the sensor signals are output for a sufficient duration can result in death, severe personal injury, and/or property damage.

Reliable detection by F-modules with input channels

The minimum duration of sensor signals for F-modules with input channels depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in "Fail-safe response times (Page 119)".

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output channels test the outputs at regular intervals. The F-module briefly turns off output channels that are turned on and turns on particular switches of output channels that are turned off. You can assign the maximum duration of the test pulses (dark and switch-on) with the "Max. readback time" and "Max. readback time switch on test" parameters, respectively.

Fast-reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration by changing the readback and readback switch-on test times correspondingly, or use actuators that have sufficient lag. Alternately, you can select "Disable Dark Test (max. SIL2, CAT3, PLd)"; however, this reduces the capability of the used output from SIL 3/Cat. 4/PL e to SIL 2/Cat. 3/PL d.

⚠ WARNING

Additional requirements for actuators
If the actuators switch voltages greater than 24 V DC (for example, 230 V AC), the outputs of a fail-safe output channel and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).
This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.
Failure to provide proper electrical isolation can result in death, severe personal injury, and/or property damage.

Technical specifications of sensors and actuators

Refer to the technical specifications (Page 110) to assist you in selecting sensors and actuators.

3.3.2.4 Crosstalk of digital input/output signals

Readback errors could occur on the F-DQ channels if the fail-safe digital output signals and fail-safe digital input signals are routed through a single cable.

Capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply test of the input channels, the steep switching edge of the output drivers caused by the coupling capacitance of the line could result in crosstalk to other non-activated output or input channels. This could then lead to a response of the readback circuit in these channels. The module detects a cross circuit/short-circuit, which leads to safety-related tripping.

To remedy this situation, do the following:

- Separate cables for fail-safe DQ channels and non-fail-safe DQ channels.
- Separate cables for F-DQ channels and F-DI channels.
- Couple relays or diodes in the outputs.
- Disable the sensor supply test if safety class requirements allow it.

Magnetic crosstalk

An inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

To remedy this situation, do the following:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

3.3.2.5 Embedded Safety Functions (ESFs)

The ET 200eco PN M12-L F module can perform additional important safety functions with local I/O, such as Emergency Stop, Internal Evaluation, and the chaining together of these safety functions. When using the ESFs, you can achieve significantly faster reaction times.

The module provides two configurable Emergency Stop safety functions and two configurable Internal Evaluation safety functions.

When using ESFs, the module can override the process value from the F-CPU to "0" if the module invokes an ESF. Additionally, when the F-CPU sets the module's output(s) to "1" and the module clears the invocation of the ESF, the module stops overriding the output. This allows the F-CPU to resume controlling the process value to the output(s). The following table explains this principle:

Table 1-1111 ESF truth table

F-CPU PV	ESF State	ESF PV Override	Output State	Description
0	Invoked	Override to 0	0	The ESF is overriding the process value from the F-CPU to "0".
0	Not invoked	No override	0	The F-CPU is in full control of the output(s).
1	Invoked	Override to 0	0	The ESF is overriding the process value from the F-CPU to "0".
1	Not invoked	No override	1	The F-CPU is in full control of the output(s).

The ESFs provide significantly faster reaction times when setting the output(s) to "0" than what can be achieved through the F-CPU safety program alone. ESFs allow the module to set the output(s) to "0" without the F-CPU safety program overhead and communication overhead from the total reaction time (Page 122).

NOTE

The numbered inputs for the ESFs, such as "Input #1" or "Emergency Stop 0", which are configurable in STEP 7 device configuration under "General > Safety Functions", do not correlate to the physical inputs of the fail-safe module.

Emergency Stop (Estop)

The module's Estop function is a safety measure used to de-energize the desired machine function(s). When activated in STEP 7 Device configuration under "Safety Functions" > "Emergency Stop" and subsequently downloaded, the module begins to evaluate the configured Estop input to determine the state of the Estop button.

When the module detects that the Estop button is pressed, the module overrides the process value provided from the F-CPU to "0". The configured Estop output is de-energized in this state. If you have configured the Estop "Stop category" parameter for delayed deactivation, then the output remains energized for the configured Estop "Delay time" before the module overrides the process value to "0".

When the module detects that the Estop button has been reset, the user acknowledgement process is initiated if the Estop "Acknowledge necessary" is set to "Manually using rising edge". The module enables the configured "Acknowledge requested output", indicating that the Estop is ready to be acknowledged. You can then perform acknowledgement with the configured "Acknowledge input".

Once acknowledgement is complete, the module removes the override of the process value from the F-CPU.

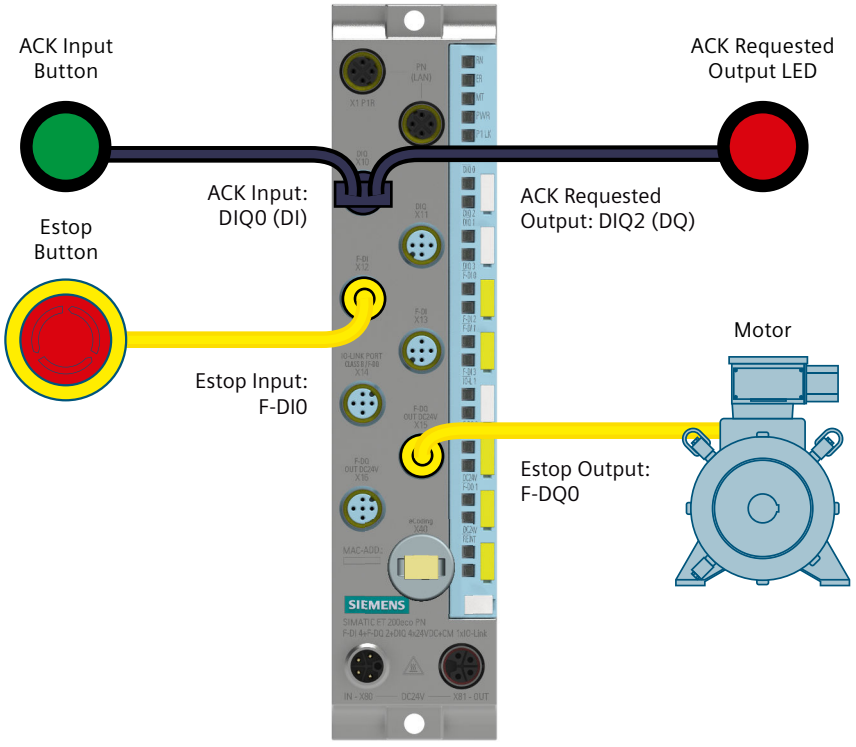


Figure 1-817 A motor controlled by the module's Estop with local I/O for acknowledgement process

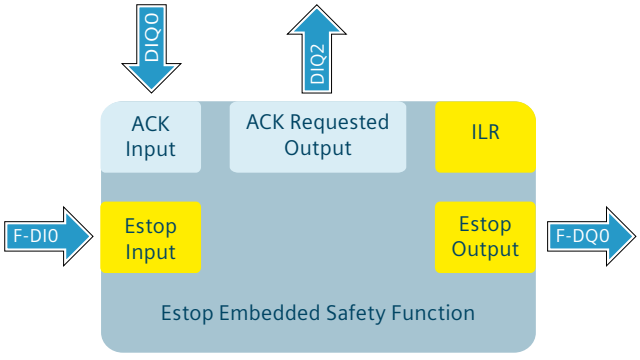


Figure 1-818 Visualization of module parameter assignment

Internal Evaluation (IE)

The module's IE function is a safety measure used to de-energize the desired machine function(s). When activated in STEP 7 Device configuration under "Safety Functions" > "Internal Evaluation" and subsequently downloaded, the module begins to evaluate the configured IE input(s) to determine the state of the connected sensor(s) and/or chained safety functions.

The IE safety function performs a Boolean "AND" operation on the configured input(s).

If the evaluation of the configured input(s) evaluates to "0", the module invokes the safety function and overrides the process value from the F-CPU to "0" to de-energize the configured output(s).

If the evaluation of the configured input(s) evaluates to "1", then the module does not override the configured output(s).

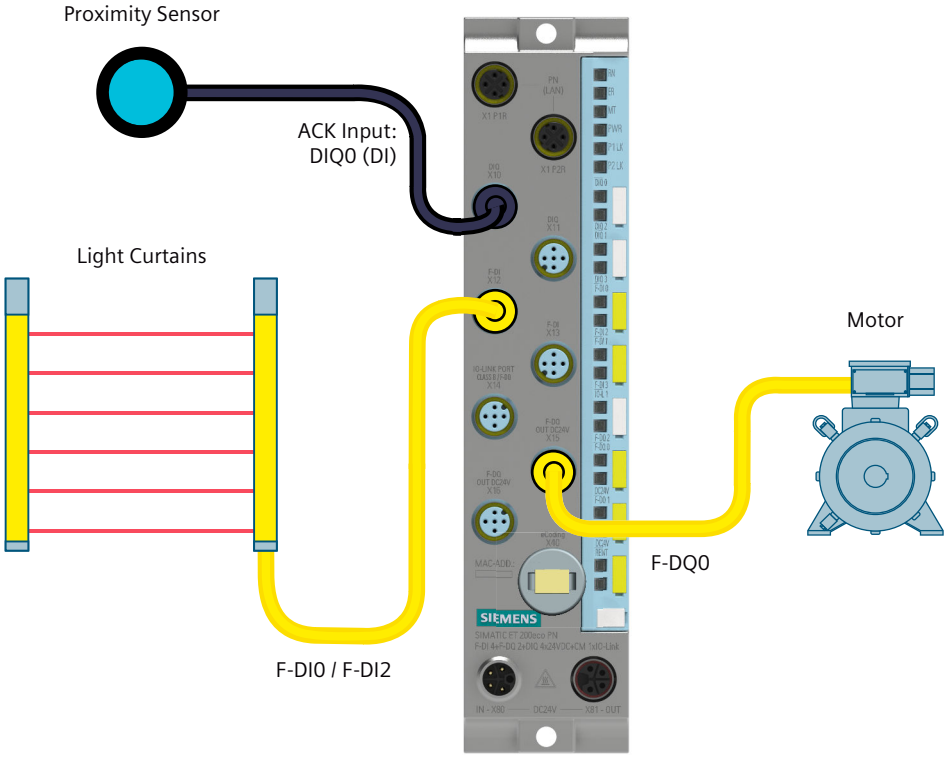


Figure 1-819 A motor controlled by the module's internal evaluation using light curtains

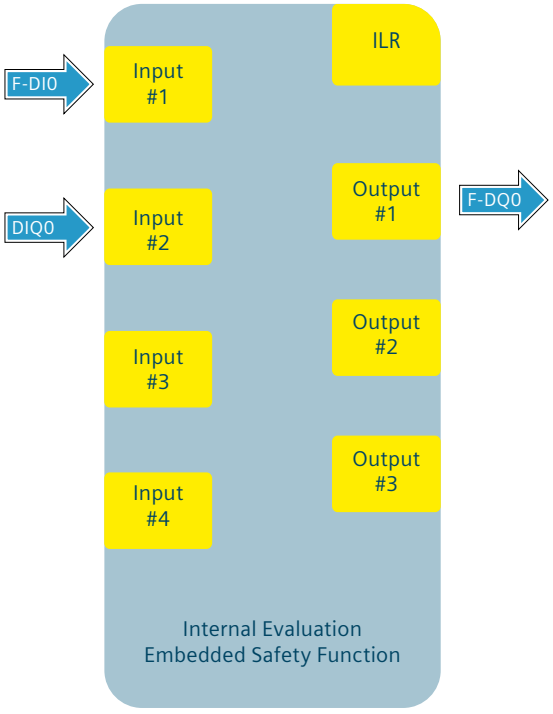


Figure 1-820 Visualization of module parameter assignment

Embedded safety function chaining

The ET 200eco PN M12-L F module allows for chaining of embedded safety function outputs to safety function inputs.

In addition to applying the evaluation result of the ESFs to the configured output(s), each ESF provides the result of its evaluation as an Internal Logic Result (ILR). The ILR for each ESF is accessible at all times through the process image and as an input to another ESF.

You create an ESF chain by configuring the input(s) of an ESF to the ILR of another ESF. You can configure these ESF chains in different ways.

NOTE

You must not create a circular dependency within an ESF chain. A circular dependency occurs when the ILR of an ESF is used in another ESF that precedes it.

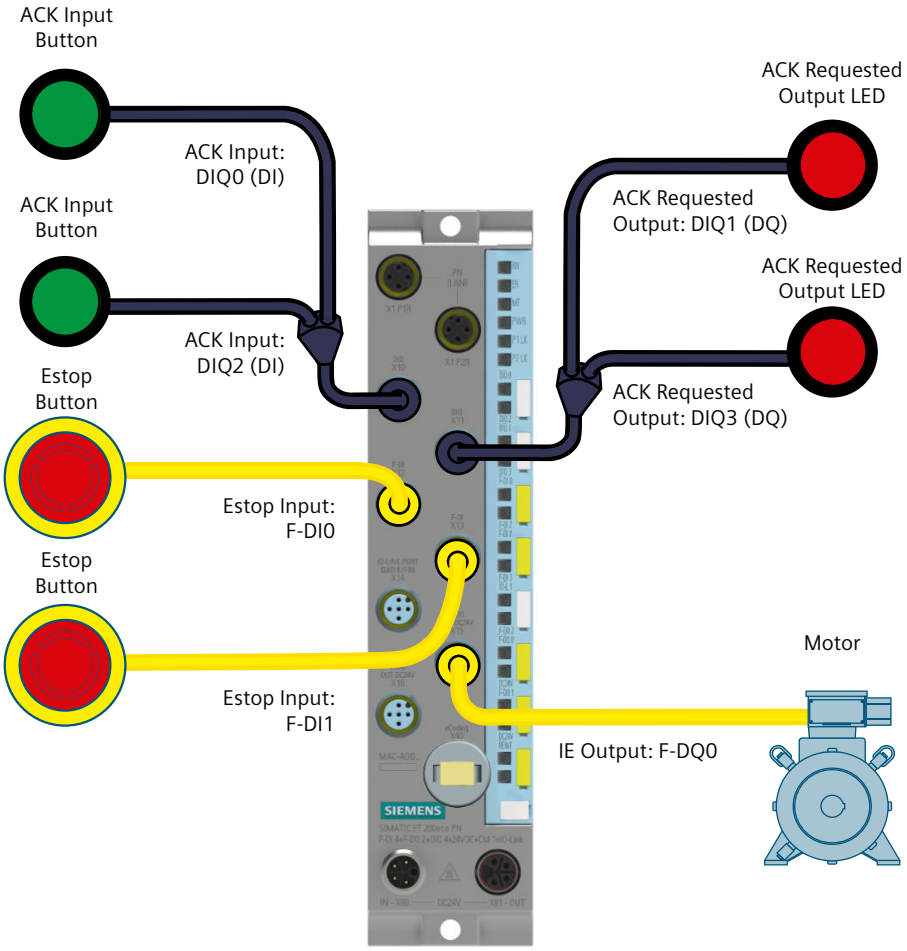


Figure 1-821 A motor controlled by the module's internal evaluation using two Estops

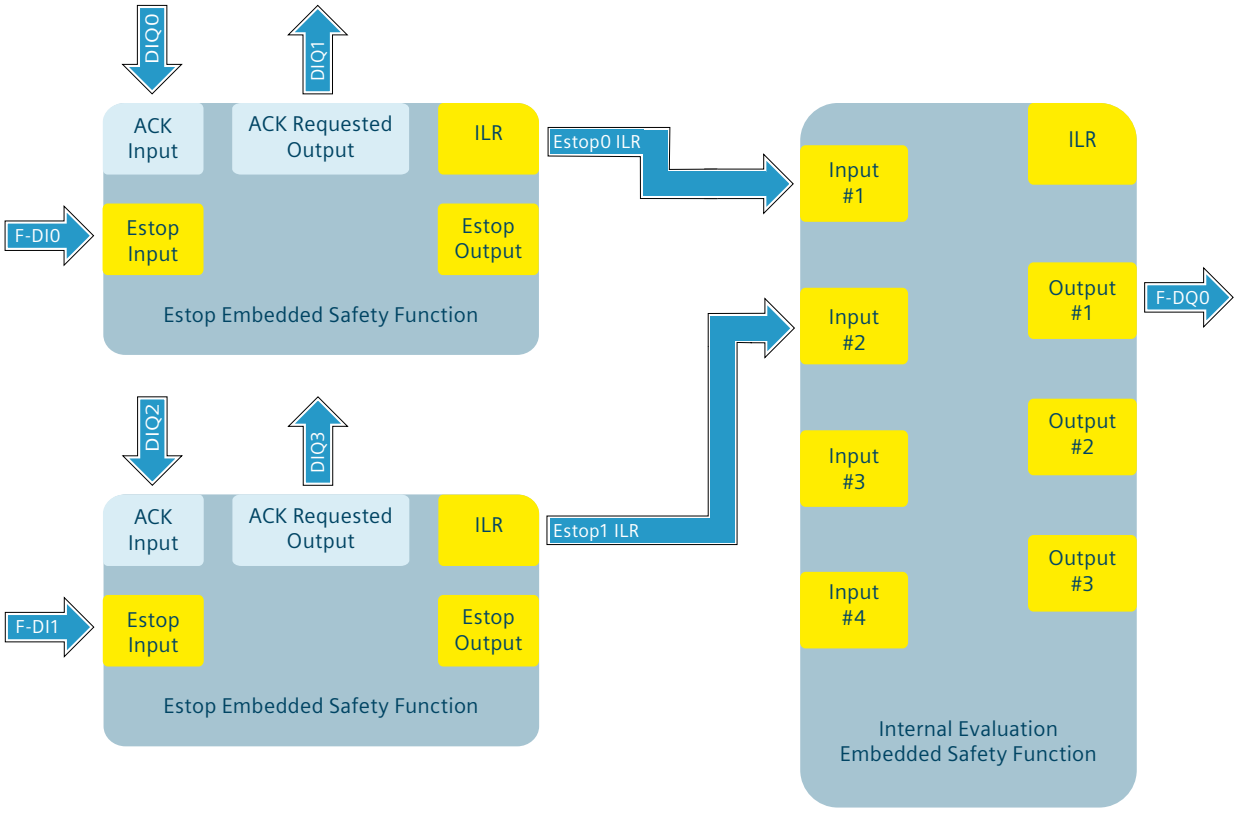


Figure 1-822 Visualization of module parameter assignment

3.3.3 Standard functions

3.3.3.1 IO-Link

IO-Link (https://support.industry.siemens.com/cs/us/en/view/65949252) is a point-to-point connection between an IO-Link master and an IO-Link device. On the IO-Link master, you can use IO-Link devices, as well as conventional sensors/actuators with unshielded standard cables using proven 3-wire technology. IO-Link is downward-compatible to conventional digital sensors and actuators. The switching state and data channels are designed with trusted 24 V DC technology.

Master backup

The "LIOLink_Master" function block is used to read all relevant IO-Link device and IO-Link master parameters. You can store these retentively at a central location, such as in a data block in the IO controller.

The "LIOLink_Master" function block can restore the status of the IO-Link devices or IO-Link ports stored in the IO-Link master. As a result, you can configure the IO-Link ports and the IO-Link master in STEP 7 with the values stored in the master backup.

A typical application is the restoration of parameters after replacement of the IO-Link master.

Port Qualifier Information (PQI)

Each port has Port Qualifier Information (PQI). This PQI provides information on the device status of the port and IO-Link. The PQI is transmitted cyclically with the process data. You cannot deactivate the PQI.

Port configuration

With an IO-Link master ET 200eco PN M12-L F, you can commission the IO-Link submodules (ports) of the IO-Link master or the connected IO-Link devices in two different ways:

- Port configuration with S7-PCT
- Port configuration without S7-PCT

NOTE

Shared device support and submodule assignment
You can assign standard I/O and IO Link submodules to either standard PLCs or fail-safe PLCs; however, you can only assign a PROFIsafe submodule to a fail-safe PLC.
Standard I/O and IO Link process data exchange are also independent of PROFIsafe process data exchange. Standard I/O data exchange is also performed when PROFIsafe data exchange is not operating.

Port configuration with S7-PCT

To configure the port with S7-PCT, do the following:

1. Deselect the "Autostart (without S7-PCT)" checkbox in the configuration of all IO-Link master submodules in STEP 7 (default).
2. Configure the IO-Link master with the Port Configuration Tool S7-PCT (PDCT) V3.5 SP3 or higher by activating the desired diagnostics.

Port configuration without S7-PCT

To configure the port without S7-PCT, do the following:

1. Select the "Autostart (without S7-PCT)" checkbox in the configuration of the IO-Link master submodule in STEP 7.
2. Configure the IO-Link master submodules directly in STEP 7 by activating the desired diagnostics.
3. Choose which mode you want the port to operate in:

- "IO-Link Autostart" (default)
- "IO-Link Manual"

3.3.3.2 Standard digital inputs/outputs

The standard digital inputs are rated for connection to 24 V DC sensors/switches and have an IEC 61131 Type 3 input rating. The standard digital outputs are rated for connection to 24 V DC and are configured as high-side outputs where a high side switch is connected to the high side of the load.

There are two sensor supply outputs provided for the standard digital inputs, which are assigned to the following connectors:

- X10: U_{S0}
- X11: U_{S1}

Inputs/outputs and test circuit

The standard DIQ consists of four channels (DIQ x.0 to x.3), which you can configure in any combination of inputs and outputs.

Connectors	Input/output channels
X10	0 and 2
X11	1 and 3

If you use a sensor supply output to provide power to a sensor, you can enable short-circuit testing. The short-circuit test checks for shorts to ground on your sensor supply. You can configure the DIQ channel to detect short-circuits. If the DIQ channel is configured as an input, then the short-circuit diagnostic detects short-circuits to ground on the sensor supply output. If the DIQ channel is configured as an output, then the short-circuit diagnostic detects short-circuits to ground and short-circuits to L+ on the output channel. The short-circuit test also detects cross-connected shorts between sensor supplies and inputs.

You can configure the DIQ channel to detect a broken wire when the channel is configured as an input.

The standard DIQ can also detect low voltage on 1L+ and trigger the "Undervoltage" maintenance event (Page 92).

You can set the reaction of the standard outputs to a CPU STOP using the parameters (Page 76) in STEP 7.

NOTE

Shared device support and submodule assignment

You can assign standard I/O and IO Link submodules to either standard PLCs or fail-safe PLCs; however, you can only assign a PROFIsafe submodule to a fail-safe PLC.

Standard I/O and IO Link process data exchange are also independent of PROFIsafe process data exchange. Standard I/O data exchange is also performed when PROFIsafe data exchange is not operating.

⚠ WARNING

Standard port safety ratings
Standard DIQ channels have no safety ratings and are not functionally safe. They should not be used in place of fail-safe I/O.
You must ensure that the appropriate I/O are used for your intended application.
Attempting to use standard I/O in place of fail-safe I/O in a safety related context could result in death, severe personal injury, and/or property damage.

Wiring

4

⚠ WARNING

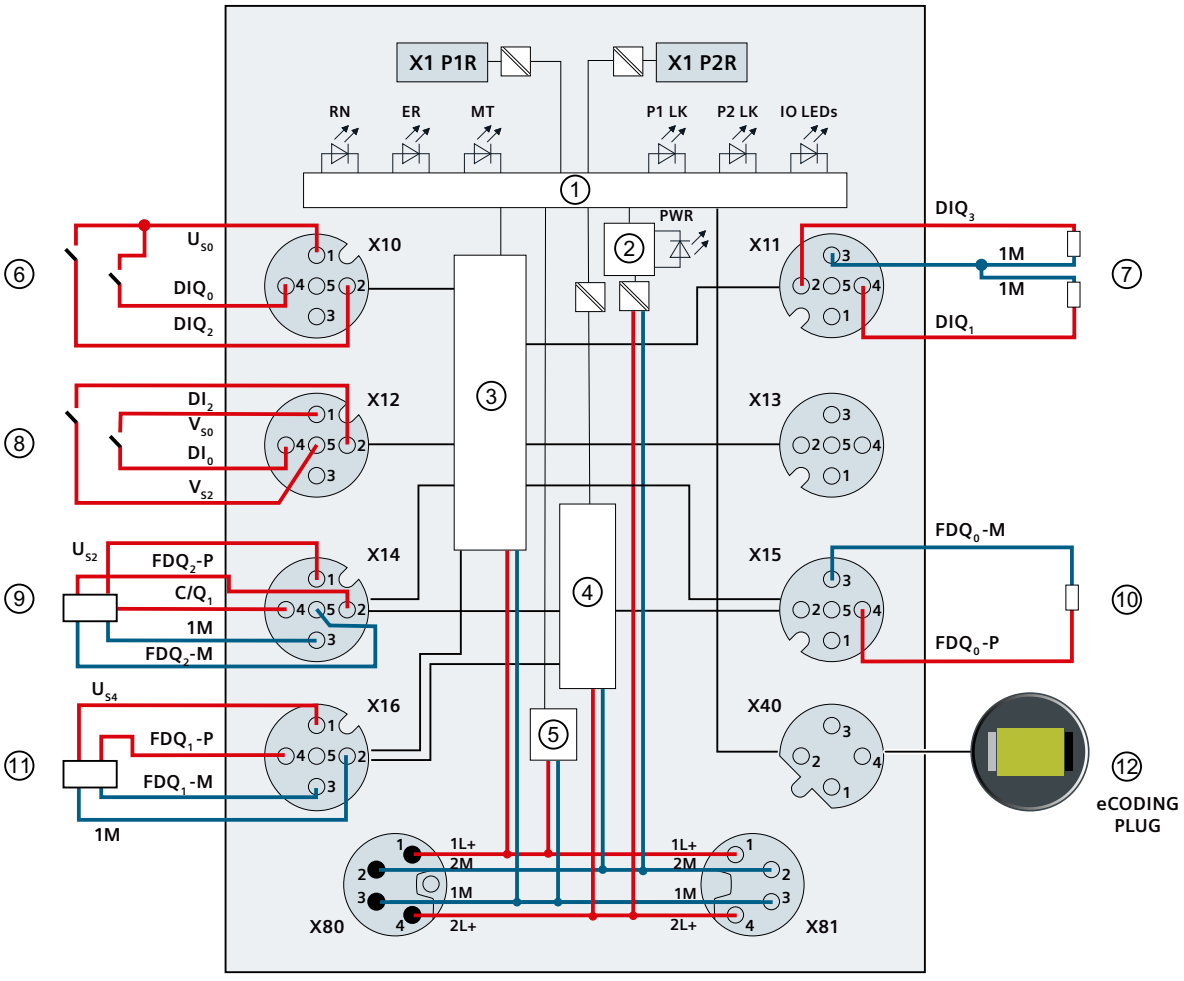
Contact with live electrical wires

You can come into contact with live electrical wires connected to the main power supply.

Shut off the supply and load voltage before you wire the fail-safe module.

Death, severe personal injury, and/or property damage could result if proper precautions are not taken.

4.1 Terminal and block diagram



1	Bus interface with integrated 2-port switch	7	DIQ channels configured as outputs
2	Diagnostic monitoring	8	F-DI with internal sensor supply power[1]
3	DIQ, F-DI, and IO-Link circuit (1L+)	9	IO-Link Class B[1]
4	F-DQ circuit	10	F-DQ[1]
5	Internal supply voltage	11	F-DQ with Safety shutdown[1]
6	DIQ channels configured as inputs	12	eCoding Plug

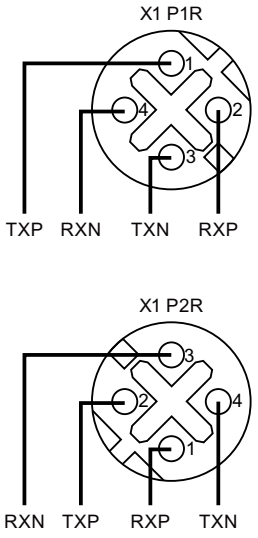
[1] See Application Mode (Page 94) descriptions for alternative wiring

4.2 Pin assignment of connectors

4.2.1 Pin assignment of the PROFINET connector

The module has two M12 connectors with four female pins that are D-coded.

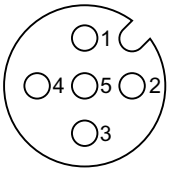
Table 1-1112 Pin assignment of the M12 cable connector for PROFINET connector, ports 1 and 2

Pin	Assignment	Front view of the sockets (PROFINET), port 1 and port 2
	Assignment X1 P1R	
1	TXP	
2	RXP	
3	TXN	
4	RXN	
Thread	Functional earth FE	
	Assignment X1 P2R	
1	RXP	
2	TXP	
3	RXN	
4	TXN	
Thread	Functional earth FE	

4.2.2 Pin assignment of standard inputs/outputs

The module has two M12 connectors with four female pins that are A-coded.

Table 1-1113 Pin assignment of Standard I/O (DIQ)

Pin	Assignment	Front view of the sockets (X10, X11)
1	24 V sensor supply U_{S0}: X10 24 V sensor supply U_{S1}: X11	
2	Standard I/O signal DIQ_2: X10 Standard I/O signal DIQ_3: X11	
3	Ground 1M	
4	Standard I/O signal DIQ_0: X10 Standard I/O signal DIQ_1: X11	
5	Not used	

NOTE

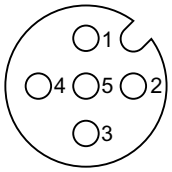
24 V encoder supplies U_{S0}-U_{S1}

Use only the 24 V encoder supplies U_{S0}-U_{S1} provided by the I/O device to supply power to the encoders.

4.2.3 Pin assignment of fail-safe digital inputs

The module has two M12 connectors with five female pins that are A-coded.

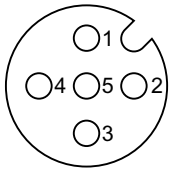
Table 1-1114 Pin assignment of fail-safe digital inputs

Pin	Assignment	Front view of the sockets (X12, X13)
1	24 V sensor supply V_{S0}: X12 24 V sensor supply V_{S1}: X13	
2	Input signal FDI_2: X12 Input signal FDI_3: X13	
3	Sensor supply ground 1M	
4	Input signal FDI_0: X12 Input signal FDI_1: X13	
5	24 V sensor supply V_{S2}: X12 24 V sensor supply V_{S3}: X13	

4.2.4 Pin assignment of IO-Link Class B / fail-safe digital output x.2

The module has one M12 connector for IO-Link Class B / fail-safe digital output x.2 with five female pins that are A-coded.

Table 1-1115 Pin assignment of IO-Link Class B / fail-safe digital output x.2

Pin	Assignment	Front view of the socket (X14)
1	24 V encoder supply U_{S2}	
2	Output signal FDQ_2P • Class B only (always on) • Class B with safety shutdown (optionally switchable) • Safety-rated F-DQ only	
3	Ground 1M (non-switched)	
4	IO-Link port 1: C/Q1	
5	Output signal FDQ_2M • Class B only (always on) • Class B with safety shutdown (optionally switchable) • Safety-rated F-DQ only	

NOTE

Port Class B

The pin assignment of the IO-Link interface of socket X14 corresponds to the IO-Link specification, as per Port Class B. Port Class B is especially suited for the connection of actuators with additional supply, such as valve terminals.

NOTE

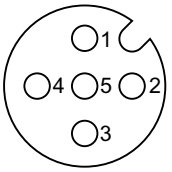
24 V encoder supply U_{S2}

Use only the 24 V encoder supply U_{S2} provided by the IO-Link master to supply power to devices.

4.2.5 Pin assignment of fail-safe digital outputs x.0 and x.1

The module has two M12 connectors with five female pins that are A-coded.

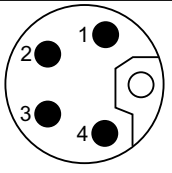
Table 1-1116 Pin assignment of fail-safe digital outputs

Pin	Assignment	Front view of the sockets (X15, X16)
1	Encoder supply U_{S3}: X15 Encoder supply U_{S4}: X16 (Optionally assigned)	
2	1M	
3	Output signal FDQ_0M: X15 Output signal FDQ_1M: X16	
4	Output signal FDQ_0P: X15 Output signal FDQ_1P: X16	
5	Functional earth (FE)	

4.2.6 Pin assignment for feeding and looping the voltage

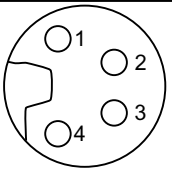
The module has an M12 connector with four male pins that are L-coded.

Table 1-1117 Pin assignment of the M12 cable connector for the supply voltage infeed

Pin	Assignment	Front view of the socket (X80)
1	Supply voltage 1L+	
2	Ground 2M	
3	Ground 1M	
4	Supply voltage 2L+	

The module has an M12 connector with four female pins that are L-coded.

Table 1-1118 Pin assignment of the M12 cable connector for loop-through of the supply voltage

Pin	Assignment	Front view of the socket (X81)
1	Supply voltage 1L+	
2	Ground 2M	
3	Ground 1M	
4	Supply voltage 2L+	

4.3 Electrical configuration of the ET 200eco PN M12-L F

Electrical isolation

The ET 200eco PN M12-L F electrical configuration features electrical isolation between the following:

- 1L+ supply voltage (electronic/fail-safe DI/fail-safe sensor supply/standard DIQ/standard sensor supply/1L+ switched 24 V DC/IO-Link Class B sensor supply and C/Q):
  Electrically isolated from PROFINET IO and 2L+ (load voltage supply).
- 2L+ supply voltage (electronic/load voltage supply for F-DQ0&1/IO-Link Class B F-DQ2):
  Electrically isolated from all other circuit components.
- PROFINET IO interface:
  Electrically isolated from all other circuit components.

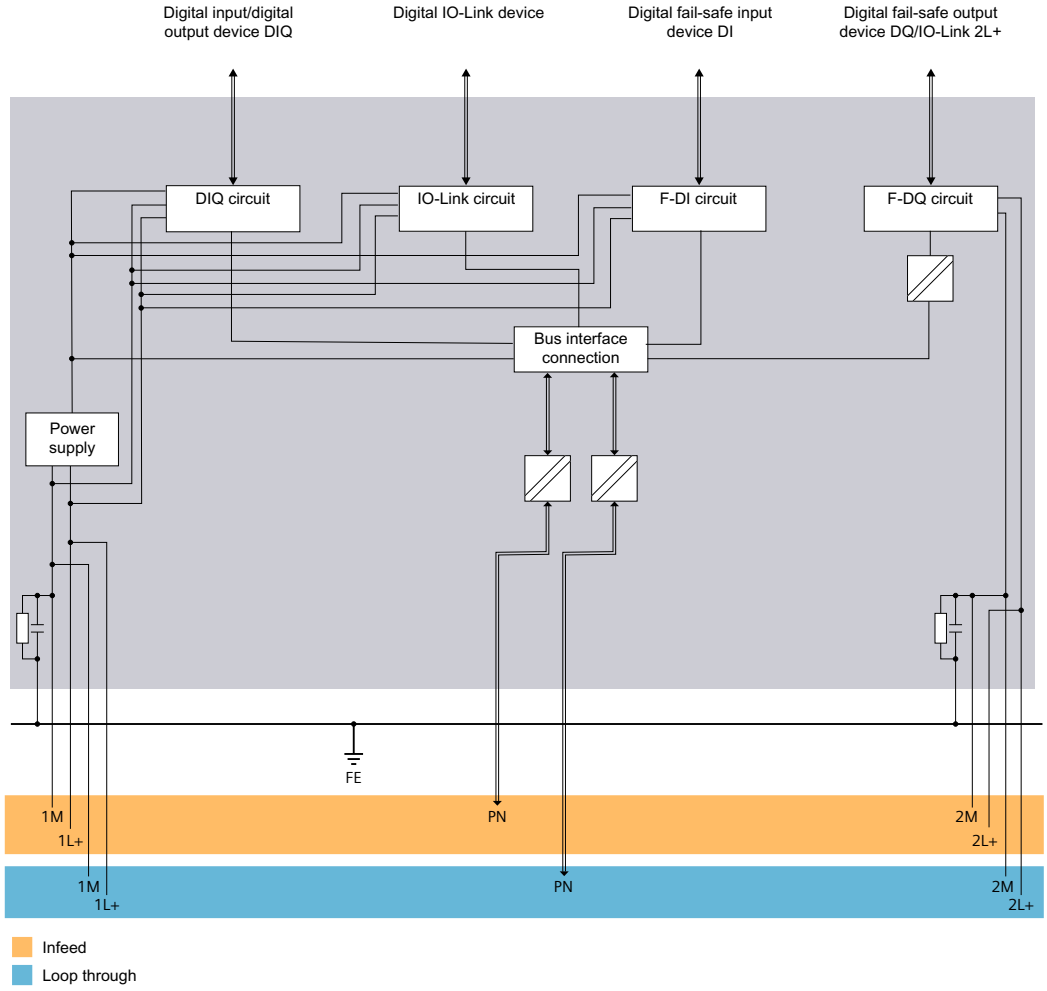


Figure 1-823 Electrical relationships

Fail-safe IO

5

5.1 Parameters/address space

You use the STEP 7 Safety configuration software to configure the properties of the fail-safe module. You must ensure that all modules in your fail-safe automation system are configured.

Configuring module I/O properties

To configure the fail-safe module's properties, follow these steps:

1. Select "Device configuration" in the project tree.
2. Place the fail-safe module into your project's "Device view".

NOTE

The fail-safe module uses both I's and Q's. There are extra bytes allocated at the end of the address space that carry safety status and data integrity information.

Number of channels	Address (I/Q)	Bytes required
4 (fail-safe input) 2 (fail-safe output)	I Q	12 6

3. Select the image of the fail-safe module and view the module's "Properties" tab.
4. On the **"**Properties**"** view, select the **"**General**"** tab.
5. Click the module properties tree and expand the branches for the fail-safe module. You can select a module and see all the properties. You can also select a module branch (for example, "F-parameters", "DI-parameters", or "Channel parameters") and see a subset of the properties.
6. Select a property and set values in the appropriate fields.
7. A successful compile and download of your Device configuration to the CPU automatically puts your new configuration settings in the I/O modules.

5.1.1 F-parameters

5.1.1.1 Parameters

You must configure and then assign the PROFIsafe addresses (F-destination address and F-source address) to the F-module before you put it into operation as follows:

- Configure the F-source address using the "Central F-source addresses" parameter in the Device configuration of the F-CPU.
- Configure the F-destination address using the "F-destination address" parameter in the Device configuration of each fail-safe module.
- Download the Device configuration to the F-CPU.
- Assign the F-destination address for each fail-safe module using the "Assign PROFIsafe address" dialog in STEP 7 Device configuration.

You can find further information on F-parameters such as the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address), F-parameter signature (with or without addresses) and the F-I/O DB in the *SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

The following table shows the F-parameters for the ET 200eco PN M12-L F:

Table 1-1119 Configurable F-parameters

Channel	Value range	Default	Scope
Manual assignment of F-monitoring time	• Unchecked • Checked	Unchecked	Module
F-monitoring time	1 to 65535 ms	150 ms (disabled)	Module
F-source address	1 to 65534	1 (always disabled)	Module
F-destination address	1 to 65534	65534	Module
F-parameter signature (with addresses)	0 to 65535	always disabled	Module
F-parameter signature (without addresses)	0 to 65535	always disabled	Module
Behavior after channel fault	• Passivate channel • Passivate entire module	Passivate channel	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	All channels manually	Module
F-I/O DB manual number assignment	• Unchecked • Checked	Unchecked	Module
F-I/O DB number	• Fixed value, if DB manual number assignment is disabled • Value can be edited by user, if DB manual number assignment is enabled	Fixed value	Module
F-I/O DB name	-	always disabled	Module

5.1.1.2 Explanation of the F-parameters

Behavior after channel fault

You can specify whether the entire F-module is passivated or only the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use the "Reintegration after channel fault" parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Set this parameter in the STEP 7 dialog of the fail-safe module as follows:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". You can specify the reintegration type of the respective channel with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

5.1.2 F-DI

5.1.2.1 Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "F I/O parameters" > "Input parameters" for the F-DI of the ET 200eco PN M12-L F:

Table 1-1120 Configurable F-DI parameters

Parameter	Value range	Default	Scope
Sensor supply			
Short-circuit test	• Unchecked • Checked	Checked	Module
Duration of short-circuit test	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms	3.2 ms	Module

Parameter	Value range	Default	Scope
Startup time after short-circuit test is completed	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms	3.2 ms	Module
Channel group settings			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation: – 2 channel - 4 wire equivalent – 2 channel - 3 wire non-equivalent – 2 channel - 4 wire non-equivalent	1oo2 evaluation, 2 channel - 4 wire equivalent	Channel
Discrepancy behavior	• Supply value 0 • Supply last valid value	Supply value 0	Channel
Discrepancy time	5 ms to 30000 ms	500 ms	Channel
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	Channel
Channel settings			
Activated	• Unchecked • Checked	Checked	Channel
Input filters	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms	3.2 ms	Channel
Channel failure acknowledge	• Automatic • Manual	Manual	Channel
Sensor supply	• Sensor supply x (where "x" is the respective channel number) • External	Sensor supply x (where "x" is the respective channel number)	Channel

5.1.2.2 Explanation of the F-DI parameters

Short-circuit test

You can enable the short-circuit detection for the sensor supplies and the fail-safe input channels configured to use their respective sensor supply. Short-circuit test only applies to one activated single sensor supply at a time.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply.

The short-circuit test switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Duration of short-circuit test". When the sensor supply is turned back on, the module will wait to evaluate the sensor signal until the sensor has powered on and the sensor signal has stabilized. The length of the startup time for the sensor is equivalent to the configured "Startup time after short-circuit test is completed".

If the module detects a short-circuit, the fault is reported to the F-CPU and the entire module can be passivated.

The following short-circuits are detectable:

- Short-circuit of input to L+
- Short-circuit of the input to another channel when it has a "1" signal
- Short-circuit of the sensor supply to L+
- Short-circuit of the sensor supply to ground
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If you disable the short-circuit test, you must make your wiring short-circuit and cross-circuit proof or select a sensor evaluation type (discrepancy, non-equivalent) that can detect the cross circuits using discrepancy.

During the execution time (duration of short-circuit test + startup time of sensor after the short-circuit test + input filters) of the short-circuit test, the state of the input before the start of the short-circuit test is provided. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

Duration of short-circuit test

You can specify the duration of the test pulse applied to the sensor supply when you select the check box "Short-circuit test".

This value is the time that the sensor supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs.

Short-circuit evaluations are dependent upon customer-selected input filter times. This means that you must take care to ensure that input filter time selections are appropriately chosen. These must be faster than the selected duration of short-circuit test settings; otherwise, the module might not detect potential sensor supply and/or input short-circuit errors because of inappropriate filter times.

Startup time after short-circuit test

You can specify the startup time after the short-circuit test completes when you select the check box "Short-circuit test".

This value is the time that the module waits to evaluate the sensor signal after it has powered on and the sensor signal has stabilized. This duration must be long enough to allow your sensor time to power on.

Sensor evaluation

You can specify signal evaluation and wiring definitions. These selections correspond with the various application mode wiring examples (Page 95).

You can assign whether “channel n” input operates individually (1oo1) or is paired with its companion channel "n+2" input (1oo2).

1oo1 evaluation: One sensor is connected to the module on a single channel.

1oo2 evaluation: Two input channels are occupied by one of the following:

- **2 channel - 4 wire equivalent**: One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair.
- **2 channel - 3 wire non-equivalent**: One two-channel non-equivalent sensor is connected to the two channels, in a channel pair.
- **2 channel - 4 wire non-equivalent** One two-channel non-equivalent sensor or two single-channel non-equivalent sensors are connected to the two channels, in a channel pair.

If you select a 1oo2 evaluation mode, you can assign the discrepancy properties.

When you select the channel group as 1oo2, STEP 7 enables the parameters in the first channel of the group and disables the parameters in the second channel of the group. The second channel derives its parameter values from the first channel's parameter values. When you select the channel group as 1oo1, STEP 7 enables all of the parameters in both channels.

NOTE

Safety program access to 1oo2 input data

For 1oo2 evaluation, two paired input channels (for example, F-DI 0 and F-DI 2) are connected to one or two sensors. The F-DI module performs the discrepancy analysis and sends the result to the safety program at the input address of the low-ordered channel of the pair (in the above example, F-DI 0).

Discrepancy behavior

A 1oo2 input configuration allows a logical difference between the two signals, without error, for the configured discrepancy time. You assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

NOTE

Sensor-actuator response time is increased when you add more input discrepancy time

The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0" but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0' and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides normal operation. Refer to "Maximum fault reaction time for 1oo2 fail-safe digital input discrepancy errors (Page 120)" for further information.

Discrepancy time

The two signals in a 1oo2 input configuration will not change exactly at the same time, due to differences in sensors, contacts, and wiring. You can configure a maximum expected duration for a mismatch between signals during transition.

Discrepancy evaluations and other diagnostic evaluations are dependent upon customer-selected input filter times. These evaluations occur using input samples generated after input filtering is complete. This means that you must take care to ensure that input filter time selections are appropriately chosen. These must be faster than selected discrepancy time evaluations; otherwise, the module might not detect potential 1oo2 input discrepancy differences because of inappropriate filter times.

Reintegration after discrepancy error

You can select whether a zero state must be detected on both 1oo2 inputs before a previously declared discrepancy can be reintegrated.

"Test 0-signal necessary"
If you have selected "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels for a duration of at least 100 ms.

If you are using non-equivalent sensors, which means you have set "Sensor evaluation" to a non-equivalent mode, a 0-signal must be present at the low-order channel of the channel pair, and a 1-signal must be present at the high-order channel of the channel pair for a duration of at least 100 ms.

"Test 0-signal not necessary"
If you have selected "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists between the two relevant input channels.

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

Input filters

The module filters the digital inputs to remove contact bounce and noise. This parameter assigns the duration of the filter time. As the filter time increases, the reaction times of the digital inputs also increase.

Channel failure acknowledge

You can specify in the F-Parameters (Page 39) whether the channel is automatically reintegrated after a fault clears or requires a manual acknowledgement. Refer to "Reactions to faults (Page 59)" for the reintegration procedure.

Sensor supply

You can select whether to supply 24 V DC power to sensors from the module's integrated sensor supply (internal) or from an external power supply (external).

Short-circuit tests are not performed for any channel where external power is selected.

5.1.3 F-DQ

5.1.3.1 Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "F I/O parameters" > "Output parameters" for the F-DQ of the ET 200eco PN M12-L F:

Table 1-1121 Configurable F-DQ parameters

Channel	Value range	Default	Scope
Maximum test period	• 100 s • 1000 s	1000 s	Channel
Channel settings			
Wire break	• Unchecked • Checked	Unchecked	Channel
Activated	• Unchecked • Checked	Checked	Channel
Channel Operating Mode	• Operate as F-DQ only • Operate as F-DQ with Safety shutdown	Operate as F-DQ only	Channel
Channel failure acknowledge	• Manual • Automatic	Manual	Channel
Maximum readback time	1.0 ms to 400.0 ms	2.0 ms	Channel
Maximum readback time switch on test	0.5 ms to 5.0 ms	1.0 ms	Channel
Disable Dark Test (max. SIL 2, Cat3, PLd)	• Unchecked • Checked	Unchecked	Channel

5.1.3.2 Explanation of the F-DQ parameters

Maximum test period

You can assign the time interval between bit pattern tests for F-DQ DC outputs to a value of either 100 seconds or 1000 seconds.

The module applies test pulses to the output switches. These tests detect faulted P- or M-output switches and wiring faults. Short-circuits to other signals or power rails can be detected by the module.

If the module detects an error on a channel, the test interval shortens to 60 seconds. If an error is no longer detected on any output channel, the configured test interval is used again.

A detected fault is reported to the fail-safe CPU, and the affected channels or the module is passivated according to the configured selection of "Behavior after channel fault".

Activated

You can enable the corresponding channel for signal processing in the safety program.

If you disable a channel, channel diagnostics are no longer reported to the F-CPU for the deactivated channel.

NOTE

Suspension of 2L+ undervoltage
Whenever you disable all output channels, you do not need to power 2L+. Undervoltage reporting is suspended for 2L+.

Channel Operating Mode

You can choose whether outputs F-DQ x.0 and x.1 operate as fail-safe outputs only or as fail-safe outputs capable of Safety shutdown. See "Fail-safe digital outputs (Page 19)".

Channel failure acknowledge

You can specify in the F-Parameters (Page 39) whether the channel is automatically reintegrated after a fault clears or requires a manual acknowledgement. Refer to "Reactions to faults (Page 59)" for the reintegration procedure.

Maximum readback time

You can configure a "Maximum readback time" that specifies the maximum amount of time that the output channel waits for the voltage to respond when the process value changes. If any P- or M-switch does not reach the expected voltage within the readback time, the module passivates the output channel.

Your configured "Maximum readback time" also sets the duration of the "OFF" test pulse during the bit pattern test. Choose a short enough duration where your load will not be affected.

The module does not apply new process values to the output channels while a test pattern is being applied to the outputs. This means that a higher "Maximum readback time" increases the response time of the F-module.

⚠ WARNING

Short-circuit (cross-circuit) detection might not be possible for high frequency signals
Through the configured "Maximum readback time", short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured "Maximum readback time") Hz cannot be detected by the module (50:50 sampling ratio).
You must take this into consideration for your application and respective requirements of your product standards.
Short-circuits (cross-circuits) to an output of the same module are recognized regardless of the frequency of the output channel.
You can adjust the maximum readback time to change the frequency of the signal that can be detected.
Short-circuits of high frequency signals that are undetected can cause death, severe personal injury, and/or property damage.

The parameter also effects the short-circuit detection (cross-circuit) with a "1" signal when the safety program changes the output signal from "1" to "0".

Setting the parameter "Maximum readback time"

Siemens recommends that you set the "Maximum readback time" as low as possible because the fault response time is extended by the configured value for this parameter; however, you must set this value to a high enough value where the module will not passivate the output channel as a result of your connected load

You determine the readback time required for your actuator with the diagram in "Switching of loads (Page 125)".

If the capacitance of the actuator is not known, it might be necessary for you to determine the value for the "Maximum readback time" by trial and error. This might also be necessary due to the part variances in the actuator, or to external influences.

Proceed as follows:

- Set the "Maximum readback time" so that the output channel can be read back correctly but your actuator does not respond during a bit-pattern test sequence.
- For verification, use the process value "0" with a minimum duration that corresponds to the "Maximum test period" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated, the "Maximum readback time" is too small for the connected capacitive load. The discharge cannot take place within the configured "Maximum readback time". Increase the "Maximum readback time".

If you have set the "Maximum readback time" to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacitance is outside the permitted range.

Maximum readback time switch on test

You can configure the "Maximum readback time switch on test" that specifies the duration of the "ON" test pulse for any P- or M-switch during the bit pattern test. You must choose a short enough duration that does not affect your load.

Any pulse during the bit pattern test does not generate a light pulse in the absence of faults.

Any pulse during the bit pattern test under fault conditions can result in a light pulse, which can energize the load if the "Maximum readback time switch on test" is long enough to affect the load.

Wire break

You can enable or disable wire break testing. The module can detect a broken wire or missing load only when the output PV is "OFF" and the load is wired in PM mode.

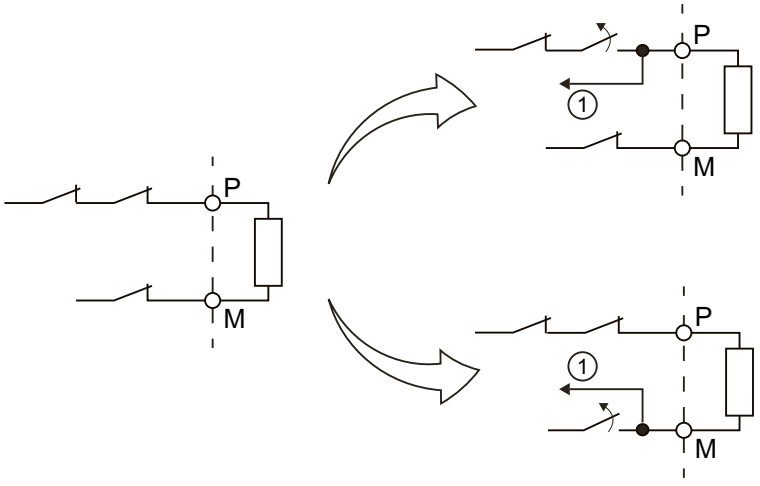
Disable Dark Test (max. SIL2, CAT3, PLd)

You can select the check box to disable dark testing for a channel.

Dark tests are switch-off tests that occur during an output bit-pattern test sequence.

For a dark test, one of the output channel's switches is briefly turned OFF while the output channel is active (output signal "1"). As a result, current flow through the output is interrupted for a short time. A sufficiently slow actuator does not respond to this and remains switched on.

When the dark test is disabled on an output channel, the parameter "Maximum readback time" is only relevant for the process value change.



① Readback

Figure 1-824 Functional principle of the dark test

Test pulses of the dark test

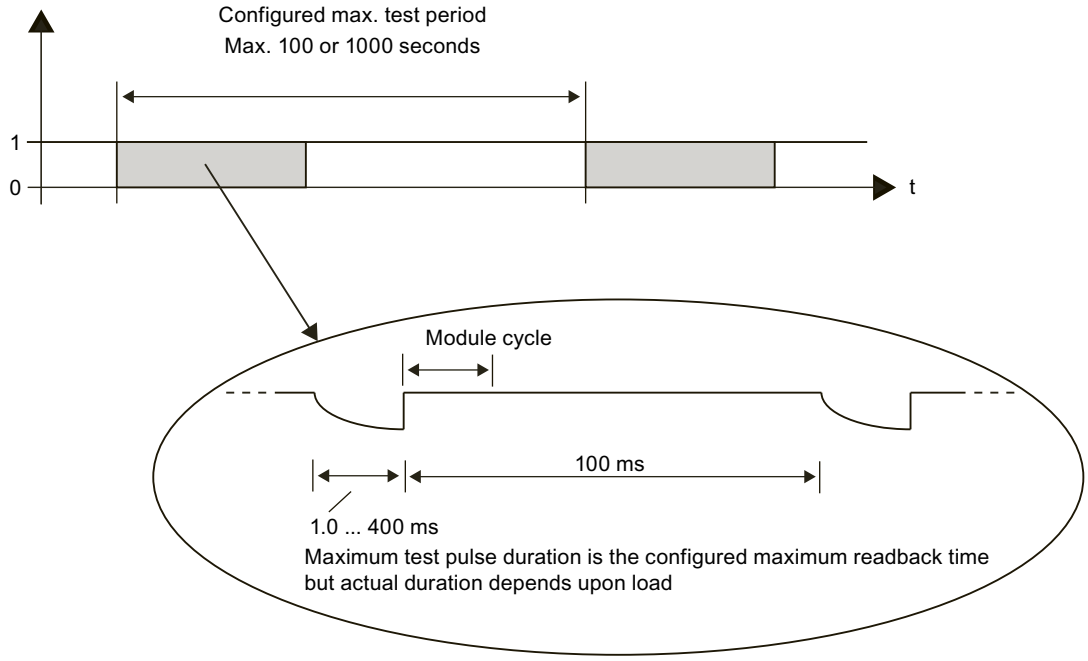


Figure 1-825 Test pulses of the dark test

You configure the time between output bit pattern test sequences to either 100 or 1000 seconds. Each output bit pattern test sequence includes multiple test pulses. The interval between two test pulses is at least 100 ms.

To prevent an unwanted reaction of the actuator to a dark test, you can also disable the dark test individually for each F-output channel.

A capacitive load that does not meet the load curve (Page 125) can result in a passivation of the output in case of a process value change or switch-on test, even if the dark test is disabled.

With the dark test disabled, you can only reach up to SIL 2/Cat. 3/PL d.

⚠ WARNING

Loss of SIL 2/Cat. 3/PL d rating, loss of output control due to potential undetected faults
SIL 2/Cat. 3/PL d requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. With the dark test disabled, an output that is turned on for more than 1 year might not be able to be turned off. This could result in an accumulation of undetected faults.
Ensure the "0" signal has a duration of at least 2 seconds. It is not enough to simply turn off the supply or load voltage of the F-module and turn it on again.
If control of an output is lost due to potential undetected faults, death, severe personal injury, and/or property damage can result.

⚠ WARNING

Reduction of short-circuit detection
When you disable dark testing, cross-circuits between channels with "1" signal are not detected. An undetected accumulation of faults could result in unexpected operation.
You must take this into consideration for your application and respective requirements of your product standards.
You must also take into consideration the respective requirements of your product standards regarding error detection time.
Unexpected operation can result in death, severe personal injury, and/or property damage.

5.1.3.3 I/O address parameters

The following table shows the parameters that you can set to specify F-input and F-output starting image register addressing:

Table 1-1122 Configurable I/O address parameters

Parameter	Value range	Default
Input addresses		
Start address	0 to 1023	Calculated
End address	N/A	Calculated
Organization block	"---"	"---"
Process image	"---"	"---"
Output addresses		
Start address	0 to 1023	Calculated
End address	"---"	"---"
Organization block	"---"	"---"
Process image	"---"	"---"

5.1.4 Embedded Safety Functions (ESF)

5.1.4.1 Estop

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Emergency Stop" for an Estop of the ET 200eco PN M12-L F:

Table 1-1123 Configurable Estop parameters

Channel	Value range	Default	Scope
Emergency Stop activated	• Checked • Unchecked	Unchecked	Module
Stop category	• 0 (Immediate deactivation) • 1 (Delayed deactivation)	0 (Immediate deactivation)	Module

Channel	Value range	Default	Scope
Emergency Stop input	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • "Internal Evaluation #0 result" • "Internal Evaluation #1 result" • "Emergency Stop #x result" (where "x" is the number of the other Emergency Stop) • "Selection Needed"	"Selection Needed"	Module
Emergency Stop output	• F-DQ 0 • F-DQ 1 • F-DQ 2 • "Selection Needed"	"Selection Needed"	Module
Delay time	500 ms to 7200000 ms (2 hrs) in 1 ms steps	500 ms	Module
Acknowledge necessary	• "Manually using rising edge" • "Automatic"	"Manually using rising edge"	Module
Type of manual acknowledge	• "Either process image or local I/O" • "Local I/O only" • "Process image only"	"Either process image or local I/O"	Module
Acknowledge input	• F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "None"	"None"	Module
Acknowledge requested output	• DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "None"	"None"	Module

Explanation of the Estop parameters

Emergency Stop activated

You can enable or disable the Emergency Stop function.

Stop Category

You can set the Estop to either deactivate the fail-safe output immediately or after a configured delay time.

Emergency Stop Input

You can select the F-input address that serves as the Estop input. You can also select the Internal Logic Result of another ESF as the input.

NOTE

Using the same input causes a compiler warning
Do not use the same input for both the "Emergency Stop Input" and the "Emergency Stop Acknowledge Input". Doing so results in a compiler warning.

Emergency Stop Output

You can select the F-output address that serves as the Estop output. When you configure this parameter, the Estop functions are only able to override the respective F-CPU's output PV to "0".

Delay Time

You can configure the time delay for how long the module waits before turning the output off when the Emergency Stop function has been invoked.

Acknowledge Necessary

You can select the acknowledgement type that returns the safety function to service, whether manual acknowledgement is required or acknowledgment is automatic.

Type of Manual Acknowledge

You can define the type of permissible manual acknowledgement.

- Either process image or local I/O: Performed using either approach.
- Local I/O only: Performed using the acknowledge input specified by "Acknowledge Input".
- Process image only: Performed using the process image "ESTOP ACK" and "ACK REQ" bits.

Acknowledge Input

You can select the DIQ I/O or F-input address that serves as the Acknowledge Input. You cannot, however, select an input already configured for Emergency Stop input.

NOTE

Using the same input causes a compiler warning
Do not use the same input for both the "Emergency Stop Input" and the "Emergency Stop Acknowledge Input". Doing so results in a compiler warning.

Acknowledge Requested Output

You can select the standard DIQ output (if so configured) that serves as the Acknowledge Requested Output. You cannot, however, select an output already configured for IE or Estop. When you configure this parameter, the ESFs are able to override the respective F-CPU's output PV to either "0" or "1".

5.1.4.2 Internal Evaluation (IE)

Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "Safety Functions" > "Internal Evaluation" for an IE of the ET 200eco PN M12-L F:

Table 1-1124 Configurable IE parameters

Channel	Value range	Default	Scope
Activated	• Checked • Unchecked	Unchecked	Module
Input #1	• "None" • F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation)	"None"	Module
Input #2	• "None" • F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation)	"None"	Module

Channel	Value range	Default	Scope
Input #3	• "None" • F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation)	"None"	Module
Input #4	• "None" • F-DI 0 • F-DI 1 • F-DI 2 • F-DI 3 • DIQ 0 • DIQ 1 • DIQ 2 • DIQ 3 • "Emergency Stop #0 result" • "Emergency Stop #1 result" • "Internal Evaluation #x result" (where "x" is the number of the other Internal Evaluation)	"None"	Module
Output #1	• "None" • F-DQ 0 • F-DQ 1 • F-DQ 2	"None"	Module
Output #2	• "None" • F-DQ 0 • F-DQ 1 • F-DQ 2	"None"	Module
Output #3	• "None" • F-DQ 0 • F-DQ 1 • F-DQ 2	"None"	Module

Explanation of the IE parameters

Activated

You can either enable or disable the IE.

Input Selection

You can select the standard DIQs or F-input addresses that serve as the IE inputs. You can also select the Internal Logic Result of another ESF as the input.

NOTE

Using the same address causes a compiler warning
Do not select two inputs with the same address. Doing so results in a compiler warning.

NOTE

Fail-safe input requirement
When choosing inputs for the IE, at least one of the enabled inputs must be fail-safe. Failure to do so results in a compilation error.
When chaining together ESFs, all inputs must be fail-safe.

Output Selection

You can select the F-output addresses that serve as the IE outputs.

NOTE

Using the same address causes a compiler warning
Do not select two outputs with the same address. Doing so results in a compiler warning.

5.1.5 Address space

The table below shows the number of I and Q bytes required by the PROFIsafe profile:

Module	PROFIsafe profile	Input (I) bytes required	Output (Q) bytes required
F-DI 4 x 24 VDC, 2xM12, F-DQ 2 x 24 VDC/2.0A PM, 2xM12, DIQ 4 x 24 VDC, 2xM12, IO-Link Class B, 1xM12	V2.6.1	12	6

NOTE

PROFIsafe profile impacts I and Q memory requirements
The I/O module uses more I and Q memory than required for the physical number of inputs and outputs on the module. The extra bytes carry the PROFIsafe safety status and data integrity information. The number of input (I) bytes and output (Q) bytes that the module requires depends upon which PROFIsafe profile your fail-safe CPU uses.

5.1.6 Control and feedback interfaces

Assignment of the control interface

Your safety program uses the control interface to influence the behavior of the module.

The following table shows the assignment of the control interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
QB x	0	0	ESTOP 1 ACK	ESTOP 0 ACK	0	F-DQ 0.2	F-DQ 0.1	F-DQ 0.0
QB x + 1-5 (PS)	PROFIsafe trailer (V2.6.1)							

Explanations of the control interface

Byte	Bit	Control bit/value	Explanation
QB x	0	F-DQ 0.0	The process value (PV) of fail-safe digital output channel 0.
	1	F-DQ 0.1	The process value (PV) of fail-safe digital output channel 1.
	2	F-DQ 0.2	The process value (PV) of fail-safe digital output channel 2.
	4	ESTOP 0 ACK	The ESTOP 0 ACK bit is used to acknowledge the reset of the Emergency Stop. Not used when you configure Emergency Stop 0's "Type of manual acknowledgement" for "Local I/O only".
	5	ESTOP 1 ACK	The ESTOP 1 ACK bit is used to acknowledge the reset of the Emergency Stop. Not used when you configure Emergency Stop 1's "Type of manual acknowledgement" for "Local I/O only".
QB x + 1-5 (PS)	1-5	PROFIsafe trailer (V2.6.1)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.6.1.

Assignment of the feedback interface

Your safety program receives current values and status information from the module by means of the feedback interface.

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IB x	0	0	0	0	F-DI 0.3 or 0 (SIL 3)	F-DI 0.2 or 0 (SIL 3)	F-DI 0.1	F-DI 0.0
IB x +1	0	0	ESTOP 1 Internal Logic Result (ILR)	ESTOP 0 Internal Logic Result (ILR)	Internal Eval. 1 Internal Logic Result (ILR)	Internal Eval. 0 Internal Logic Result (ILR)	ESTOP 1 ACK REQ	ESTOP 0 ACK REQ
IB x +2	ESTOP #1 Status bit 3	ESTOP #1 Status bit 2	ESTOP #1 Status bit 1	ESTOP #1 Status bit 0	ESTOP #0 Status bit 3	ESTOP #0 Status bit 2	ESTOP #0 Status bit 1	ESTOP #0 Status bit 0
IB x +3	0	0	0	0	CQ F-DI 0.3 or 0 (SIL 3)	CQ F-DI 0.2 or 0 (SIL 3)	CQ F-DI 0.1	CQ F-DI 0.0
IB x +4	0	0	0	0	0	0	0	0

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IB x +5	0	0	0	0	0	0	0	0
IB x +6	0	0	0	0	0	CQ F-DQ 0.2	CQ F-DQ 0.1	CQ F-DQ 0.0
IB x +7-11 (PS)	PROFIsafe trailer (V2.6.1)							

Explanations of the feedback interface

Byte	Bit	Control bit/value	Explanation
IB x	0	F-DI 0.0	The process value (PV) of fail-safe digital input channel 0.
	1	F-DI 0.1	The process value (PV) of fail-safe digital input channel 1.
	2	F-DI 0.2, or 0 (SIL 3)	The process value (PV) of fail-safe digital input channel 2. Not used when you configure the input channel pair for 1oo2 evaluation.
	3	F-DI 0.3, or 0 (SIL 3)	The process value (PV) of fail-safe digital input channel 3. Not used when you configured the input channel pair for 1oo2 evaluation.
IB x +1	0	ESTOP 0 ACK REQ	The Acknowledge Input state of Emergency Stop 0. Not used when you configure Emergency Stop 0's "Type of manual acknowledgement" for "Local I/O only".
	1	ESTOP 1 ACK REQ	The Acknowledge Input state of Emergency Stop 1. Not used when you configure Emergency Stop 1's "Type of manual acknowledgement" for "Local I/O only".
	2	Internal Eval. 0 Internal Logic Result (ILR)	The internal logic result from the execution of the Internal Evaluation 0 ESF.
	3	Internal Eval. 1 Internal Logic Result (ILR)	The internal logic result from the execution of the Internal Evaluation 1 ESF.
	4	ESTOP 0 Internal Logical Result (ILR)	The internal logic result from the execution of the Emergency Stop 0 ESF.
	5	ESTOP 1 Internal Logical Result (ILR)	The internal logic result from the execution of the Emergency Stop 1 ESF.
IB x +2	0	ESTOP #0 Status	The ESF reports one of the following status codes: • "1" - The module detects the acknowledge input as on when the Emergency Stop is not awaiting manual acknowledgement. • "2" - The module detected the acknowledge input as on when the Emergency Stop began awaiting manual acknowledgement; the module must detect a rising edge on the acknowledge input for acknowledgement to occur. • "3" - The module detects that the DIQ channel assigned as the Emergency Stop's acknowledge requested output has been incorrectly configured as an input channel; you must configure the DIQ channel as an output for the acknowledge requested output. More than one status code might be present at a given time; however, only one is represented in the process image. Therefore, the status code with the highest priority is returned. Any other status codes are retained such that if a higher priority status code is cleared, the lower priority status code is presented.
	1		
	2		
	3		
	4	ESTOP #1 Status	The ESF reports one of the following status codes:
	5		
	6		

Byte	Bit	Control bit/value	Explanation
IB x +2	7	ESTOP #1 Status	• "1" - The module detects the acknowledge input as on when the Emergency Stop is not awaiting manual acknowledgement. • "2" - The module detected the acknowledge input as on when the Emergency Stop began awaiting manual acknowledgement; the module must detect a rising edge on the acknowledge input for acknowledgement to occur. • "3" - The module detects that the DIQ channel assigned as the Emergency Stop's acknowledge requested output has been incorrectly configured as an input channel; you must configure the DIQ channel as an output for the acknowledge requested output. More than one status code might be present at a given time; however, only one is represented in the process image. Therefore, the status code with the highest priority is returned. Any other status codes are retained such that if a higher priority status code is cleared, the lower priority status code is presented.
IB x +3	0	CQ F-DI 0.0	The channel quality (value status) of fail-safe digital input channel 0. This represents the channel quality (value status) of input channel pair 0/2 when you configure the input channel pair for 1oo2 evaluation.
	1	CQ F-DI 0.1	The channel quality (value status) of fail-safe digital input channel 1. This represents the channel quality (value status) of input channel pair 1/3 when you configure the input channel pair for 1oo2 evaluation.
	2	CQ F-DI 0.2, or 0 (SIL 3)	The channel quality (value status) of fail-safe digital input channel 2. Not used when the input channel pair is configured for 1oo2 evaluation.
	3	CQ F-DI 0.3, or 0 (SIL 3)	The channel quality (value status) of fail-safe digital input channel 3. Not used when the input channel pair is configured for 1oo2 evaluation.
IB x +6	0	CQ F-DQ 0.0	The channel quality (value status) of fail-safe digital output channel 0.
	1	CQ F-DQ 0.1	The channel quality (value status) of fail-safe digital output channel 1.
	2	CQ F-DQ 0.2	The channel quality (value status) of fail-safe digital output channel 2.
IB x +7-11 (PS)	0-7	PROFIsafe trailer (V2.6.1)	The number of additional I and Q bytes used for safety status and data integrity information, according to PROFIsafe profile V2.6.1.

Evaluating the value status

The channel quality (value status) bits provide information regarding the validity of the channel quality (value status):

- Bit = 1: Corresponding process value is valid.
- Bit = 0: Channel is passivated.

5.2 Interrupts/diagnostic alarms

5.2.1 Reaction to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends upon the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

The safety function requires that safe state values be applied to one or more of the fail-safe channels instead of process values (passivation of the fail-safe module or of one or more channels) in the following situations:

- When the fail-safe system starts up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters information about detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not retain errors after a power cycle. When you power down and restart the system, fail-safe modules detect any faults that still exist.

⚠ WARNING

No error handling or diagnostics for deactivated channels
When channels are set to "deactivated", fail-safe diagnostic responses or error handling do not occur. This could result in an accumulation of undetected faults.
For channels that you set to "deactivated" in STEP 7, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).
An accumulation of undetected faults can result in death, severe personal injury, and/or property damage.

Fail-safe value for fail-safe modules

If fail-safe digital input channels are passivated by the module, the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If fail-safe digital output channels are passivated, the fail-safe system always transfers safe state values ("0") to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

NOTE
If you select "Passivate the entire module" in the Device configuration properties "F-IO parameters > F-parameters > Behavior after channel fault" field for the module, a single channel fault results in passivation of all channels.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates the entire module.

Table 1-1125 Module signal type and passivation result

Module signal type	Passivation of channel result	Passivation of module result
Fail-safe digital inputs	For a 1oo1 input channel: • The passivated channel reports a diagnostic. • The module reports the safe state value "0" for the affected channel's process and quality values. For a 1oo2 input channel pair: • The passivated channel, as well as the other input channel in the channel pair, report a diagnostic.[1)] • The module reports the safe state value of "0" for the low-order input channel pair's process and quality values. The high-order input always reports "0".	For a 1oo1 input channel: • The passivated channel reports a diagnostic. • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels. For a 1oo2 input channel pair: • The passivated channel, as well as the other input channel in the channel pair, report a diagnostic.[1)] • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels.
Fail-safe digital outputs	• The passivated channel reports a diagnostic. • The F-CPU substitutes the safe state value "0" for the affected channel's process and quality values.	• The passivated channel reports a diagnostic. • The module reports the safe state value "0" for all channels' process and quality values, and the F-CPU substitutes the safe state value "0" for the process value of all output channels.

1) A discrepancy error between two inputs in a channel pair results in one diagnostic. The diagnostic's message indicates which type of discrepancy occurred (0/0, 0/1, 1/0, or 1/1).

Response to faults in the fail-safe system

To remedy faults in your fail-safe system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and in IEC 61508-2:2010 section 7.6.2.1 e.

A maintenance procedure, for example, might include a statement to perform the following steps:

1. Diagnose and repair the fault.
2. Revalidate the safety function.
3. Record steps taken in the service report.

Reintegration of a fail-safe module

A channel or module can be reintegrated into an operational state after diagnostics determine that a fault has cleared successfully.

You can configure reintegration as automatic or manual. You can make this selection on a per-channel basis in the Device configuration. Module-wide errors such as PROFIsafe communication errors or supply voltage errors are always manually reintegrated. Fatal diagnostic errors require a power cycle to reintegrate.

Automatic reintegration

Channels that you select to be automatically reintegrated are immediately reintegrated when the fault has cleared.

Manual reintegration

Channels that you select to be manually reintegrated are acknowledged after the fault has cleared.

The "ACK_REQ" bit for the module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

Reintegration after high-stress events

High temperature, high voltage, or excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure might be increased.

⚠ WARNING

Reintegration of a channel or module with an undetected fault

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics. Undetected faults can result in unexpected operation.

After any reported fault, follow the steps outlined in this chapter and in safety standards applicable to your system to assure that you understand the reason for the fault and how to take corrective action before reintegration.

Reintegration of a faulty system can result in unexpected operation, which can cause death, severe personal injury, and/or property damage.

For an exact list of faults for the module, refer to "Fault types, causes, and corrective measures (Page 67)".

After reintegration, the following occurs:

- For a fail-safe digital input, the process values pending at the fail-safe inputs are again provided for the safety program.
- For a fail-safe digital output, the output values provided in the safety program are again transferred to the fail-safe outputs.

Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. Respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O are not being diagnosed and are subject to dangerous failure without warning.

If any error persists for 100 hours, the module issues a fatal diagnostic error and can only be recovered by power cycling.

If a repair within 100 hours is not possible, take passivated fail-safe outputs out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating CPU Safety program logic that can result in activation of a safety function output.

Do not depend upon channel or module passivation to maintain safe state for more than 100 hours.

Do not depend upon channel deactivation or removal of the module from hardware configuration to maintain safe state in any circumstances.

⚠ WARNING

Unintentional activation of F-I/O module with fail-safe output

If a fail-safe output is passivated for a period longer than the safety repair time (> 100 hours) and the fault remains uncorrected, an F-output could be activated unintentionally due to a second fault, placing the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of a fail-safe output by using measures for the physical circuits or other organizational measures. Some possibilities are the shutdown of the power supply to the affected F-module or taking the outputs out of service. Required measures are often standardized for operations with defined design and risk reduction principles. For all other situations, necessary measures must be defined and approved.

The unintentional activation of an F-output can result in death, severe personal injury, and/or property damage.

Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* (https://support.industry.siemens.com/cs/ww/en/view/54110126).

5.2.2 Fault diagnostics

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe module, communication with the F-CPU, or external circuits. Diagnostic information is specific to either a single channel or to the entire fail-safe module.

Most diagnostics operate without user selection. You can configure the following diagnostic options:

- Short-circuit testing using the digital input sensor supplies can be enabled. The duration and startup time of the short-circuit tests are configurable for each sensor supply.
- Discrepancy times for 1oo2 digital inputs are configurable.
- The readback times for 24 V DC digital outputs are configurable.
- The timeout intervals for failures in the safety communication or failure of a safety program to run is configurable.
- Wire break testing is supported only when the output is wired in PM mode, and is only detected when the output is off.
- Dark testing of the digital outputs can be disabled (max. SIL 2, Cat. 3, PL d).

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These reports are offered as maintenance and debugging aids. Observe and interpret the reports with caution.

In the presence of single faults, any or all LED indications can be wrong. Do not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages can fail to be delivered, or the numerical event ID or text message can be wrong. Do not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

⚠ WARNING

Diagnostic and status reports and single point failure errors
Diagnostic and status reports through LEDs and text messages are subject to single point failure errors. These are not sufficient for determining a safety-controlled state.
If the integrity of your fail-safe system is in doubt, use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.
Relying solely upon such reported information to determine that a system or I/O point is in a safety-controlled state can result in death, severe personal injury, and/or property damage.

5.2.2.1 Diagnostics performed at startup

The ET 200eco PN M12-L F executes self-diagnostics at power-up to assure that the electronics and software operate as expected before allowing the module to participate in process control. If tests are not successful, the module passivates the affected channel or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

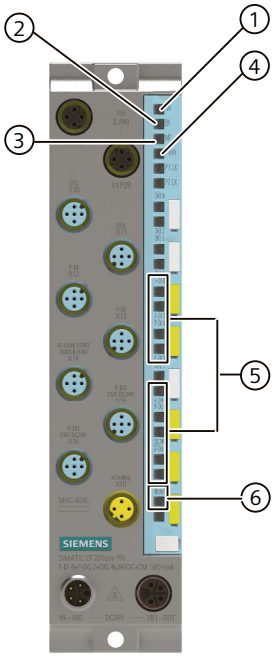
The fail-safe module executes tests for its digital input sensor supplies at power-up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the module also executes a short-circuit test according to your configured parameters after receiving the parameters from the F-CPU at power-up.

The fail-safe module executes tests for the digital outputs of the P- and M-switches. These tests are defined by your configured parameters for "Maximum readback time" and "Maximum readback time switch on test" in STEP 7 Device configuration under "F I/O parameters" > "Output parameters" after the module receives configuration parameters from the F-CPU at power-up. P- and M-switch ON tests are sequenced so that there is no energy applied to the load in the absence of faults.

5.2.2.2 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the ET 200eco PN M12-L F module:



① RUN LED (RN - Green)
② ERROR LED (ER - Red)
③ MAINTENANCE LEDs (MT - Green/Red)
④ POWER LED (PWR - Green)
⑤ F-DQ / F-DI channel status / channel fault LEDs (Green/Red)
⑥ REINTEGRATION LED (REINT - Green/Red)

Figure 1-826 Fail-safe IO LED displays

Meaning of the LEDs

The following tables describe the meaning of the status and error displays. You can find remedial measures for diagnostic alarms in "Fault types, causes, and corrective measures (Page 67)".

Module LED states

The behavior of the module-relevant LEDs follows the definitions in the table below:

Count	LED	Description
1	RN/NS	RUN/network status • RN/NS LED is Green ON when configuration/parameterization is complete and all coming events have been acknowledged by going events. • RN/NS LED is Green blinking when configuration/parameterization has not been received and all incoming events have been acknowledged by outgoing events.
1	ER/MS	ERROR/module status • ER/MS LED is Red blinking when coming diagnostic events are currently active.
1	MT/IO	MAINT/IO status • MAINT LED Yellow ON during a firmware update • MAINT LED Yellow ON when the 1L+ bus supply voltage is below tolerance • MAINT LED Yellow blinking during a "Node flash test"

LED states for module and channel behaviors

Description	RN/NS LED	ER/MS LED	MT/IO LED	Input Channel LEDs		Output Channel LEDs	
LED color	Green	Red	Yellow	Red	Green	Red	Green
Missing or insufficient supply voltage	Off	Off	Off	Off	Off	Off	Off
Module / System / Parameter Fault[2)]	Blinking[2)]	Off	Off	Off	Off	Off	Off
Not or improperly configured, includes overvoltage of 1L+ and 2L+ when not configured[2)]	Blinking[2)]	Off	Off	Off	Off	Off	Off
Parameters are being assigned or F/W update during startup	Blinking[2)]	Off	Off	Off	Off	Off	Off
Reset to Factory Operation	On[3)]	On[3)]	On[3)]	Off	Off	Off	Off
Startup LED test	On[4)]	On[4)]	On[4)]	Off	Off	Off	Off
States after the module is successfully configured							
Channel deactivated	On	Off	Off	Off	Input state	Off	Off
No channel faults	On	Off	Off	Off	Input state	Off	Output state
Channel faults	On	Blinking[2)]	Off	On	Off	On	Off

1) Alternating blinking of Red and Green LEDs, for channels awaiting reintegration (blinking frequency: 2 Hz)
2) Blinking frequency (2 Hz)
3) LED is on for approximately 2.0 seconds.
4) LED is on for approximately 0.25 seconds.

Description	RN/NS LED	ER/MS LED	MT/IO LED	Input Channel LEDs		Output Channel LEDs	
LED color	**Green**	**Red**	**Yellow**	**Red**	**Green**	**Red**	**Green**
Awaiting manual reintegration after channel fault	On	Blinking[2)]	Off	Blinking[1)]	Blinking[1)]	Blinking[1)]	Blinking[1)]
Awaiting manual reintegration of module after 1L+/2L+ voltage too high/too low	On	Blinking[2)]	Off	Blinking[1)]	Blinking[1)]	Blinking[1)]	Blinking[1)]
Awaiting reintegration after PROFIsafe communication error (detected by host)	On	Blinking[2)]	Off	Off	Input state	Off	Off
1L+ module supply voltage too high/too low	On	Blinking[2)]	Off	On	Off	On	Off
2L+ module supply voltage too high/too low	On	Blinking[2)]	Off	On	Off	On	Off
PROFIsafe communication error (detected by module)	On	Blinking[2)]	Off	Off	Input state	Off	Off
Identification of the F-module when assigning the PROFIsafe address	On	Off	Off	Off	Blinking[2)]	Off	Blinking[2)]
PROFIsafe address does not match the configured PROFIsafe address	On	Blinking[2)]	Off	On	Off	On	Off
Inconsistent FW versions and/or HW revisions between TPS and uCs	On	Blinking[2)]	Off	Off	Input state	Off	Off
F-DQ Channels 1L+ pin	On	Off	Off	N/A	N/A	Off	1L+ state
F-DQ Channels 1L+ pin error	On	Blinking[2)]	Off	N/A	N/A	On	Off
IO-Link 2L+ pin (switched, non-switched)	On	Off	Off	N/A	N/A	Off	2L+ state
IO-Link 2L+ pin error (switched, non-switched)	On	Blinking[2)]	Off	N/A	N/A	On	Off

1) Alternating blinking of Red and Green LEDs, for channels awaiting reintegration (blinking frequency: 2 Hz)
2) Blinking frequency (2 Hz)
3) LED is on for approximately 2.0 seconds.
4) LED is on for approximately 0.25 seconds.

Reintegration LED states

The behavior of the module's reintegration LEDs follows the definitions in the table below:

Count	LED	Description
1	REINT	Reintegration status: REINT LED is Green/Red blinking whenever a reintegratable module-wide diagnostic event has been resolved and is awaiting reintegration. The following events are applicable: • Reintegratable overvoltage • Reintegratable undervoltage • Module-detected PROFIsafe CRC error • Module-detected PROFIsafe timeout error REINT LED is Red whenever there is a hardware/firmware version mismatch.

5.2.2.3 Fault types, causes, and corrective measures

The table below lists the messages of the fail-safe I/O. These messages are displayed in STEP 7 under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight an individual text line in the diagnostic buffer, the Event ID for that text item is displayed, along with the module identity and location that generated the message. You might need to expand the window to see all of the information.

Table 1-1126 Fault types, causes, and corrective measures

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0001	Short-circuit	Fail-safe digital outputs	Short-circuit on one of the switches in the output	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			"Maximum readback time switch on test" value is configured too small	Increase "Maximum readback time switch on test" if permissible.
			Defective output driver	Replace the fail-safe module.
0x0005	Overtemperature	Module	Excessive heat within the module	Check the ambient temperature. Once the fault has been eliminated, the power must be switched off and on.
			Excessive heat within the environment surrounding the module	
0x0006	Wire break	Fail-safe digital outputs	No load is connected to the PM output.	Check the wiring between the affected output channel and the load.
			Output is configured as a PM output, but not wired as a PM output.	Check that the affected output channel is wired in PM mode.
			Too small of a load is detected.	Change the output load.
			There is a fault in the external circuitry.	Deactivate the "Wire break" diagnostic.
			A PM output load with reverse voltage protection could cause a wire break diagnostic.	Provide a small reverse current path through the PM load.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0009	Error	Module	Hardware version of the module is set to "0" due to an internal error.	Replace module.
0x0010	Parameter error	Module	i-Parameter CRC error	Check the communications connection or eliminate any electrical interference.
				Resolve the invalid parameters and perform another download.
			Invalid F-parameters, I-parameters, and/or parameter CRCs were configured and downloaded to the module.	Assign the new fail-safe address to the module's eCoding plug.
				Determine if parameter ranges have been exceeded.
				Determine if parameter dependency requirements have been violated.
				Check if CRC needs updating when using GSDML.
			A different F-Source and/or F-Destination address has been downloaded and does not match what had been previously assigned to the module's eCoding plug.	Change the fail-safe addresses back to what had been previously assigned to the module's eCoding plug and download.
0x0040	Mismatch of safety destination address (F_Dest_Add)	Module	eCoding plug has been replaced with a different plug.	Change the F-Destination address back to what had been previously assigned to the module's eCoding plug and download.
			The downloaded F-Destination address does not match what has been previously assigned to the module's eCoding plug.	Reassign the new F-Destination address to the module's eCoding plug.
0x0041	Safety destination address not valid (F_Dest_Add)	Module	Invalid F-Destination address was downloaded.	The downloaded F-Destination address does not match what had been previously assigned to the module's eCoding plug.
				Resolve the invalid F-Destination address and perform another download.
0x0042	Safety source address not valid (F_Source_Add)	Module	eCoding plug has been replaced with a different plug	Reassign or reinitialize the PROFIsafe F addresses using STEP 7.
0x004D	PROFIsafe communication	Module	Communication interference between the fail-safe	Check the communications connection.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x004D	error (CRC)	Module	CPU and the fail-safe module (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)	Eliminate the interference.
0x004E	PROFIsafe communication failure (timeout)	Module	F-monitoring time exceeded.	Adjust F-monitoring time.
			Transmission error: timeout (watchdog time 1 or 2 elapsed)	Check Safety program and all other CPU activities for excessive execution or demands: • Interrupts • Ethernet communication • OB scheduling conflicts • Long program paths
0x004F	User acknowledgement request of channel failures	Module	Fail-safe module awaits an acknowledge of channel failures.	Acknowledge channel failures.
0x0100	Module is defective	Module	Fail-safe module is defective.	Replace the fail-safe module.
0x0102	Error (0102)	Module	The front connector is not plugged in correctly, or there is no voltage to operate the module.	Check the front connector or correct the process wiring.
0x0103	Watchdog tripped	Module	Fail-safe module is defective.	Replace the fail-safe module.
0x0105	Short-circuit to L+	Fail-safe digital outputs	Short-circuit to L+	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			Defective output driver	Replace the fail-safe module.
			"Maximum readback time" value is configured too small.	Increase readback time.
0x0106	Short-circuit to ground	Fail-safe digital outputs	Short-circuit to M.	Eliminate the short-circuit.
			Short-circuit between channels with different signals	Eliminate the short-circuit.
			Defective output driver	Replace the fail-safe module.
			"Maximum readback time" value is configured too small.	Increase readback time.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x011B	Invalid/inconsistent firmware present	Module	Inconsistent firmware version can occur between Network Interface ASIC firmware, IO-Link firmware, and/or fail-safe microcontroller firmware if the firmware update was interrupted.	Repeat the firmware update operation.
0x013E	Diagnostic event queue overflow	Module	This can happen if channel errors come and go very quickly (for example, discrepancy errors when automatically acknowledged).	
0x0300	Discrepancy failure, channel state 0/0	Fail-safe digital inputs	Process signal faulty, sensor can be defective. Configured discrepancy time too short Short-circuit Sensor mechanical activation or alignment out of tolerance	Check process signal, replace sensor if necessary. Check the configured discrepancy time. Check the wiring. Check that both sensors are mounted and aligned to be activated together.
0x0301	Discrepancy failure, channel state 0/1	Fail-safe digital inputs		
0x0302	Discrepancy failure, channel state 1/0	Fail-safe digital inputs		
0x0303	Discrepancy failure, channel state 1/1	Fail-safe digital inputs		
0x0306	Sensor supply short-circuit to P	Fail-safe digital inputs	Sensor supply shorted to P	Eliminate the short-circuit.
			Short-circuit test duration configured too short	Increase short-circuit test duration.
			Failed sensor supply	Replace the fail-safe module.
0x0307	Sensor supply short-circuit to ground	Fail-safe digital inputs	Short-circuit	Eliminate the short-circuit.
			Excessive load on sensor supply	Reduce load on sensor supply.
			Failed sensor supply	Replace the fail-safe module.
0x030D	F-address memory not accessible	Module	eCoding plug is missing.	Install an eCoding plug into X40 of the module and power cycle.
			eCoding plug is defective.	Replace the defective eCoding plug and power cycle.
0x030E	No valid F-address available	Module	eCoding plug has never been assigned a PROFIsafe address.	Assign the PROFIsafe Address.
			eCoding plug is defective.	Replace the eCoding plug.
0x0311	Frequency too high	Fail-safe digital outputs	Process value from safety program changing too rapidly for module to follow	Change safety program logic to guarantee more time between output changes.
0x0312	Undertemperature	Module	The ambient temperature is too cold.	Check the ambient temperature. Once the fault has been eliminated, the power must be cycled.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x0313	Failure in the input circuit	Fail-safe digital inputs	The module has detected a failure in the input circuitry during diagnostic testing.	If intermittent, possibly due to interference. Eliminate interference. If persistent, or repeats after efforts to eliminate interference, replace the fail-safe module.
0x0314	Discrepancy failure	Fail-safe digital inputs	The discrepancy time set for two-channel mode in the input pair of the module has been exceeded.	Check the discrepancy time, the encoders, and their wiring.
			Incorrect parameter assignment	
			Short-circuit of the disconnected encoder cable	
			Short-circuit of the connected encoder cable	
			Wire break of the encoder supply cable	
			Encoder error	
0x0315	Internal discrepancy failure	Module	The module has detected an internal error.	Replace the module if the error continues.
			Increased EMC interference	
			Module is defective.	
0x031C	Input shorted to P	Fail-safe digital inputs	External signal for input or sensor supply shorted to L+	Check/correct external short-circuit.
			Input configured for internal sensor supply with short-circuit detection enabled, but wired to external L+	Make wiring and configuration agree.
			Input defective	Replace the module.
0x031D	Output defective	Fail-safe digital outputs	The module has detected an internal error.	Replace the module.
			The module is defective.	
0x031E	Read back failure	Fail-safe digital outputs	"Maximum readback time" or "Maximum readback time switch on test" configured value is too small.	Increase readback time or readback switch on test time.
			Output switch failure	Replace the fail-safe module if output does not respond.
0x0320	Overload	Fail-safe digital outputs	Excessive load on output	Reduce the current demand on output.

Event ID	Diagnostic message	Diagnostic type	Possible causes	Corrective measures
0x032F	Module is defective	Module	Fail-safe module is defective.	Replace the fail-safe module.
0x0321	Supply too high	Module	Supply is set too high.	Adjust 1L+ and/or 2L+ voltage.
0x0322	Supply too low	Module	Supply is set too low.	Adjust 1L+ and/or 2L+ voltage.

Electromagnetic interference and diagnostic reports

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not relate to an identifiable device failure, wiring problem, programming, or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load in-rush currents.

PROFINET IO

6

6.1 Parameters/address space

6.1.1 IO-Link

6.1.1.1 Parameters

The following table shows the parameters that you can set in Device configuration for each port (submodule) of the IO-Link master ET 200eco PN M12-L F:

Table 1-1127 Diagnostics and port parameters

Parameters	Value range	Default	Scope in STEP 7
Port			
Port 1	• Disable • Enable	Enable	Channel
Diagnostics			
Low Voltage 1L+	• Disable • Enable	Disable	Channel
Port	• Disable • Enable	Disable	Channel
Enable hardware interrupt	• Disable • Enable	Disable	Channel
Port configuration			
Autostart (without S7 PCT)	• Disable • Enable	Disable	Channel
Operating mode	• IO-Link Autostart • IO-Link Manual	Disable	Channel
Vendor ID*	Vendor ID of the connected IO-Link device	Disable	Channel
DeviceID*	Device ID of the connected IO-Link device	Disable	Channel
Inspection / Backup level*	• Same type (V1.0) without Backup&Restore • Type compatible (V1.1) without Backup&Restore • Type compatible (V1.1) with Backup&Restore • Type-compatible (V1.1) with Restore	Disable	Channel

* Only configurable if you use the "IO-Link Manual" port mode.

Parameters	Value range	Default	Scope in STEP 7
Port cycle time*	• As fast as possible • 1.6 ms • 3.2 ms • 4.8 ms • 8.0 ms • 20.8 ms • 40.0 ms • 80.0 ms • 120.0 ms	Disable	Channel

* Only configurable if you use the "IO-Link Manual" port mode.

6.1.1.2 Explanation of the IO-Link parameters

Low Voltage 1L+

This parameter enables the diagnostics for insufficient supply voltage 1L+.

Port

This parameter enables the diagnostics for the selected IO-Link port.

The diagnostics make a distinction between error and maintenance interrupts. The possible diagnostics are dependent upon your specific IO-Link device. More information about the diagnostic interrupts can be found in the description of the utilized IO-Link device.

Enable hardware interrupt

This parameter enables the hardware interrupt for the selected IO-Link port.

The possible hardware interrupts are dependent upon your specific IO-Link device. More information on the hardware interrupts can be found in the description of your specific IO-Link device.

NOTE

Configuration as digital input or digital output

You cannot enable any port parameters or diagnostics alarms in SIO mode.

Autostart (without S7-PCT)

This parameter releases the port configuration without S7-PCT for the module.

NOTE

Changes to the port configuration

If you have assigned the IO-Link device parameters using port configuration without S7-PCT, or you have configured the port as a digital input, digital output or deactivated, you can no longer change the port configuration using S7-PCT.

Operating mode

This parameter determines the mode in which the selected port is operated.
You can select from the following options:

- IO-Link Autostart: The connected IO-Link device starts automatically (Plug&Play functionality). The IO-Link device is immediately ready for operation.
- IO-Link Manual: The connected IO-Link device is **not** started automatically. You must store the Vendor ID and Device ID of the connected IO-Link device in STEP 7.

Vendor ID

This parameter displays the Vendor ID of the connected IO-Link device. You can configure this parameter only if you use the "IO-Link Manual" port mode.

DeviceID

This parameter determines the Device ID of the connected IO-Link device. You can configure this parameter only if you use the "IO-Link Manual" port mode.

Inspection/Backup level

You can select the inspection level for data storage:

- Same type (V1.0) without Backup&Restore
- Type-compatible (V1.1) without Backup&Restore
- Type-compatible (V1.1) with Backup&Restore
- Type-compatible (V1.1) with Restore

Port cycle time

This parameter sets the IO-Link cycle time at the corresponding port.

ET 200eco PN M12-L F IO-Link devices configured on the IO-Link submodules

You can find the parameters for the ET 200eco PN M12-L F IO-Link modules that can be selected as IO-Link submodules in the manual for the respective module: ET 200eco PN, CM 8x IO-Link, M12-L (6ES7148-6JG00-0BB0).

6.1.2 DIQ

6.1.2.1 Parameters

The following table shows the parameters that you can set in STEP 7 Device configuration under "I/O parameters" > "Inputs/Outputs" for the DIQ of the ET 200eco PN M12-L F:

Table 1-1128 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Scope in STEP 7
Undervoltage 1L+	• Deactivated • Activated	Deactivated	Channel
Short-circuit	• Deactivated • Activated	Deactivated	Module (sensor supplies) Standard digital outputs
Wire break	• Deactivated • Activated	Deactivated	Channel (Standard digital inputs)
Input delay	• 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Channel (Standard digital inputs)
Hardware interrupt on rising edge	• Deactivated • Activated	Deactivated	Channel (Standard digital inputs)
Hardware interrupt on fall edge	• Deactivated • Activated	Deactivated	Channel (Standard digital inputs)
Operating mode	• DI • DQ	DI	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	Channel (Standard digital outputs)

6.1.2.2 Explanation of the DIQ parameters

Undervoltage 1L+

This parameter enables the diagnostics for insufficient supply voltage 1L+.

Short-circuit

This parameter enables diagnostics for the following events:

- Short-circuit of the encoder supply to ground
- Short-circuit of the standard output to ground
- Short-circuit of the standard output to 1L+

Wire break

This parameter activates wire break detection and enables diagnostics for the standard digital input. In the event of an interruption of the cable between the encoder and the I/O device, a diagnostics alarm is generated.

NOTE

This diagnostic is only available for channels configured as standard inputs. If the parameter is deactivated, wire break detection is switched off. A wire break does not affect the value status.

Input delay

This parameter suppresses signal interference. Changes to the signal are only detected if they are present consistently for longer than the set input delay time.

For standard input channels with longer input delays, the read-in time is moved accordingly. This means that individual channels can be assigned input delays, if necessary, without a negative impact upon the possible cycle time.

Hardware interrupt on rising edge

This parameter specifies whether a hardware interrupt is generated for a rising edge on the channel.

Hardware interrupt on falling edge

This parameter specifies whether a hardware interrupt is generated for a falling edge on the channel.

Operating mode

This parameter specifies whether the channel operates as a standard digital input (DI) or a standard digital output (DQ).

Reaction to CPU STOP

This parameter sets the reaction of the standard digital outputs of the I/O device after a CPU STOP:

- Shutdown: The standard digital output is de-energized.
- Keep last value: The last value of the standard digital output remains activated.
- Output substitute value 1: The standard I/O device outputs the substitute value "1".

6.1.3 Address space

The IO-Link master ET 200eco PN M12-L F has one port. The port is represented by a submodule.

Configuration of the IO-Link ports of the IO-Link master ET 200eco PN M12-L F

The different operating modes of each IO-Link port are defined by configuring a corresponding submodule in STEP 7:

- As a digital input by configuring a digital input submodule
- As a digital output by configuring a digital output submodule
- As an IO-Link device by configuring an IO-Link submodule

Port disabled:

- In STEP 7: By deactivating the port enable

The IO-Link ports are preconfigured as 2I + PQI.

When configuring IO-Link submodules, you can select the address spaces for I/O data in the following byte scales:

- 1 I/1 O + PQI
- 2 I + PQI
- 2 I/2 O + PQI
- 4 I/4 O + PQI
- 8 I/8 O + PQI
- 16 I/16 O + PQI
- 32 I/32 O + PQI

For more information, refer to the IO-Link system (https://support.industry.siemens.com/cs/us/en/view/65949252) function manual.

Port Qualifier Information (PQI)

NOTE

Port Qualifier Information (PQI)

The Port Qualifier Information (PQI) with the size 1 byte is always transmitted together with the input data of the IO-Link device. The PQI cannot be deactivated.

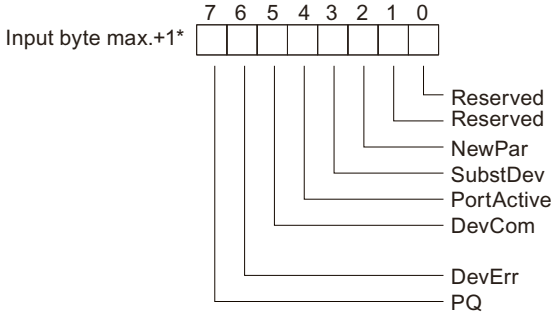
	Description	Value	Meaning
Bit0	-	-	Reserved
Bit1	-	-	Reserved
Bit2	NewPar*	0	No update of the device parameters detected
		1	Device parameter update detected
Bit3	SubstDev*	0	No backup device detected (identical serial number)
		1	Backup device detected (different serial number)
Bit4	PortActive	0	Port disabled
		1	Port enabled

* Bits are reset with function block "LIOLink_Master" .

	Description	Value	Meaning
Bit5	DevCom	0	IO-Link device is not available
		1	IO-Link device is in the "Preoperate" or "Operate" state
Bit6	DevErr	0	No error
		1	An error or warning has occurred.
Bit7	PQ	0	The data of the IO-Link device is invalid
		1	The data of the IO-Link device is valid

* Bits are reset with function block "LIOLink_Master" .

Port Qualifier Information (PQI)



* The PQI byte is always after the last input byte of the port.

6.1.4 Control and feedback interfaces

Assignment of the feedback interface

Your program receives current values and status information from the module by means of the feedback interface.

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
IB x	0	0	0	0	DI 0.3 or 0 (DQ)	DI 0.2 or 0 (DQ)	DI 0.1 or 0 (DQ)	DI 0.0 or 0 (DQ)

Explanations of the feedback interface

Byte	Bit	Control bit/value	Explanation
IB x	0	DI 0.0, or 0 (DQ)	The process value (PV) of standard digital input channel 0.
	1	DI 0.1, or 0 (DQ)	The process value (PV) of standard digital input channel 1.
	2	DI 0.2, or 0 (DQ)	The process value (PV) of standard digital input channel 2.
	3	DI 0.3, or 0 (DQ)	The process value (PV) of standard digital input channel 3.

Assignment of the control interface

Your program uses the control interface to influence the behavior of the module.
The following table shows the assignment of the control interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
QB x	0	0	0	0	DQ 0.3 or 0 (DI)	DQ 0.2 or 0 (DI)	DQ 0.1 or 0 (DI)	DQ 0.0 or 0 (DI)

Explanations of the control interface

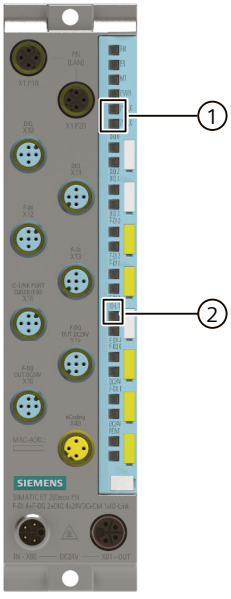
Byte	Bit	Control bit/value	Explanation
QB x	0	DQ 0.0, or 0 (DI)	The process value (PV) of standard digital output channel 0.
	1	DQ 0.1, or 0 (DI)	The process value (PV) of standard digital output channel 1.
	2	DQ 0.2, or 0 (DI)	The process value (PV) of standard digital output channel 2.
	3	DQ 0.3, or 0 (DI)	The process value (PV) of standard digital output channel 3.

6.2 Interrupts/diagnostics alarms

6.2.1 IO-Link

6.2.1.1 Status and error displays

The figure below shows the LED displays (status and error displays) of the ET 200eco PN M12-L F module for IO-Link:



① P1 LK / P2 LK LEDs (Green)
② IO-Link channel status / channel fault LED (Green/Red)

Figure 1-827 IO-Link IO LED displays

Meaning of LEDs

The following tables describe the meaning of the status and error displays:

Behavior of the LEDs RN/NS (RUN/network status), ER/MS (ERROR/module status) and MT/IO (MAINT/IO status)

Table 1-1129 Error display of the LED

LED			Meaning	Remedy
RN/NS (green)	ERR/MS (red)	MT/IO (yellow)		
Off	Off	Off	No or insufficient supply voltage	Check the supply voltage.
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
			The three LEDs light up simultaneously for approximately 2 s while "Reset to factory settings" is running.	-
Flashes	Off	Off	Module is disabled.	Activate ET 200eco PN M12-L F with the configuration software or with the user program.
			Module is not configured.	Configure ET 200eco PN M12-L F using the configuration software.
			Module is starting up.	-
			Parameters are assigned to the module.	
			Loading firmware (when the firmware update is performed during startup, all LEDs retain their current status).	-
On	N/A	N/A	The ET 200eco PN M12-L F is currently exchanging data with the IO controller.	-
N/A	Flashes	N/A	Module diagnostics are available.	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration.	Check the configuration of the ET 200eco PN M12-L F.
			Parameter error	Correct the errors in the parameter assignment.
N/A	N/A	On	Maintenance	Evaluate the maintenance events.
Flashes	Flashes	Flashes	The "Node flash test" is running (the P1 LK and P2 LK LEDs of the PROFINET interface are also flashing).	-
			Hardware or firmware faulty. (The P1 LK and P2 LK LEDs of the PROFINET interface are not flashing).	Replace the ET 200eco PN M12-L F I/O device.

PWR LED

Table 1-1130 Status display of the PWR LED

PWR LED	Meaning
□ Off	Load voltage 2L+ is missing or too low.
■ On	Load voltage 2L+ is present.

LEDs P1 LK and P2 LK

The following table describes the behavior of LEDs that indicate the connection status with a PROFINET IO controller or a PROFINET switch:

Table 1-1131 Status displays of the LEDs P1 LK and P2 LK

P1 LK and P2 LK LEDs	Meaning	Remedy
□ Off	There is no Ethernet connection between the communications interface of your IO device and a communication partner (for example, an IO controller).	Check whether the bus cable to the switch/communication partner is interrupted.
■ On	There is an Ethernet connection between the communications interface of your IO device and a communication partner (for example, an IO controller).	-
☼ Flashes	The "Node flash test" is running (the RN/NS, ER/MS and MT/IO LEDs also flash).	-
	Communication error: A physical connection exists, but communication is not possible.	Check the PROFINET IO settings.

LEDs channel status DI

Table 1-1132 Status displays of the DI0, DI1, DI2, and DI3 LEDs

LEDs Channel status/channel error	Meaning
□ Off	Process value = 0
■ On	Process value = 1

Channel status/channel error LEDs IO-Link

Table 1-1133 Status displays of the channel/channel error LEDs for IO-Link

LEDs Channel status/error	Meaning
Off	Input or output value is 0 or port is disabled.
On	IO-Link communication established, active device or channel fault.
Flashes	At startup or permanently, if no functional IO-Link device was found.
On	• DI/DQ operating mode: Input or output value is "1". • IO-Link operating mode: Communication is running.

6.2.1.2 Interrupts

The IO-Link Master ET 200eco PN M12-L F supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts (at submodule port)
- Pull/plug interrupt (at submodule port)

If you have added these interrupt OBs to your STEP 7 program, the CPU of the IO controller calls the appropriate OB when one of these interrupts occurs. Information on the cause and class of the error is available, based upon the OB number and start information.

You can use the "RALRM" instruction to obtain detailed information on the error event in the error OB.

Diagnostics interrupts

All IO-Link events of the type "Error" or "Warning" are mapped to the diagnostic interrupts of the assigned submodule. If you have parameterized the IO-Link master accordingly, it triggers a diagnostic interrupt for an incoming or outgoing event (alarm). The coding of the events corresponds to the PROFINET standard of the extended channel diagnostics (USI=0x8002).

The CPU interrupts STEP 7 program execution and processes the diagnostics interrupt OB. You can determine the error events (channel diagnostics) with the "RALRM" instruction.

Hardware interrupts

All IO-Link events of the type "Notification" generated by the IO-Link device are mapped to the hardware interrupts of the assigned submodule.

The coding of the additional alarm information corresponds to the PROFINET standard "ProcessAlarmReason" (USI = 0x8320).

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the hardware interrupt OB. You can determine the events (ProcessAlarmReason) with the "RALRM" instruction.

Pull/plug interrupts

If you remove an IO-Link device or the IO-Link communication is interrupted, the assigned submodule generates a pull alarm.

As soon as you plug the IO-Link device back in or the IO-Link communication is re-established, the assigned submodule generates a plug alarm.

When an insert/remove module interrupt occurs, the F-CPU interrupts execution of the STEP 7 program and processes the insert/remove module interrupt OB. The event that triggered the interrupt is set in the start information of the insert/remove OB.

6.2.1.3 Alarms

Diagnostics alarms

IO-Link master error types

All IO-Link events of the type Error generated by the IO-Link device or port are mapped to the PROFINET diagnostics alarm of the type (severity) "Diagnosis" of the assigned submodule.

IO-Link device diagnostics

The IO-Link master generates PROFINET channel diagnostics (CET, ECET) from the IO-Link events of an IO-Link device according to the following mapping regulations:

- The "IO-Link Device Diagnostics - Page 1" (CET $0x9500_H$) displays IO-Link event codes in the range 0x0000 - $0x7FFF_H$ directly: $ECET_H$ = IO-Link Event $Code_H$
- The "IO-Link Device Diagnostics - Page 2" (CET $0x9501_H$) displays IO-Link event codes in the range 0x8000 - $0xFFFF_H$ directly: $ECET_H$ = (IO-Link Event $Code_H$ - $0x8000_H$)

Table 1-1134 Overview of error types for IO-Link device diagnostics

IO-Link event code	Error type (CET)	Extended error type (ECET)	Error text	Meaning
0x0000 - $0x7FFF_H$	$0x9500_H$ (38144_D)	0x0000 - $0x7FFF_H$ (0 - 32767_D)	Error / warning	See the manual of the IO-Link device or IODD file used.
0x8000 - $0xFFFF_H$	$0x9501_H$ (38134_D)	0x0000 - $0x7FFF_H$ (0 - 32767_D)	Error / warning	See the manual of the IO-Link device or IODD file used.

Example

An IO-Link device generates event code $0x4000_H$ (type "Error").

The channel diagnostics from the event code as follows:

PROFINET channel diagnostics type: Diagnosis, CET: $0x9500_H$, ECET: 0x4000

Diagnostics alarm "IO-Link Device Diagnostics - Pag 1, Temperature fault - Overload", generated from the IO-Link event code $0x4000_H$.

IO-Link port diagnostics

The IO-Link master generates channel diagnostics for each port. The port diagnostics (CET $0x9502_H$) show port-specific channel diagnostics.
The following table provides an overview of the possible diagnostic events and their meanings:

Error type (CET)	Extended Error type (ECET)	Error text	Meaning
$0x9502_H$ (38136_D)	$0x17FF_H$ (6143_D)	Process data mismatch	Check module configuration.
	$0x1800_H$ (32546_D)	Device does not exist.	Communication cancelled
	$0x1801_H$ (6145_D)	Parameter assignment error in startup	Check parameter assignment.
	$0x1802_H$ (6146_D)	Wrong device VendorID	Check device.
	$0x1803_H$ (6147_D)	Wrong device DeviceID	Check device.
	$0x1804_H$ (6148_D)	Short-circuit to C/Q	Check port connection.
	$0x1805_H$ (6149_D)	IO-Link PHY overtemperature	
	$0x1806_H$ (6150_D)	Short-circuit to L+	Check port connection.
	$0x1808_H$ (6152_D)	Event overflow on the device	
	$0x1809_H$ (6153_D)	Backup failed	Memory outside of range (2k)
	$0x180A_H$ (6154_D)	Backup invalid	Mismatch when identifying data storage
	$0x180B_H$ (6155_D)	Backup invalid	Data storage unspecified error
	$0x180C_H$ (6156_D)	Backup invalid	Upload error
	$0x180D_H$ (6157_D)	Backup invalid	Download error
	$0x180E_H$ (6158_D)	P24 (Class B) missing or undervoltage	Check voltage supply.
	$0x180E_H$ (6158_D)	Short-circuit at P24 (Class B)	Check port connection.
	$0x6000_H$ (24576_D)	Cycle time invalid	Check cycle time.
	$0x6001_H$ (24577_D)	Revision error	Incompatible protocol version
	$0x6002_H$ (24578_D)	ISDU batch failed	Parameter inconsistency

Maintenance events

All IO-Link events of the type "Warning" generated by the IO-Link device or port are mapped to the PROFINET diagnostics alarm of the type "Maintenance" of the assigned submodule. The purpose of this is the early detection and elimination of potential faults.

For the IO-Link master, maintenance events signal to the user when a network component must be checked or replaced.

Examples of displaying the IO-Link event codes

An IO-Link device generates EventCode $0x8CA0_H$ (type "Warning").

The following event code results in channel diagnostics:

PROFINET channel diagnostics type: Maintenance CET: $0x9501_H$, ECET: $0x0CA0_H$.

Maintenance "IO-Link Device Diagnostics - Page 2, Ambient light interference", generated from the IO-Link event code $0x8CA0_H$.

Process alarm events

All IO-Link events (event codes) of the Notification type that are generated by the IO-Link device are mapped to the PROFINET process alarm of the assigned submodule.

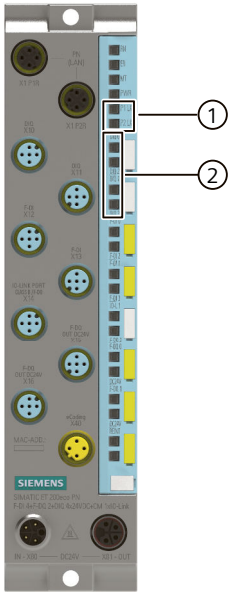
The additional alarm information read out using RALRM contains the relevant IO-Link event code.

The coding of the additional alarm information corresponds to the coding USI = 0x8320 (ProcessAlarmReason).

6.2.2 DIQ

6.2.2.1 Status and error displays

The figure below shows the LED displays (status and error displays) of the ET 200eco PN M12-L F module for DIQ:



① P1 LK / P2 LK LEDs (Green)
② DIQ channel status / channel fault LEDs (Green/Red)

Figure 1-828 LED displays

Meaning of LEDs

The following tables describe the meaning of the status and error displays:

Behavior of the LEDs RN/NS (RUN/network status), ER/MS (ERROR/module status) and MT/IO (MAINT/IO status)

Table 1-1135 Error display of the LED

LED			Meaning	Remedy
RN/NS (green)	ER/MS (red)	MT/IO (yellow)		
□ Off	□ Off	□ Off	Missing or insufficient supply voltage at the I/O device.	Check the supply voltage.
■ On	■ On	■ On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-

LED			Meaning	Remedy
RN/NS (green)	ER/MS (red)	MT/IO (yellow)		
On	On	On	The three LEDs light up simultaneously for approximately 2 s while "Reset to factory settings" is running.	-
Flashes	Off	Off	Module is disabled.	Activate the ET 200eco PN M12-L F with the configuration software or with the user program.
			Module is not configured or is incorrectly configured.	Configure the ET 200eco PN M12-L F using the configuration software.
			Module is starting up.	-
			Parameters are being assigned to the module.	
			Loading firmware (when the firmware update is performed during startup, all LEDs retain their current status).	-
On	N/A	N/A	The ET 200eco PN M12-L F is currently exchanging data with the IO controller.	-
N/A	Flashes	N/A	Module diagnostics is available.	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration.	Check the configuration of the ET 200eco PN M12-L F.
			Parameter error	Correct the errors in the parameter assignment.
N/A	N/A	On	Maintenance	Evaluate the maintenance events.
Flashes	Flashes	Flashes	The "Node flash test" is running (the P1 LK and P2 LK LEDs of the PROFINET interface are also flashing).	-
			Hardware or firmware defective (The P1 LK and P2 LK LEDs of the PROFINET interface are not flashing).	Replace the ET 200eco PN M12-L F IO device.

PWR LED

Table 1-1136 Status display of the PWR LED

PWR LED	Meaning
Off	Load voltage 2L+ is missing or too low.
On	Load voltage 2L+ is present.

P1 LK and P2 LK LEDs

Table 1-1137 Error display of the P1 LK and P2 LK LEDs

P1 LK and P2 LK LEDs	Meaning	Remedy
Off	There is no Ethernet connection between the communications interface of your IO device and a communication partner (for example, an IO controller).	Check whether the bus cable to the switch/communication partner is interrupted.
On	There is an Ethernet connection between the communications interface of your IO device and a communication partner (for example, an IO controller).	-
Flashes	The "Node flash test" is running (the RN/NS, ER/MS, and MT/IO LEDs also flash).	-
	Communication error: A physical connection exists, but communication is not possible.	Check the PROFINET IO settings.

Channel status/channel error LEDs

Table 1-1138 Status and error display of the channel status/channel error LEDs

LEDs Channel status/error	Meaning
Off	Process value = 0
On	Process value = 1
On	Channel diagnostics

6.2.2.2 Interrupts

The DIQs support diagnostic and maintenance interrupts.

Diagnostics interrupt

The I/O device generates a diagnostic interrupt on the following events:

- Wire break
- Internal module fault
- Parameter error
- Hardware interrupt lost
- Short-circuit

Maintenance alarm

The I/O device generates a maintenance alarm on the following events:

- Low voltage 1L+
- Loss of synchronization

Hardware interrupt

If the fault-free signal (value status/QI = 1) is pending at the channel, meaning no diagnostic interrupt is present, the I/O device generates a hardware interrupt for the following events:

- Rising edge
- Falling edge

6.2.2.3 Alarms

Diagnostics alarms

Each diagnostics event triggers a diagnostics alarm. On the I/O device ET 200eco PN M12-L F, the LED ER/MS flashes red. You can read out the diagnostics alarms in the diagnostics buffer of the CPU and evaluate error codes with the user program.

NOTE

Wiring two outputs in parallel

For parallel connection of two outputs for redundant control of a load, deactivate the channel diagnostics "Wire break" and "Short-circuit".

Uncouple the parallel switched outputs with external diodes.

Table 1-1139 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Corrective measures
Wire break	6_H	Fault in the external circuitry	Check the external circuitry and correct the fault.
		Encoder faulty	Replace the encoder.
		Impedance of encoder circuitry is too high.	Use a different encoder type or modify the wiring. For example, use cables with a larger cross-section.
		Interruption of cable between the I/O device and sensor.	Establish the connection.
		Channel not connected (open).	• Disable diagnostics. • Connect a resistor of 25 kΩ to 45 kΩ to the encoder contacts.
Parameter error	10_H	• I/O device cannot evaluate parameters for the channel. • Incorrect parameter assignment	Correct the parameter assignment.

Diagnostics alarm	Error code	Meaning	Corrective measures
Hardware interrupt lost	16_H	The I/O device cannot trigger an interrupt because the previous interrupt was not acknowledged; possible configuration error	• Change the interrupt handling on the CPU and reassign the parameters to the I/O device, if necessary. • The error persists until the I/O device is assigned new parameters.
Short-circuit	105_H	Short-circuit to L+	• Correct the process wiring. • Replace the defective encoder/actuator.
	106_H	Short-circuit to ground	

Maintenance events

Triggering of a maintenance event

The MultiFieldbus interfaces of the ET 200eco PN M12-L F support the diagnostics concept and maintenance concept in PROFINET according to the IEC 61158-6-10 standard. The goal is to detect and remove potential problems as soon as possible.

The I/O device signals a maintenance event to the higher-level diagnostic system on the following event:

Table 1-1140 Triggering of a maintenance event

Maintenance alarm	Error code	Event	Meaning
Maintenance demanded MT/IO LED is lit	2_H	Undervoltage	Supply voltage 1L+ is below the tolerance limit.
	8003_H	Loss of synchronization	• No synchronization frame received. No synchronization telegram was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization telegrams are located outside of permitted limits (jitter).

System alarms in STEP 7

The maintenance information is generated in STEP 7 for the "Maintenance demanded" system alarm, indicated for each port by a yellow wrench icon in the device view or in the device configuration.

You can find additional information in the TIA Portal Information System.

Hardware interrupts

During a hardware interrupt, the CPU interrupts processing of the user program and processes the hardware interrupt organization block.

For detailed information on the event, refer to the hardware interrupt organization block with the "RALRM" instruction to read additional interrupt info, as well as to the TIA Portal Information System. The start information of the organization block shows information on which channel of the I/O device triggered the hardware interrupt. The figure below shows the assignment to the bits of the local data double word 8:

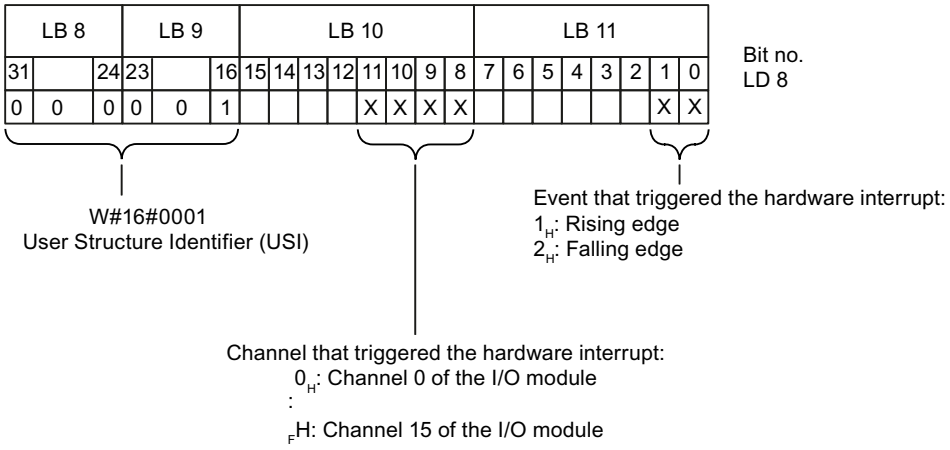


Figure 1-829 Start information of the organization block

Applications

7

This chapter presents typical application examples for connection of fail-safe input and output channels, with a statement of the safety performance (SIL/Cat./PL) that is possible for each example.

The PLC system has an extremely low failure rate and therefore contributes only a small part of the total probability of dangerous failure of an automated system. The probability of dangerous failures of the sensors and actuators is typically far larger than the probability of dangerous failure per hour (PFH)/probability of dangerous failure on demand (PFD) of the PLC system. Estimates for quantitative safety properties like PDF and PFH are calculated using the following methods:

- Standard data tables
- Calculation methods according to international standards, which include the following:
  - IEC 61508
  - ISO 13849
  - IEC 61131-6

  The values are based on the following assumptions:
  - Continuous full nominal load
  - Nominal voltage
  - Equipment ambient temperature of 60 °C

Faults in the wiring system can also be a substantial contributor to failures.

To achieve a targeted level of safety performance for each safety function, perform these actions:

- Choose an appropriate architecture.
- Choose sensors and actuators that are appropriately rated.
- Provide a safety program that meets the requirements of the safety function.
- Provide diagnostics and proof-tests to maintain the ratings of the sensors and actuators.
- Use wiring installation practices, diagnostics, and proof-tests to assure wiring integrity.
- Generate and control operating and maintenance procedures for the lifetime of the installation.

The S7-1200/S7-1200 G2/S7-1500, ET 200pro (IP67 compliant), ET 200S/ET 200SP, ET 200eco PN, and ET 200M/ET 200MP Fail-safe systems provide a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each fail-safe PLC component is stated assuming no field proof-test within the lifetime of the product. Sensors and actuators typically require regular proof-tests to maintain an expected level of safety performance.

The reaction time (Page 119) of each safety function depends on the reaction time of each component, including the sensor, the PLC system, and the actuator. You must choose PLC parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to the total delay (Page 119) from the fail-safe input to the safe actuator response, you must consider these additional time-related factors:

- To be assured of a safety response, a safety signal from the fail-safe input sensor must last long enough to be seen by the safety program, which varies based upon your configured input filter, the duration of short-circuit test, and startup after short-circuit test is completed times.
- The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is functional and under independent control. The OFF test pulse duration can be as long as your configured "Maximum readback time". The ON test pulse duration can be as long as your configured "Maximum readback time switch on test". For a given output, the ON test pulse is only provided to one of the P- or M- switches at a time, but in the presence of a single fault this could apply energy to your load. Make sure that your actuator does not respond to an OFF signal up to the "Maximum readback time" or to an ON signal up to the "Maximum readback time switch on test".
- The fail-safe digital outputs verify that any transition of the output process value reaches the expected state within the configured "Maximum readback time". When an output process value transition occurs, your program must wait the configured "Maximum readback time" before changing the output process value again. If the output does not reach the expected state in the configured "Maximum readback time", the output channel passivates.

⚠ WARNING

Safety performance depends upon design and continued maintenance
The ET 200pro, ET 200SP, and S7-1200/S7-1200 G2/S7-1500 Fail-safe CPUs and F-DI 4/F-DQ 2/DIQ 4/IOL 1 Fail-safe module provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.
You must choose all components of your installation and complete your design according to accepted safety standards and practices to achieve your required level of safety.
Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage.

7.1 Digital input applications

Consider the application modes presented here along with the features of the fail-safe module as described in the product overview (Page 15):

You configure each channel as a 1oo1 or as part of a 1oo2 evaluation pair. The corresponding channels from input bytes "a" (a.0, a.2), (a.1, a.3) form 1oo2 channel groups. Within this restriction, you can assign 1oo1 and 1oo2 in any order.

Short-circuit testing requires use of the internal sensor supply. Each input can optionally have its own Vs supply. If you enable the short-circuit test, and your inputs are configured as 1oo2, sensors used with the 1oo2 pair are configured with the same parameters. All channels you configured for internal sensor supply are subject to the same short-circuit test. You configure a test duration and sensor startup time.

The sensor supply is monitored to detect short-circuit or overload. It is cycled on each power up to assure control and readback are working, and the sensor supply continuously monitors the readback. You configure a discrepancy time to identify unacceptable differences between 1oo2 inputs. You configure a filter time for each channel or each 1oo2 pair.

Achieving SIL 2/Cat. 3/PL d in 1oo1 configuration

You can achieve SIL 2/Cat. 3/PL d in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach SIL 2/Cat. 3/PL d by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failure, unless additional measures are applied.

Achieving SIL 3/Cat. 4/PL e in 1oo2 configuration

You can achieve SIL 3/Cat. 4/PL e in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Cat. 4.
- The duplicated external wiring of 2 sensors to 2 input points is vulnerable to accumulated fault dangerous failure, unless additional measures are applied.

The F-DI is recommended for SIL 3/Cat. 4/PL e only when 1oo2 evaluation is selected. A single high-integrity sensor can be rated up to SIL 3/Cat. 4/PL e, but it should be wired and configured for 1oo2 evaluation for the channel to achieve SIL 3/Cat. 4/PL e.

7.1.1 Selecting the digital input application

Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

You can choose a digital input application based upon your functional and safety-related needs when wiring inputs. The applications and their achievable safety ratings are described in the table below:

Table 1-1141 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Sensor supply *	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
1	Internal	1oo1 evaluation	Single input	1 channel	2/3/d	
2	External					

* The ET 200eco PN M12-L F uses M12 connections and is intended for use outside a cabinet in IP67 applications (everything sealed). If you require the use of an external supply, cut the M12 cable and make the connection inside a sealed cabinet or inside a sealed sensor. For external supplies, do not connect the pin 1 wire (V_{S1}) or the pin 5 wire (V_{S2}) in the M12 cable. In addition, make the external 24 V DC connection inside a sealed cabinet or inside a sealed sensor.

Application	Sensor supply *	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
3	Internal	1oo2 evaluation	Two inputs	2 channel equivalent	3/3/e	3/4/e
4	External				3/3/d	
5	Internal				3/3/e	3/4/e
6	External				3/3/e	
7	Internal			2 channel - 3 wire non-equivalent	3/3/e	3/4/e
8	External				3/3/e	
9	Internal			2 channel - 4 wire non-equivalent	3/3/e	3/4/e
10	External				3/3/e	

* The ET 200eco PN M12-L F uses M12 connections and is intended for use outside a cabinet in IP67 applications (everything sealed). If you require the use of an external supply, cut the M12 cable and make the connection inside a sealed cabinet or inside a sealed sensor. For external supplies, do not connect the pin 1 wire (V_{S1}) or the pin 5 wire (V_{S2}) in the M12 cable. In addition, make the external 24 V DC connection inside a sealed cabinet or inside a sealed sensor.

⚠ WARNING

Incorporation into SIL 2 and SIL 3 applications

To incorporate an Application Mode into a SIL 2 or SIL 3 rated application, the sensor must be an appropriately qualified device for that SIL level. Failure to use an appropriately qualified device can prevent your safety application from reaching a sufficient safety rating, which increases the probability of dangerous failures occurring.

Use sensors that are appropriately qualified devices: either SIL 3 or SIL 2 with Systematic Capability rules defined in IEC 61508-2:2010 observed (sufficient independence in design and application or SC3).

Dangerous failures could result in death, severe personal injury, and/or property damage.

7.1.2 F-DI Applications 1 and 2: 1oo1 evaluation of a single sensor

F-DI application mode 1

This Application Mode features a single one-channel sensor using 1oo1 evaluation and an internal sensor supply.

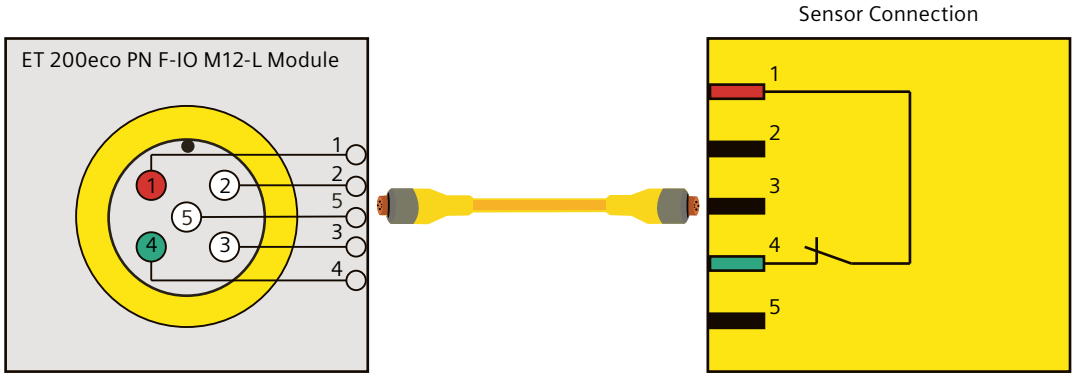


Figure 1-830 F-DI Application Mode 1

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	Sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 2

This Application Mode features a single one-channel sensor using 1oo1 evaluation and an external sensor supply.

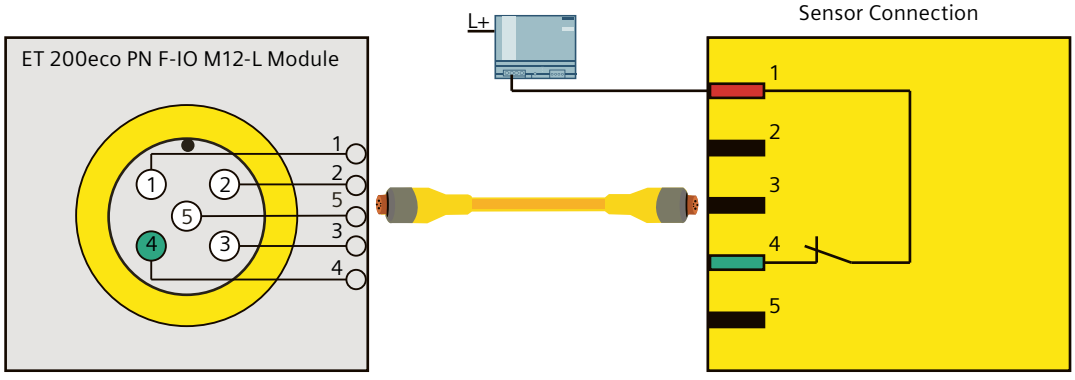


Figure 1-831 F-DI Application Mode 2

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	External

7.1.3 F-DI Applications 3 and 4: 1oo2 equivalent evaluation of a single sensor

F-DI application mode 3

This Application Mode features a single two-channel sensor using 1oo2 equivalent evaluation and an internal sensor supply.

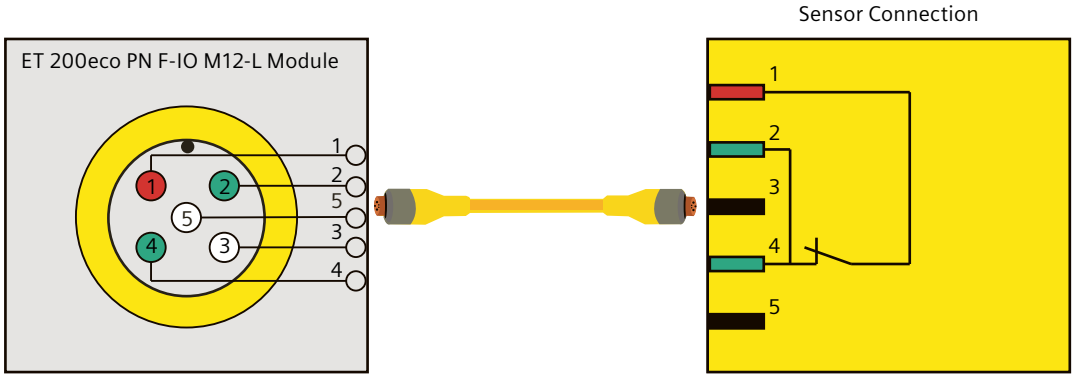


Figure 1-832 F-DI Application Mode 3

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire equivalent
Sensor supply	Sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 4

This Application Mode features a single two-channel sensor using 1oo2 equivalent evaluation and an external sensor supply.

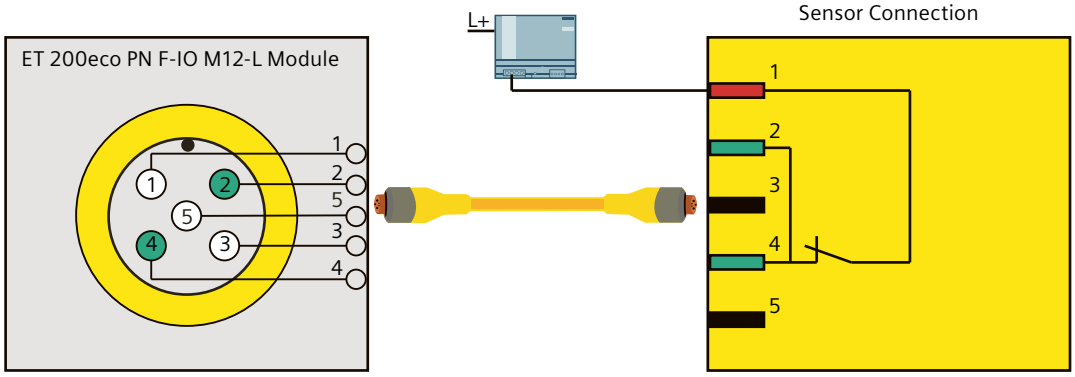


Figure 1-833 F-DI Application Mode 4

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire equivalent
Sensor supply	External

7.1.4 F-DI Applications 5 and 6: 1oo2 evaluation of a mechanically-coupled two-channel sensor

F-DI application mode 5

This Application Mode features a single two-channel sensor, with two mechanically-coupled contacts, using 1oo2 equivalent evaluation and internal sensor supplies.

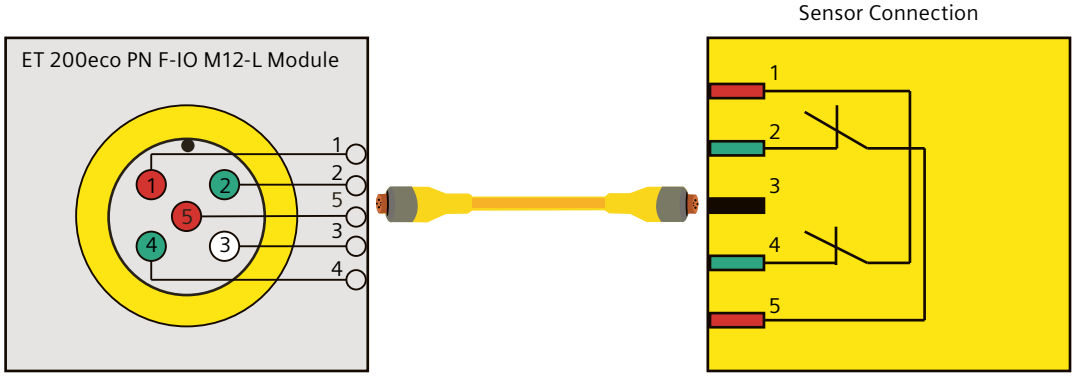


Figure 1-834 F-DI Application Mode 5

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire equivalent
Sensor supply	Sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 6

This Application Mode features a single two-channel sensor, with two mechanically-coupled contacts, using 1oo2 equivalent evaluation and external sensor supplies.

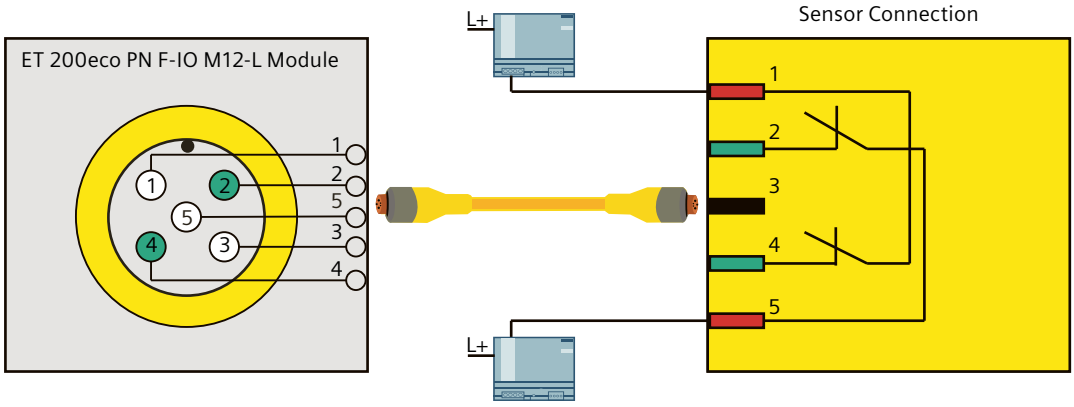


Figure 1-835 F-DI Application Mode 6

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire equivalent
Sensor supply	External

7.1.5 F-DI Applications 7 and 8: 1oo2 evaluation of a single 3 wire non-equivalent sensor

F-DI application mode 7

This Application Mode features a single two-channel sensor using 1oo2, 3 wire non-equivalent evaluation and an internal sensor supply.

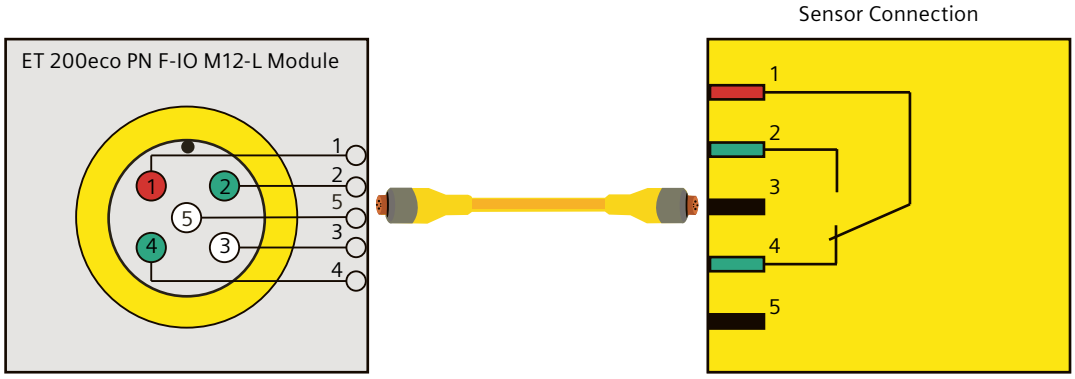


Figure 1-836 F-DI Application Mode 7

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire non-equivalent
Sensor supply	Sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI application mode 8

This Application Mode features a single two-channel sensor using 1oo2, 3 wire non-equivalent evaluation and an external sensor supply.

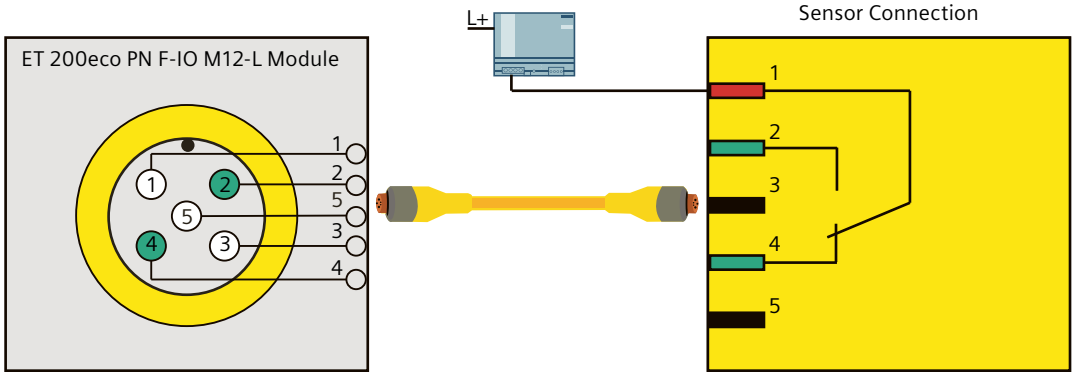


Figure 1-837 F-DI Application Mode 8

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire non-equivalent
Sensor supply	External

7.1.6 F-DI Applications 9 and 10: 1oo2 non-equivalent evaluation of a non-equivalent single channel sensor

F-DI Application Mode 9

This Application Mode features a single two-channel sensor using 1oo2, 4 wire non-equivalent evaluation and internal sensor supplies.

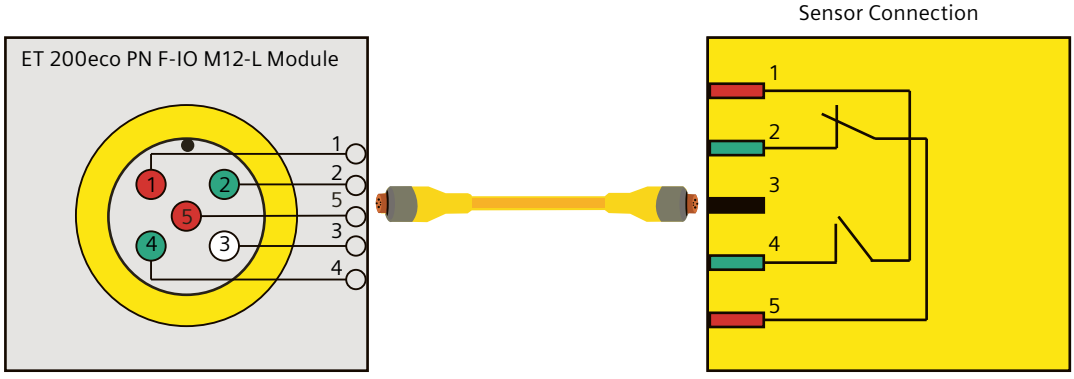


Figure 1-838 F-DI Application Mode 9

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire non-equivalent
Sensor supply	Sensor supply x (where "x" is the respective input channel number)
Short-circuit test	Optional (configurable)

F-DI Application Mode 10

This Application Mode features a single two-channel sensor using 1oo2, 4 wire non-equivalent evaluation and external sensor supplies.

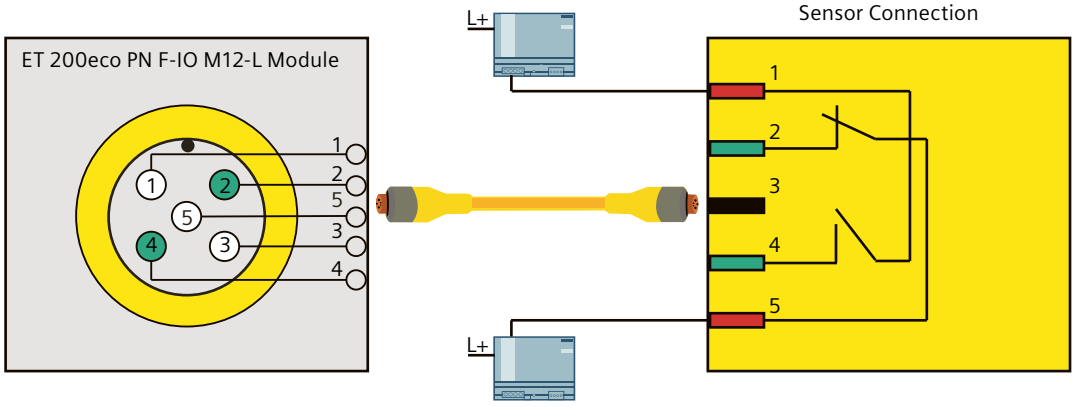


Figure 1-839 F-DI Application Mode 10

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire non-equivalent
Sensor supply	External

7.2 Digital output applications

The main features of the fail-safe digital outputs (Page 19) include the following:

- The fail-safe module separately controls current flow in the P (24 V DC to load) and M (load to common) sides of the circuit.
- The voltage at each P- and M- switch is read back to confirm proper state.
- The P- and M- switches are regularly tested with short ON and OFF pulses to confirm control.
- You must configure readback times that allow the external voltage to respond, but do not cause your load to physically respond.
- Internal current limiting as described in the data sheet is sufficient in combination with your 24 V DC supply. However, you must consider whether additional current limits or fuses are necessary. Refer to "Specifications" (Page 111).

The module controls all output channels with cross-diagnostics.

All applications shown are capable of reaching SIL 3/Cat. 4/PL e.

To reach Cat. 4, external contactors must be SIL-rated with sense contacts. Read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs, but external feedback inputs can also be standard inputs.

7.2.1 Selecting the digital output application

You can choose a digital output application based upon your functional and safety-related needs when wiring output actuators. The applications and their achievable safety ratings are described in the table below:

Application	Description	Achievable SIL/Category/PL
1	Directly-connected SIL-rated actuator	3/4/e
2	External contactors: Separate P- and M-controlled contactors	3/4/e
3	External contactors: Parallel-connected contactors between P and M	3/4/e
5	External contactors: Separate output channels for each contactor	3/4/e
6	External contactors: Separate output channels for each contactor connected across the PM	3/4/e

7.2.2 F-DQ Application 1: Wiring a load directly to a digital output, channel 2

This Application Mode features directly connecting a load to the P- and M- outputs of fail-safe output channel 2.

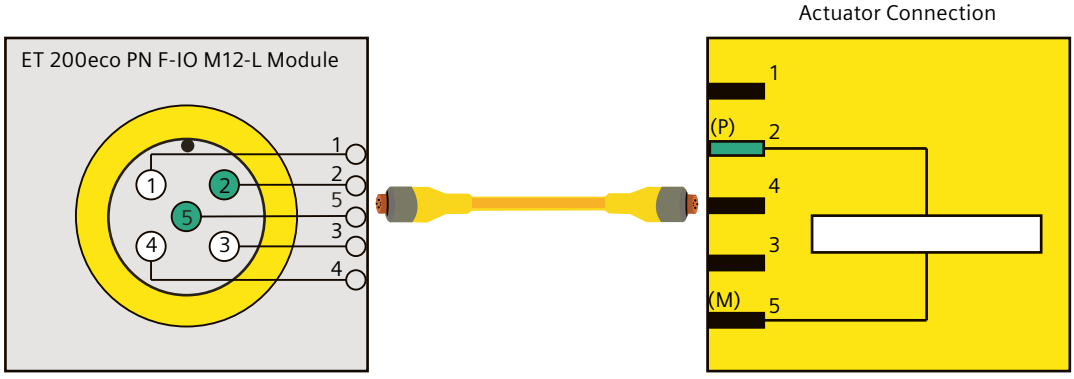


Figure 1-840 F-DQ Application Mode 1

NOTE

This fail-safe output uses the IO-Link Class B port, and the pinning of the output is different than the other fail-safe output channels.

7.2.3 F-DQ Application 2: Wiring a load directly to a digital output, channels 0 and 1

This Application Mode features directly connecting a load to the P- and M- outputs of one channel.

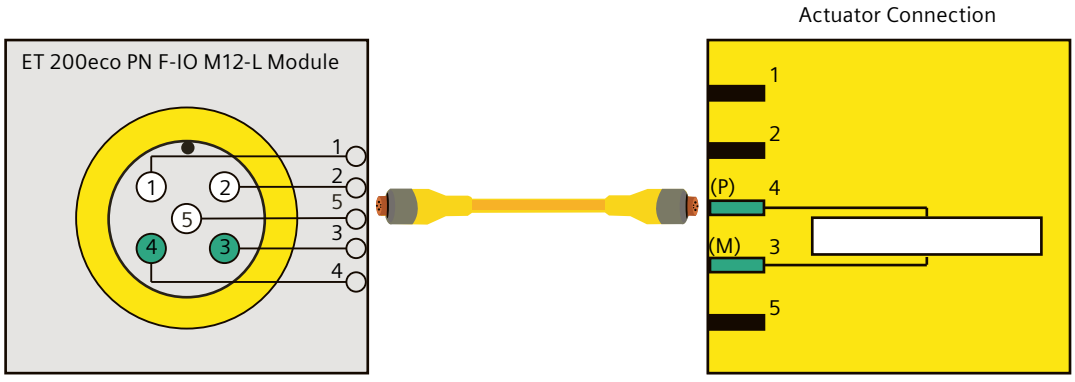


Figure 1-841 F-DQ Application Mode 2

7.2.4 F-DQ Application 3: Using two relays to control an actuator, relays connected between output and supply rail

This Application Mode features controlling a load by means of the series-connected, normally-open contacts of two relays. The coil of one relay is connected between the P-output of a channel and M, while the coil of the other relay is connected between the M-output of the same channel and L+.

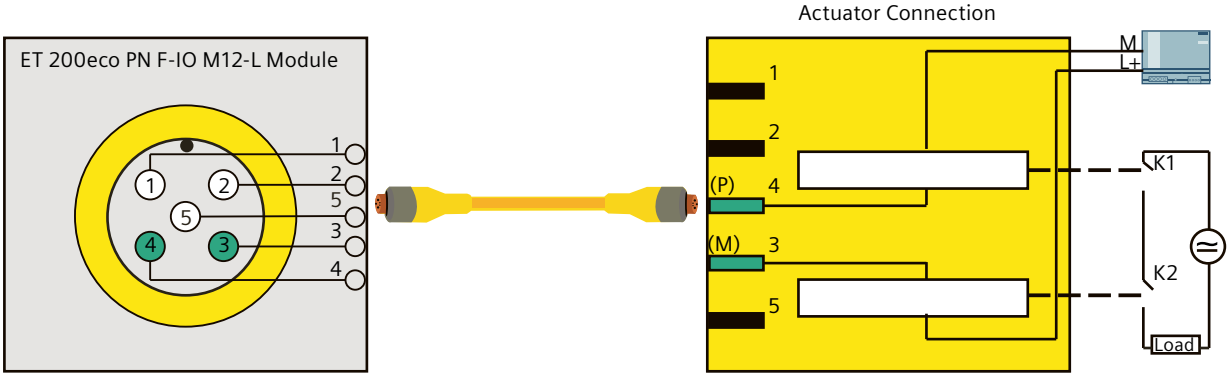


Figure 1-842 F-DQ Application Mode 3

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if the following conditions are fulfilled:

- You check the relay status by means of a separate digital input.
- You adequately protect the wiring against shorts between the P- and M- outputs, as you cannot switch off the actuator if such a fault occurs.

7.2.5 F-DQ Application 5: Using two relays to control an actuator, relays connected in parallel across one output

This Application Mode features controlling a load by means of series-connected, normally-open contacts of two relays. The coils of both relays are connected in parallel across the outputs of one channel.

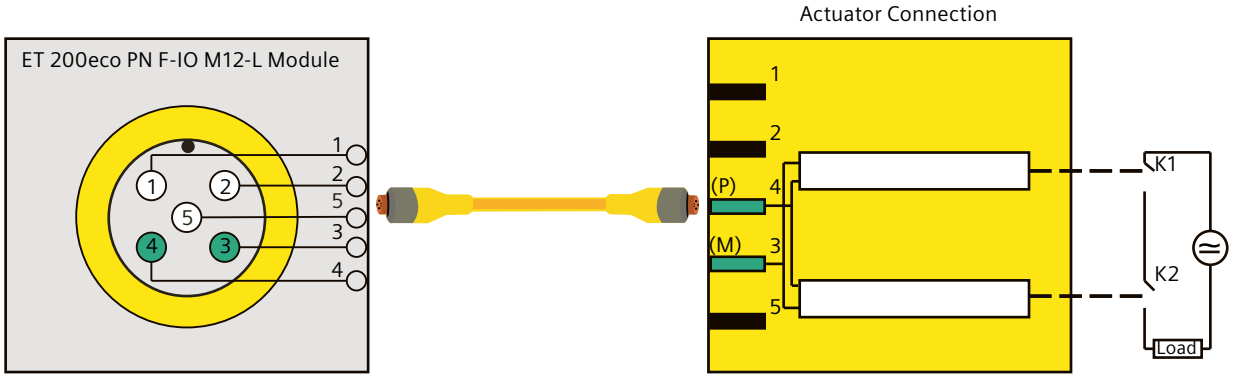


Figure 1-843 F-DQ Application Mode 5

NOTE

This configuration achieves SIL 3/Cat. 4/PL e if you check the relay status by means of a separate digital input.

7.2.6 F-DQ Application 6: Using separate relays to control an actuator, relays connected in parallel across two outputs

This Application Mode features controlling a load by means of series-connected, normally-open contacts of two relays. The coil of each relay is connected across the PM output of a unique output channel. Both outputs are independent of each other and are independently controlled and enabled from the safety program.

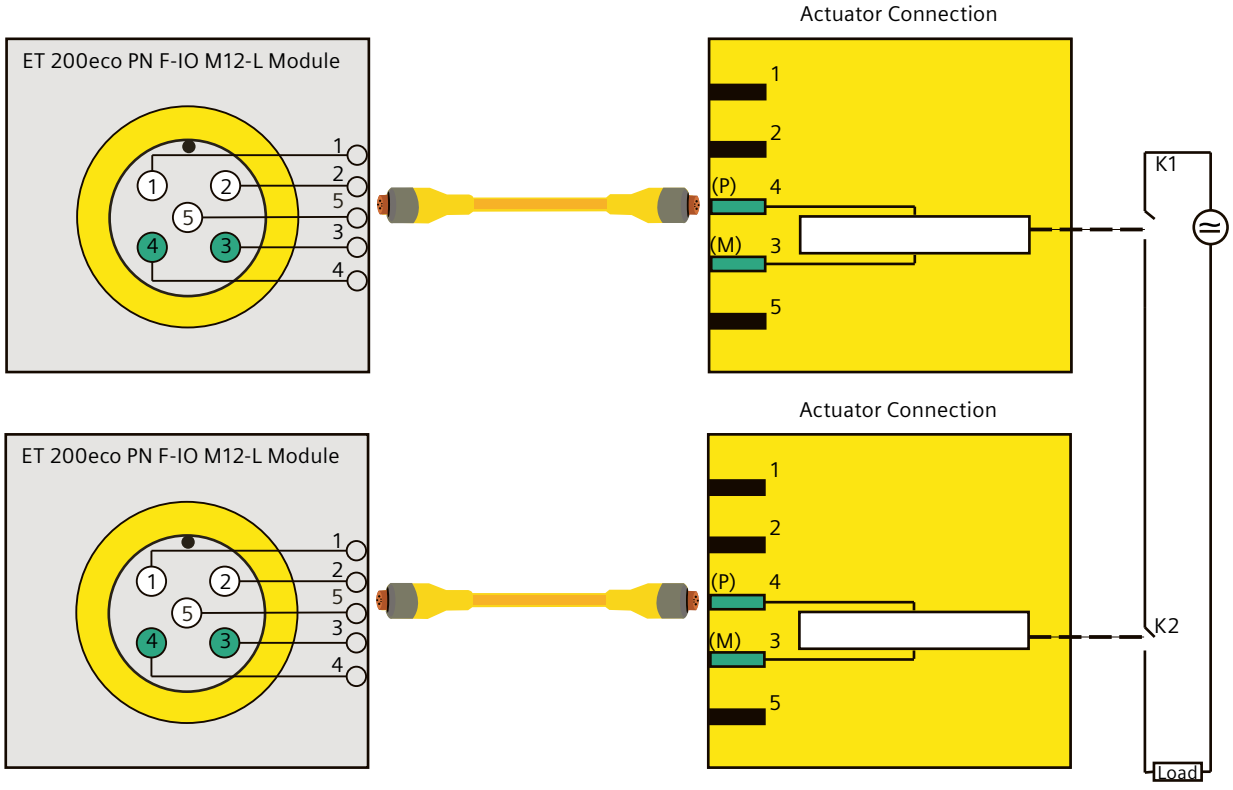


Figure 1-844 F-DQ Application Mode 6

NOTE
This configuration achieves SIL 3/Cat. 4/PL e if you check the relay status by means of a separate digital input.

7.3 Digital input/output applications

7.3.1 DIQ Application 1: Internal sensor supply

This Application Mode features a single one-channel sensor using an internal sensor supply.

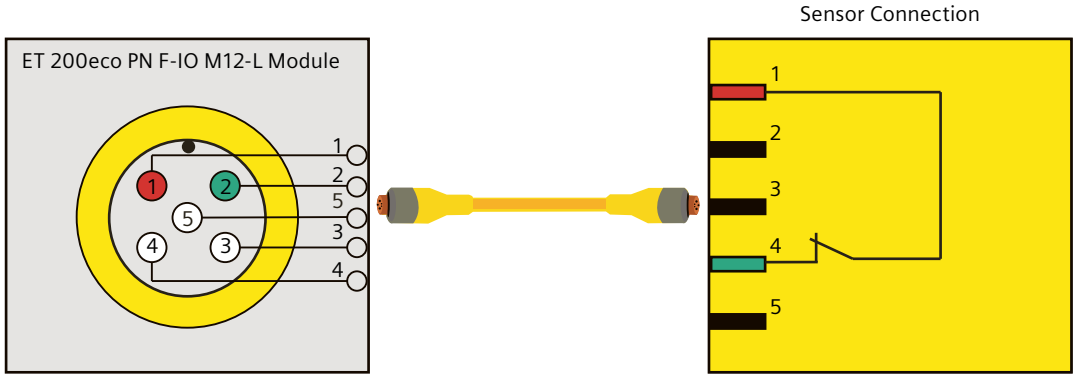


Figure 1-845 DIQ Application Mode 1

Parameter assignment

Parameter name	Parameter value
Short-circuit test	Optional (configurable)

7.3.2 DIQ Application 2: External sensor supply

This Application Mode features a single one-channel sensor using an external sensor supply.

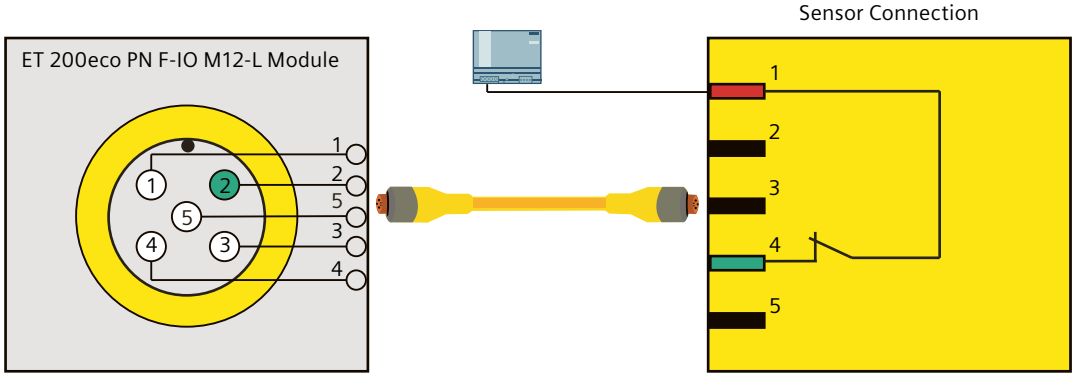


Figure 1-846 DIQ Application Mode 2

Technical specifications

A

A.1 Details on insulation, protection class, degree of protection, and rated voltage

The ET 200eco PN M12-L F module varies from other M12-L modules in specific ways, meaning that there are exceptions for the F-module.

Severity for voltage interruption

This I/O device meets the severity class PS1 for voltage interruption (1 ms). To ensure compliance with IEC 61131-2, use only power supply units/power supplies with a power failure bridging time of at least 10 ms. Observe the relevant requirement in your product standards (for example, 30 ms for "burners" according to EN 298) with regard to possible voltage interruptions.

Immunity to surge voltages

The ET 200eco PN M12-L F module is equipped with internal protection for overloads coupled by surge voltage caused by lightning that meets the levels called out as "high-energy single pulse (surge) to IEC 61000-4-5" in the *Distributed I/O system ET 200eco PN M12-L System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109778292). If you need higher limit values, then use external protective circuits, for example a surge filter, between the voltage power supplies and the voltage input of the module to ensure surge immunity for the ET 200eco PN M12-L F module. Additionally, use external protection between the I/O and the sensors/actuators to which the module is connected.

You can find further information in the *Designing interference-free controllers* (https://support.industry.siemens.com/cs/ww/en/view/59193566) function manual.

NOTE

Overvoltage protection measures always require a case-by-case examination of the entire application. Optimal overvoltage protection requires a comprehensive protective scheme that encompasses the entire facility infrastructure and all peripheral installations. In particular, this involves structural measures in the building design phase.
For detailed information regarding overvoltage protection, contact your Siemens representative or a company specializing in lightning protection.

Use in industrial burner and firing environments

The ET 200eco PN M12-L F module meets the requirements and criteria of the following standards when using 10m or less maximum cable length for the F-DQs:

- EN 298:2022 - Automatic burner control systems for burners and appliances burning gaseous or liquid fuels
- EN 50156-1:2015 - Electrical equipment for furnaces and ancillary equipment - Part 1: Requirements for application design and installation
- EN 50156-2:2015 - Electrical equipment for furnaces and ancillary equipment - Part 2: Requirements for design, development, and type approval of safety devices and subsystems

A.2 Specifications

Standards compliance

The ET 200eco M12-L F design conforms with the following standards and test specifications. The test criteria for the ET 200eco M12-L F are based on these standards and test specifications.

Note that certification status can change without notification. It is your responsibility to determine applicable certifications by referring to the ratings marked on the product. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

All ET 200eco M12-L F modules are certified by TÜV SÜD. The fail-safe module is certified to the IEC 61508, EN ISO 13849, and IEC 62061 standards and guidelines for functional safety. For further information, refer to the current associated Annex of the report for the TÜV SÜD certificate (https://support.industry.siemens.com/cs/ww/en/view/109825198) for the F-module (https://support.industry.siemens.com/cs/ww/en/view/109825395).

Technical specifications

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7146-6FF00-0BB0/td?dl=en).

Article number	6ES7146-6FF00-0BB0
General information	
HW functional status	from FS01
Firmware version	V1.1.x
• FW update possible	Yes
Vendor identification (VendorID)	002AH
Device identifier (DeviceID)	0306H
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• IRT	No; module will participate within an IRT topology
• Fast startup	No

Article number	**6ES7146-6FF00-0BB0**
• Prioritized startup	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V20 or higher with HSP0468
• PROFINET from GSD version/GSD revision	GSDML V2.43 2025.05
Operating mode	
• DI	Yes
• Counter	No
• DQ	Yes
• MSI	No
• MSO	No
Supply voltage	
Rated value (DC)	24 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Load voltage 1L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	20.4 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes; Against destruction; encoder power supply outputs applied with reversed polarity
Load voltage 2L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	20.4 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes; against destruction
Input current	
Current consumption (rated value)	100 mA 1L+ without load; 45 mA 2L+ without load
from load voltage 1L+ (unswitched voltage)	12 A; Maximum value
from load voltage 2L+, max.	12 A; Maximum value
Encoder supply	
Number of outputs	6; Us0, Us1, Vs0 - Vs3
24 V encoder supply	
• Short-circuit protection	Yes; per channel, electronic
• Output current, max.	0.5 A
Actuator supply	
Number of outputs	3; Us2 - Us4
Short-circuit protection	Yes; per channel, electronic
Output current	
• Rated value	1 A
Power loss	
Power loss, typ.	12 W

Article number	**6ES7146-6FF00-0BB0**
Address area	
Address space per module	
• Inputs	46 byte
• Outputs	39 byte
Hardware configuration	
Submodules	
• Number of configurable submodules, max.	3
Digital inputs	
Number of digital inputs	4 single-channel F-DI (SIL2) parameterizable as 2 two-channel (SIL3); 4 parameterizable as DIQ
Digital inputs, parameterizable	Yes
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes; F-DI
Input characteristic curve in accordance with IEC 61131, type 3	Yes; DIQ
Number of simultaneously controllable inputs	
all mounting positions	
– up to 60 °C, max.	8
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-3 to +5V
• for signal "1"	+15 to +30 V F-DI; +11 to +30 V DIQ
Input current	
• for signal "1", typ.	3 to 6 mA F-DI; 2.5 mA DIQ
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.8 / 1.6 / 3.2 / 6.4 / 12.8 ms F-DI; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms DIQ
Cable length	
• unshielded, max.	30 m
Digital outputs	
Number of digital outputs	7; 2 F-DQ; 1 parameterizable F-DQ or IO-LINK Class B (with or without safety-shutdown); 4 parameterizable as DIQ
• in groups of	3 F-DQ (2L+); 4 DIQ (1L+)
Short-circuit protection	Yes; per channel, electronic
• Response threshold, typ.	10 A F-DQ; 1 A DIQ
Limitation of inductive shutdown voltage to	Typ. -74 V (typ. -26 V P-switch; typ. +48 V M-switch) F-DQ; Typ. 1L+ (-70 V) DIQ
Controlling a digital input	No F-DQ; Yes DIQ
Switching capacity of the outputs	
• with resistive load, max.	2 A F-DQ; 0.5 A DIQ
• with inductive load, max.	2 A F-DQ; 0.5 A DIQ
• on lamp load, max.	10 W F-DQ; 5 W DIQ

Article number	6ES7146-6FF00-0BB0
Load resistance range	
• lower limit	12 Ohm F-DQ; 48 Ohm DIQ
• upper limit	2 kOhm F-DQ; 4 kOhm DIQ
Output voltage	
• for signal "1", min.	2L+ (-2 V) F-DQ (2L+ (-1.5 V) P-switch; 0.5 V M-switch); 1L+ (-0.8 V) DIQ
Output current	
• for signal "1" rated value	2 A F-DQ; 0.5 A DIQ
• for signal "0" residual current, max.	0.5 mA F-DQ; 0.1 mA DIQ
Output delay with resistive load	
• "0" to "1", max.	100 µs
• "1" to "0", max.	100 µs; F-DQ; 150 µs DIQ
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	No F-DQ; Yes DIQ
Switching frequency	
• with resistive load, max.	30 Hz F-DQ; 100 Hz DIQ
• with inductive load, max.	0.1 Hz F-DQ; 0.5 Hz DIQ
• on lamp load, max.	30 Hz F-DQ; 100 Hz DIQ
Cable length	
• unshielded, max.	30 m; 10 m F-DQ in hardware revision FS-01 for burner applications related to EN 298
Encoder	
Connectable encoders	
• 2-wire sensor	No F-DI; Yes DIQ
– permissible quiescent current (2-wire sensor), max.	0.5 mA F-DI; 1.5 mA DIQ
IO-Link	
Number of ports	1
IO-Link protocol 1.0	Yes
IO-Link protocol 1.1	Yes
Transmission rate	4.8 kBd (COM1); 38.4 kBd (COM2)
Cycle time, min.	2 ms
Size of process data, input per port	33 byte
Size of process data, input per module	33 byte
Size of process data, output per port	32 byte
Size of process data, output per module	32 byte
Memory size for device parameter	2 kbyte
Master backup	Possible with function block IO_LINK_MASTER
Configuration without S7-PCT	Possible; autostart/manual function
Cable length unshielded, max.	20 m
Connection of IO-Link devices	
• Port type A	Yes; via 3-core cable
• Port type B	Yes; additional device supply: max. 2 A; also available with integrated Safety Shutdown via F-DQ 2

Article number	**6ES7146-6FF00-0BB0**
Interfaces	
Number of PROFINET interfaces	1
1. Interface	
Interface type	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
Interface types	
• M12 port	Yes; 2x M12, 4-pin, D-coded
• Number of ports	2
• integrated switch	Yes
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
PROFINET IO Device	
Services	
– IRT	No; module will participate within an IRT topology
– Prioritized startup	No
– Shared device	Yes
– Number of IO Controllers with shared device, max.	2
Interface types	
M12 port	
• Autonegotiation	Yes
• Autocrossing	Yes
• Transmission rate, max.	100 Mbit/s
Protocols	
Supports protocol for PROFINET IO	Yes
PROFIsafe	Yes
EtherNet/IP	No
Modbus TCP	No
Redundancy mode	
• PROFINET system redundancy (S2)	Yes
• PROFINET system redundancy (R1)	No
• H-Sync forwarding	No
Media redundancy	
– MRP	Yes
Open IE communication	
• TCP/IP	No
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
• ping	Yes
• ARP	Yes
Interrupts/diagnostics/status information	
Substitute values connectable	Yes

Article number	6ES7146-6FF00-0BB0
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Maintenance interrupt	Yes; Parameterizable
• Hardware interrupt	Yes; Parameterizable
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; DI, input current < 0.3 mA, per channel
• Wire-break in actuator cable	Yes
• Short-circuit	Yes; F-DI, F-DQ, DIQ as output, encoder supply
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green LED
• NS LED	No
• MS LED	No
• IO LED	Yes; red/green/yellow LEDs
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• For load voltage monitoring	Yes; green LED
• Connection display LINK TX/RX	Yes; green LED, only link
Potential separation	
between the load voltages	Yes
between Ethernet and electronics	Yes
Potential separation channels	
• between the channels	Yes
• between the channels and the power supply of the electronics	4 F-DI / 4 DIQ / 1 IO-LINK are non-isolated and 3 F-DQ are isolated from supply voltage 1L+
Isolation	
tested with	
• 24 V DC circuits	707 V DC (type test)
• Test voltage for interface, rms value [Vrms]	1 500 V; According to IEEE 802.3
Degree and class of protection	
IP degree of protection	IP65/67/69K
Standards, approvals, certificates	
Suitable for safety-related tripping of standard modules	No
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLd (F-DI single-channel, F-DQ with dark test disabled), PLe (F-DI two-channel, F-DQ with dark test enabled)

Article number	**6ES7146-6FF00-0BB0**
• Category according to ISO 13849-1	Cat. 3 (F-DI single-channel, F-DQ with dark test disabled), Cat. 4 (F-DI two-channel, F-DQ with dark test enabled)
• SIL acc. to IEC 61508	SIL 2 (F-DI single-channel, F-DQ with dark test disabled), SIL 3 (F-DI two-channel, F-DQ with dark test enabled)
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL2	< 8.00E-05 F-DI; < 3.00E-04 F-DQ for altitude <= 5 000 m
– Low demand mode: PFDavg in accordance with SIL3	< 7.00E-05 F-DI; < 8.00E-05 F-DQ for altitude <= 5 000 m
– High demand/continuous mode: PFH in accordance with SIL2	< 1.00E-09 1/h F-DI; < 5.00E-09 1/h F-DQ for altitude <= 5 000 m
– High demand/continuous mode: PFH in accordance with SIL3	< 6.00E-10 1/h F-DI; < 4.00E-09 1/h F-DQ for altitude <= 5 000 m
Use in hazardous areas	
• Explosion protection category for gas	ATEX, UKEX, IECEx, CCCEx for Zone 2
• Explosion protection category for dust	ATEX, UKEX, IECEx, CCCEx for Zone 22
Security	
signed firmware update	Yes
safely removing data	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-25 °C
• max.	60 °C
Altitude during operation relating to sea level	
• Ambient air temperature-barometric pressure-altitude	Up to max. 5 000 m, at installation height > 2 000 m additional restrictions
Connection method	
Design of electrical connection	4/5-pin M12 circular connectors
Design of electrical connection for the inputs and outputs	M12, 5-pin, A-coded
Design of electrical connection for supply voltage	M12, 4-pin, L-coded
Dimensions	
Width	45 mm
Height	200 mm
Depth	48 mm
Weights	
Weight, approx.	900 g

Power reduction (derating) to total current of sensor supplies, actuator supplies, and outputs per module

The following derating tables show the load capacity of the sensor supplies, actuator supplies, and outputs in relation to the ambient temperature:

	Up to 40 °C	Up to 50 °C	Up to 60 °C
Total current of the outputs X10-X11 (DIQ_0 - DIQ_3 via 1L+)	2 A	1.5 A	1 A
Total current of the sensor supplies X10-X13 (U_{S0} - U_{S1}, and V_{S0} - V_{S3} via 1L+)	3 A	2.5 A	2 A
Total current of the actuator supplies X14-X16 (U_{S2} - U_{S4} via 1L+)	3 A	2.5 A	2 A
Total current of the fail-safe outputs X14-X16 (FDQ_0 - FDQ_2 via 2L+)	4 A	3.5 A	3 A

Refer to "Connecting cables for ET 200eco PN M12-L" in the *Distributed I/O System ET 200eco PN M12-L System Manual* (https://support.industry.siemens.com/cs/ww/en/view/109778292) for more information about derating of input currents to the module.

Fail-safe response times

B

B.1 Maximum response time of the system

This section shows the response times of the F-DI 4/F-DQ 2/ DIQ 4/IOL 1 Fail-safe module. The response times are included in the calculation of the F-system response time.

Times required for the calculation

T_{cycle} 11 ms	Firmware cycle time: This is the maximum internal cycle time of the fail-safe module.
T_{DAT_i} 18 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the fail-safe module's digital inputs to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

You assign the "Maximum readback time" and "Maximum readback time switch on test" settings in STEP 7.

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (https://support.industry.siemens.com/cs/us/en/view/58856512)" Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{cycle} parameter values include an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

B.2 Response time parameters for the ET 200eco PN F-I/O M12-L digital inputs

Maximum reaction time for 1oo1 fail-safe digital inputs

$T_{WCDT_i} = (2 \times T_{cycle}) + T_{filter} + T_{sct} + T_{stup}$

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the availability of the PROFIsafe message frame for request from the fail-safe CPU.
T_{filter}	Configured "Input filters" time for the channel
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in the equation for T_{WCDT_i} if the short-circuit test is configured).
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test is configured • Duration of the startup time

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

Maximum reaction time for 1oo2 fail-safe digital inputs

$T_{WCDT_i} = (2 \times T_{cycle}) + T_{filter}$ + SUM (T_{sct} primary input, T_{sct} secondary input) + SUM (T_{stup} primary input, T_{stup} secondary input)

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input to the availability of the PROFIsafe message frame for request from the fail-safe CPU.
T_{filter}	Configured "Input filters" time for the channel
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in the equation for T_{WCDT_i} if the short-circuit test is configured).
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test is configured • Duration of the startup time

Maximum fault reaction time for 1oo2 fail-safe digital input discrepancy errors

$T_{OFDT_i} = (2 \times T_{cycle}) + T_{filter} + T_{dis} + MAX (SUM (T_{sct}$ primary input, T_{stup} primary input, T_{sct} secondary input, T_{stup} secondary input), $T_{cycle})$

An activated short-circuit test summation is included for each sensor supply.

Where:

T_{OFDT_i}	One Fault Delay Time: Maximum response time for the F-DI 1oo2 channel to report as passivated
T_{dis}	Discrepancy time: • Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" • Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior
T_{sct}	Time delay for short-circuit test: • "0" if no short-circuit test is configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in the equation for T_{WCDT_i} if the short-circuit test is configured).
T_{stup}	Startup time after short-circuit test completion: • "0" if no short-circuit test configured • Duration of the startup time

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

The term "MAX (SUM (T_{sct} primary input, T_{stup} primary input, T_{sct} secondary input, T_{stup} secondary input), T_{cycle})" includes an addition T_{cycle} to ensure that the minimum amount of time for a complete firmware cycle is included. This applies to situations where the summation of the short-circuit times are less than the time of a firmware cycle.

Maximum fault reaction time for external short-circuit errors on the fail-safe digital inputs

$T_{OFDT_isc} = (2 \times T_{cycle}) + T_{filter} + T_{scf}$

Where:

T_{OFDT_isc}	One Fault Maximum Delay Time: Maximum delay time to passivate an F-DI channel with an external short-circuit.
T_{filter}	Configured "Input filters" time for the channel
T_{scf}	T_{base} + MAX (T_{fmax} - T_{othr}, 0): The total time interval for short-circuit testing for all channels whose short-circuit test is enabled • T_{base} = SUM (T_{dur}): The total test duration for all channels where short-circuit testing is enabled. This includes both the short-circuit test durations and sensor startup times. • $T_{othr} = T_{base}$ - MAX (T_{dur}): The total test duration for all channels other than the channel with the largest duration • T_{fmax} = MAX (T_{filter}) + 1: Maximum filter of all channels where short-circuit testing is enabled

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

B.3 Response time parameters for the ET 200eco PN F-I/O M12-L digital outputs

Maximum reaction time for the fail-safe digital outputs

$T_{WCDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{WCDT_q}	Maximum response time of the F-DQ DC from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel

The term "2 x T_{cycle}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

After the F-DQ DC commands the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Maximum fault reaction time for the fail-safe digital outputs

$T_{OFDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{OFDT_q}	One Fault Delay Time: Maximum response time for the F-DQ DC to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel

Maximum fault reaction time for the fail-safe digital outputs with the Dark Test disabled

$T_{OFDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycle}$

Where:

T_{OFDT_q}	One Fault Delay Time: Maximum response time for the F-DQ DC to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel

NOTE

When dark testing is disabled for a given output, particular channel faults for this output might not be detected until a process value change occurs from "1" to "0". When dark testing is disabled and the process value is "1" for a given channel, the various safety measures do not manipulate the respective output switches.

B.4 Response time parameters for the ET 200eco PN F-I/O M12-L embedded safety functions

Maximum reaction time for an embedded safety function

$T_{WCDT_esf} = MAX (T_{WCDT(1oo1)}, T_{WCDT(1oo2)}) + MAX (T_{WCDT_q})$

Where:

T_{WCDT_esf}	Worst Case Delay Time: Maximum response time from a signal transition at the digital input(s) to a corresponding action at the specified digital output(s)
$T_{WCDT(1oo1)}$	$T_{filter} + T_{sct} + T_{stup}$ • T_{filter}: Configured "Input filters" time for the channel • T_{sct}: Time delay for short-circuit test: – "0" if no short-circuit test is configured – "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured • T_{stup}: Startup time after short-circuit test completion: – "0" if no short-circuit test configured – Duration of the startup time
$T_{WCDT(1oo2)}$	T_{filter} + MAX (T_{sct} primary input, T_{sct} secondary input) + T_{stup} • T_{filter}: Configured "Input filters" time for the channel • T_{sct}: Time delay for short-circuit test: – "0" if no short-circuit test is configured – "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured • T_{stup}: Startup time after short-circuit test completion: – "0" if no short-circuit test configured – Duration of the startup time
T_{WCDT_q}	T_{rb} + MAX(T_{rb}, T_{rb_swon}) • T_{rb}: Configured "Maximum readback time" for the channel • T_{rb_swon}: Configured "Maximum readback time switch on test" for the channel

MAX ($T_{WCDT(1oo1)}$, $T_{WCDT(1oo2)}$) applies to each individual 1oo1 and/or 1oo2 input used with the respective embedded safety function. Each input is calculated separately and the maximum time applied.

T_{WCDT_q} applies to each output used within the respective embedded safety function. Each output is calculated separately and the maximum time applied.

Maximum fault reaction time for an embedded safety function

$T_{_OFDT_esf}$ = MAX ($T_{OFDT(1oo1)}$, $T_{OFDT(1oo2)}$) + MAX (T_{OFDT_q})
Where:

T_{OFDT_esf}	One Fault Delay Time: Maximum response time for the safety function to turn an output OFF. Refer to the individual $_{OFDT}$ fault reaction time calculations.
$T_{OFDT(1oo1)}$	T_{filter} + SUM (T_{sct} + T_{stup} + T_{cycle}) • T_{filter}: Configured "Input filters" time for the channel • T_{sct}: Time delay for short-circuit test: – "0" if no short-circuit test is configured – "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured • T_{stup}: Startup time after short-circuit test completion: – "0" if no short-circuit test configured – Duration of the startup time
$T_{OFDT(1oo2)}$	T_{filter} + MAX (T_{dis}, SUM (T_{sct} + T_{stup} + T_{cycle}) • T_{filter}: Configured "Input filters" time for the channel • T_{dis}: Discrepancy time – Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" – Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior – "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • T_{sct}: Time delay for short-circuit test: – "0" if no short-circuit test is configured – "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured • T_{stup}: Startup time after short-circuit test completion: – "0" if no short-circuit test configured – Duration of the startup time
T_{OFDT_q}	T_{rb} + MAX (T_{rb}, T_{rb_swon}) • T_{rb}: Configured "Maximum readback time" for the channel • T_{rb_swon}: Configured "Maximum readback time switch on test" for the channel

MAX ($T_{OFDT(1oo1)}$, $T_{OFDT(1oo2)}$) applies to each input used within the respective embedded safety function. Each input is calculated separately and the maximum time applied.

T_{OFDT_q} applies to each output used within the respective embedded safety function. Each output is calculated separately.

Switching of loads

C

C.1 Connecting capacitive loads

If a fail-safe module is interconnected with loads that require little current and have capacitance, it is important that the readback time parameters are set to a large enough value to allow the capacitive load time to charge or discharge. If the value is too small, the module could issue a diagnostic error due to the load not responding with the correct process value in time. To avoid this, you must calculate appropriate readback time values. This ensures that your load does not respond to test pulses but has sufficient time to react to changes of the process value. Load capacitance can delay the diagnostic voltage response at the P- and M-switches of the fail-safe module's digital outputs. The pattern testing of this module requires the voltage at the P- and M-switches to be nearly zero across the load whenever the process value is "1".

You can place a diode between the P-switch and the capacitive load. This ensures that when the output is turned off, the voltage on the capacitor is not present at the P-switch during diagnostic testing. Typically, this diode is built into power supplies with input capacitors that have reverse voltage protection implemented. Using an additional diode can greatly reduce the "Maximum readback time". The reduced "Maximum readback time" allows the load to operate normally (load stays ON) during diagnostic testing. Alternatively, you can change the parameterization of a channel to not perform dark testing by selecting the check box for the "Disable Dark Test (max. SIL2, CAT3, PLd)" parameter.

Stray capacitance between the load circuit/wiring and ground, as well as between M and P, can increase the time needed for the "Maximum readback time switch on test". During module diagnostics when the P- or M-switch is turned on to a load that is not powered during bit pattern testing, both sides of the load are influenced by stray capacitance. This effect is typically minor, but it is important for the "Maximum readback time switch on test" duration to be long enough for the load circuit voltage to react, yet short enough that if one side of the load connects to P or M, the testing of the opposite switch does not cause the load to react.

Capacitive loads with low series resistance, including power supplies with input capacitors, can experience large inrush current. To avoid this, you should add series resistance to reduce inrush on large capacitive loads. Doing so reduces inrush current and minimizes risk of blown fuses or overcurrent fault detection during normal load switch-on events.

C.2 Switching of inductive loads

The diagram below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the fail-safe module digital outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the fail-safe module digital output switch. External suppression conducts the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression.

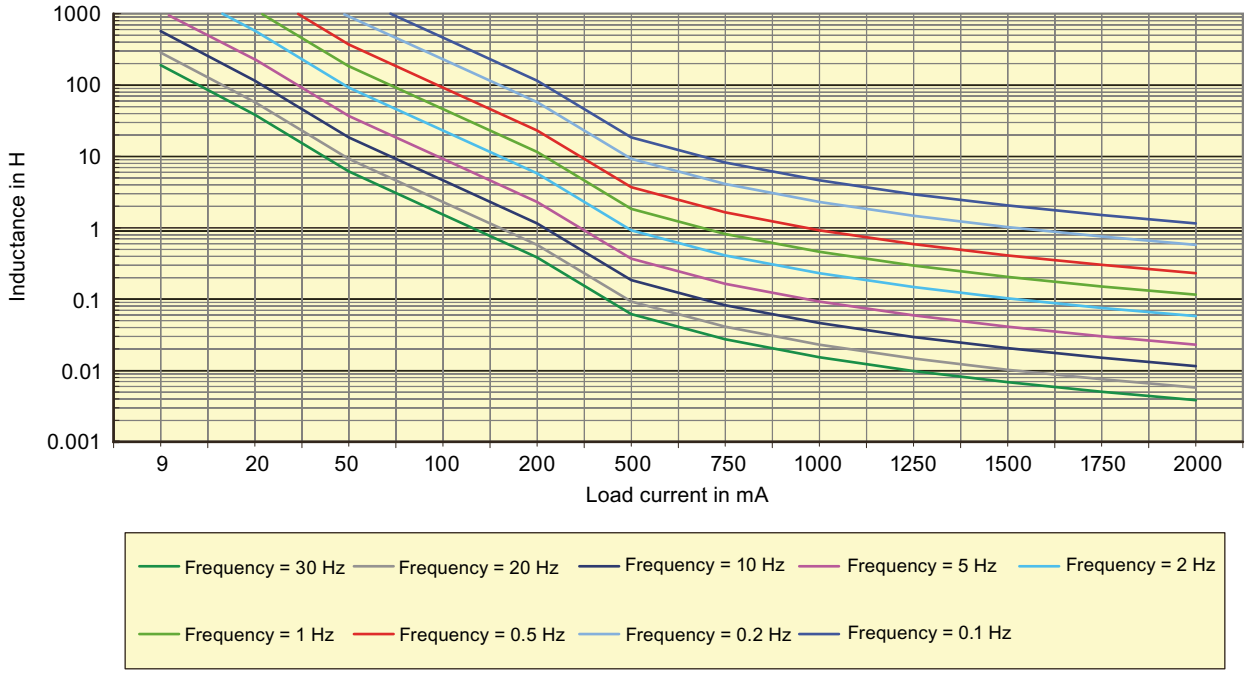


Figure 1-847 Switching of inductive loads depending on the load current and switching frequency

NOTE

Minimum permissible OFF time for fail-safe digital outputs

The fail-safe module's digital outputs expect to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than T_{WCDT_q} can cause the channel to passivate.

⚠ WARNING

Failures of unsuppressed inductive loads

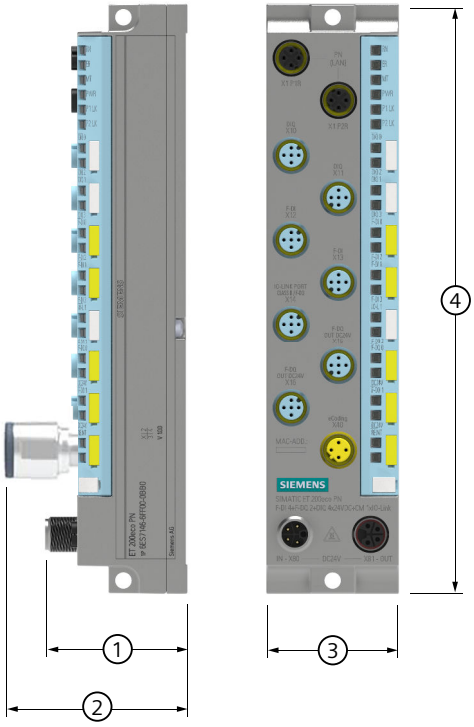
The following failures can result from a lack of suppression of inductive loads:

- Unsuppressed inductive loads can lead to early "stuck-on"" failures of the Fail-safe module digital outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.
Failure to observe proper precautions can result in death, severe personal injury, and/or property damage.

Dimension drawing

The following figure shows the dimension drawing of the ET 200eco PN M12-L F mix module in side and front view:



①	Depth	48 mm
②	Depth with eCoding Plug installed	65 mm
③	Width	45 mm
④	Height	200 mm

Communication protocols and ports

E

You can find tables showing the different layers and protocols used in ET 200 interface modules in the S7-1500/ET 200 Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925/184317883915). The layers and protocols used by the ET 200eco PN M12-L F module are the same, with the following exceptions:

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
Connection-oriented communication protocols				
IGMPv2	Not relevant	(3) Network layer	Internet Group Management Protocol. IGMPv2 is a network protocol for the organization of multicast groups (UDP multicast only).	IGMPv2 is a functionality of the IP stack. This system function is activated by the multicast function.
MODBUS TCP Slave	502	(4) TCP	MODBUS Transmission Control Protocol.	Default: Deactivated. Can be activated via MultiFieldbus Configuration Tool (MFCT).
EtherNet/IP CIP	44818 (TCP) 2222 (UDP)	(4) TCP (4) UDP	The EtherNet/IP protocol and Common Industrial Protocol (CIP) protocols enable communication between interface modules and CPUs. EtherNet/IP use MultiFieldbus devices for data exchange. CIP Implicit Messaging is used for the continuous transmission of real-time data in time-critical applications. CIP Explicit Messaging is used for the targeted retrieval or transmission of configuration and diagnostic data.	Default: Deactivated. Can be activated via MultiFieldbus Configuration Tool (MFCT).

SIEMENS

SIMATIC
ET 200eco PN M12-L
Product Information for ET 200eco PN M12-L System Manual to add the F-DI 4 x 24 VDC, 2xM12, F-DQ 2 x 24 VDC/2.0A PM, 2xM12, DIQ 4 x 24 VDC, 1xM12, IO-Link Class B, 1xM12

Product Information

Validity

Scope of the product information

This product information amends the *ET 200eco PN M12-L Distributed I/O system ET 200eco PN System Manual* (https://support.industry.siemens.com/cs/us/en/view/109778292) to include the ET 200eco PN M12-L Fail-safe module.

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
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To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://new.siemens.com/cert.

This document contains the following updates

- Addition of Special information (Page 1)
- Change to "What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?" (Page 2)
- Change to Components table (Page 3)
- Change to "Rules and regulations for operation" (Page 6)
- Addition of "What are fail-safe automation systems and fail-safe modules?" (Page 6)
- Addition of "Additional rules and regulations for the operation of the ET 200eco PN M12-L with fail-safe modules" (Page 8)
- Change to Y cable and addition of Inverted Y cable (Page 9)
- Change to Configuration software and requirements table (Page 10)
- Addition of "Assigning the PROFIsafe addresses" (Page 10)
- Changes and additions to Standards and authorizations (Page 11)
- Additions to "Accessories/spare parts" (Page 12)
- Additions to "Glossary" (Page 12)

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Addition of Special information

The following supplements "Introduction", "Standards":

Maintaining operational safety of your plant

NOTE

Operators of plants with safety-related features must meet operational safety requirements. Suppliers must also take measures when monitoring products.

To stay up-to-date on the latest operational safety requirements, visit the Siemens Industry Online Support (https://support.industry.siemens.com/) site and subscribe to email notifications:

1. Follow one of the links below:
   - SIMATIC S7-1200 G2/SIMATIC S7-1200 G2 F (https://support.industry.siemens.com/cs/us/en/ps/30068)
   - Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
   - STEP 7 TIA Portal (https://support.industry.siemens.com/cs/ww/en/ps/14667)
2. To subscribe to notifications, select "email on update".

NOTE

To reduce the risks associated with malicious or counterfeit CPUs and modules, use only official sales channels, such as the following:

- Siemens Industry Mall
- Official Siemens distributors
- Country-specific official Siemens sales and distribution channels

NOTE

To reduce the risks associated with compromised CPU or module firmware, only download firmware from the Siemens Industry Online Support website and verify the file integrity against the associated published SHA checksum.

NOTE

To reduce the risk of physical tampering with critical industrial equipment, implement the measures defined in the Operational guidelines (https://www.siemens.com/global/en/products/services/cert/news/operational-guidelines-for-industrial-security.html).

Change to "What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?"

The following is a correction to "What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?", "Customer benefits of the system":

Easy to use

- Simple wiring through coded M12 connections
- CAx compliant labeling of all interfaces
- Quick, comfortable configuration and commissioning viaSTEP 7 (TIA Portal)

Simple power supply concept

- High power input through power connector M12-L
- Supply of 2 power supplies isolated from each other

Compact design

- High IP quantity structures for module widths of 45 mm
- High degree of protection IP65/IP67 and IP69K
- Suitable for temperatures from -40 ° C to +60 °C and accelerations up to 20 g



Communication standards

- PROFINET IO
- EtherNet/IP
- Modbus TCP

Flexible mounting

- Simple installation in all mounting positionseven in the very confined
- Spatially separated assemblyof the I/O devices
- Integration of sensor technology and actuator technology via M12 connection technology

Flexible automation concepts

- Access of multiple controllers with shared device and module-internal shared input / shared output (MSI/MSO)
- Deterministic connection of the sensors / actuators by means of clock-synchrono-us operation
- Use in fault-tolerant applications using S2 redundancy

Figure 1 Row of connected devices (M12-L Standard and Fail-safe)

The following is a correction to "What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?", "Configuration example of the ET 200eco PN M12-L":

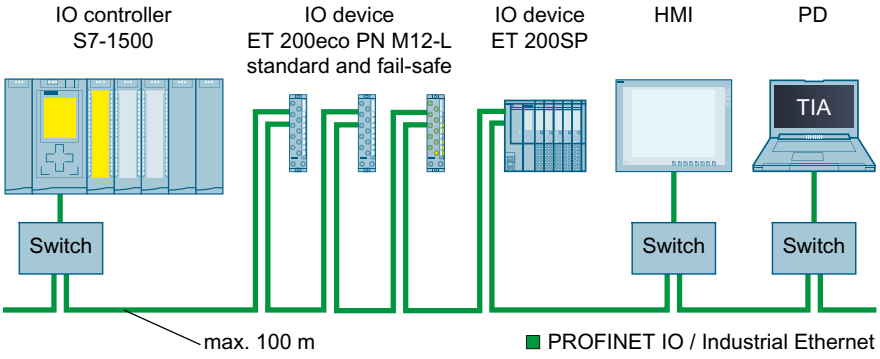


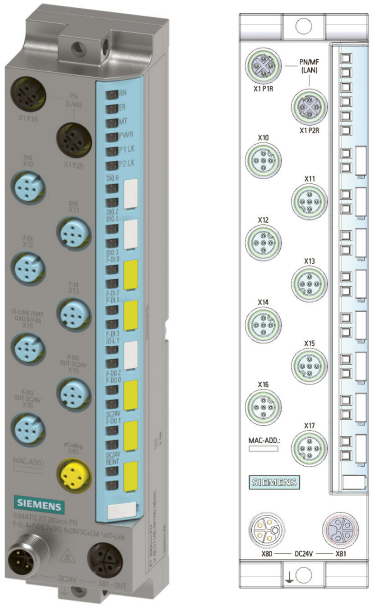
Figure 2 Configuration Example with M12-L F

Change to Components table

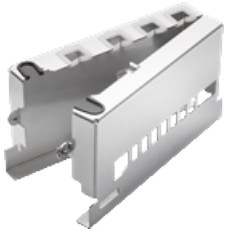
The following is a correction to "Components", "Overview of components":

Components of the ET 200eco PN M12-L distributed I/O system
The following table shows and explains the function of the most important components of the ET 200eco PN M12-L distributed I/O system:

Table 1 Overview of components

Component	Function	Figure
I/O devices	• The I/O devices form the interface to the process. • Recording and controlling of the current process status via the connected sensors and actuators	
Mounting rail	• Simple installation of several I/O devices next to one another • Without drilling holes for I/O devices	
Profile screws for mounting rail	• Suitable screw for mounting the I/O device on the mounting rail	

Component	Function	Figure
Identification labels	• The identification labels come with the module and can be machine printed. • Can be ordered separately (white or yellow (used on fail-safe modules)).	
Sealing cap	• Caps for unused connections • IP protection class is maintained through use.	
PROFINET IO cable and M12-D plug	• Connection to the MultiFieldbus	
eCoding plug	• Electronic coding element has an electronic, rewritable memory for module-specific fail-safe addressing data, such as the F-destination address.	
Power connecting cable and M12-L plug / coupling	• Connection of supply and load voltages • Looping through of supply and load voltages to other devices	

Component	Function	Figure
Y cable	• Double connection of actuators or sensors to one socket • IP protection class is maintained when 2 actuators or sensors are connected to one socket.	
Y-connector	• Double connection of actuators or sensors to one socket • IP protection class is maintained when 2 actuators or sensors are connected to one socket.	
Plug cover	• For use in Zone 2 / Zone 22 hazardous area.	

Change to "Rules and regulations for operation"

The following supplements "Rules and regulations for operation", "24 V supply" after the last bullet:

- Sustained operation of the fail-safe modules above 28.8 V DC can cause injury to personnel and equipment damage.

⚠ WARNING

Sustained operation of fail-safe modules above 28.8 V DC

Sustained operation of fail-safe modules above 28.8 V DC can cause injury to personnel and equipment damage.

Defined transients from defined source impedances (for example, EN 61000-4-2, 61000-4-4, and 61000-4-5), as specified in the "Electromagnetic compatibility" section, can be imposed on this voltage without interruption operation or causing damage.

Operate the fail-safe module within the voltage parameters in technical specifications to prevent unacceptable temperature rise and thermal damage that can cause the product to become inoperable.

Failure to operate the fail-safe module within the defined voltage parameters can result in death, severe personal injury, and/or property damage.

Requirements for power supplies in the event of voltage interruption

To ensure adherence to IEC 61131-2, only use power packs/power supply units (https://support.industry.siemens.com/cs/ww/en/) (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirement in your product standards (for example, 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions.

Addition of "What are fail-safe automation systems and fail-safe modules?"

Description of change to manual

The following supplements "System overview" after "What are the SIMATIC ET 200eco PN M12-L distributed I/O devices?":

What are fail-safe automation systems and fail-safe modules?

SIMATIC ET 200eco PN M12-L Fail-safe system
The objective of safety engineering is to minimize danger to humans and the environment as much as possible through use of safety-oriented technical installations without restricting industrial production and the use of machines and chemical products any more than necessary. The SIMATIC safety fail-safe system is available to implement safety concepts in the area of machine and personnel protection (for example, for emergency STOP devices for machining and processing equipment).

What are fail-safe automation systems?
Safety-related automation systems are primarily concerned with applications whose failure could have impact upon the safety of people and/or the environment. As a result, safety-related systems are used to mitigate hazards or failures that are likely to cause physical harm. Their intent is to achieve safety to an acceptable level of tolerable risk.
F-systems serve to control processes and ensure safe states upon detected failures. Failures are detected using very high levels of diagnostic coverage. Upon detection of failures, actions are taken to attempt to bring the respective application to a safe state.
F-systems provide improved fault detection and fault localization through detailed diagnostic identification and reporting. This is the primary difference between fail-safe systems and standard systems. Use of fail-safe systems should be considered for applications in which hazards are inherently present and may result in physical harm.

What are fail-safe modules?
The fail-safe CPU (F-CPU) communicates with the fail-safe modules via the PROFIsafe protocol.
Fail-safe digital I/O modules detect the signal states of safety-oriented sensors and cause safety-related shutdown procedures with short-circuit and cross-circuit protection up to the actuator.

Use in SIMATIC Safety F-systems
ET 200eco PN M12-L fail-safe modules can be used with the *STEP 7 Safety Advanced V20* or later using PROFINET configuration, together with an F-CPU.

Achievable safety classes
SIMATIC Safety fail-safe systems can satisfy the following safety requirements:

Table 2

Safety class		
According to IEC 61508	**According to ISO 13849-1**	
SIL 2	Category 3	(PL) Performance Level d
SIL 3	Category 3	(PL) Performance Level e
SIL 3	Category 4	(PL) Performance Level e

⚠ WARNING

The safety performance of your installation depends on your design and continued maintenance of each complete safety function.
SIMATIC Fail-safe CPUs and ET 200eco PN M12-L Fail-safe modules provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions.
You must choose all components of your installation and complete your design and maintenance according to accepted safety standards and practices to achieve your required level of safety.
Failure to comply with these guidelines could cause damage or unpredictable operation which can result in death, severe personal injury, and/or property damage.

Addition of "Additional rules and regulations for the operation of the ET 200eco PN M12-L with fail-safe modules"

Description of change to manual

The following supplements "Additional rules and regulations for ET 200eco PN M12-L with fail-safe modules" before "Connecting", "Operation on grounded/non-grounded infeed":

Safety extra-low voltage (SELV, PELV) for fail-safe modules

⚠ WARNING

Operation of fail-safe modules with safety extra-low voltage (SELV, PELV)
You can find more information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.
The fail-safe modules operate with the 24 V DC rated voltage. The tolerance range is 20.4 V DC to 28.8 V DC.
Within the overvoltage range from 28.8 V DC to 35 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 35 V DC, the F-modules are permanently de-energized.
Use a power supply unit that does not exceed U_m = 35 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.
All system components that can supply electrical energy in any form whatsoever must fulfill this condition.
Each additional circuit (24 V DC) used in the system must have a safety extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.
Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module may not exceed a fault voltage U_m in the event of a fault.
Failure to operate fail-safe modules with safety extra-low voltage (SELV, PELV) can result in death, severe personal injury, and/or property damage.

⚠ WARNING

Permissible potential difference

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.

An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage U_m to be exceeded.

Exceeding the fault voltage U_m can result in death, severe personal injury, and/or property damage.

Change to Y cable and addition of Inverted Y cable

The following is a correction to "Wiring", "Y-connection":

Y cables

Use of the Y cable is recommended when two channels are occupied for each socket of the distributed I/O device. The Y cable distributes the channels to two circular connectors as follows:

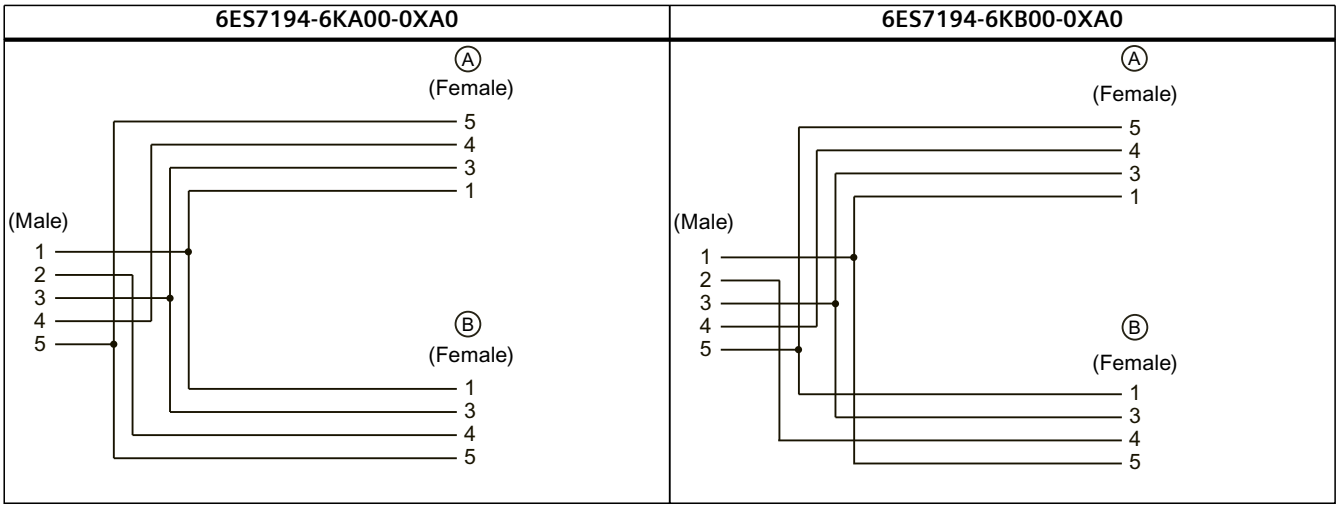
- Y cable (6ES7194-6KA00-0XA0) allows you to connect two actuators or sensors for double connection of inputs (including fail-safe inputs) or for double connection of outputs with one cable.
- Y cable (6ES7194-6KB00-0XA0) allows you to connect two sensors for double connection of fail-safe inputs with one cable.

Refer to the respective product user manual for connection details.



Figure 3 Y cable (6ES7194-6KA00-0XA0 or 6ES7194-6KB00-0XA0)

Wiring of the Y cable (6ES7194-6KA00-0XA0 or 6ES7194-6KB00-0XA0) is shown below:



Inverted Y cable

Inverted Y cable (6ES7194-6KC00-0XA0) provides a method of connecting fail-safe inputs and a fail-safe output to an I/O device (for example, Siemens SIRIUS safety position switch with an interlock) with one cable.
Refer to the respective product user manual for connection details.

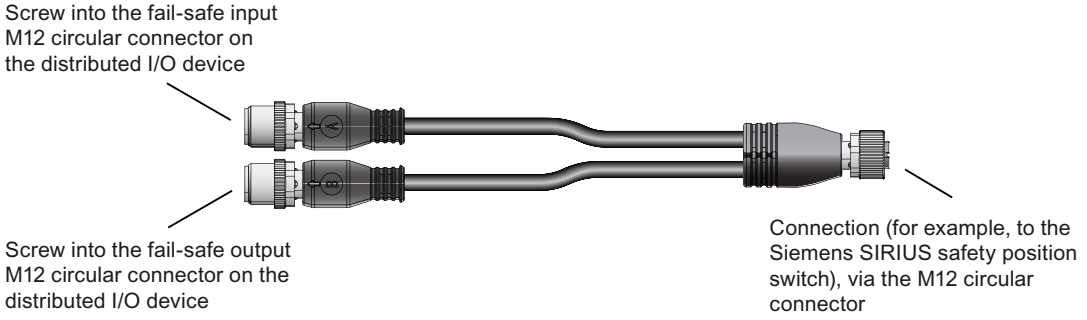
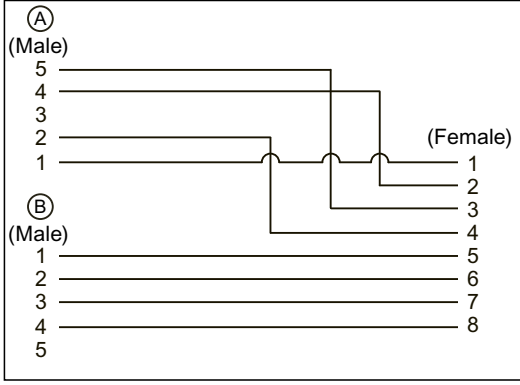


Figure 4 Inverted Y cable (6ES7194-6KC00-0XA0)

Wiring of the inverted Y cable (6ES7194-6KC00-0XA0) is shown below:

6ES7194-6KC00-0XA0	
	

Change to Configuration software and requirements table

The following supplements "Configuring the ET 200eco PN M12-L", "Requirements for installation" to add new rows at the top of the table:

Configuration software	Requirements	Installation information
STEP 7 (TIA Portal) as of V20	PROFINET	STEP 7 online help
STEP 7 (TIA Portal) as of V20	PROFINET GSD file	The GSD versions are largely downward compatible.

Addition of "Assigning the PROFIsafe addresses"

The following supplements "Configuring" after "MF Shared Device":

Assigning the PROFIsafe addresses
The F-destination address is saved permanently on the eCoding plug of the ET 200eco PN M12-L F Fail-safe modules.

NOTE
During assignment of the PROFIsafe addresses, the F-modules must be supplied with supply voltage 1L+.

NOTE
Note the following in conjunction with configuration control:
Before you can use configuration control together with F-modules, you must assign the PROFIsafe addresses to the F-modules at the designated slots. For this, each F-module must be inserted in the slot configured for it. The actual configuration can then differ from the specified configuration.

For additional information on assigning the PROFIsafe addresses, refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/us/en/view/54110126).

Changes and additions to Standards and authorizations

The following are corrections to "Codes and approvals" in their respective sections:

CE marking

The ET 200eco PN M12-L distributed I/O system fulfills the requirements and protection targets of the following directives and complies with the harmonized European standards (EN) which have been promulgated for programmable logic controllers in the official gazettes of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC guidelines)
- 2011/65/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (RoHS Directive)

The fail-safe modules belonging to the ET 200eco PN M12-L distributed I/O system satisfy requirements and safety-related objectives according to the EC directives listed below and conform to the harmonized European standards (EN) for the programmable controllers listed in the Official Journals of the European Union:

- 2014/30/EU "Electromagnetic Compatibility" (EMC guidelines)
- 2011/65/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (RoHS Directive)
- 2006/42/EC "Machinery Directive"

The EU declarations of conformity are also available for download from the Siemens Industry Online Support Web site, under the keyword “Declaration of Conformity”.
Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA AS SYS
Postfach 1963
D-92209 Amberg
Germany

UKCA mark



The object of the declaration described above is in conformity with the relevant Union harmonisation legislation and the designated British regulations, depending on the components used, as described in Annexes EMC 1, EMC 2, ATEX/UKEX, RoHS, which are an integral part of this declaration of conformity:

- Directive of the European Parliament and of the Council of 26 February 2014 and the harmonisation of the laws of the Member States relation to electromagnetic compatibility; Official Journal of the EU L96, 29/03/2014, p. 79-106
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (S.I. 2016 No. 1107), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments
- Supply of Machinery (Safety) Regulations 2008 (S.I. 2008 No. 1597), and related amendments for ET 200eco PN M12-L safety components (fail-safe modules)

UK Declarations of Conformity are available to the relevant authorities at the following address:
Siemens Aktiengesellschaft
Digital Factory
Factory Automation
DI FA TI COS TT
Postfach 1963
D-92209 Amberg

Additions to "Accessories/spare parts"

The following is a correction to "Accessories/spare parts", "Y-connection":

Table 3 Y cables

Designation		Article number
SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable, 5-pin M12	200 mm	6ES7194-6KB00-0XA0
SIMATIC DP, Inverted Y cable for distributed I/O for connecting an F-DI and F-DQ with one cable, 5-pin M12	200 mm	6ES7194-6KC00-0XA0

Change to "Accessories/spare parts", "Additional accessories" adds the following rows at the end of the table:

Designation	Article number
eCoding plug Stores the F-destination and F-source addresses for F-modules	6ES7194-6KB01-0AA0
Identification labels 10 x 5 mm RAL1018, yellow, composed of 200 labels on frames, 40 labels per frame	6ES7194-2BB00-0AA0
Identification labels 10 x 7 mm, yellow, composed of 816 labels on frames, 48 labels per frame (used on eCoding plug)	6ES7194-6HA00-0AA0

Additions to "Glossary"

The following supplements the Glossary with terms used in the context of fail-safe modules:

1oo1
A functional safety architecture with no redundancy. The safety function requires 1 out of 1 provided signal/logic channels for implementation. A single dangerous fault results in dangerous loss of the safety function.

1oo2
A functional safety architecture with two channels. The safety function requires 1 out of 2 provided signal/logic channels for implementation. The safety function is still fulfilled in the presence of a dangerous fault in one channel.

Actuator
Field device that converts the electrical signal from the PLC into an action of controlled machinery. In this manual, the term can include interposing contactors and relays that control machinery, as well as directly connected motors or solenoids.

Category
Category according to EN ISO 13849 defines architectural requirements for functional safety. The products in this manual can fulfill Category 2 to Category 4. Category 4 requires that no single fault can be dangerous and no undetected accumulation of faults can be dangerous.
See also Overvoltage category.

CET
In the context of IO-Link, CET (Cyclic Event Timer) refers to a parameter used to define the interval at which cyclic data is transmitted between the IO-Link master and the connected outputs devices, such as sensors or actuators.

Channel
In IEC 61508 terminology, a channel is a single signal/logic path that supports a safety function. The definition of 1oo1 and 1oo2 above uses channel in this sense. In most uses in this manual, a channel refers to one process value, whether implemented as 1oo1 or 1oo2.

Channel fault
A fault that causes one process value to be passivated, such as a detected wiring fault on one input. Other channels in the module can continue to support a safety function.

CRC signature
The CRC (Cyclic Redundancy Check) signature is a cyclic redundancy checksum that confirms the integrity of the PROFIsafe message contents and sequence.

Cyclic interrupt / cycle time
The start-to-start user configured time delay between executions of the safety program.

Dark test / dark time
The test or time in which a "0" signal is deliberately created to confirm that "0" can be controlled or detected when needed. On DC outputs, the F-DQ performs a dark test by briefly turning off one of the P or M output switches.

Discrepancy time (of inputs)
The configured discrepancy time during which you expect 1oo2 inputs to disagree due to mechanical and electrical differences in input signals. The F-DI interprets differences between inputs lasting longer than the discrepancy time as a channel fault.

ECET
In the context of IO-Link, ECET (Event Code Extended Text) is used in diagnostics to provide detailed information about events and errors that occur within an IO-Link system.

ESF
Embedded Safety Function (ESF): A safety function that is evaluated locally by the module and can override its configured output(s) to "0". Emergency Stop and Internal Evaluation are supported ESFs.

Equivalent (input)
A 1oo2 input channel where both signal inputs interpret high voltage as a process value "1" and low voltage as a process value "0".

Fail-safe
A system or component designed to reliably provide a defined, safe result in the event of a fault.

F-I/O
A general term for fail-safe input and output modules.

F-monitoring time
The F-monitoring time is the amount of time a fail-safe module or F-CPU waits for an error-free communication including the expected new Virtual Monitoring Number before passivating channels.

Internal Evaluation
The module's Internal Evaluation (IE) function is a safety measure used to de-energize the desired machine function(s).

Internal Logic Result
An Internal Logic Result (ILR) is the result of an ESF's evaluation to determine the override state of a configured output(s). This result can be used as an input to another ESF during embedded safety function chaining.

IODD
An IO-Link Device Description describes sensors and actuators with an IO-Link communication interface containing information about the device's identity, parameters, process data, diagnostic data, communication properties, and the design of the user interface of engineering tools.

Light test / light time
The test or time in which a "1" signal is deliberately created to confirm that "1" can be controlled or detected when needed. The signal modules described in this manual do not deliberately conduct light tests that can affect your program or the output load. The fail-safe module produces ON test pulses up to the Maximum readback time switch on test on each of the P and M switches individually, but do not intentionally turn on both P and M switches at once for a test when commanded process value is "0". In the unlikely event of an undetected fault on the opposite switch, the test pulses can result in energy applied to the load.

Load voltage
The voltage supplied to or required by a device connected to one of the module's I/O. This load must match the supplies to controlled devices (24 VDC).
Output modules need to provide the correct voltage to external devices to ensure they function correctly, while input modules need to be compatible with the voltage levels output by the sensors or devices to which they are connected.

M
Refers to the 24 V DC power circuit 0 V DC reference. In the context of the F-DQ DC module outputs, M can refer to the switch output connecting the load to M.

Module fault
A fault that affects all channels of a fail-safe module. The fail-safe module attempts to passivate all channels.
See also Channel fault.

Non-equivalent (input)
A 1oo2 input channel where one signal input interprets high voltage as a process value "1" and the redundant signal input interprets high voltage as a process value "0". A common configuration is complementary normally-open and normally-closed switches connected to the same process event.

Overvoltage category
A definition of transient voltage threat due to lightning strikes and other sources, generally associated with how closely the circuit is coupled to outdoor electrical wiring. Category III represents a higher voltage level threat than Category II.

P
Refers to the 24 V DC positive supply. In the context of the F-DQ DC module outputs, P can refer to the switch output connecting the load to P.

Passivate / passivated / passivation
The F-CPU or fail-safe module has identified a channel or module as faulty. The F-CPU or fail-safe module supplies the fail-safe process value "0" instead of any detection or logic evaluation that can result in process value "1".

PFD_avg
Average probability of a dangerous failure on demand (PFD_avg). An estimate of how likely a safety function will fail to perform as expected when required to function only rarely (on demand). PFD is typically used for safety function applications that are required to operate in response to unusual accidental or emergency events occurring less frequently than once per year.

PFH
Average frequency of a dangerous failure per hour (PFH). The average frequency of dangerous failures for systems that are required more frequently than once per year to initiate or maintain a safe state. Most safety functions associated with routine machine operation use PFH as a defining safety metric.

PL
Performance Level (PL): Levels "a" through "e" are defined in EN ISO 13849, with level "e" being the high level of safety performance. A higher PL is associated with a lower probability of dangerous failure.

PM
In the context of the F-DQ DC output module, refers to the DC output point including a switch to P and a switch to M. The typical application is for the load to be connected between the P and M switches, sometimes called "PM mode".

Process value bit
The data bit accessible to the user program representing the process value. If an input channel is passivated, the process value bit is set to "0". If an output channel is passivated, the user program can set the process value bit to "1", but this is not effective at the SM outputs.

PROFIsafe
A communication protocol providing for secure transport of safety information, including provisions for sequence and time monitoring of messages.

PROFIsafe address
A unique identifier for every F-IO in a network including central F-IOs. The PROFIsafe address consists of the F-source address and the F-destination address.

Proof-test / Proof-test interval
A proof test is a verification that a safety component or system operates as expected. Immediately after each successful proof test, the safety component or system is considered to have a minimum probability of dangerous failure. The probability of dangerous failure increases with time until the next proof test. The maximum probability of dangerous failure is calculated assuming the component or system is tested or replaced within the proof test interval.

Reintegration
The procedure that allows a passivated channel or module to become active again after diagnostics indicate that faults are removed or corrected.

Safe state
The basic principle behind the safety concept is the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

Safety function (context: PLC internals)
The term "safety function" can refer to PLC system internal features, including program block elements, which contribute to the development of your safety program and the assurance that your user or application safety function is executed as designed.

Safety function (context: user or application level)
One specific action of a safety system. While the term can be used for general goals (for example, "Protect the operator from the saw blade"), safety system analysis typically includes decomposing the general goal into elemental specific actions designed to minimize risk (for example, "When the hand control is released, turn off the motor" or "Keep the access guard locked until the motor has been deenergized for at least 60 seconds"). Each of these items can be considered a safety function.

Safety mode
1. Safety mode is the operating mode of the fail-safe modules that allows safety-related communication using safety message frames.
2. Operating mode of the safety program: In safety mode of the safety program, all safety mechanisms for fault detection and fault reaction are activated. The safety program cannot be modified during operation in safety mode. Safety mode can be deactivated by the user (deactivated safety mode).

Safety program
The safety program is a safety-related STEP 7 program.

Sensor
Field device that converts a physical quantity (for example, location, temperature, or speed) into an electrical signal that can be read by the PLC.

SIL
Safety Integrity Level (SIL) values 1 through 4 are defined in IEC 61508. A higher safety integrity level is associated with a lower probability of dangerous failure.

SIO mode
Standard I/O mode allows unidirectional data transfer between the IO-Link master module and the standard I/O.

Standard user program
The standard program is a non-safety-related STEP 7 program.

Value status
The data bit accessible to the STEP 7 program indicating whether or not a safety I/O channel is passivated. If the value status bit is "0", the channel is passivated or deactivated. For a 1oo2 input, the low numbered value status bit is effective, and the high numbered status value bit is always "0". If encountered, consider the terms "Quality bit" and "Qualifier" synonymous to "Value status (bit)".

SIEMENS

SIMATIC

Distributed I/O ET 200eco PN F-DI 8x24VDC, 4xM12 / F-DQ 3x24VDC/2.0A, 3xM12

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Preface

Preface

Purpose of the manual

The S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), and ET 200S/ET 200SP series are families of Siemens programmable logic controllers (PLCs) that can control a variety of automation applications. The S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), and ET 200S/ET 200SP models and Windows-based programming tools give you the flexibility you need to solve your automation problems.

This manual provides information about installing, wiring, configuring, commissioning, and maintaining the ET 200eco PN F-DI 8 / F-DQ 3 module to work with the S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), and ET 200S/ET 200SP fail-safe CPUs. The manual is designed for engineers, programmers, installers, and electricians who have a general knowledge of programmable logic controllers.

NOTE

"ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12" is the official name of the product. For ease of use, the manual uses the shortened name "ET 200eco PN F-DI 8 / F-DQ 3" and "ET 200eco PN F" throughout the manual.

Required basic knowledge

To understand this manual, you require a general knowledge of automation and programmable logic controllers.

Scope of the manual

This manual describes or references the following products:

- *STEP 7 Professional V15* or later with *STEP 7 Safety Advanced V15* or later
- S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), and ET 200S/ET 200SP fail-safe CPUs
- ET 200eco PN F-DI 8 / F-DQ 3 module
- Hardware Support Packages (HSP) 204, required with *STEP 7 Professional V15* and *STEP 7 Safety Advanced V15*. With *STEP 7 Professional V15.1* or later and *STEP 7 Safety Advanced V15.1* or later, the HSP is no longer required.

For a complete list of the products described in this manual, refer to "Ordering information" (Page 185).

WARNING

The "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" in the current version is the authoritative source for Functional Safety-related information concerning configuring and programming.
Siemens identifies the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) as the authoritative and/or original source in the case of discrepancies between the manuals.
All warnings in the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" have to be observed.

NOTE

Refer to the "Distributed I/O ET 200eco PN Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW) for further information about the ET 200eco PN system.

Certification, CE label, C-Tick, and other approvals

Refer to the technical specifications (Page 168) for more information.

Glossary

The definitions in the glossary are provided to give the reader an easy first reference for understanding the terms used in this manual. Some terms have detailed formal definitions in IEC 61508, EN ISO 13849, EN 62061, IEC 61784-3-3, and associated standards, and must be understood in terms of broad safety concepts detailed in these standards.

Another reference for more exact definitions is the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Contact your Siemens distributor or sales office for assistance in answering any technical questions, for training, or for ordering S7 products. Because your sales representatives are technically trained and have specific knowledge about your operations, processes, and industry, as well as the individual Siemens products that you are using, they can provide the fastest and most efficient answers to any problems you might encounter.

Documentation and information

STEP 7; S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), and ET 200S/ET 200SP CPUs; and ET 200eco PN provide a variety of documentation and other resources for finding the technical information that you require:

- The *SIMATIC ET 200eco PN F-DI 8 / F-DQ 3 Manual* presents an overview of the Siemens Safety software, fail-safe CPUs and distributed I/O, and a Getting Started configuration and programming example. However, the focus of the manual is the ET 200eco PN F-DI 8 / F-DQ 3 module. Module installation, configuration, diagnostics, applications, and technical specifications are emphasized.

  The English version of the *SIMATIC ET 200eco PN F-DI 8 / F-DQ 3 Manual* is the authoritative (original) language for Functional Safety-related information. All translated manuals refer back to the English manual as the authoritative, original source. Siemens identifies the English manual as the authoritative, original source in the case of discrepancies between the translated manuals.
- The *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual* provides information that enables you to configure and program SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance testing of a SIMATIC Safety fail-safe system. Read and understand this entire manual before attempting to configure and program an actual live, fail-safe operation.
- The *SIMATIC Distributed I/O ET 200eco PN, Operating Instructions* provides information that enables you to operate the ET 200eco PN F distributed I/O device on PROFINET.
- The *SIMATIC S7-1200 Functional Safety Manual* presents an overview of the Siemens Safety software, fail-safe CPUs and SMs, and a Getting Started configuration and programming example. However, the focus of the manual is the S7-1200 fail-safe SMs. SM installation, configuration, diagnostics, applications, and technical specifications are emphasized.

- The *SIMATIC S7-1200 Programmable Controller System Manual* provides specific information about the operation, programming, and the specifications for the complete S7-1200 product family. In addition to the system manual, the *S7-1200 Easy Book* provides a more general overview to the capabilities of the S7-1200 family.
- The *SIMATIC S7-1200/S7-1500 F-CPUs Product Information* provides important information on the available S7-1200/1500 F-CPUs.
- The *SIMATIC S7-1500, ET 200MP Automation System Manual* provides you with important information on how to configure, install, wire, and commission the S7-1500 automation system/ET 200MP distributed I/O system.
- The *SIMATIC S7-300 CPU 31xC and CPU 31x: Technical specifications Manual* and *SIMATIC S7-300 Module Data Manual* is a reference to operating, to functions, and to the technical data of the signal modules, power supply modules, and interface modules of the S7-300.
- The *SIMATIC S7-400 Automation System, CPU Specifications Manual* and *SIMATIC S7-400 Module Data Manual* is a reference to operating, to functions, and to the technical data of the signal modules, power supply modules, and interface modules of the S7-400.
- The *SIMATIC ET 200SP Distributed I/O system, System Manual* provides important information on configuring, installing, wiring, and commissioning the ET 200SP distributed I/O system.
- The *SIMATIC ET 200pro Distributed I/O system, Operating Instructions* provide important information on configuring, installing, wiring, and commissioning the ET 200pro distributed I/O system.
- *SIMATIC ET 200pro CPU 1516PRO-2 PN, Operating Instructions:* The information provided in this manual and the operating instructions of the ET 200pro enables you to commission the ET 200pro CPU 1516PRO-2 PN and to run it as an IO controller on PROFINET.
- *SIMATIC ET 200pro IM 154-8 PN/DP CPU interface module, Operating Instructions:* The information provided in this manual and the operating instructions of the ET 200pro enables you to commission the ET 200pro IM 154-8 PN/DP CPU interface module and to run it as an IO controller on PROFINET.
- The *SIMATIC ET 200S Distributed I/O system, Operating Instructions* provide important information on configuring, installing, wiring, and commissioning the ET 200S distributed I/O system.
- *SIMATIC ET 200S Distributed I/O, IM 151-8 PN/DP CPU interface module, Operating Instructions*: The information provided in this manual and the operating instructions of the ET 200S enables you to commission ET 200S with the IM 151-8 PN/DP CPU interface module and to run it as an IO controller on PROFINET.
- The *SIMATIC ET 200AL Distributed I/O system, System Manual* provides you with important information on how to configure, install, wire, and commission the SIMATIC ET 200AL distributed I/O system.
- The following manuals/product informations are available as electronic (PDF) manuals. You can download or view the electronic manuals from the Siemens Industry Online Support Web site (http://support.industry.siemens.com).
  - *SIMATIC ET 200eco PN F-DI 8 / F-DQ 3 Manual*
  - *SIMATIC Safety - Configuring and Programming, Programming and Operating Manual*
  - *SIMATIC Distributed I/O ET 200eco PN, Operating Instructions*
  - *SIMATIC S7-1200 Functional Safety Manual*
  - *SIMATIC S7-1200 Programmable Controller System Manual*

  - *SIMATIC S7-1200 Easy Book*
  - *SIMATIC S7-1200/S7-1500 F-CPUs Product Information*
  - *SIMATIC S7-1500, ET 200MP Automation System Manual*
  - *SIMATIC S7-300 CPU 31xC and CPU 31x: Technical specifications Manual* and *SIMATIC S7-300 Module Data Manual*
  - *SIMATIC S7-400 Automation System, CPU Specifications Manual* and *SIMATIC S7-400 Module Data Manual*
  - *SIMATIC ET 200SP Distributed I/O system System Manual*
  - *SIMATIC ET 200pro Distributed I/O system, Operating Instructions*
  - *SIMATIC ET 200pro CPU 1516PRO-2 PN, Operating Instructions*
  - *SIMATIC ET 200pro IM 154-8 PN/DP CPU interface module, Operating Instructions*
  - *SIMATIC ET 200S Distributed I/O system, Operating Instructions*
  - *SIMATIC ET 200S Distributed I/O, IM 151-8 PN/DP CPU interface module*
  - *SIMATIC ET 200AL Distributed I/O system System Manual*
- The TIA portal STEP 7 online help information system provides immediate access to the conceptual information, specific instructions, and error code event IDs that describe the operation and functionality of the programming package and basic operation of SIMATIC CPUs.
- The Siemens Industry Online Support Web site (http://support.industry.siemens.com) provides access to the electronic (PDF) versions of the SIMATIC documentation set. Existing documents are available from the Product Support link. With this online documentation access, you can also drag and drop topics from various documents to create your own custom manual.

  You can access online documentation by clicking "mySupport" from the left side of the page and selecting "Documentation" from the navigation choices. To use the mySupport Documentation features, you must sign up as a registered user.
- Siemens also provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, Functional Examples guide you in your safety applications, SITRAIN classes offer training in safety standards and products, and you can calculate your maximum system response time using the RT_calculator Excel file. Visit the following web sites to access these support activities:
  - Safety Evaluation Tool (http://www.siemens.com/safety-evaluation-tool)
  - Functional examples (http://www.siemens.com/safety-functional-examples)
  - SITRAIN (http://www.siemens.com/sitrain-safetyintegrated)
  - SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (http://support.automation.siemens.com/WW/view/en/49368678/133100).) Excel file (RT_calculator)
- The customer support web site also provides FAQs and other helpful documents for STEP 7. Visit the following web site to access the collection of podcasts: STEP 7 Professional (http://w3.siemens.com/mcms/simatic-controller-software/en/step7/step7-professional/Pages/Default.aspx)

- You can also follow or join product discussions on the Service & Support technical forum (https://support.industry.siemens.com/tf/ww/en/?Language=en&siteid=csius&treeLang=en&groupid=4000002&extranet=standard&viewreg=WW&nodeid0=34612486). These forums allow you to interact with various product experts.
  - Forum for ET 200eco (https://support.industry.siemens.com/tf/us/en/posts/et200-eco-pn/70418/?page=0&pageSize=10)
  - Forum for S7-1200 (https://support.industry.siemens.com/tf/ww/en/threads/237?title=simatic-s7-1200&skip=0&take=10&orderBy=LastPostDate+desc)
  - Forum for S7-1500 (https://support.industry.siemens.com/tf/ww/en/threads/277/?page=0&pageSize=10)
  - Forum for S7-300 (https://support.industry.siemens.com/tf/ww/en/threads/130/?page=0&pageSize=10)
  - Forum for S7-400 (https://support.industry.siemens.com/tf/ww/en/threads/131/?page=0&pageSize=10)
  - Forum for Decentral Peripherie (https://support.industry.siemens.com/tf/ww/en/threads/140/?page=0&pageSize=10)
  - Forum for STEP 7 Professional (https://support.industry.siemens.com/tf/ww/en/threads/243?title=step-7-tia-portal&skip=0&take=10&orderBy=LastPostDate+desc)
  - Safety Newsletter Product Information (https://support.industry.siemens.com/cs/ww/en/view/109477906)

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Product overview

1

SIMATIC Safety fail-safe system

The objective of safety engineering is to minimize danger to humans and the environment as much as possible through use of safety-oriented technical installations without restricting industrial production and the use of machines and chemical products any more than necessary. The SIMATIC Safety Fail-Safe system is available to implement safety concepts in the area of machine and personnel protection (for example, emergency STOP devices as a part of machining and processing equipment).

What are fail-safe automation systems?

Fail-safe automation systems control processes that can achieve a safe state immediately as a result of an unexpected operation or failure. These are fail-safe control processes where an immediate shutdown to safe state does not endanger humans or the environment.

Fail-safe systems go beyond conventional safety engineering to enable far-reaching intelligent systems that extend all the way to the electrical drives and measuring systems. You use fail-safe systems in applications with specific safety requirements. You can resume production quickly following a safety-related interruption, using the improved fault detection and localization provided in fail-safe systems through detailed diagnostic information.

Achievable safety requirements

SIMATIC Safety fail-safe systems can satisfy the following safety requirements:

- Safety class (Safety Integrity Level) SIL 1 to SIL 3 in accordance with IEC 61508
- Category 2 to 4, Performance Level (PL) a to e in accordance with EN ISO 13849-1

Principles of safety functions in SIMATIC Safety

You implement functional safety using the hardware and firmware of the fail-safe CPUs and modules in conjunction with the safety program downloaded by the TIA Portal software Engineering System (ES). The SIMATIC Safety system executes the safety function to bring the system to a safe state or maintain a safe state in case of a dangerous event.

The fail-safe modules ensure the safe application of process information (for example, sensors such as pushbuttons and light curtains that initiate emergency OFF operations and actuators that move or control a mechanism). The fail-safe modules have the required hardware and software components for safe processing, in accordance with the required Safety Integrity Level (SIL).

You provide the safety function for the process through the application program that you create or by the reaction of the fail-safe system to a fault. In the event of an error, the fail-safe system executes the fault reaction function (for example, the fail-safe system shuts down the associated outputs).

Example of user safety function

If an object interrupts the beam of a light curtain, the fail-safe system stops the motion in the area protected by the light curtain (user safety function):

- The light curtain provides a "1" signal, perhaps redundantly, to say the light beam is not broken or "0" to say the light beam is broken.
- The fail-safe digital inputs acquire the signal from the light curtain and provide the state to the fail-safe CPU through a safe communication protocol. Redundant microcontrollers with mutual diagnostics in the fail-safe digital inputs provide a high assurance that a "1" or a "0" is provided only when correct.
- The fail-safe CPU executes your user program for normal control of the motion and includes your programmed safety logic that says a "1" from the light curtain is required to enable the motion. Your programmed safety logic is encoded by the Engineering System in redundant logic steps that gives a high assurance that any fault in CPU execution results in outputs of "0". If the CPU fails to receive verifiable communication from the fail-safe digital inputs within a required time, the fail-safe CPU replaces the signal from the fail-safe digital inputs with "0".
- The fail-safe CPU delivers the results of the safety logic to the fail-safe digital outputs through the safe communication protocol. A "1" signal from your safety logic enables motion by turning an output channel ON, or a "0" turns the output channel OFF. Redundant microcontrollers with mutual diagnostics in the fail-safe digital outputs provide a high assurance that redundant output switches (P/M 24 V DC solid state switches) are turned ON only when this condition is correct and at least one output switch turns OFF if a fault occurs. If the fail-safe digital outputs fail to receive verifiable communication from the fail-safe CPU within a required time, the fail-safe digital outputs replace the signal from the fail-safe CPU with "0" and turn outputs OFF.

1.1 Hardware and software components

Fail-Safe CPUs

You can use any of the following fail-safe CPUs with the ET 200eco PN F-DI 8 / F-DQ 3 module:

- S7-1200/1500
- S7-300/400
- ET 200pro (IP67 compliant)
- ET 200S/ET 200SP

A fail-safe system requires a fail-safe CPU with fail-safe central I/O and/or fail-safe distributed I/O.

Hardware components for PROFINET IO

You can use the following fail-safe PROFINET IO hardware components in a fail-safe system:

- Fail-Safe CPUs with built-in PROFINET interface
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200eco PN fail-safe modules (includes module described in this manual)
  - ET 200SP fail-safe modules
  - ET 200MP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200M fail-safe modules
  - ET 200pro fail-safe modules
  - Fail-Safe GSDML-based, PROFIsafe-capable I/O devices (for example, a light curtain or laser scanner)

Hardware components for PROFIBUS DP

You can use the following fail-safe PROFIBUS DP hardware components in a fail-safe system:

- Fail-Safe CPUs with the CM 1243-5 (PROFIBUS DP master)
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - ET 200MP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200M fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-Safe GSDML-based, PROFIsafe-capable DP slaves (for example, a light curtain or laser scanner)

Required software components

You require the *STEP 7 Professional V15* or later with *STEP 7 Safety Advanced V15* or later optional package software combination to configure and program the ET 200eco PN F-DI 8 / F-DQ 3 in a SIMATIC Safety Fail-Safe system.

In the *STEP 7 Safety Advanced V15* software package, you receive the following:

- Support for configuring the fail-safe CPUs with fail-safe central I/O and/or fail-safe distributed I/O in the hardware and network editor of the TIA portal
- Support for creating the safety program using LAD and FBD and integrating error detection functions into the safety program
- Instructions for programming your safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your safety program in LAD and FBD with special safety functions

1.2 Fail-Safe CPUs

1.2.1 Overview

You can use any of the following fail-safe CPUs with the ET 200eco PN F-DI 8 / F-DQ 3 module:

- S7-1200/1500
- S7-300/400
- ET 200pro (IP67 compliant)
- ET 200S/ET 200SP

The fail-safe CPU can execute your safety program along with a standard applications program. Communication between the fail-safe CPU and the fail-safe module is verified using the PROFIsafe protocol.

 S7-300 F	 IM 154-8F PN/DP CPU for ET 200pro	 S7-400 F
 S7-1200 F	 S7-1500 F	 ET 200pro 1516PRO F-2 PN
 ET 200SP F	 ET 200S PN F	

Safety program

You can create a safety program using the program editor. You can program fail-safe function blocks (FB) and functions (FC) in the Function Block Diagram (FBD) or Ladder Logic (LAD) programming languages and create fail-safe data blocks (DB).

The fail-safe CPU performs a dual execution using coded processing. The fail-safe ES automatically performs safety checks and inserts additional fail-safe logic for error detection and error response when the safety program compilation occurs. These safety checks and additional fail-safe logic ensure the detection of failures and faults and appropriate execution of reactions to maintain the fail-safe system in the safe state or bring it to a safe state.

In addition to the safety program, you can run a standard user program on the fail-safe CPU. A standard program can coexist with a safety program in a fail-safe CPU. The fail-safe CPU protects the safety-related data of the safety program from the unintentional effects of the standard user program data.

⚠ WARNING

You cannot put an S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP Fail-Safe system that provides safety-related functions into operation after installation or modification until after you successfully validate the safety-related functionality.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
An S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP Fail-Safe system that provides both safety-related functions and standard (non safety-related) functions must not be put into operation in order to use the standard functions before you successfully validate the safety-related functions, even if all fail-safe signal modules go to the error state and thus remain safe.

You can exchange data between the safety program and the standard user program in the fail-safe CPU by means of bit memory or data of a standard DB.

1.2.2 Behavior differences between standard and fail-safe CPUs

1.2.2.1 Safety mode

Safety mode

In safety mode, the safety functions for fault detection and fault reaction are activated in the following:

- Safety program of the fail-safe CPU
- Fail-safe modules

Safety mode of safety program

The safety program runs in the fail-safe CPU in safety mode. The safety program activates safety mechanisms for fault detection and fault reaction. You cannot modify the safety program during operation in safety mode, while the fail-safe CPU is in RUN mode.

You can deactivate and reactivate the safety mode of the safety program. "Deactivated safety mode" enables the safety program for online tests and changes as needed while the fail-safe CPU is in RUN mode.

For SIMATIC Safety, you can switch back to safety mode only after an operating mode change of the fail-safe CPU from RUN to STOP to RUN.

Safety message frame

The fail-safe CPU and fail-safe modules consistently transmit data between each other in a safety message frame. The safety message frame in accordance with PROFIsafe standards consists of the following:

- Process data (user data)
- Status byte/control byte (coordination data for safety mode)
- Virtual Monitoring Number (encoded in CRC signature, provides keep-alive mechanism and detection of out-of-sequence messages)
- CRC signature

1.2.2.2 Fault reactions

Safe state

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. The safe state value of "0" (de-energized) applies to both sensors and actuators.

Passivation

Passivation applies safe state values to the fail-safe channel(s) instead of process values when the fail-safe system detects faults. The safety function requires passivation of the fail-safe channel(s) in the following situations:

- When the fail-safe system starts up
- If the fail-safe system detects overall module faults, such as RAM or Processor failures
- If the fail-safe system detects errors during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If fail-safe channel faults occur (for example, short-circuit and discrepancy errors or internal faults of fail-safe input or output channels)

When passivation occurs in the digital inputs of the fail-safe module, SIMATIC Safety provides the safety program with safe state values (0) instead of the process data pending at the fail-safe inputs in the input process image.

When passivation occurs in the digital outputs of the fail-safe module, the module sets the passivated channel(s) to a value of (0).

Reintegration

Reintegration returns the process from passivation to a normal state after successful diagnostics determine that the fault has cleared. After reintegration of a fail-safe digital input, SIMATIC Safety again provides the process data pending at the inputs to the safety program. For a fail-safe digital output, SIMATIC Safety again transfers the output values provided by the safety program to the fail-safe outputs. Reintegration from safe state values to process data can be automatic or require acknowledgement by your safety program. See "Reactions to faults" (Page 148) for steps to reintegrate.

Detection and response to faults

SIMATIC Safety systems detect and respond to faults in several different conditions:

- Faults in the fail-safe CPU hardware and firmware
- Faults in the fail-safe user program
- PROFIsafe communication errors caused by conditions in either the fail-safe CPU or modules
- Fail-safe module-wide errors such as microprocessor errors or memory errors
- Fail-safe module channel errors such as discrepancy errors, wiring shorts, or internal channel faults

Fail-safe CPU faults and fail-safe user program faults often result in the CPU operating mode being set to STOP. You can reintegrate PROFIsafe communication faults once communication is successfully restored. In some cases, you can reintegrate module-wide faults. In other cases, you must power cycle the fail-safe module to recover from a module-wide fault. You can often reintegrate and return channel faults to proper operation by removing the fault and reintegrating the channel.

Virtual monitoring number, cyclic interrupt time, and F-monitoring time

The following parameters are integral to fault reactions:

- Virtual monitoring number: The PROFIsafe protocol provides time monitoring and detection of message sequence errors by means of a periodically-updated monitoring number.
- Cyclic interrupt time: The cyclic interrupt time is the interval by which the F-runtime group executes and determines how often the fail-safe CPU sends the PROFIsafe frame to the fail-safe modules. When you add a fail-safe CPU to your project, STEP 7 creates Functional Safety Organization Block 1 (FOB_1) (OB123 by default). FOB_1 contains the cyclic time interrupt time. You can configure the cyclic interrupt time (100 ms by default).
- F-monitoring time: The F-monitoring time is the amount of time a fail-safe module or CPU waits for an error-free communication including a new Virtual Monitoring Number before passivating channels. You can configure the F-monitoring time. The fail-safe CPU and modules must receive a valid, current safety message frame with a valid monitoring number within the configured F-monitoring time.

If the fail-safe system fails to detect a valid monitoring number within the F-monitoring time, the fail-safe system passivates the fail-safe module. Expiration of a module's F-monitoring time causes a transition to safe state for all F-inputs and F-outputs of the module.

CRC (Cyclic Redundancy Check) signature

A CRC signature contained in the safety message frame protects the validity of the process data in the safety message frame, the accuracy of the assigned address references, and the safety-relevant parameters.

If a CRC signature error occurs during communication between the fail-safe CPU and fail-safe modules, the fail-safe system passivates the fail-safe modules.

1.2.2.3 Restart of fail-safe system

The operating modes of the SIMATIC Safety system differ from those of the standard system only in terms of the restart characteristics.

Restart characteristics

When you switch a fail-safe CPU from STOP to RUN mode, the standard user program restarts in the usual way. When you restart the safety program, the fail-safe system initializes all data blocks having the F-Attribute with values from load memory. This action is comparable to a cold restart.

The fail-safe system attempts to reintegrate each fail-safe module at restart. In contrast to the standard user program, you cannot use startup OBs in the safety program.

1.3 ET 200eco PN F-DI 8 / F-DQ 3 module

1.3.1 Overview

Siemens intends for you to use the ET 200eco PN F-DI 8 / F-DQ 3 module to help achieve functional safety in machine applications.

Redundant two-microcontroller functional safety design

The major difference between the ET 200eco PN F-DI 8 / F-DQ 3 and standard modules is that this module uses redundancy to achieve functional safety, including two microcontrollers that control fail-safe operation. Both microcontrollers monitor each other verifying they are executing the same code at the same time, automatically test the I/O circuits, and setting the fail-safe module to safe state in the event of a fault. Each processor monitors internal and external power supplies and module internal temperature and can passivate the module if an abnormal condition is detected.

Safety-related input and output signals form the interface to the process. This interface enables direct connection of single-channel and two-channel input signals from devices such as emergency STOP buttons or light curtains. If in two-channel mode, the fail-safe module redundantly combines the safety-related signals internally and passes the unified result on to the CPU in a fail-safe manner for further processing.

The fail-safe CPU sends the safety-related output states from the CPU to the fail-safe module for each individual output channel. Each output then sets two independent switches for each channel, a P and M solid-state switch. For each channel, the P switch is controlled by one processor, and the M switch is controlled by the other processor.

Use as a safety module

You can use the ET 200eco PN F-DI 8 / F-DQ 3 as a safety module, but not as a standard module.

1.3.2 Description

The ET 200eco PN F-DI 8 / F-DQ 3 module is a safety module with built-in distributed PROFINET device capability (in other words, the safety module does not require the presence of a separate interface module). The ET 200eco PN F-DI 8 / F-DQ 3 is IP67 compliant and is capable of being installed independently from typical IP20 control cabinetry.

You can connect to the module from a PROFIsafe compliant controller, V2.6.x (RIOforFA-Safety profile) or PROFIsafe V2.4. The module supports either version.

The ET 200eco PN F-DI 8 / F-DQ 3 contains twelve M12 connectors which support the following connections. Refer to the figure below:

- Two PROFINET communication connections (X01 P1 and X01 P2) which function as a single switch, useful for passing PROFINET to the next module
- One eCoding plug (X40) which contains the PROFIsafe address assignment unique to this module
- Four pairs of inputs (X1 through X4) which allow up to eight 1oo1 or up to four 1oo2 safety inputs
- Three PM outputs (X5 through X7)
- One power input (X03) which contains both logic and input power (1L+) and output power (2L+)
- One power output (X02) to send 1L+ and 2L+ to the next module

⚠ WARNING

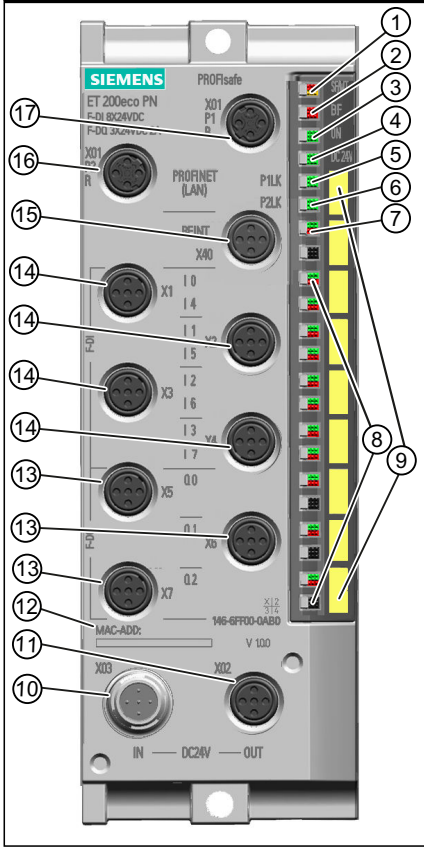
If you insert an M12 I/O cable (X1 to X7 connectors) into the M12 X02 power connector, you can damage the ET 200eco PN F module or provide power to a safety load. On the ET 200eco PN F module, M12 I/O connectors and the M12 X02 power connector are the same physical connector.

Death or serious personal injury and damage to the ET 200eco PN F module and associated machines/equipment may result if proper precautions are not taken.

Only insert an M12 I/O cable into the X1 to X7 connectors. Always comply with the required standards and safety guidelines when configuring a system.

Table 1-1144 Components of the ET 200eco PN F-DI 8 / F-DQ 3

I/O device	Components	
	①	SF/MT LED (Red/Yellow)
	②	BF LED (Red)
	③	ON LED (Green)
	④	DC 24V LED (Green)
	⑤	P1 LK LED (Green)
	⑥	P2 LK LED (Green)
	⑦	REINT (Green/Red)
	⑧	Channel status (Green) / channel fault (Red)
	⑨	Plastic yellow connector labels
	⑩	X03: Voltage infeed
	⑪	X02: Loop through of the voltage

I/O device	Components	
	⑫	MAC address
	⑬	Output signal
	⑭	Input signal
	⑮	X40 eCoding Plug connection
	⑯	X01 P2 LAN: PROFINET IO connection
	⑰	X01 P1 LAN: PROFINET IO connection

1.3.3 Properties

Article number

6ES7146-6FF00-0AB0

Properties

The ET 200eco PN F-DI 8 / F-DQ 3 module has the following features:

- PROFINET IO Device
- PROFIsafe communication
- Supports the "RIOforFA-Safety" profile on S71200/1500 fail-safe CPUs
- PROFIsafe address type 2
- Four pairs of inputs (X1 through X4) which allow up to eight 1oo1 (SIL 2/Category 3/PL d) or up to four 1oo2 (SIL 3/Category 3 or Category 4/PL e) safety inputs
- Three PM outputs (X5 through X7) (SIL 3/Category 3 or Category 4/PL e)
- One eCoding plug (X40) which contains the PROFIsafe address assignment unique to this module
- One power input (X03) which contains both logic and input power (1L+) and output power (2L+)

- One power output (X02) to send 1L+ and 2L+ to the next module
- Two PROFINET connections (X01 P1 and X01 P2) which function as a single switch (single MAC address), useful for passing PROFINET to the next module
- 24 V DC-rated input voltage
- Suitable for switches and 3/4-wire proximity switches (BEROs)
- Two short-circuit proof sensor supplies, each one for four inputs
- External sensor supply possible
- Module fault display (System Fault (SF) red LED)
- Status display for each input and each output (green LED)
- Fault display for each input and each output (red LED)
- Refer to "Fault diagnostics" (Page 151) for a description of LED and diagnostic message functions.

The module supports the following functions:

- Firmware update
- I&M identification data

1.3.4 User data space

The ET 200eco PN F-DI 8 / F-DQ 3 module's digital inputs user data space is one byte (8 bits) of Process value input, followed by one byte of Value status bits.

This is the bit structure for the module's digital inputs configured with the input start address of 8:

Table 1-1145 Input terminal F-DI start F-DI end

Input terminal	F-DI start	F-DI end
Process value bit	I8.0	I8.7
Value status bit	I9.0	I9.7

The ET 200eco PN F-DI 8 / F-DQ 3 module's digital outputs user data space is the first three bits of one byte (8 bits) of Process value output, followed by the first three bits of the third byte of Value status bits.

This is the bit structure for the module's digital outputs configured with the output start address of 8:

Output terminal	Process value bit	Value status bit
Process value bit	Q8.0	Q8.2
Value status bit	I10.0	I10.2

1.3.5 Fail-Safe digital inputs

The digital inputs of the ET 200eco PN F-DI 8 / F-DQ 3 are rated for connection to 24 V DC sensors/switches and 3/4-wire proximity switches (for example, BEROs: Siemens line of no-touch sensors) and have an EN61131-2 type 1 input rating.

The fail-safe module has two sensor supply outputs that can power external sensors (inputs). All 1oo1 and 1oo2 application modes, except the "1oo2, 2 channel 3-wire nonequivalent" application mode, use the Vs1 sensor supply to provide power for channels 0 to 3 and the Vs2 sensor supply to provide power for channels 4 to 7. The "1oo2, 2 channel 3-wire

nonequivalent" application mode uses the Vs1 sensor supply to provide power for all eight inputs and does not use the Vs2 sensor supply.

Inputs and test circuit

The fail-safe digital inputs consist of eight input channels (F-DI x.0 to x.7). You can configure these inputs as eight one-out-of-one (1oo1) inputs (SIL 2/Category 3/PL d), four one-out-of-two (1oo2) inputs (SIL 3/Category 3 or Category 4/PL e), or combinations of 1oo1 and 1oo2 channels.

Connections	Input channel pairs
X1	0 and 4
X2	1 and 5
X3	2 and 6
X4	3 and 7

NOTE

A configuration of an input channel pair as one-out-of-one (1oo1) inputs requires the use of a Y cable. Refer to Appendix B.2: "Accessories for the ET 200eco PN F-DI 8 / F-DQ 3 module" (Page 185) for ordering information on the Siemens SIMATIC DP, Y cable.

One microcontroller monitors inputs 0 to 3, and the other microcontroller monitors inputs 4 to 7. The corresponding channels (0, 4), (1, 5), (2, 6), and (3, 7) each form a 1oo2 channel group. The first of the two inputs, conveys the signal in a 1oo2 configuration. For example, if you wire I0.0 and I0.4 in a 1oo2 configuration and configure STEP 7 to use 1oo2 sensor evaluation, the signal appears at only the I0.0 input when you close or open the circuit for both.

When you configure a channel group as 1oo2, the two controllers must sense the same input change within a configured time. Otherwise, the two controllers detect a discrepancy error.

If you use a sensor supply output to provide power to a sensor, you can enable short-circuit testing. The short-circuit test checks for shorts to 24 V DC by periodically pulsing the sensor output off and verifying that the associated input is off.

This short-circuit test also checks for shorts to the other circuit in "1oo2, 2 channel equivalent" and "1oo2, 2 channel 4-wire nonequivalent" because the test pulses the two sensor outputs off at different times.

Both microcontrollers cooperate in providing internal test pulses to each others process input circuits to verify that sensing electronics are responsive to "1" and "0" inputs.

1.3.6 Fail-Safe digital outputs

The digital outputs of the ET 200eco PN F-DI 8 / F-DQ 3 are for use in fail-safe applications and are suitable for various actuators including solenoid valves, DC contactors, and indicator LEDs. The three digital outputs have P- and M-switching that are rated for connection to 24 V DC actuators with up to a 2.0 A rating. The three digital outputs use the supply voltage 2L+, having a maximum infeed current of 4.0 A. This means that the total current usage by the three digital outputs cannot exceed 4.0 A.

Outputs

The fail-safe digital outputs consist of three output channels (F-DQ x.0 to x.2). You can use each output for SIL 3 applications.

Connections	Output channel
X5	0
X6	1
X7	2

Each output consists of two switches:

- A P-switch connects 24 V DC positive (L+) through the load.
- An M-switch connects the load to M or 24 V DC return.

Both switches must be turned ON for current to flow to the load.

The fail-safe digital outputs use two microcontrollers to implement the safety function. One microcontroller controls the P-switch while the other microcontroller controls the M-switch. There is feedback from the P-switch output to the other microcomputer that is controlling the M-switch. Likewise, there is feedback from the M-switch output to the other microcomputer that is controlling the P-switch. The feedback verifies that the output switches are operating properly and in the commanded state.

You must configure a "Maximum readback time" that specifies the allowed delay for the output voltage to respond to the switch change.

The fail-safe digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. Your configured "Maximum readback time" also sets the duration of the "OFF" test pulse. You must configure a "Maximum readback time switch on test" which sets the duration of the "ON" test pulse. You should choose these durations short enough to not affect your load.

The module can detect a broken wire or missing load only when the output PV is "OFF" and the load is wired as a PM mode.

Getting started

2

2.1 Introduction to example

2.1.1 Requirements for configuring and programming

These instructions will guide you step-by-step through a specific example for configuring and programming with *STEP 7 Safety Advanced V15* or later.

You will become acquainted with the basic functions and special features of *STEP 7 Safety Advanced V15* or later.

You can work through this example in one or two hours, depending on your level of experience.

Requirements for the example

The following requirements must be met:

- In order to understand these Getting Started instructions, you need general knowledge of automation technology. You also need to be familiar with *STEP 7 Professional V15* or later and *STEP 7 Safety Advanced V15* or later.
- You need a PLC station consisting of the following components:
  - Fail-Safe CPU (S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPUs)
  - ET 200eco PN 16DI module
  - ET 200eco PN F-DI 8 / F-DQ 3 module
- *STEP 7 Professional V15* or later and *STEP 7 Safety Advanced V15* or later must be correctly installed on your Windows-based programming device with an Ethernet interface.
- You must install an HSP in order to add the ET 200eco PN F-DI 8 / F-DQ 3 module to the Hardware catalog. TIA Portal V15 does not include the ET 200eco PN F module in its initial release. Hardware Support Packages (HSP) provide a way to configure modules that are not contained in the hardware catalog of your current STEP 7 installation. Refer to "Installing the Hardware Support Package (HSP)" (Page 35) for further information.
- You must connect a programming device to the fail-safe CPU through the PROFINET interface.
- The S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPUs must be fully installed and wired. Documentation on the installation and wiring of these fail-safe CPUs can be found in the Preface, "Documentation and information" (Page 4).
- You can find information on the installation and wiring of the ET 200eco PN 16DI in the "Distributed I/O ET 200eco PN, Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW) and of the ET 200eco PN F-DI 8 / F-DQ 3 in the "Installation (Page 95)" and "Wiring" (Page 101) chapters of this manual.

WARNING

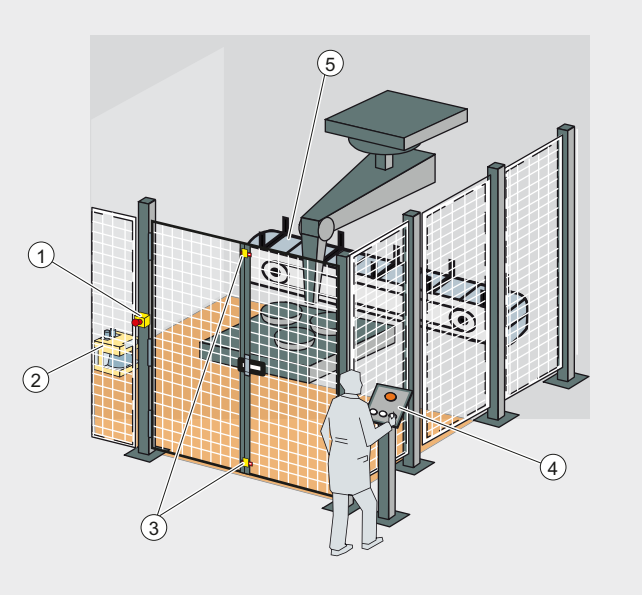
As components in plants and systems, the S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPUs and the ET 200eco PN F-DI 8 / F-DQ 3 module are subject to specific standards and regulations depending on the area of application. Please note the applicable safety and accident prevention regulations (for example, IEC 60204-1 (General Requirements for Safety of Machinery)).

The example in these Getting Started instructions serves as an introduction to configuring and programming of *STEP 7 Safety Advanced V15* or later. The example does not lead to actual live operation in every case. Before you work on the example, it is essential that you refer to the current version of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en). The warnings and other notes contained in that manual must be heeded at all times even if they are not repeated in this document.

Serious injury and damage to machines and equipment may result if these regulations are ignored.

2.1.2 Example structure and task definition

The Getting Started example consists of a production cell with access protection. Your task is to configure and program the field devices (shown in the image below) to provide that access protection.



① Emergency stop (E-Stop)
② Laser scanner
③ Safety door
④ Control panel with start and acknowledgement pushbuttons
⑤ Conveyor motor

A laser scanner monitors the entry to the production area. A safety door secures the service area.

Entering the production area or opening the safety door results in a stop or shutdown of the production cell similar to an emergency stop.

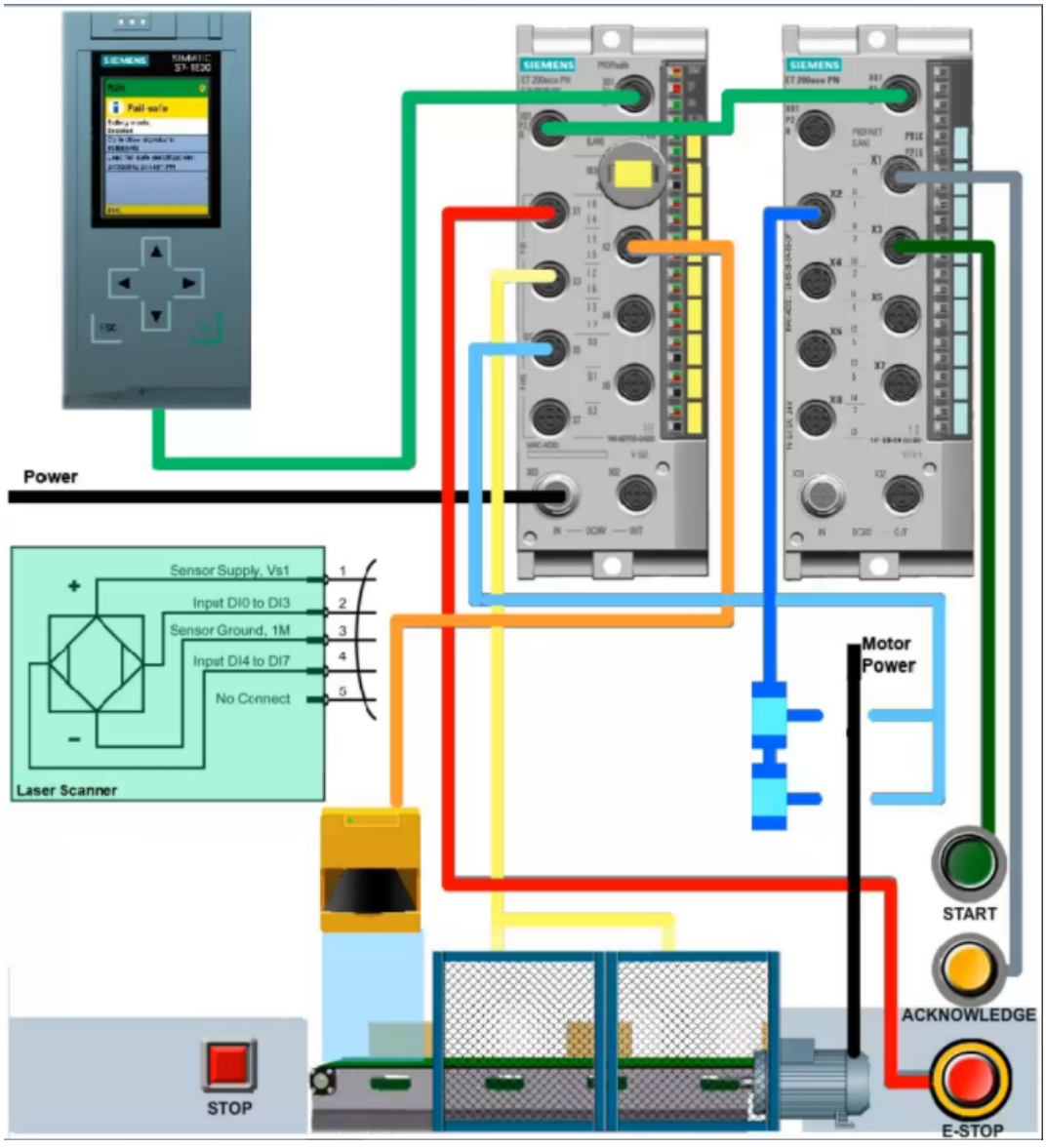
The system can only be restarted when the emergency stop is cancelled, the safety door is closed, and the laser scanner detects no one in the protected area. The user must acknowledge that conditions have returned to a safe state before production can be restarted.

2.1.3 Operating the Getting Started example

The following graphic gives you the opportunity to become familiar with how the example functions in this Getting Started.

This example switches the Laser Scanner, E-Stop, and Safety Door on and off to simulate unsafe conditions. Each device operates independently of the other two devices. If you do activate a device, you must deactivate that device before continuing.

The example also shows that you must press the "Acknowledge" button to notify the system that you have returned to a safe state. Then, you can press the "Start" button to operate the system again.



The table below describes the steps and their actions:

Step	Action	Description
1	Press the Stop button.	The motor stops.
2	Press the Start button.	The motor restarts.
3	Activate the E-Stop. [1, 2]	This action prevents resumption of the operation.
4	Deactivate the E-Stop. [3]	The E-Stop deactivates.
5	Press the Acknowledge button.	The safety program requires manual acknowledgement.
6	Press the Start button.	The motor restarts.
7	Open the Safety Door. [1, 2]	This action prevents resumption of the operation.
8	Close the Safety Door. [3]	The Safety Door closes.
9	Press the Acknowledge button.	The safety program requires manual acknowledgement.
10	Press the Start button.	The motor restarts.
11	Trigger the Laser Scanner. [1, 2]	This action prevents resumption of the operation.
12	Deactivate the Laser Scanner. [3]	The Laser Scanner deactivates.
13	Press the Acknowledge button.	The safety program requires manual acknowledgement.
14	Press the Start button.	The motor restarts.

1 You can activate the E-STOP, trigger the Laser Scanner, or open the Safety Door individually or in any order to stop operations and bring the system to a safe state.

2 To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device, 2. Press the Acknowledge button, and 3. Press the Start button.

3 This action allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart the motor.

2.1.4 Procedure

In summary, the example in these Getting Started instructions consists of the following sections:

Configuring

1. Configure the following components:
   - S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU
   - ET 200eco PN 16DI module
   - ET 200eco PN F-DI 8 / F-DQ 3 module.
2. Use the ET 200eco PN 16DI module standard digital inputs for a user acknowledgement, a feedback loop, and a start pushbutton.
3. Configure the ET 200eco PN F-DI 8 / F-DQ 3 module fail-safe inputs for connecting an emergency stop switch, the position switches for monitoring a safety door, and the laser scanner for monitoring the entry area.
4. Finally, configure an ET 200eco PN F-DI 8 / F-DQ 3 module fail-safe output for connecting a motor.

The "Configuring" (Page 30) section describes the configuration process.

Programming

Once you successfully complete the configuration, program your safety program.
In the example, you program a fail-safe block with the following instructions:

- Emergency stop
- Safety door function
- Feedback loop (as restart protection, when an incorrect load exists)
- User acknowledgement for reintegration

You then compile the block to form a safety program.
The "Programming" (Page 52) section describes the programming process.

2.2 Configuring

2.2.1 Introduction

You require a PLC station consisting of an S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU, an ET 200eco PN 16DI module, and an ET 200eco PN F-DI 8 / F-DQ 3 module. Your programming device must be connected to the fail-safe CPU through a PROFINET interface.

⚠ WARNING

You may come into contact with live electrical wires connected to the main power supply.
Only wire the fail-safe CPU, ET 200eco PN 16DI, and ET 200eco PN F-DI 8 / F-DQ 3 control system when the input power is turned OFF.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.

Documentation on the installation and wiring of the S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPUs can be found in the Preface, "Documentation and information" (Page 4). You can find information on the installation and wiring of the ET 200eco PN 16DI in the "Distributed I/O ET 200eco PN, Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW) and of the ET 200eco PN F-DI 8 / F-DQ 3 in the "Installation (Page 95)" and "Wiring" (Page 101) chapters of this manual.

Configuring the Hardware

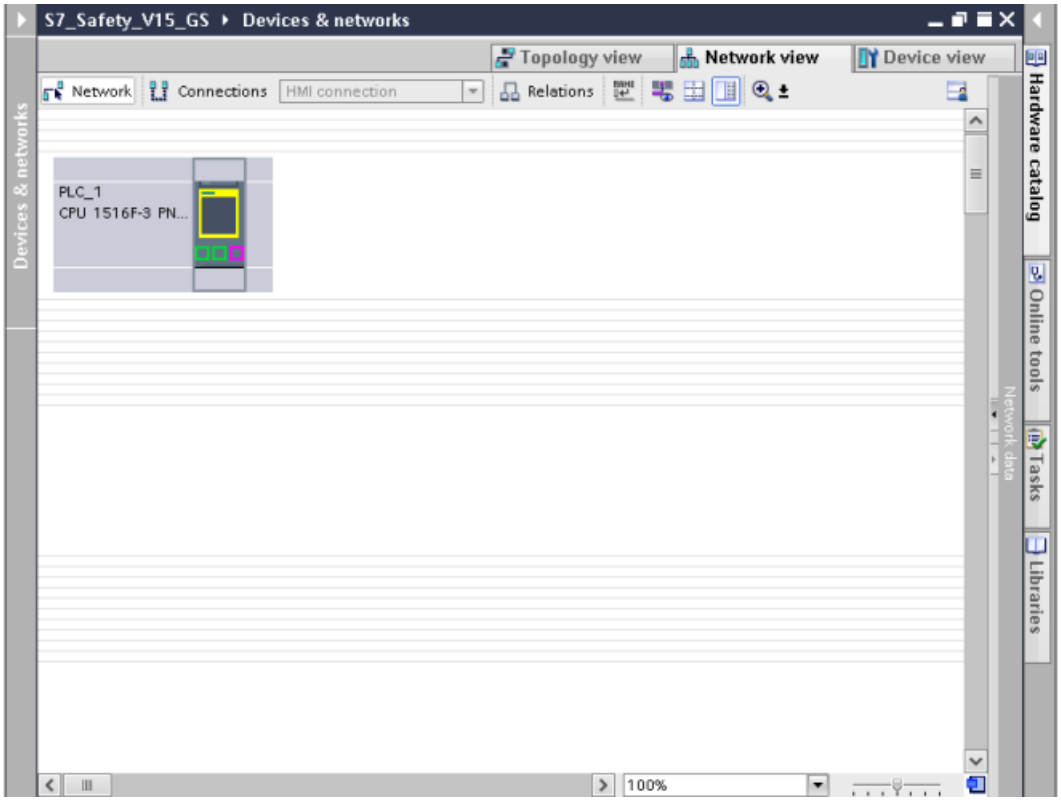
After installing and wiring your PLC station, in STEP 7 Safety, you configure the following components:

- Fail-Safe CPU
- ET 200eco PN 16DI standard digital inputs for user acknowledgement, feedback loop, and start pushbutton
- ET 200eco PN F-DI 8 / F-DQ 3 module fail-safe digital inputs for connecting an emergency stop switch and position switches for monitoring a safety door and the laser scanner
- ET 200eco PN F-DI 8 / F-DQ 3 module fail-safe digital output for connecting a motor

2.2.2 Step 1: Configuring the fail-safe CPU

In this step, you create a new project, add a fail-safe CPU, and assign parameters..

Procedure



1. In the portal view of STEP 7 Safety, create a new project named "S7_Safety_V15_GS"
2. Use "Add new device" to add a CPU 1516F-3 PN/DP.

NOTE

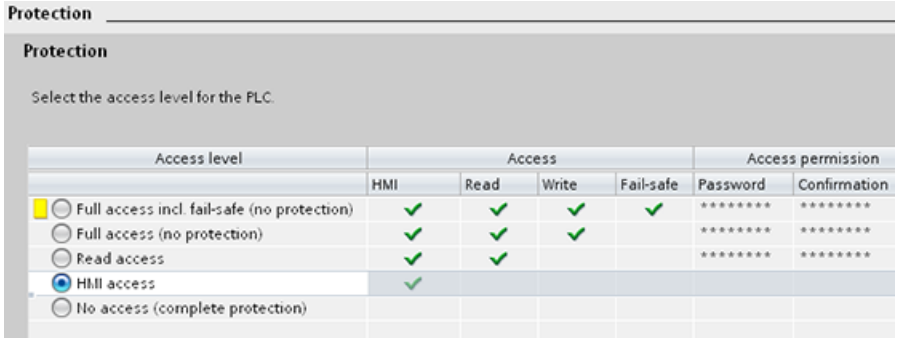
You can use any of the following fail-safe CPUs in this example:

- S7-1200/1500
- S7-300/400
- ET 200pro (IP67 compliant)
- ET 200S/ET 200SP

Result: The Device View containing the CPU 1516F-3 PN/DP opens.

3. Locate the "Fail-safe: F-parameters" area.
   You can change the following parameters or accept the default setting:
   – "Low limit for F-destination addresses": Default value is suitable for a stand-alone S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU.
   – "High limit for F-destination addresses": Default value is suitable for a stand-alone S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU.
   – "Central F-source address": Default value is suitable for a stand-alone S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU.

   Refer to "Configuring F-parameters" (Page 131) for further information.
   Leave the default values unchanged for this example.
4. Move to the "Protection & Security" area.
   Select the "Access level" property to select the access level and enter passwords. "Full access incl. fail-safe (no protection)" access level is the lowest level for a fail-safe CPU. Enter and confirm a password for the required protection. Passwords are case-sensitive.



When you download the protection configuration, in the figure above, to the fail-safe CPU, you have HMI access and can access HMI functions without a password. To read data, you must enter the configured password for one of the following access levels:

– "Read access"
– "Full access (no protection)"
– "Full access incl. fail-safe (no protection)".

To write data, the user must enter the configured password for one of the following access levels:

– "Full access (no protection)"
– "Full access incl. fail-safe (no protection)"

NOTE

If you require a password for only the Read access security level, you must also enter a password for the "Full access incl. fail-safe (no protection)" access security level.
If you require a password for only the Full access (no protection) security level, you must also enter a password for "Full access incl. fail-safe (no protection)" access security level.

Access protection for the fail-safe CPU

The fail-safe CPU provides five levels of security for restricting access to specific functions. When you configure the security level and password for a fail-safe CPU, you limit the functions and memory areas that can be accessed without entering a password.

Each level allows certain functions to be accessible without a password. The default condition for the fail-safe CPU is to have no restriction and no password-protection. To restrict access to a fail-safe CPU, you configure the properties of the fail-safe CPU, and enter and confirm the password.

Table 1-1146 Access levels for the CPU

Access level	Access restrictions
Full access incl. fail-safe (no protection)	Allows full access without password. This is the lowest level of protection for a fail-safe CPU.
Full access (no protection)	Allows full access, except write access to fail-safe blocks, without password protection. Password is required for the following operations: • Modifying (writing to) fail-safe blocks • Changing the CPU mode (RUN/STOP)
Read access	Allows reading the data in the CPU, HMI access, and all forms of PLC-to-PLC communications without password protection. Password is required for following operations: • Modifying (writing to) fail-safe blocks • Modifying (writing to) the CPU • Changing the CPU mode (RUN/STOP)
HMI access	Allows HMI access and all forms of PLC-to-PLC communications without password protection. Password is required for the following operations: • Modifying (writing to) fail-safe blocks • Modifying (writing to) the CPU • Reading the data in the CPU • Changing the CPU mode (RUN/STOP)
No access (complete protection)	Allows no access without password protection. Password is required for the following operations: • Modifying (writing to) fail-safe blocks • Modifying (writing to) the CPU • Reading the data in the CPU • Changing the CPU mode (RUN/STOP) • Access to HMI

Result

The new project has been created and the configuration of the fail-safe CPU is complete.

2.2.3 Step 2: Configuring the ET 200eco PN 16DI

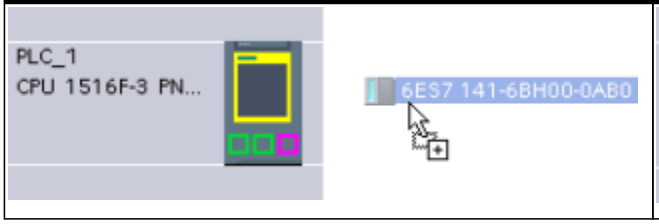
In the "Devices and networks" portal, use the hardware catalog to add PROFINET IO devices.

For example, expand the following containers in the hardware catalog to add an ET 200eco PN IO device:

- Distributed I/O
- ET 200eco PN
- Interface modules
- PROFINET
- DI
- 16DI x 24VDC 8xM12
- 6ES7141-6BH00-0AB0

You can then select from the list of ET 200eco PN devices (sorted by part number) and add the ET 200eco PN 16DI IO device.

Table 1-1147 Adding an ET 200eco PN 16DI IO device to the device configuration

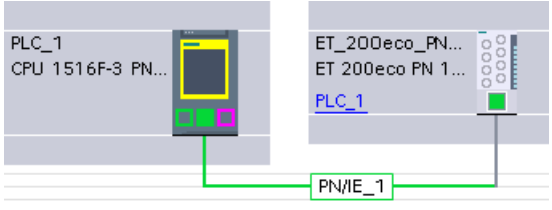
Insert the IO device	Result
	

You can now connect the PROFINET IO device to the CPU:

1. Right-click the "Not assigned" link on the device and select "Assign to new IO controller" from the context menu to display the "Select IO controller" dialog.
2. Select your S7-1516F-3 PN/DP CPU (in this example, "PLC_1") from the list of IO controllers in the project.
3. Click "OK" to create the network connection.

You can also go to the "Devices and networks" portal and use the "Network view" to create the network connections between the devices in your project:

1. To create a PROFINET connection, click the green (PROFINET) box on the first device, and drag a line to the PROFINET box on the second device.
2. Release the mouse button and your PROFINET connection is joined.
3. Save the configuration, or download it to the fail-safe CPU.



2.2.4 Step 3: Configuring the ET 200eco PN F-DI 8 / F-DQ 3

2.2.4.1 Installing the Hardware Support Package (HSP)

Hardware Support Packages (HSP) provide a way to configure modules that are not contained in the hardware catalog of your current STEP 7 installation. You can download the HSPs from the Siemens Industry Online Support Web site at "Support Packages for the hardware catalog in the TIA Portal (HSP)" (https://support.industry.siemens.com/cs/us/en/view/72341852). Use the following steps to install the ET 200eco PN F-DI 8 / F-DQ 3 HSP:

1. Create a project.
2. Select project view.
3. From the TIA Portal main menu, select the Options > Support Packages menu command.
4. In the dialog, ensure that you select "Installation of support packages" in the left pane (should already be selected).
5. Click the "Download from the Internet" link.
6. Navigate to the required HSP zip file (that contains HSP_V15_0204_001_ET200eco_FDI8_FDQ3_1.0.isp15) in the Siemens support site's "Support Packages for the hardware catalog in the TIA Portal (HSP)".
7. Click the required HSP zip file, download to a folder on your computer, and unzip the HSP.
8. Click the "Add from file system" button.
9. Navigate to the HSP (HSP_V15_0204_001_ET200eco_FDI8_FDQ3_1.0.isp15) on your local drive.
10. Click the "Open" button.
11. The HSP is inserted into the "Local support packages" list. Select the HSP by putting a check mark in the check box on the left.
12. Click the "Install" button on the bottom right of the dialog.
13. Click "Continue" on the pop up that appears
14. Click "Finish".
15. Click "Close".

2.2.4.2 Configuring the PROFINET IO device

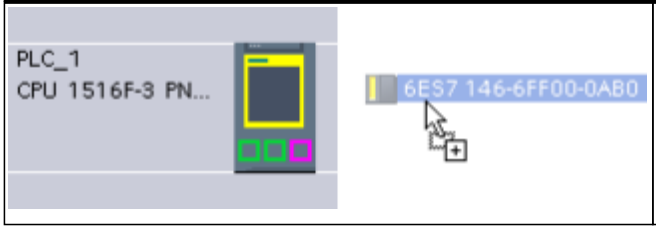
In the "Devices and networks" portal, use the hardware catalog to add PROFINET IO devices.

For example, expand the following containers in the hardware catalog to add an ET 200eco PN F IO device:

- Distributed I/O
- ET 200eco PN
- Interface modules
- PROFINET
- DI/DO
- F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A, 3xM12
- 6ES7146-6FF00-0AB0

Add the ET 200eco PN F-DI 8 / F-DQ 3 IO device. You can double-click the part number or drag it to the "Devices and networks" view to insert the module.

Table 1-1148 Adding an ET 200eco PN F-DI 8 / F-DQ 3 IO device to the device configuration

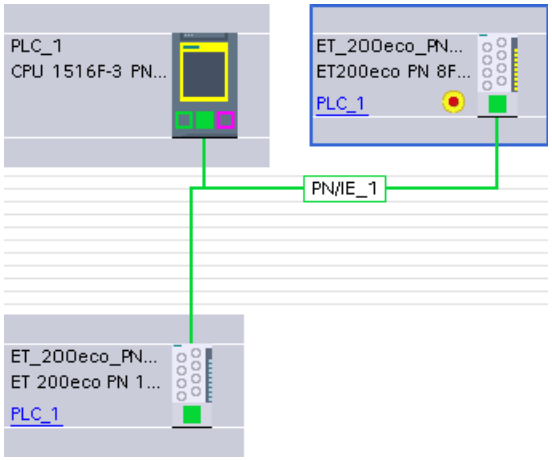
Insert the IO device	Result
	

You can now connect the PROFINET IO device to the CPU:

1. Right-click the "Not assigned" link on the device and select "Assign to new IO controller" from the context menu to display the "Select IO controller" dialog.
2. Select your S7-1516F-3 PN/DP CPU (in this example, "PLC_1") from the list of IO controllers in the project.
3. Click "OK" to create the network connection.

You can also go to the "Devices and networks" portal and use the "Network view" to create the network connections between the devices in your project:

1. To create a PROFINET connection, click the green (PROFINET) box on the first device, and drag a line to the PROFINET box on the second device.
2. Release the mouse button and your PROFINET connection is joined.
3. Save the configuration, or download it to the fail-safe CPU.



2.2.4.3 Configuring F-parameters

Procedure

1. Under the "Properties" tab, select the "General" tab, and then select the "F-parameters" area. Here, you can change the following parameters or apply the default settings:
   – "F-monitoring time": A valid current safety message frame must be received from the fail-safe CPU to the ET 200eco PN F-DI 8 / F-DQ 3 within the F-monitoring time. Otherwise, the fail-safe module goes to safe state. The F-monitoring time must be set high enough so that message frame delays are tolerated and, at the same time, low enough that the process can react as quickly as possible when a fault occurs.

   NOTE
   The "F-runtime group cycle time" is a closely-related parameter to the F-monitoring time. The cycle time is the interval by which the F-runtime group executes and determines how often the fail-safe CPU sends the PROFIsafe frame to the ET 200eco PN F-DI 8 / F-DQ 3.
   When you add a fail-safe CPU to your project, STEP 7 creates Functional Safety Organization Block 1 (FOB_RTG1) (OB123 by default). FOB_RTG1 is a cyclic-interrupt OB which executes using the "cycle time" interval specified in the Safety Administration editor for the corresponding F-runtime group.

   – "F-destination address": A unique PROFIsafe address is critical for every F-IO module used in a safety system (network and CPU-wide). Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for procedures to set and verify unique PROFIsafe addresses in networked systems.

   Leave the settings unchanged for the F-parameters for this example.

Result

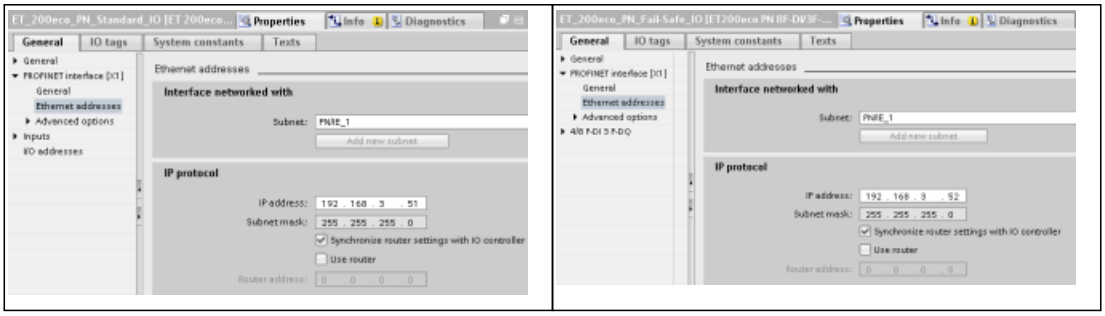
The configuration of the ET 200eco PN F-DI 8 / F-DQ 3 F-parameters is now complete.

2.2.5 Step 4: Assigning the IP addresses and PROFINET device names

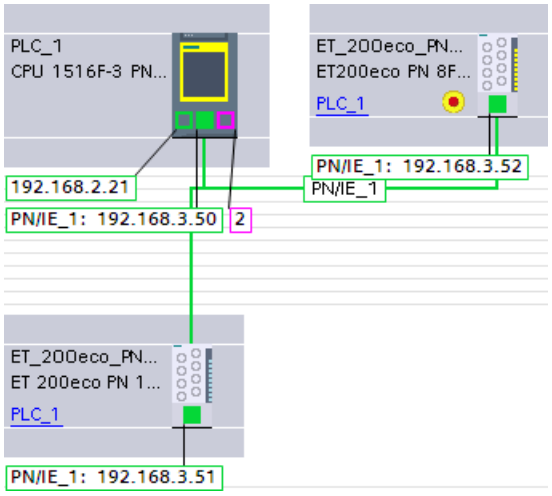
2.2.5.1 Assigning the IP addresses

An IO device is configured and an IP address assigned in the hardware configuration.

To assign an IP address to your ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3 modules, navigate to each module's Property page, and select **General > PROFINET interface [Xn] > Ethernet addresses**. Locate the "IP protocol" field, and enter the IP address for your ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3. as shown in the figure below:



The TIA portal, Network view displays your IP addresses as shown in the example below:



2.2.5.2 Assigning the PROFINET device names

Every PROFINET device is assigned a unique device ID (MAC address) before it leaves the factory.

Each ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3 IO device is addressed based on its device name during configuration.

Requirements

- An online PROFINET connection from the programming device to the IO device is required for assigning the device name to the IO device.
- The IO device is configured and an IP address assigned in hardware configuration.

NOTE

When you assign PROFINET device names to devices on the PROFINET network using an S7-1500 CPU, your programming device, S7-1500 CPU, and distributed IO devices must all be on the same subnet.

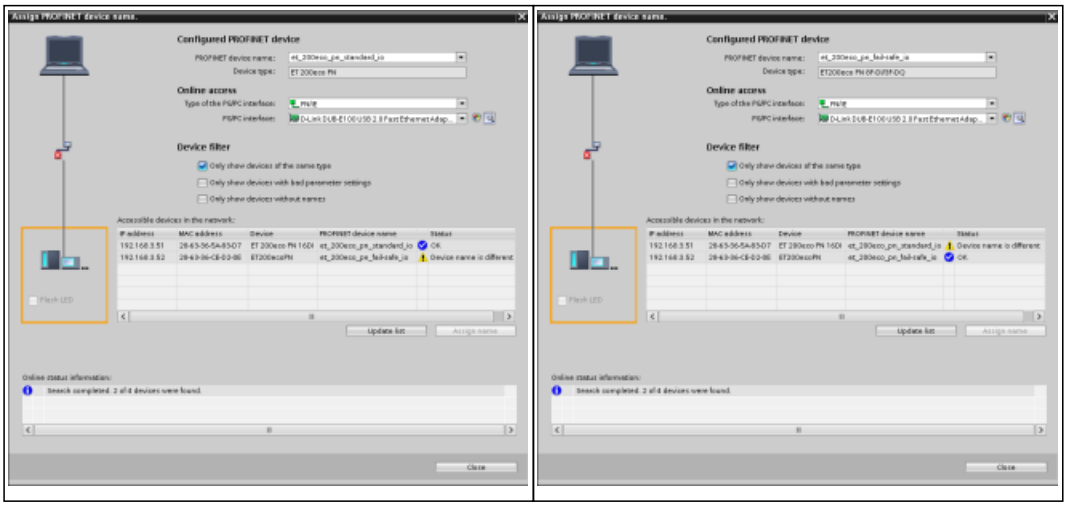
In this example, you communicate from your S7-1500 CPU to your programming device through the S7-1500 CPU's "X2" Ethernet port. You communicate from your S7-1500 CPU to your distributed IO devices through the S7-1500 CPU's "X1" Ethernet port. The "X1" Ethernet port has two physical Ethernet cable connections.

In order to have all of your PROFINET devices on the same subnet, you must communicate to all of your devices through the S7-1500 "X1" Ethernet port. Therefore, you must move the S7-1500 "X2" port Ethernet connection cable to the bottom "X1" Ethernet port. Then, you can communicate with the modules because then you are on the same Ethernet network.

Assigning device names

1. Switch on the supply voltages for the ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3 modules.
2. Open the ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3 Property pages.
3. Select **General > Project information > Name** and enter a device name.

4. Right-click on the module in the "Devices and networks" view, and select "Assign device name" to bring up the "Assign PROFINET device name" dialog.



5. Ensure that you select the "Only show devices of the same type" check box (should be selected by default).
6. Click the "Update list" button.
7. Select the MAC address for your IO device from the list.
8. Click the "Assign name" button.

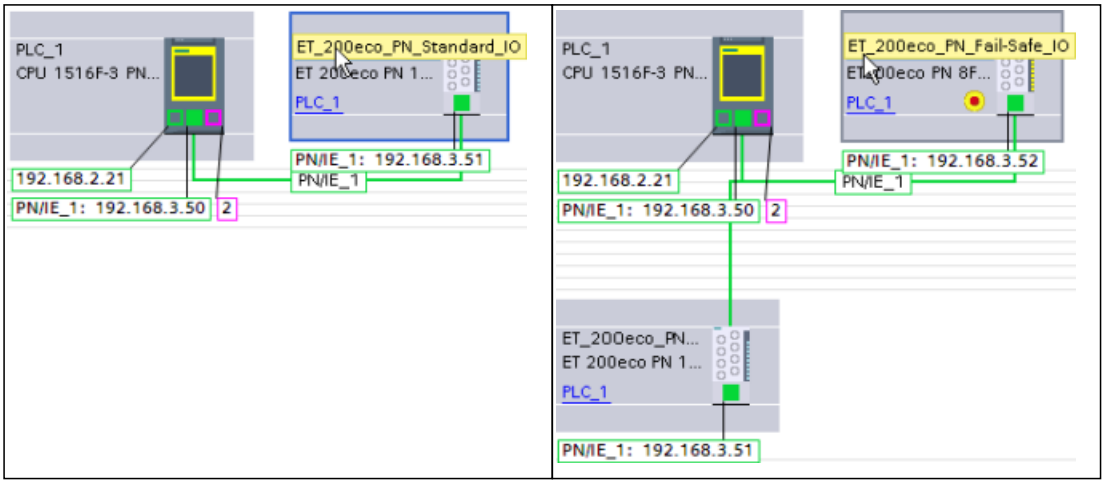
NOTE

If the module is not found, be sure the programming device is on the same network as the module (can connect Ethernet cable direct from the programming device to the module for this function).

Refer to the TIA Portal online help for further information on assigning PROFINET IO device names.

Result

The device name is saved internally in the ET 200eco PN 16 DI and ET 200eco PN F-DI 8 / F-DQ 3:



Node flash test

The "Assign PROFINET device name" dialog box displays all IO devices used. Compare the MAC address of the device with the MAC address displayed, and then select the correct IO device.

A node flash test facilitates the identification of IO devices in a plant. You activate the flash test as follows:

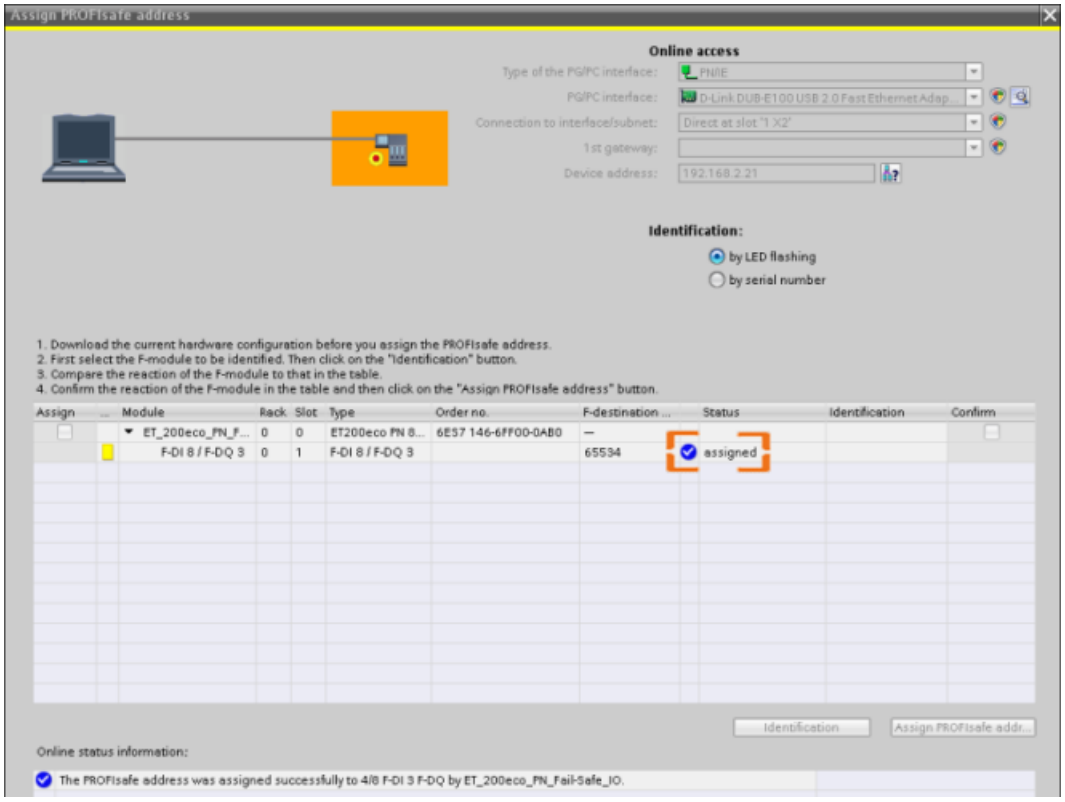
1. Select the required IO device from the "Accessible devices in the network" list.
2. Select the "Flash LED" check box.

The LINK LEDs flash on the selected IO device.

2.2.6 Step 5: Assigning PROFIsafe addresses

In this step, you identify the ET 200eco PN F-DI 8 / F-DQ 3 module for assignment and assign a PROFIsafe address to it.

Procedure



Identifying the module

You identify the ET 200eco PN F-DI 8 / F-DQ 3 module using the following steps:

1. Download the current hardware configuration before you assign the PROFIsafe addresses.
2. In the network view, select the ET 200eco PN F module to which you want to assign the PROFIsafe address.
3. Right-click the ET 200eco PN F module, and select "Assign PROFIsafe address" from the context menu to display the "Assign PROFIsafe address" dialog.
4. In the "Identification" field, select the method to be used for identifying the ET 200eco PN F module:
   - "By LED flashing": This is the default setting. The System Fault, Channel Fault, and Channel Status LEDs of the ET 200eco PN F module that you want to identify flash upon identification.
   - "By serial number": If you cannot see the ET 200eco PN F module directly, you can identify the module by the serial number of the module.
5. In the "Assign" column, select the check box for the ET 200eco PN F module to which you want to assign PROFIsafe address.

6. Click the "Identification" button, and compare the reaction of the fail-safe module to that in the table:
   - Check whether the Channel Status LEDs of the ET 200eco PN F modules whose PROFIsafe addresses you want to assign are flashing green.
   - If you identify using the serial number, compare the displayed serial number to the serial number of the module.
7. In the "Confirm" column, select the check box for the ET 200eco PN F module for which you want to confirm the reaction of the fail-safe module in the table.

Assigning a PROFIsafe address to the module

To assign an F-destination address, proceed as follows:

1. Ensure that you install an eCoding plug on each ET 200eco PN F-DI 8 / F-DQ 3 module.
2. Use the "Assign PROFIsafe addr..." button to assign the PROFIsafe address to the ET 200eco PN F-DI 8 / F-DQ 3 module. You may have to enter the password of the fail-safe CPU.
3. You must answer "yes" to the "Confirm PROFIsafe address assignment" dialog within 60 seconds to assign the PROFIsafe address.

NOTE

Refer to the "Assigning PROFIsafe addresses" (Page 140) for further information about PROFIsafe address identification and assignment.

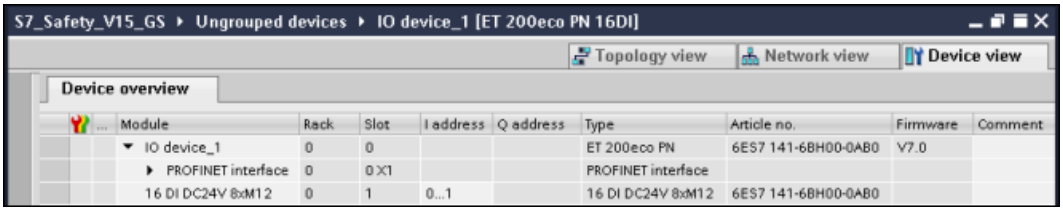
2.2.7 Step 6: Configuring the standard digital inputs for the user acknowledgement, feedback circuit, and start pushbutton

In this step, you connect ET 200eco PN 16DI standard digital inputs to the non-fail-safe signals (user acknowledgement, feedback loop, and start pushbutton) in your program.

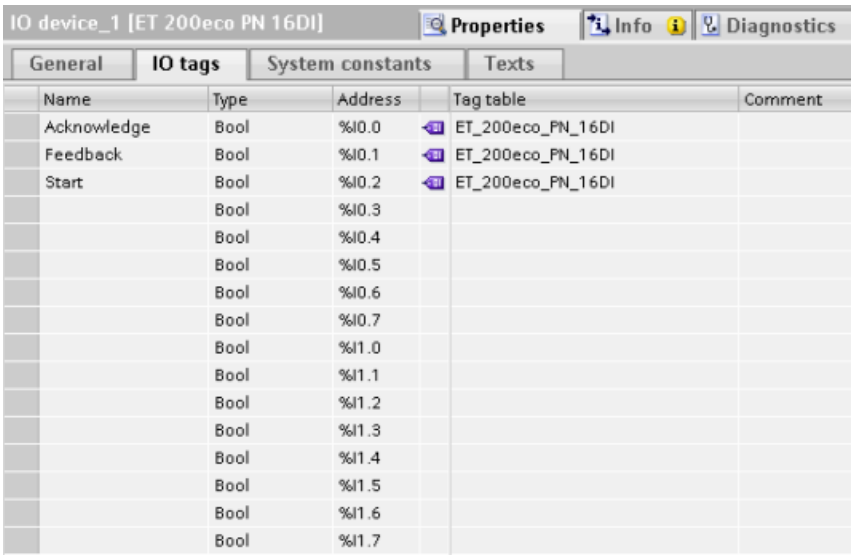
Procedure

1. Assign the input address of the ET 200eco PN digital input module (16 DI DC 24 V DC 8xM12 (6ES7141-6BH00-0AB0)) to "0" for this example. You can assign these addresses in the ET 200eco PN digital input module's device configuration under "16 DI DC24V 8xM12", "I/O addresses".

   Refer to the "ET 200eco PN 16DI Device view" information from the TIA Portal shown below:



2. Return to the "Device view" and select the ET 200eco PN 16DI. Under the "Properties" tab, select the "IO tags" tab. Here, you can define tags for each channel:



Name	Type	Address	Tag table	Comment
Acknowledge	Bool	%I0.0	ET_200eco_PN_16DI	
Feedback	Bool	%I0.1	ET_200eco_PN_16DI	
Start	Bool	%I0.2	ET_200eco_PN_16DI	
	Bool	%I0.3		
	Bool	%I0.4		
	Bool	%I0.5		
	Bool	%I0.6		
	Bool	%I0.7		
	Bool	%I1.0		
	Bool	%I1.1		
	Bool	%I1.2		
	Bool	%I1.3		
	Bool	%I1.4		
	Bool	%I1.5		
	Bool	%I1.6		
	Bool	%I1.7		

Result

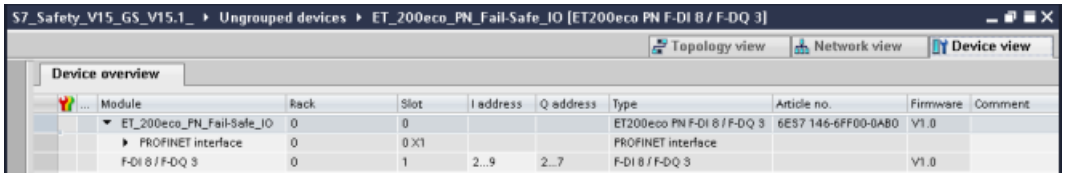
The configuration of the ET 200eco PN 16DI standard digital inputs is now complete.

2.2.8 Step 7: Configuring the Process value and Value status bits

In this step, you configure the Process value and Value status bits of the ET 200eco PN F-DI 8 / F-DQ 3.

Procedure

1. Select the "Device view" tab to display the "Device overview" area. Here, you can change the starting addresses for the inputs and outputs of your fail-safe module. Use the module default I/O addresses of "2" and "2" for this example (inputs begin at byte 2, and outputs begin at byte 2).



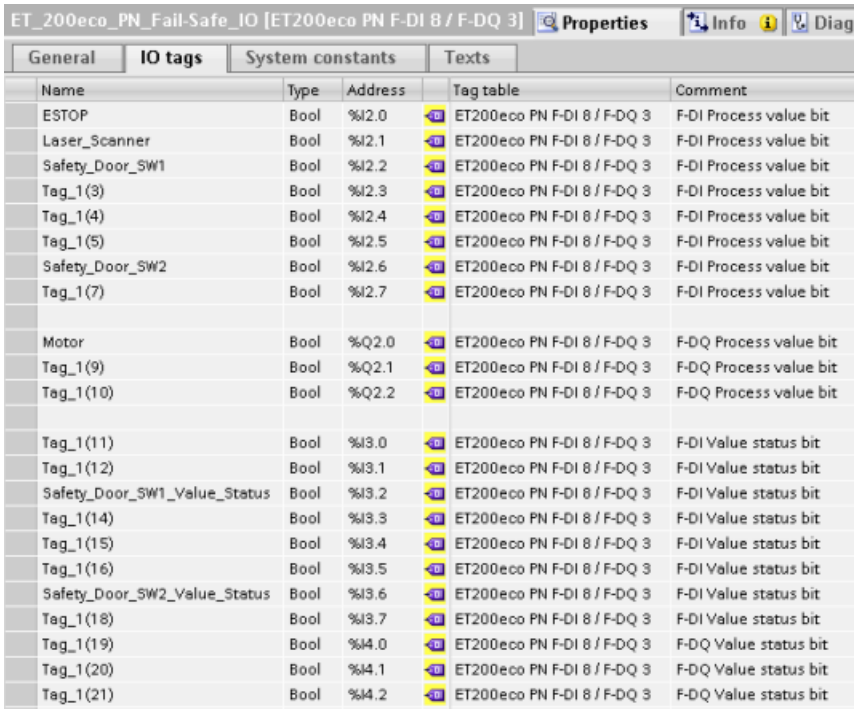
NOTE

The ET 200eco PN F-DI 8 / F-DQ 3 internally uses both Is and Qs to work with the physical input and output channels.

The ET 200eco PN F-DI 8 / F-DQ 3 digital inputs can have 4 - 8 input channels, and the digital outputs have 3 output channels.

The number of input (I) bytes and output (Q) bytes that the ET 200eco PN F-DI 8 / F-DQ 3 requires depends upon which PROFIsafe profile your fail-safe CPU uses. If using PROFIsafe profile V2.4 (with S7-300/S7-400), the module requires 7 input (I) bytes and 5 output (Q) bytes. If using PROFIsafe profile V2.6 (with S7-1200/S7-1500), the module requires 8 input (I) bytes and 6 output (Q) bytes.

2. Return to the "Device view" and select the ET 200eco PN F-DI 8 / F-DQ 3. Under the "Properties" tab, select the "IO tags" tab. This action displays the "Process value" and "Value status" bits for the fail-safe module. Here, you can define tags for each channel:



ET_200eco_PN_Fail-Safe_IO [ET200eco PN F-DI 8 / F-DQ 3] | Properties | Info | Diag

General | IO tags | System constants | Texts

Name	Type	Address	Tag table	Comment
ESTOP	Bool	%I2.0	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Laser_Scanner	Bool	%I2.1	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Safety_Door_SW1	Bool	%I2.2	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(3)	Bool	%I2.3	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(4)	Bool	%I2.4	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(5)	Bool	%I2.5	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Safety_Door_SW2	Bool	%I2.6	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(7)	Bool	%I2.7	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Motor	Bool	%Q2.0	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(9)	Bool	%Q2.1	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(10)	Bool	%Q2.2	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(11)	Bool	%I3.0	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(12)	Bool	%I3.1	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Safety_Door_SW1_Value_Status	Bool	%I3.2	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(14)	Bool	%I3.3	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(15)	Bool	%I3.4	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(16)	Bool	%I3.5	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Safety_Door_SW2_Value_Status	Bool	%I3.6	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(18)	Bool	%I3.7	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(19)	Bool	%I4.0	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit
Tag_1(20)	Bool	%I4.1	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit
Tag_1(21)	Bool	%I4.2	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit

Each Process value bit has an associated Value status bit that reports whether the corresponding process value is valid (ON) or associated with a passivated channel (OFF). If an entire module is passivated, then the Value status bits associated with all channels are all OFF.

Digital input Process value and Value status bits

To check the Process value bits and the Value status bits, you must know where these bits are mapped in the module. For an ET 200eco PN F-DI 8 / F-DQ 3, the first byte of the input (I) image register is the Process value bits for the digital inputs, and the next byte of the input (I) image register is the Value status bits for the digital inputs. For example, if the module starting address is I2.0 and Q2.0 for the ET 200eco PN F-DI 8 / F-DQ 3 and you have a 1oo1 configuration, then the Process value bits and corresponding Value status bits for the digital inputs are allocated as shown in the following table:

Digital input Process value bits - 1oo1 configuration	Digital input Value status bits - 1oo1 configuration
I2.0	I3.0
I2.1	I3.1
I2.2	I3.2
I2.3	I3.3
I2.4	I3.4

Digital input Process value bits - 1oo1 configuration	Digital input Value status bits - 1oo1 configuration
I2.5	I3.5
I2.6	I3.6
I2.7	I3.7

If you have all channel pairs configured to use 1oo2 evaluation, then the Process value bits and corresponding Value status bits for the digital inputs are allocated as shown in the following table:

Digital input Process value bits - 1oo2 configuration	Digital input Value status bits - 1oo2 configuration
I2.0	I3.0
I2.1	I3.1
I2.2	I3.2
I2.3	I3.3
-	-
-	-
-	-
-	-

Digital Output Process value and Value status bits

To check the Process value bits and the Value status bits, you must know where these bits are mapped in the module. For an ET 200eco PN F-DI 8 / F-DQ 3, the first three bits of the output (Q) image register are the Process value bits, and the first three bits of the third byte of the input (I) image register are the Value status bits for the digital outputs. For example, if the module starting address is I2.0 and Q2.0 for the ET 200eco PN F-DI 8 / F-DQ 3, then the Process value bits and corresponding Value status bits for the digital outputs are allocated as shown in the following table:

Digital output Process value bits	Digital output Value status bits
Q2.0	I4.0
Q2.1	I4.1
Q2.2	I4.2

Result

The configuration of the ET 200eco PN F-DI 8 / F-DQ 3 Process value and Value status bits is now complete.

2.2.9 Step 8: Connecting digital inputs to an emergency stop switch, position switches, and a laser scanner

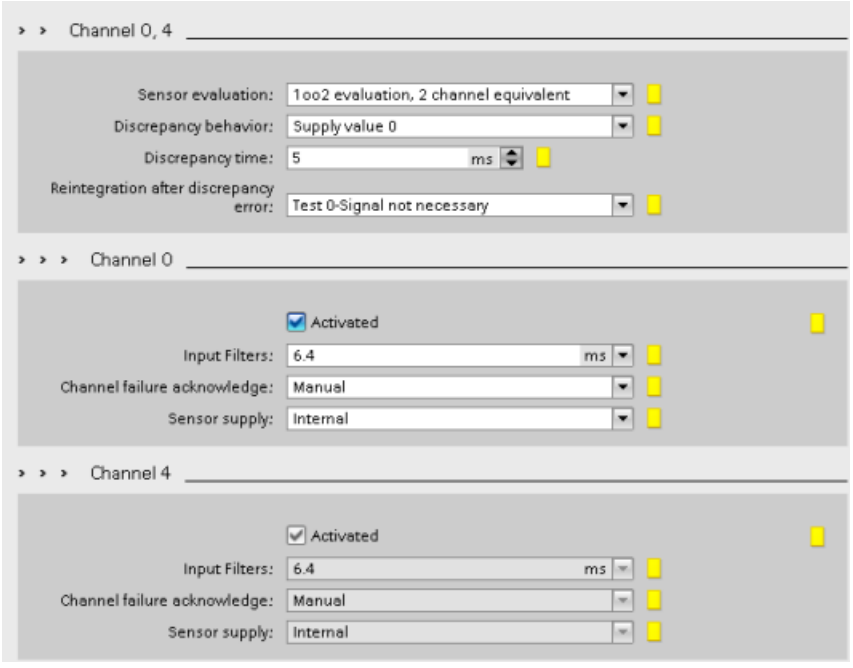
In this step, you connect ET 200eco PN F-DI 8 / F-DQ 3 digital inputs to an emergency stop switch, the position switches for monitoring a safety door, and a laser scanner for monitoring the entry area.

Procedure

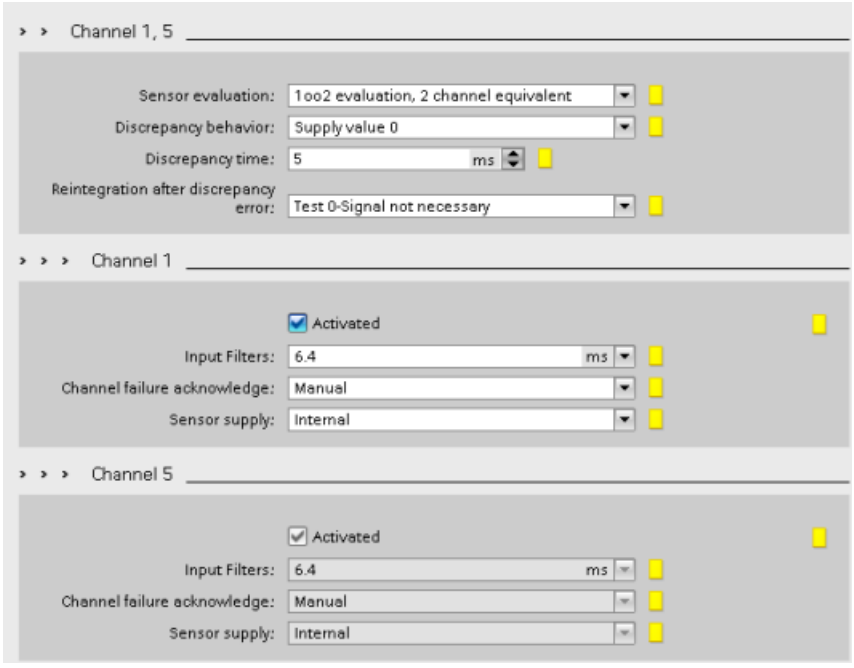
1. Select "4/8 F-DI 3 F-DQ", "DI parameters", and "Channel parameters".
2. Connect a two-channel emergency stop switch (emergency stop) to channels 0 and 4.

   Our example wires these channels to Process value bits I2.0 and I2.4. The first of the two inputs, I2.0, conveys the signal in this 1oo2 configuration. Expand "DI parameters" and "Channel parameters", and select "Channel 0, 4".

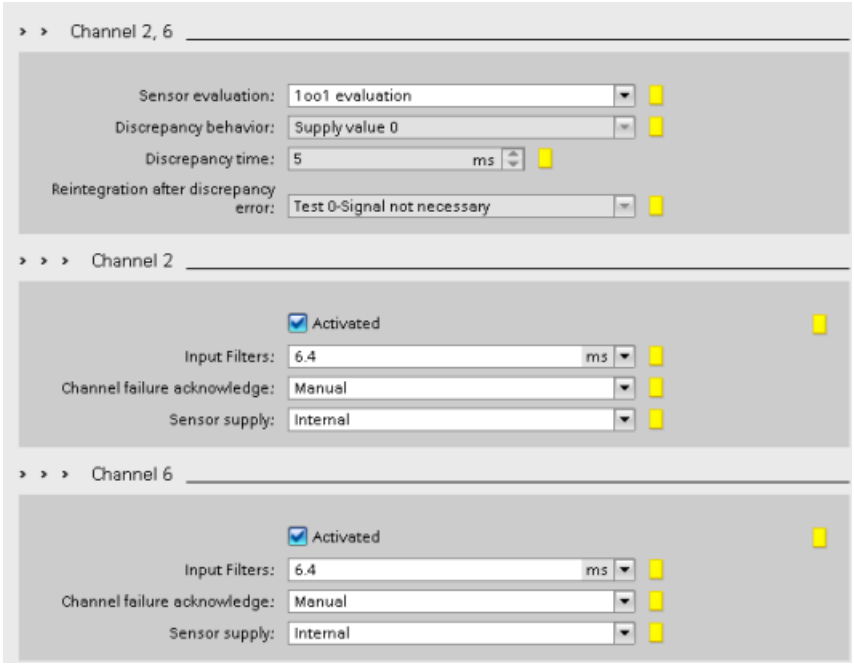
   Enter the settings as shown in the following figure:



3. In this example, in a 1oo2 configuration, connect the laser scanner for monitoring the accessible entry area to channels 1 and 5. Make the settings as shown in the following figure:



4. In this example, in a 1oo1 configuration, connect the position switches for monitoring a two-switch safety door to channels 2 and 6. Make the settings as shown in the following figure:



5. Disable the unused DI channels 3 and 7 by clearing the "Activated" check box:



Result

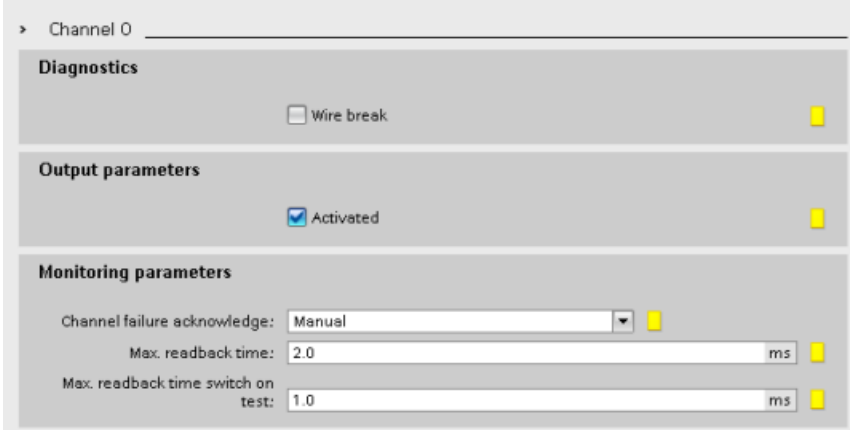
The configuration of the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs is now complete.

2.2.10 Step 9: Connecting a digital output to a motor

In this step, you configure an ET 200eco PN F-DI 8 / F-DQ 3 module's digital outputs for indirect connection of a motor to channel 0, using 2 contactors.

Procedure

1. Select the "DQ parameters" area. Here, you can change channel-specific parameters or apply the default settings.
   Enter the settings for the example as shown in the following figure:



2. Disable the unused DQ channels 1 and 2 by clearing the "Activated" check box.

Result

The configuration of the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs is now complete.

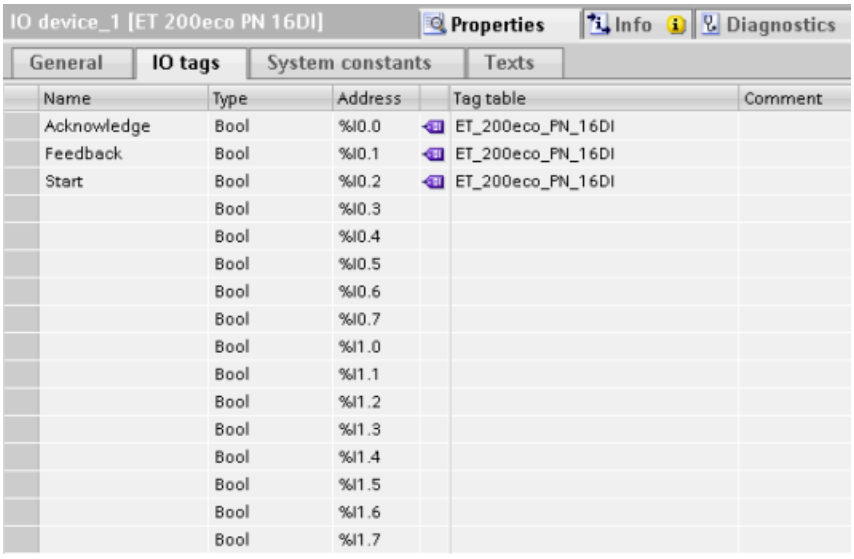
2.2.11 Summary: Configuring the Hardware

Summary

So far, you have configured the CPU 1516F-3 PN/DP and ET 200eco PN F-DI 8 / F-DQ 3 module according to the task definition for the example:

- CPU 1516F-3 PN/DP
- ET 200eco PN 16 DI standard digital inputs for user acknowledgment, feedback loop, and start pushbutton:

  - Starting byte addresses of the input and output data areas: IB0 and QB0
  - Input channel (bit) 0 for reintegration acknowledgement (I0.0)
  - Input channel (bit) 1 for feedback (I0.1)
  - Input channel (bit) 2 for start (I0.2)



Name	Type	Address	Tag table	Comment
Acknowledge	Bool	%I0.0	ET_200eco_PN_16DI	
Feedback	Bool	%I0.1	ET_200eco_PN_16DI	
Start	Bool	%I0.2	ET_200eco_PN_16DI	
	Bool	%I0.3		
	Bool	%I0.4		
	Bool	%I0.5		
	Bool	%I0.6		
	Bool	%I0.7		
	Bool	%I1.0		
	Bool	%I1.1		
	Bool	%I1.2		
	Bool	%I1.3		
	Bool	%I1.4		
	Bool	%I1.5		
	Bool	%I1.6		
	Bool	%I1.7		

- ET 200eco PN F-DI 8 / F-DQ 3 fail-safe digital inputs for connecting an emergency stop switch, position switches for monitoring a safety door, and the laser scanner for monitoring the accessible production area:

  - Starting byte addresses of the input and output data areas: IB2 and QB2
  - Input channel (bits) 0 and 4 for the emergency stop (I2.0)
  - Input channel (bits) 1 and 5 for the laser scanner (I2.1)
  - Input channel (bit) 2 for one safety door position switch (I2.2)
  - Input channel (bit) 6 for other safety door position switch (I2.6)

- ET 200eco PN F-DI 8 / F-DQ 3 fail-safe digital output for connecting a motor:
  - Starting byte addresses of the input and output data areas: IB2 and QB2
  - Output channel (bit) 0 for indirect switching of a motor using 2 contactors (Q2.0)

ET_200eco_PN_Fail-Safe_IO [ET200eco PN F-DI 8 / F-DQ 3] Properties Info Diag

General | IO tags | System constants | Texts

Name	Type	Address	Tag table	Comment
ESTOP	Bool	%I2.0	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Laser_Scanner	Bool	%I2.1	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Safety_Door_SW1	Bool	%I2.2	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(3)	Bool	%I2.3	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(4)	Bool	%I2.4	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(5)	Bool	%I2.5	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Safety_Door_SW2	Bool	%I2.6	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Tag_1(7)	Bool	%I2.7	ET200eco PN F-DI 8 / F-DQ 3	F-DI Process value bit
Motor	Bool	%Q2.0	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(9)	Bool	%Q2.1	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(10)	Bool	%Q2.2	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Process value bit
Tag_1(11)	Bool	%I3.0	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(12)	Bool	%I3.1	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Safety_Door_SW1_Value_Status	Bool	%I3.2	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(14)	Bool	%I3.3	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(15)	Bool	%I3.4	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(16)	Bool	%I3.5	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Safety_Door_SW2_Value_Status	Bool	%I3.6	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(18)	Bool	%I3.7	ET200eco PN F-DI 8 / F-DQ 3	F-DI Value status bit
Tag_1(19)	Bool	%I4.0	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit
Tag_1(20)	Bool	%I4.1	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit
Tag_1(21)	Bool	%I4.2	ET200eco PN F-DI 8 / F-DQ 3	F-DQ Value status bit

You can now continue with programming the safety program.

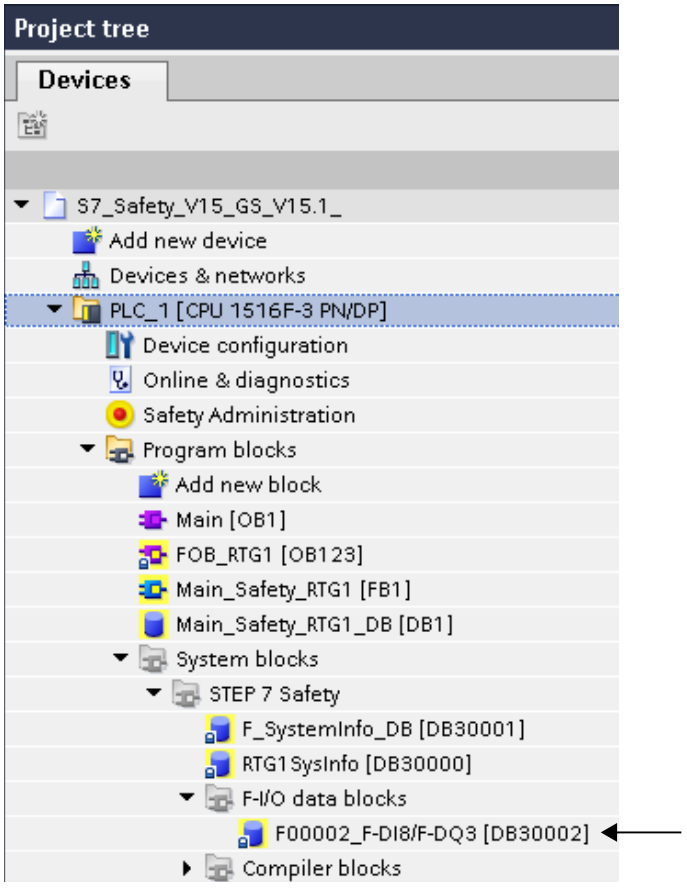
2.3 Programming

2.3.1 Introduction

In this example, a fail-safe function block (F-FB) will be programmed with a safety door function, an emergency stop function (safety circuit for switch-off in case of emergency stop, open safety door, or someone entering the protected area monitored by the laser scanner), a feedback circuit (as protection against reclosing in case of faulty load), a user acknowledgement for reintegration, and indirect switching of a motor using two contactors. The programmed F-FB will then be compiled to form a safety program and downloaded to the fail-safe CPU.

Fail-Safe module data blocks (F-IO DBs)

An F-IO DB is automatically generated when you add a fail-safe module to your configuration. The F-I/O DBs generated for the example I/O are located in the "Project tree" in the "Program blocks", "System blocks" folder:



The default name of the F-I/O DB is formed from the fixed prefix "F", the start input address of the fail-safe module, and the names entered in the properties for the fail-safe module in the hardware and network editor.

You can access the tags of the F-I/O DB with a fully qualified DB access (that is, by specifying the name of the F-I/O DB and the name of the tag).

Programming

You can program the safety program in LAD and FBD. In so doing, the instructions, data types, and operand areas you can use are subject to certain restrictions (see the "Programming" chapter, "Overview of programming" section of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en)).

The FBD programming language is used in this example.

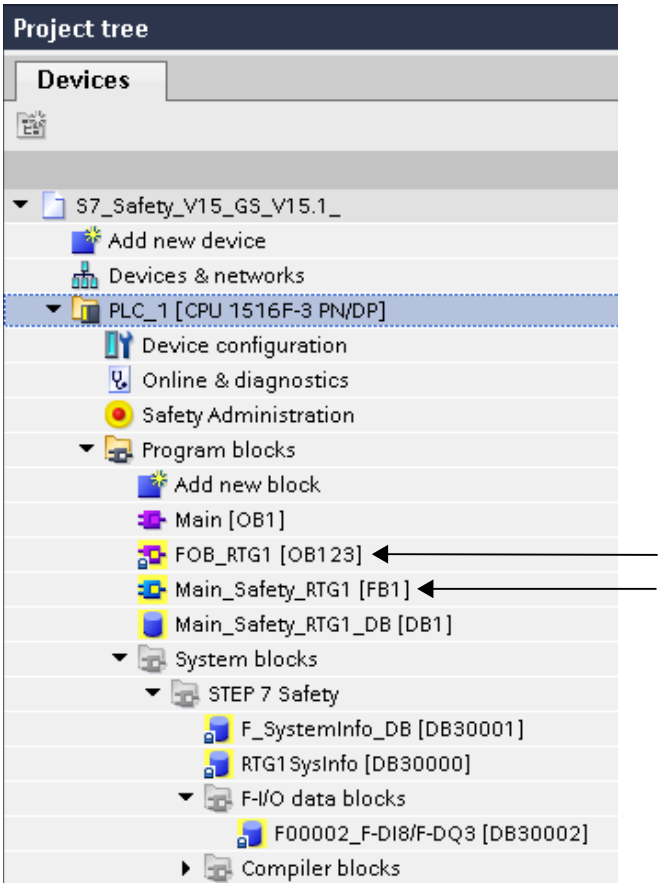
NOTE

Fail-safe signals are shown in yellow in the "LAD/FBD Editor".

NOTE
Note the rules for the program structure in the "Programming" chapter, "Defining F-runtime groups" section of the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

2.3.2 Step 10: Specifying the centralized settings for the safety program

When the fail-safe CPU is inserted, an F-runtime group and the associated main safety block are created by default and assigned to the CPU. An F-runtime group consists of an F-OB (cyclic interrupt OB) that calls a main safety block FB. Additional user-specific safety functions must then be called from this main safety block:



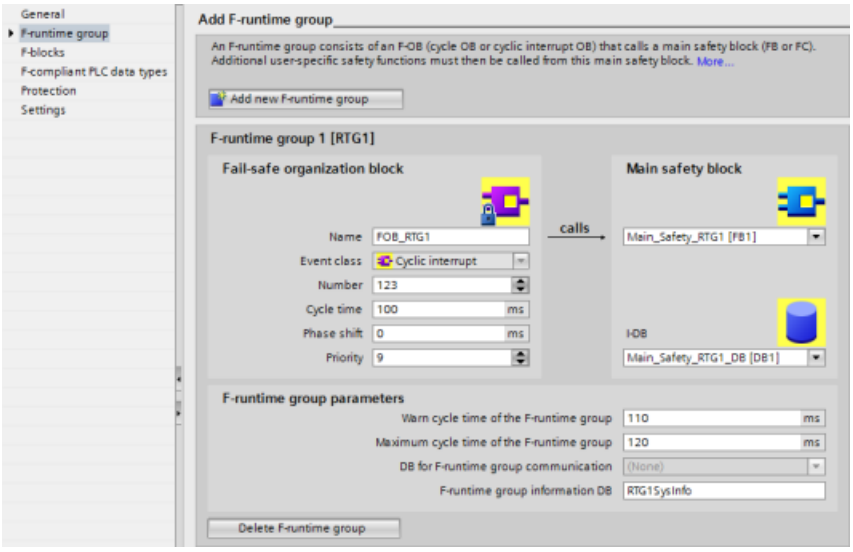
The first step in programming of the safety program is the main safety block. The program calls the main safety block (which is an F-FB (with instance DB)) from the "Fail-Safe Organization Block" (F-OB) (cyclic interrupt OB), assigned in each F-runtime group. By default, the F-OB has a higher priority than other standard OBs.

The program calls the F-blocks that you create from the main safety block. You can change the calling block and the called block at any time.

After the CPU executes the safety program, the standard user program will resume.

Opening the Safety Administration editor

1. In the "Project tree" of the fail-safe CPU, double-click on "Safety Administration".
   Result: The "Safety Administration" editor opens.
   You make central settings for the safety program in the Safety Administration editor.
2. In the area navigation of the Safety Administration editor, click "F-runtime group". The F-runtime group is created automatically when the fail-safe CPU is created and the associated main safety block is displayed:



The cyclic interrupt OB (FOB_RTG1 [OB123]) calls the main safety block (Main_Safety_RTG1 [FB1]) by default. The program calls the F-blocks that you create from the main safety block. You can change the calling block and the called block at any time.

Leave the preset blocks for this example.

For additional information on the Safety Administration editor, refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

Numbering ranges of fail-safe system blocks

When the safety program is compiled, F-blocks are automatically added in order to generate an executable safety program.

By default, the system automatically manages the numbering range, which is displayed in the Safety Administration editor under "Settings".

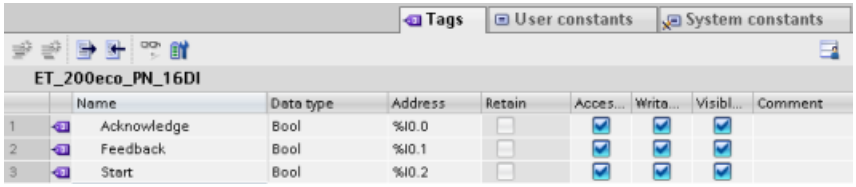
Keep the pre-assigned settings for this example.

Specifying inputs and outputs for the safety program

After configuring the hardware as described in Configuring (Page 30) in steps 1 to 6, the CPU creates the following standard module and fail-safe module symbolic names and DBs for programming the example:

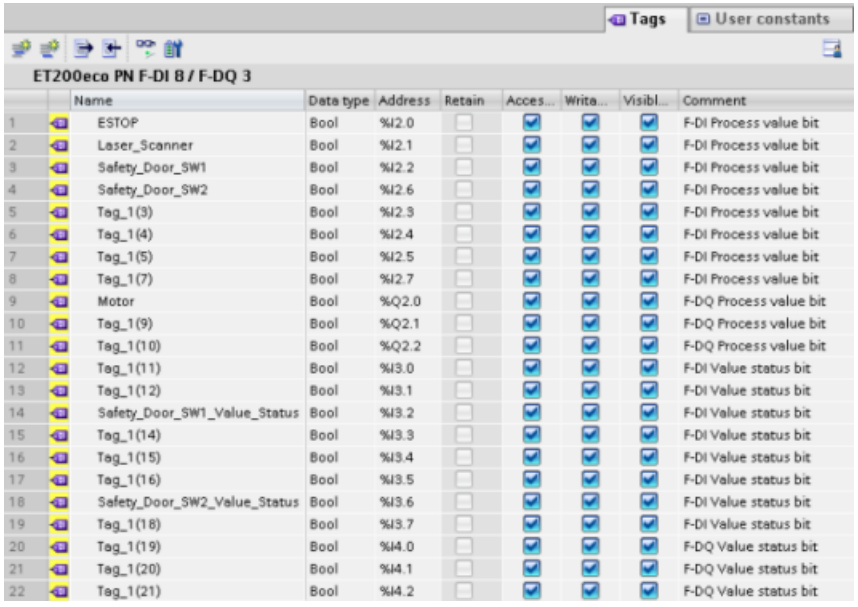
Configured hardware	Starting input/output address	Symbolic name
ET 200eco PN 16DI standard digital inputs	IB0	IO device_1 [ET 200eco PN 16DI]
ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	IB2	F00002_F-DI 8 / F-DQ 3[DB30002]
ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	QB2	F00002_F-DI 8 / F-DQ 3[DB30002]

Assign the following symbolic names for the standard inputs and outputs:



	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	Acknowledge	Bool	%I0.0		☑	☑	☑	
2	Feedback	Bool	%I0.1		☑	☑	☑	
3	Start	Bool	%I0.2		☑	☑	☑	

Assign the following symbolic names for the fail-safe inputs and outputs:

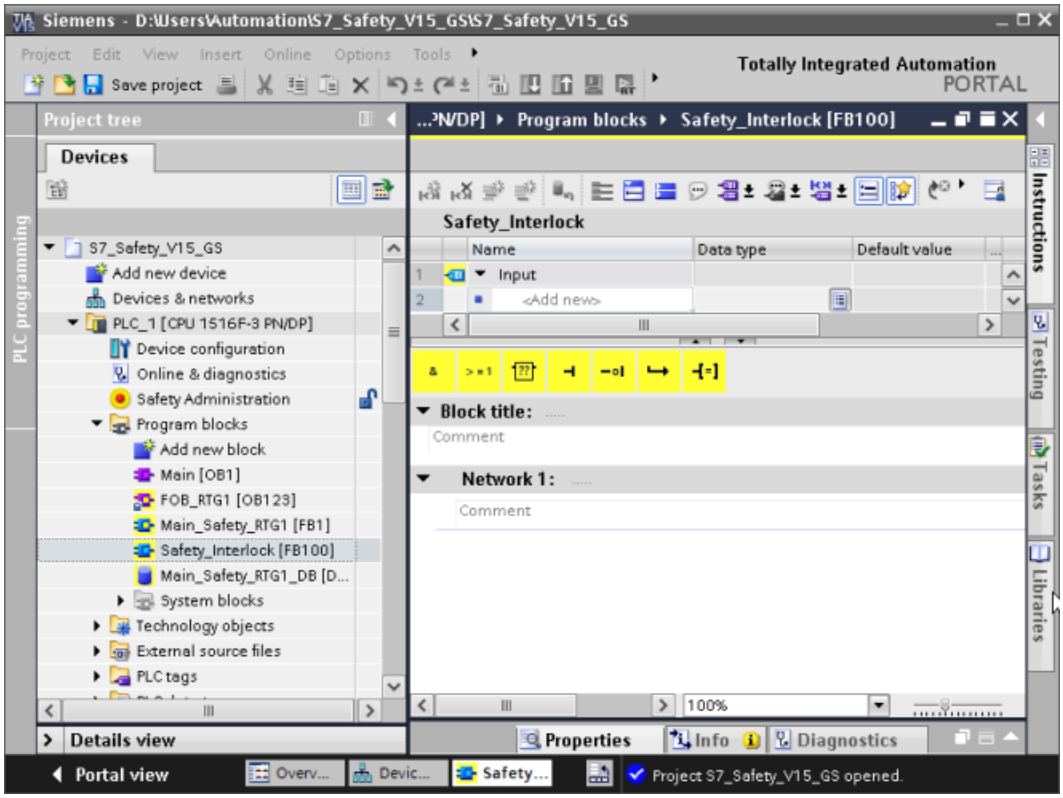


	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment
1	ESTOP	Bool	%I2.0		☑	☑	☑	F-DI Process value bit
2	Laser_Scanner	Bool	%I2.1		☑	☑	☑	F-DI Process value bit
3	Safety_Door_SW1	Bool	%I2.2		☑	☑	☑	F-DI Process value bit
4	Safety_Door_SW2	Bool	%I2.6		☑	☑	☑	F-DI Process value bit
5	Tag_1(3)	Bool	%I2.3		☑	☑	☑	F-DI Process value bit
6	Tag_1(4)	Bool	%I2.4		☑	☑	☑	F-DI Process value bit
7	Tag_1(5)	Bool	%I2.5		☑	☑	☑	F-DI Process value bit
8	Tag_1(7)	Bool	%I2.7		☑	☑	☑	F-DI Process value bit
9	Motor	Bool	%Q2.0		☑	☑	☑	F-DQ Process value bit
10	Tag_1(9)	Bool	%Q2.1		☑	☑	☑	F-DQ Process value bit
11	Tag_1(10)	Bool	%Q2.2		☑	☑	☑	F-DQ Process value bit
12	Tag_1(11)	Bool	%I3.0		☑	☑	☑	F-DI Value status bit
13	Tag_1(12)	Bool	%I3.1		☑	☑	☑	F-DI Value status bit
14	Safety_Door_SW1_Value_Status	Bool	%I3.2		☑	☑	☑	F-DI Value status bit
15	Tag_1(14)	Bool	%I3.3		☑	☑	☑	F-DI Value status bit
16	Tag_1(15)	Bool	%I3.4		☑	☑	☑	F-DI Value status bit
17	Tag_1(16)	Bool	%I3.5		☑	☑	☑	F-DI Value status bit
18	Safety_Door_SW2_Value_Status	Bool	%I3.6		☑	☑	☑	F-DI Value status bit
19	Tag_1(18)	Bool	%I3.7		☑	☑	☑	F-DI Value status bit
20	Tag_1(19)	Bool	%I4.0		☑	☑	☑	F-DQ Value status bit
21	Tag_1(20)	Bool	%I4.1		☑	☑	☑	F-DQ Value status bit
22	Tag_1(21)	Bool	%I4.2		☑	☑	☑	F-DQ Value status bit

2.3.3 Step 11: Creating an F-FB

In this step, you create the F-FB where you will program the safety functions for this example.

Procedure



1. Insert an F-FB. Go to the "Program blocks" folder of the fail-safe CPU and double-click "Add new block".

   The "Add new block" dialog opens.
2. Under "Name" enter "Safety_Interlock" for the name of the F-FB.
3. Click the "Function block" button on the left.
4. Select "FBD" as the language for the F-FB.
5. Under "Number" choose the "Manual" option, and enter 100.
6. Ensure that you select the "Create F-block" check box so that a fail-safe function block is created.
7. Close the dialog box with "OK"

Result

The F-FB "Safety_Interlock" is created in the "Program blocks" folder and opens automatically in the "FBD Editor".

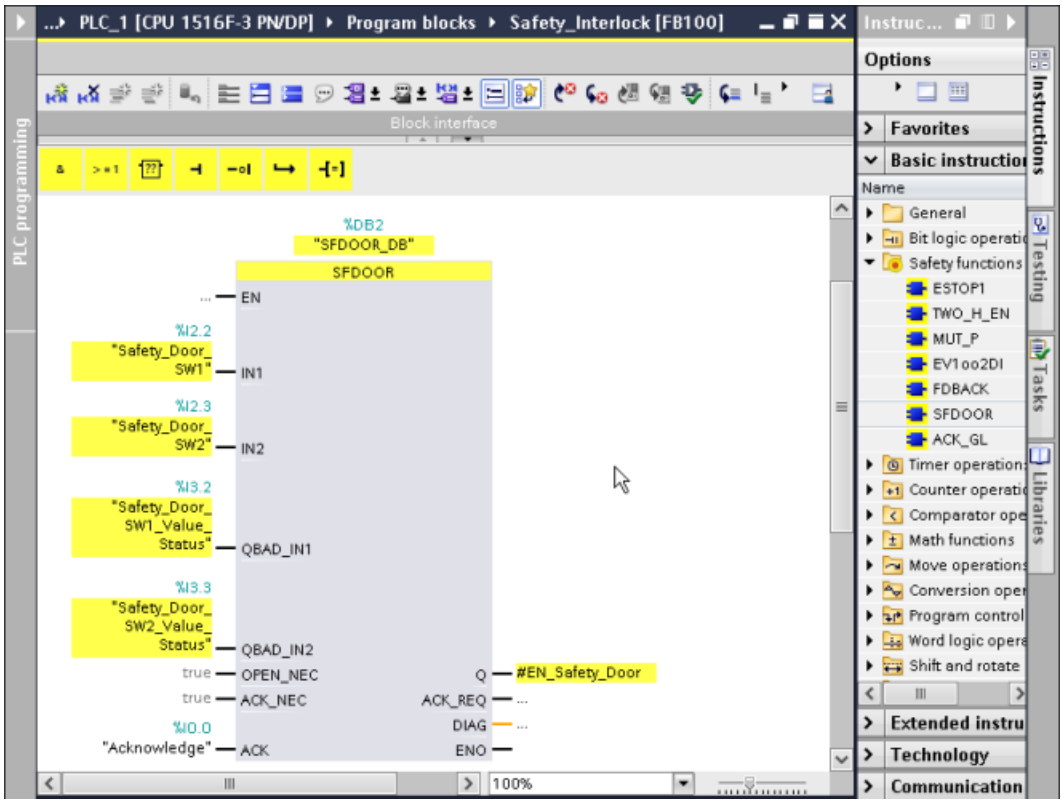
You can now continue with programming the safety functions in the next step.

2.3.4 Step 12: Programming the safety door function

In this step, you program the safety door function for this example.

The safety door secures the application's service area. Opening the safety door results in a stop or shutdown of the production cell similar to an emergency stop.

Procedure



1. In the interface of the "Safety_Interlock" F-FB, create a static tag of data type "Bool" named "EN_Safety_Door" (Enable safety door).
2. Insert the "SFDOOR" instruction from the "Safety functions" subfolder of the "Instructions" task card.
3. Click "OK" to confirm the "Call options" dialog.
4. Initialize the inputs and outputs with parameters as described in the table below.

Parameter assignment of the "SFDOOR" instruction

Inputs/outputs	Parameter	Data type	Description	Default
"Safety_Door_SW1" (I2.2)	IN1	Bool	Input 1	FALSE
"Safety_Door_SW2" (I2.6)	IN2	Bool	Input 2	FALSE

[1] The two inputs QBAD_IN1 and QBAD_IN2 must be interconnected. In this example, both safety door position switches are connected through the SFDOOR and ESTOP1 program logic with the QBAD signal of the F-I/O DB of the ET 200eco PN F-DI 8 / F-DQ 3 in the FDBACK program logic.

Inputs/outputs	Parameter	Data type	Description	Default
"Safety_Door_SW1_Value_Status" (I3.2)	QBAD_IN1	Bool	Value status bit signal for input IN1 [1]	TRUE
"Safety_Door_SW1_Value_Status" (I3.6)	QBAD_IN2	Bool	Value status bit signal for input IN2 [1]	TRUE
TRUE	OPEN_NEC	Bool	TRUE = Opening required on startup	TRUE
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (Pushbutton)	FALSE
#EN_Safety_Door	Q	Bool	Output (Enable safety door)	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

[1] The two inputs QBAD_IN1 and QBAD_IN2 must be interconnected. In this example, both safety door position switches are connected through the SFDOOR and ESTOP1 program logic with the QBAD signal of the F-I/O DB of the ET 200eco PN F-DI 8 / F-DQ 3 in the FDBACK program logic.

Result

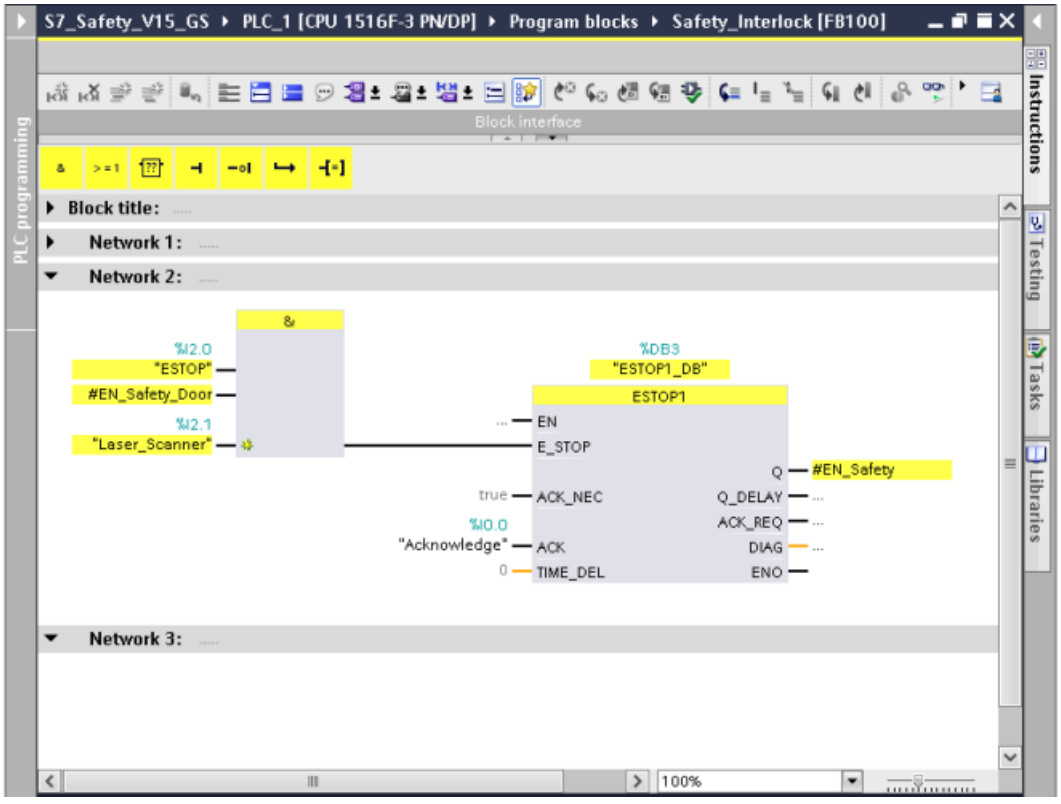
You have completed the programming of the safety door function.

2.3.5 Step 13: Programming the emergency stop function

In this step, you program the emergency stop function for this example.

Used for emergencies only, the emergency stop button is a safety measure to immediately shut down all machine functions. An emergency stop button must be highly visible in color and shape and must be easy to operate in emergency situations. In this example, the emergency stop is a manual push button attached next to the safety door entrance to the service area enclosure. The emergency stop function provides shutdown in the case of an emergency stop, an open safety door, or someone entering the protected area monitored by the laser scanner.

Procedure



1. In the interface of the "Safety_Interlock" F-FB, create a static tag of data type "Bool" named "EN_Safety" (Enable safety circuit).

NOTE

If the emergency stop is off, the safety door is closed, and nothing triggers the protected area laser scanner, the inputs from the emergency stop, safety door, and the laser scanner are all true. All three inputs must be true, before the ESTOP1 instruction can power "EN_Safety". When "EN_Safety" is true, then you know that your operation is back to normal and that you can startup safely.

2. Insert a new network.
3. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card.
4. Insert a third input to the "AND logic operation" instruction and initialize the inputs of the instruction with parameters as described in the table below.
5. Insert the "ESTOP1" instruction from the "Safety functions" subfolder of the "Instructions" task card.
6. Click "OK" to confirm the "Call options" dialog.
7. Initialize the inputs and outputs of the instruction with parameters as described in the tables below.
8. Connect the output of the "AND logic operation" instruction to the "ESTOP" input of the "ESTOP1" instruction.

Parameter assignment of the "AND logic operation" instruction

Inputs	Parameter	Data type	Description	Default
"ESTOP" (I2.0)	Input 1	Bool	Emergency STOP	FALSE
#EN_Safety_Door	Input 2	Bool	Enable safety door	FALSE
"Laser_scanner" (I2.1)	Input 3	Bool	Laser scanner	FALSE

Parameter assignment of the "ESTOP1" instruction

Inputs/outputs	Parameter	Data type	Description	Default
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (using a pushbutton)	FALSE
T#0MS	TIME_DEL	Time	Time delay	T#0MS
#EN_Safety	Q	Bool	Enable safety circuit	FALSE
—	Q_DELAY	Bool	Enable is OFF delayed	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

Result

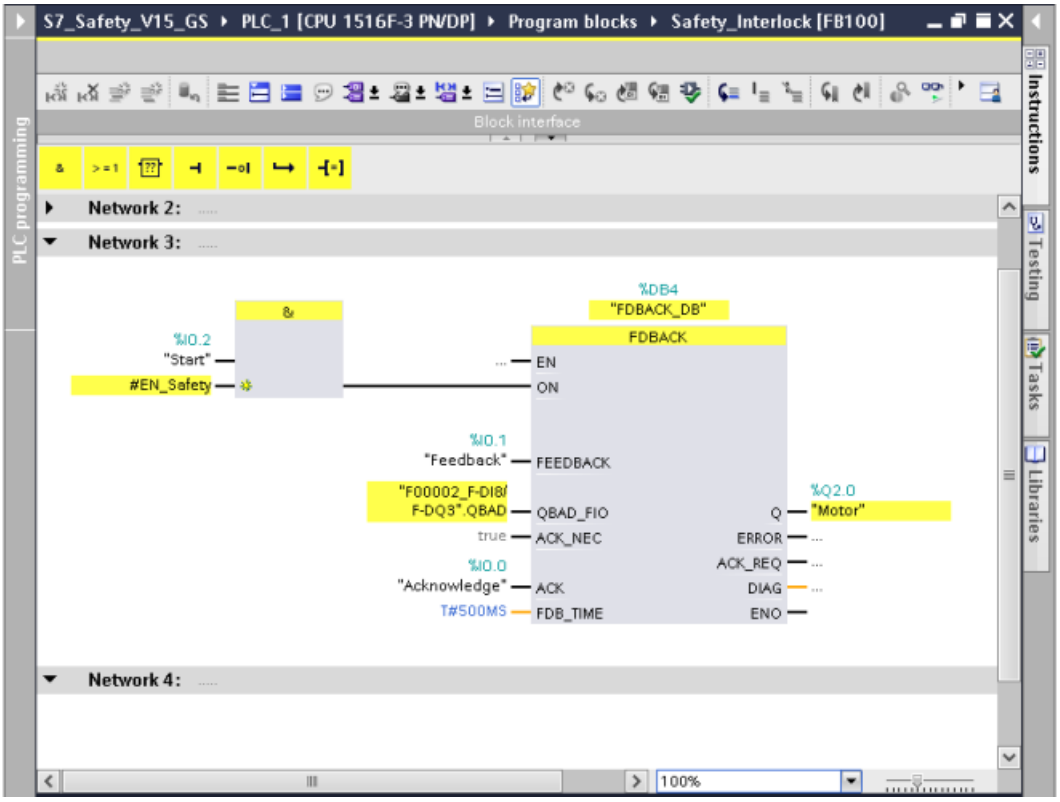
You have completed the programming of the emergency stop function.

2.3.6 Step 14: Programming the feedback monitoring

In this step, you program the feedback circuit monitoring for this example.

The feedback circuit provides protection against restarting normal operations while unsafe conditions still exist. The system can only be restarted when the emergency stop is cancelled, the safety door is closed, and the laser scanner detects no one in the protected area.

Procedure



1. Insert a new network.
2. Insert the "AND logic operation" instruction from the "Bit logic operations" subfolder of the "Instructions" task card.
3. Initialize the inputs of the instruction with parameters as described in the table below
4. Insert the "FDBACK" instruction from the "Safety functions" subfolder of the "Instructions" task card.
5. Click "OK" to confirm the "Call options" dialog.
6. Initialize the inputs and outputs of the instruction with parameters as described in the tables below.
7. Connect the output of the "AND logic operation" instruction to the "ON" input of the "FDBACK" instruction.

Parameter assignment of the "AND logic operation" instruction

Inputs	Parameter	Data type	Description	Default
"Start" (I0.2)	Input 1	Bool	TRUE = Switch on output	FALSE
#EN_Safety	Input 2	Bool	Enable safety circuit	FALSE

Parameter assignment of the "FDBACK" instruction

Inputs/outputs	Parameter	Data type	Description	Default
"Feedback" (I0.1)	FEEDBACK	Bool	Readback input	TRUE (No error detected)
"F00002_4/8F-DI3F-DQ". QBAD	QBAD_FIO	Bool	QBAD signal from the fail-safe signal module DB of output Q [1]	FALSE (No error detected)
TRUE	ACK_NEC	Bool	TRUE = Acknowledgment required	TRUE
"Acknowledge" (I0.0)	ACK	Bool	User acknowledgement (via pushbutton)	FALSE
T#500MS	FDB_TIME	Time	Readback time	T#0MS
"Motor" (Q2.0)	Q	Bool	Output	FALSE
—	ERROR	Bool	Readback error	FALSE
—	ACK_REQ	Bool	Acknowledgement prompt	FALSE
—	DIAG	Byte	Service information	B#16#0

[1] In this example, this is the QBAD signal from the F-I/O DB of the ET 200eco PN F-DI 8 / F-DQ 3.

Result

You have completed the programming of the feedback monitoring.

2.3.7 Step 15: Programming the user acknowledgment for reintegration of the fail-safe module

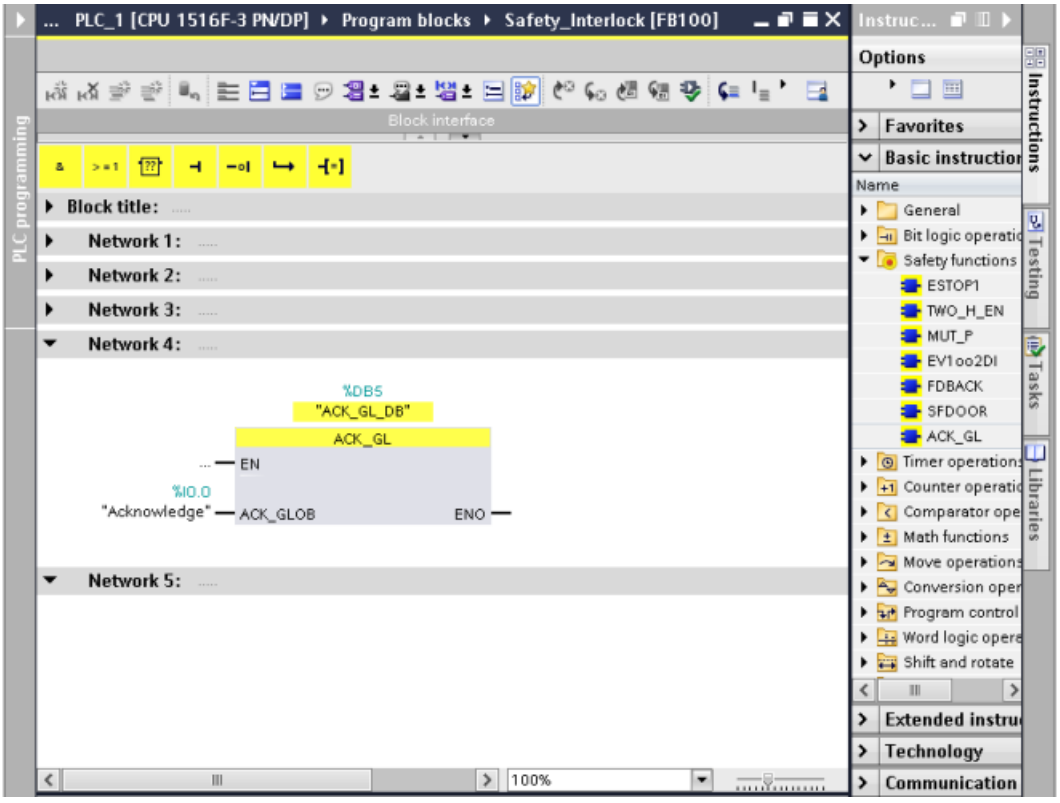
In this step, you program the user acknowledgement for reintegration of the fail-safe module I/O for this example.

The user must acknowledge that conditions have returned to a safe state before production operations can be restarted.

Procedure

In your safety program, you must provide a user acknowledgment for the reintegration of the fail-safe module I/O. In order to acknowledge in the event of passivated F-I/O, the acknowledgement pushbutton is evaluated using a standard input. In this example, this is the "Acknowledge" input.

You can use the ACK_GL instruction to reintegrate all F-I/O of an F-runtime group.



1. Insert a new network.
2. Insert the "ACK_GL" instruction from the "Safety functions" subfolder of the "Instructions" task card.
3. Click "OK" to confirm the "Call options" dialog.
4. Initialize the input with parameters as described in the table below.

Parameter assignment of the "ACK_GL" instruction

Input	Parameter	Data type	Description	Default
"Acknowledge" (I0.0)	ACK_GLOB	Bool	Acknowledgement for reintegration	FALSE

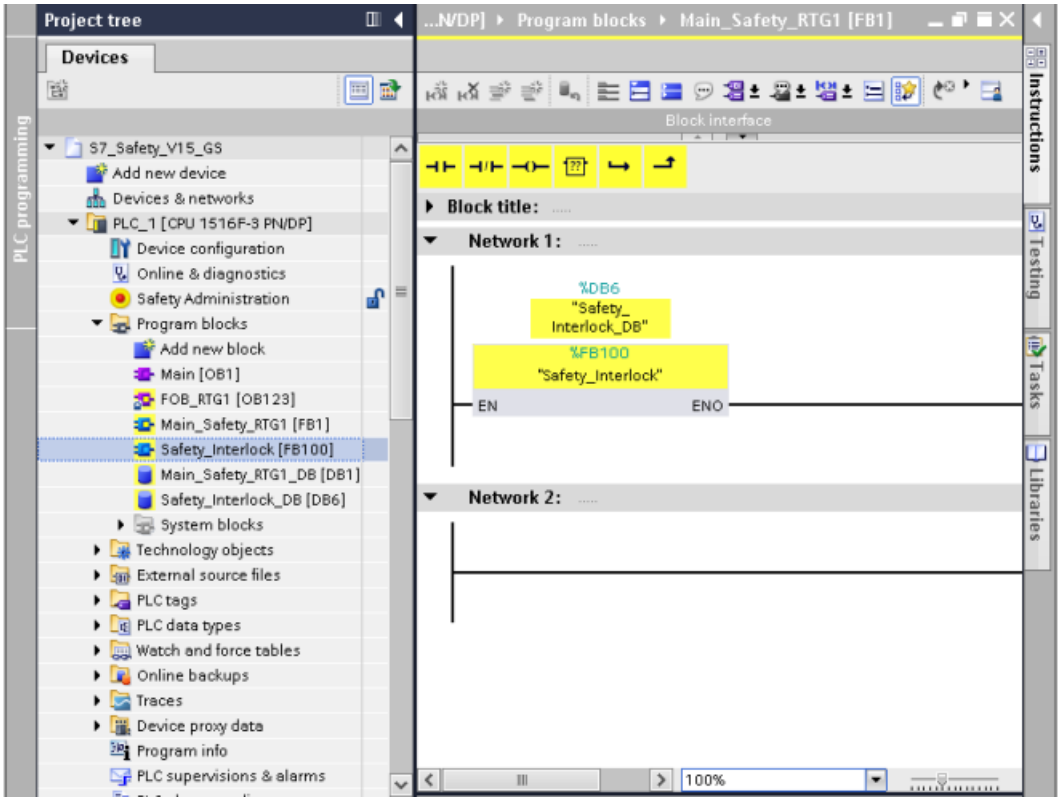
Result

You have completed the programming of the user acknowledgment.

2.3.8 Step 16: Programming of the main safety block

In this step, you program the main safety block for this example.

Procedure



1. Double-click in the project navigation to open the main safety block "Main_Safety".
2. Use drag-and-drop to insert the F-FB "Safety_Interlock" in Network 1 of the main safety block.
3. Click "OK" to confirm the "Call options" dialog.

Result

The main safety block cyclically calls the F-FB "Safety_Interlock".

You have now programmed the functionality according to the task definition of the example. You can proceed with the next steps to compile the safety program and download the safety program, along with the hardware configuration, to the fail-safe CPU.

NOTE

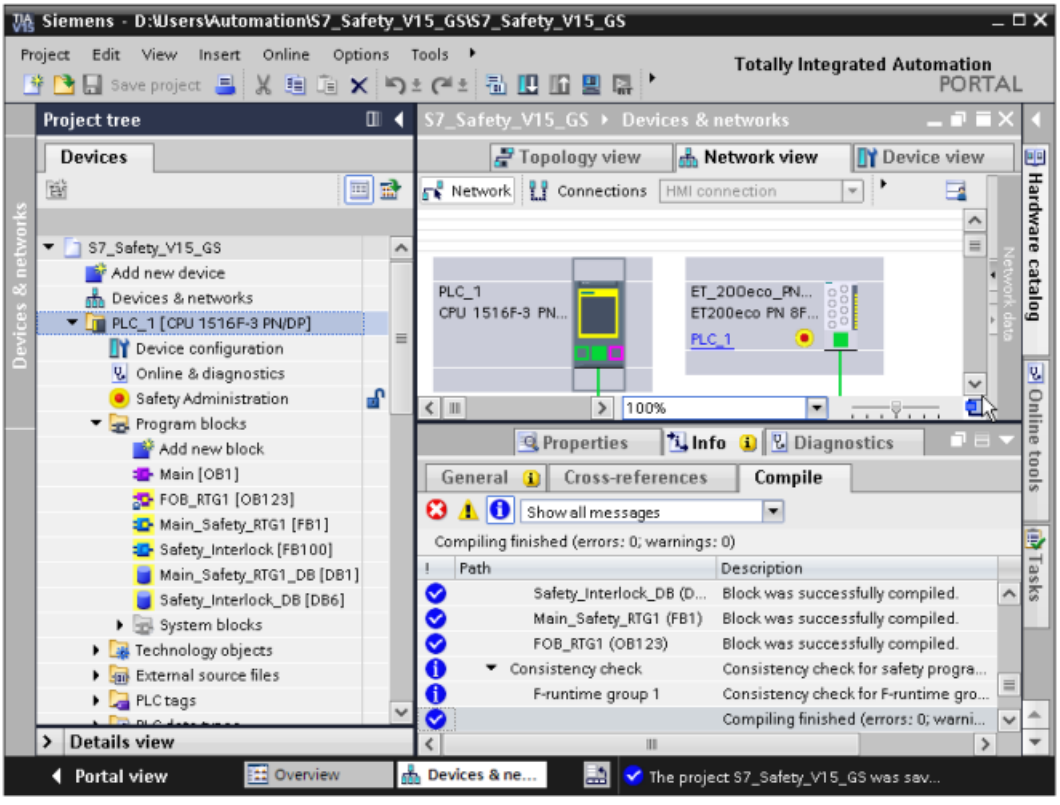
For simpler safety programs, you can locate the entire safety program code directly within the main safety block rather than in FBs or FCs called from the main safety block.

2.3.9 Step 17: Compiling the safety program

In this step, you compile the safety program and the hardware configuration.

A consistency check is performed on the execution-relevant F-blocks when the safety program is compiled, that is, the safety program is checked for errors. Any error messages are output in an error window. After a successful consistency check, the additionally required F-blocks are generated automatically and added to the F-runtime group in order to generate an executable safety program.

Procedure



1. Select the fail-safe CPU in the project tree.
2. In the shortcut menu for the fail-safe CPU, select "Compile", then select "Hardware and software (only changes)".
   The CPU compiles the safety program.

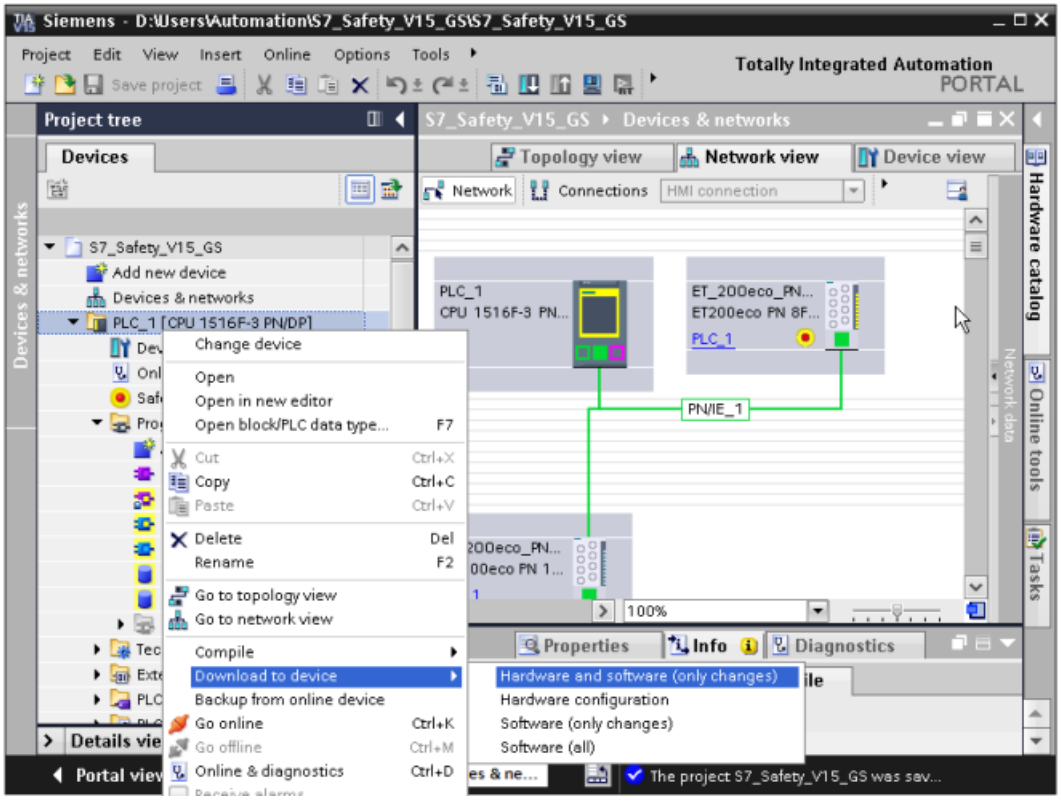
Result

If compilation is successful, the result is always a consistent and executable safety program comprising all F-blocks with F-attributes. STEP 7 notifies you of this with the message "Safety program is consistent".

2.3.10 Step 18: Downloading the complete safety program to the fail-safe CPU and activating safety mode

In this step, you download the hardware configuration and the safety program to the fail-safe CPU.

Procedure



1. In the "Project tree", select the fail-safe CPU.
2. In the shortcut menu for the fail-safe CPU, select "Download to device", then select "Hardware and software (only changes)". If an online connection to the fail-safe CPU does not yet exist, you will be prompted to establish this connection.

3. Select "Consistent download" in the "Action" column in each case.

NOTE
To download the entire safety program, the fail-safe CPU must be in STOP mode.

4. Click the "Load" button.
   Result: The "Load results" dialog is displayed.
5. Click the "Finish" button.
6. In the "Project tree", double-click "Safety Administration".
7. In the "Safety Administration" editor, check to see if the F-collective signatures of all F-blocks with F-attributes match online and offline to confirm whether your offline safety program blocks match what is in your connected CPU. You must be online in order to perform the signature comparison.
8. To activate safety mode, switch the fail-safe CPU from STOP to RUN mode.
   The Safety Administration editor displays the current safety mode status in the "General" area under "Safety Mode Status".

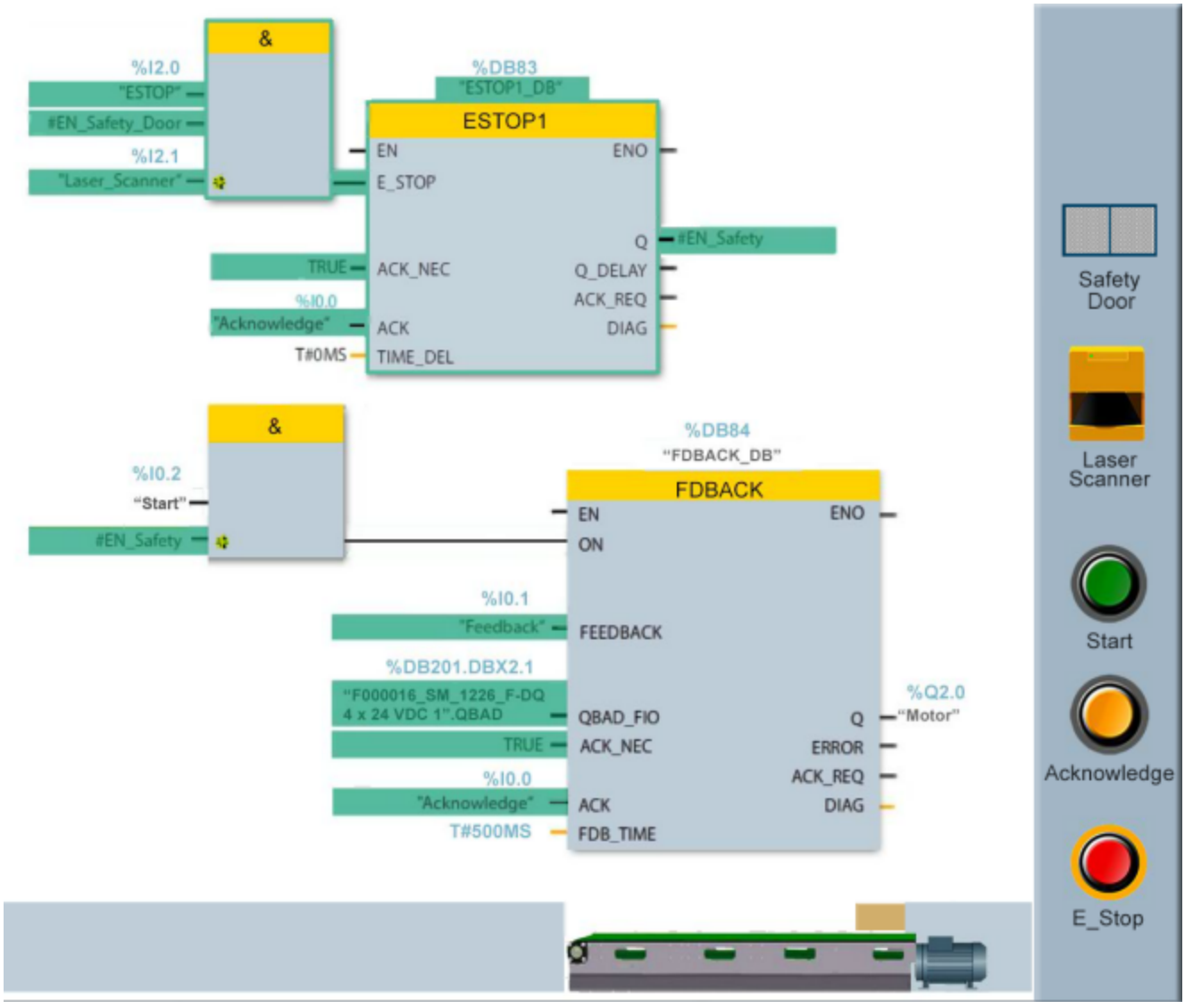
NOTE
Once a safety program has been created, you must perform a full function test according to your automation task (see SIMATIC Safety Configuring and Programming Manual (http://support.automation.siemens.com/WW/view/en/54110126/0/en)).

Result of programming

You have now finished creating the safety program according to the task definition of the example.

The example below switches the Laser Scanner, E-Stop, and Safety Door on and off to simulate unsafe conditions. Each device operates independently of the other two devices. If you do activate a device, you must deactivate the device before continuing.

You must press the "Acknowledge" button to notify the system that you have returned to a safe state. Then, you can press the "Start" button to operate the system again.



The table below describes the steps and their actions:

Step	Action	Description
1	Activate the E-Stop. [1, 2]	This action prevents resumption of the operation.
2	Deactivate the E-Stop. [3]	The E-Stop deactivates.
3	Press the Acknowledge button.	The safety program requires manual acknowledgement.
4	Press the Start button.	The motor restarts.
5	Trigger the Laser Scanner. [1, 2]	This action prevents resumption of the operation.

1 You can activate the E-STOP, trigger the Laser Scanner, or open the Safety Door individually or in any order to stop operations and bring the system to a safe state.

2 To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device, 2. Press the Acknowledge button, and 3. Press the Start button.

3 This action allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart the motor.

Step	Action	Description
6	Deactivate the Laser Scanner. [3]	The Laser Scanner deactivates.
7	Press the Acknowledge button.	The safety program requires manual acknowledgement.
8	Press the Start button.	The motor restarts.
9	Open the Safety Door. [1, 2]	This action prevents resumption of the operation.
10	Close the Safety Door. [3]	The Safety Door closes.
11	Press the Acknowledge button.	The safety program requires manual acknowledgement.
12	Press the Start button.	The motor restarts.

1 You can activate the E-STOP, trigger the Laser Scanner, or open the Safety Door individually or in any order to stop operations and bring the system to a safe state.

2 To continue operations, you must do the following steps in this order: 1. Deactivate the fail-safe device, 2. Press the Acknowledge button, and 3. Press the Start button.

3 This action allows reintegration from safe state values to process data and, if required, acknowledgement by your safety program. You can now restart the motor.

Applications

3

This chapter presents typical application examples for connection of functional safety input and output channels, with a statement of the safety performance (SIL/Category/PL) that is possible for each example.

The PLC system has an extremely low failure rate and therefore contributes only a small part of the total probability of dangerous failure of an automated system. The probability of dangerous failures of the sensors and actuators is typically far larger than the probability of dangerous failure per hour (PFH)/probability of dangerous failure on demand (PFD) of the PLC system. Estimates for quantitative safety properties like PDF and PFH are calculated using the following methods:

- Standard data tables
- Calculation methods according to international standards which include the following standards:
  - IEC 61508
  - ISO 13849
  - IEC 61131-6

  The values are based on the following assumptions:
  - Continuous full nominal load
  - Nominal voltage
  - Equipment ambient temperature of 60 °C

Faults in the wiring system can also be a substantial contributor to failures.

To achieve a targeted level of safety performance for each safety function, perform these actions:

- Choose an appropriate architecture
- Choose sensors and actuators that are appropriately rated
- Provide a safety program that meets the requirements of the safety function
- Provide diagnostics and proof-tests to maintain the ratings of the sensors and actuators
- Use wiring installation practices, diagnostics, and proof-tests to assure wiring integrity
- Generate and control operating and maintenance procedures for the lifetime of the installation

The S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), ET 200S/ET 200SP, ET 200eco PN, and ET 200M/ET 200MP Fail-Safe systems provide a high level of internal diagnostic coverage. Diagnostic coverage of your external circuits, sensors, and actuators depends on your design choices using features of the PLC system and other measures.

The PFH/PFD of each fail-safe PLC component is stated assuming no field proof-test within the lifetime of the product. Sensors and actuators typically require regular proof-tests to maintain an expected level of safety performance.

The reaction time of each safety function depends on the reaction time of each component, including the sensor, the PLC system, and the actuator. "Fail-Safe response times" (Page 190) gives further information on delay times through the PLC components. You must choose PLC parameters and external component reaction times to achieve a total safety reaction time goal.

In addition to the total delay from the safety demand input to the safe actuator response, you must consider these additional time-related factors. Refer to "Fail-Safe response times" (Page 190) for exact information:

- To be assured of a safety response, a safety demand signal from the input sensor must last long enough to be seen by the safety program. Your configured filter time, discrepancy resolution time, and short circuit test duration all contribute to this time.
- The ET 200eco PN F-DI 8 / F-DQ 3 digital outputs regularly test each P- and M-switch to verify that each switch is still functional and under independent control. The OFF test pulse duration can be as long as your configured "Maximum readback time". The ON test pulse duration can be as long as your configured "Maximum readback time switch on test". For a given output, the ON test pulse is only provided to one of the P or M switches at a time, but in the presence of single fault this could apply energy to your load. Your actuator should not respond to an OFF signal up to the "Maximum readback time" duration, or to an ON signal up to the "Maximum readback time switch on test" duration.
- The ET 200eco PN F-DI 8 / F-DQ 3 digital outputs expect to complete and confirm any commanded transition from the ON to OFF output state. After your program changes the process output value from "1" to "0", do not change the "0" back to a "1" until the program completes the fail-safe digital outputs' readback time. The affected output passivates on commanded "0" states that are too short to confirm.

⚠ WARNING

The safety performance of your installation depends on your design and continued maintenance of each complete safety function.
The ET 200pro, ET 200SP and S7-1200/1500 Fail-Safe CPUs and F-DI 4/F-DQ 2 Fail-Safe module provide components for logic processing with a certified level of safety integrity when used in accordance with ratings, specifications, and instructions. Failure to comply with these guidelines could cause damage or unpredictable operation which could result in death or severe personal injury and/or property damage. You must choose all components of your installation and complete your design according to accepted safety standards and practices to achieve your required level of safety.

3.1 Digital input applications

3.1.1 Overview

You should consider the application modes presented here along with the features of the ET 200eco PN F-DI 8 / F-DQ 3 as described in the overview. Refer to "Fail-Safe digital inputs" (Page 23).

The main features of the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs include the following items:

- Inputs are 24 V DC rated inputs that meet the requirements of IEC 61131-2 as Type 1 inputs.
- Configure each channel as a 1oo1 or part of a 1oo2 evaluation pair. The corresponding channels (x.0, x.4), (x.1, x.5), (x.2, x.6), and (x.3, x.7) form a 1oo2 channel group. The lower numbered channel of the group is called the primary input and the other channel is called the secondary input. Within this restriction, you can assign 1oo1 or 1oo2 in any order.

- Short-circuit testing requires use of the internal sensor supply. For all evaluation and sensor interconnections except for 1oo2, 2 channel - 3 wire nonequivalent, use Vs1 with inputs x.0 to x.3 and Vs2 with inputs x.4 to x.7. For evaluation and sensor interconnection for 1oo2, 2 channel - 3 wire nonequivalent, use Vs1 with inputs x.0 to x.7, and do not use Vs2.
- If you enable the short-circuit test, you configure both Vs1 and Vs2 with the same parameters. All channels that you configure for internal sensor supply are subject to the same short-circuit test. You configure a test duration (length of dark time) and test interval (time between the start of the dark tests).
- The module performs these short-circuit functions for F-DI channels:
  - Monitors the sensor supply to detect short-circuit or overload
  - Cycles the sensor supply once on each power up to assure control and readback are working. This ensures operational integrity of the sensor supply at power up even when disabled.
  - Monitors the readback during input short-circuit tests
- Configure a discrepancy time to identify unacceptable differences between 1oo2 inputs.
- Configure a filter time for each 1oo1 channel or each 1oo2 channel pair.

You can achieve Category 3 in 1oo1 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- Each F-DI input includes sufficient diagnostics and redundant components such that no single internal fault can cause a dangerous failure.
- An appropriately-rated, single sensor can reach Category 3 by internal fault tolerance.
- The external wiring of a single sensor to a single input is vulnerable to single fault dangerous failures unless you apply additional measures.

You can achieve Category 4 in 1oo2 configurations if you diagnose external wiring faults or exclude them according to standards by proper routing, protection, and proof-testing of conductors:

- With 1oo2 evaluation, a pair of F-DI inputs is not subject to dangerous internal failure within a reasonable number of accumulated internal faults.
- Appropriately-rated, external-paired sensors or equivalent redundancy can achieve Category 4.
- The duplicated external wiring of two sensors to two input points is vulnerable to accumulated fault dangerous failure unless you apply additional measures.

The fail-safe digital inputs are certified for SIL 3/PL e only when you select 1oo2 evaluation.

3.1.2 Selecting the digital input application

Input architectures for achieving Safety Integrity Level (SIL)/Category/Performance Level (PL)

Table 1-1149 Safety Integrity Level (SIL)/Category/Performance Level (PL) requirements

Application	Sensor supply *	Sensor evaluation	Channel connection	Type of sensor connection	Achievable SIL/Category/PL	
					Without short-circuit detection	With short-circuit detection
1	Internal or External	1oo1 evaluation	Single input	1 channel	2/3/d	
3	Internal	1oo2 evaluation	Two inputs	2 channel equivalent	3/3/e	3/4/e
2	External				3/3/e	
5	Internal			2 channel - 3 wire nonequivalent	3/3/e	3/4/e
6	External				3/3/e	
7	Internal			2 channel - 4 wire nonequivalent	3/3/e	3/4/e
8	External				3/3/e	

* The ET 200eco PN F-DI 8 / F-DQ 3 uses M12 connections and is intended for use outside a cabinet in IP67 applications (everything sealed). If you require the use of an external supply, cut the M12 cable and make the connection inside a sealed cabinet or inside a sealed sensor. For external supplies, do not connect the pin 1 wire (Vs1) or the pin 5 wire (Vs2) in the M12 cable. This action prevents the Vs (which may be ON due to a different channel being configured as internal) from being shorted to the external 24 V DC. In addition, make the external 24 V DC connection inside a sealed cabinet or inside a sealed sensor.

Refer to "Pin assignment of connectors" (Page 117) for further information on connector pin assignments.

3.1.3 F-DI Applications 1 and 2: 1oo1 evaluation of single-channel sensors

F-DI application mode 1

This application mode uses two single-channel sensors with a 1oo1 evaluation for each sensor, as shown in the following illustrations. When you use an internal sensor supply, you can successfully perform short-circuit detection.

NOTE

To incorporate F-DI Application Mode 1 into a SIL 2-rated application, the sensor must be an appropriately qualified device.



Figure 1-852 F-DI Application Mode 1: Internal sensor supply (1oo1 evaluation of a single-channel sensor shown)

This application mode uses two single-channel sensors with a 1oo1 evaluation for each senseor. When you use an internal sensor supply, you can successfully perform short-circuit detection. Use Y cable (6ES7194-6KB00-0XA0) for F-DI application mode 1 to connect two single-channel sensors in 1oo1 evaluation as follows:

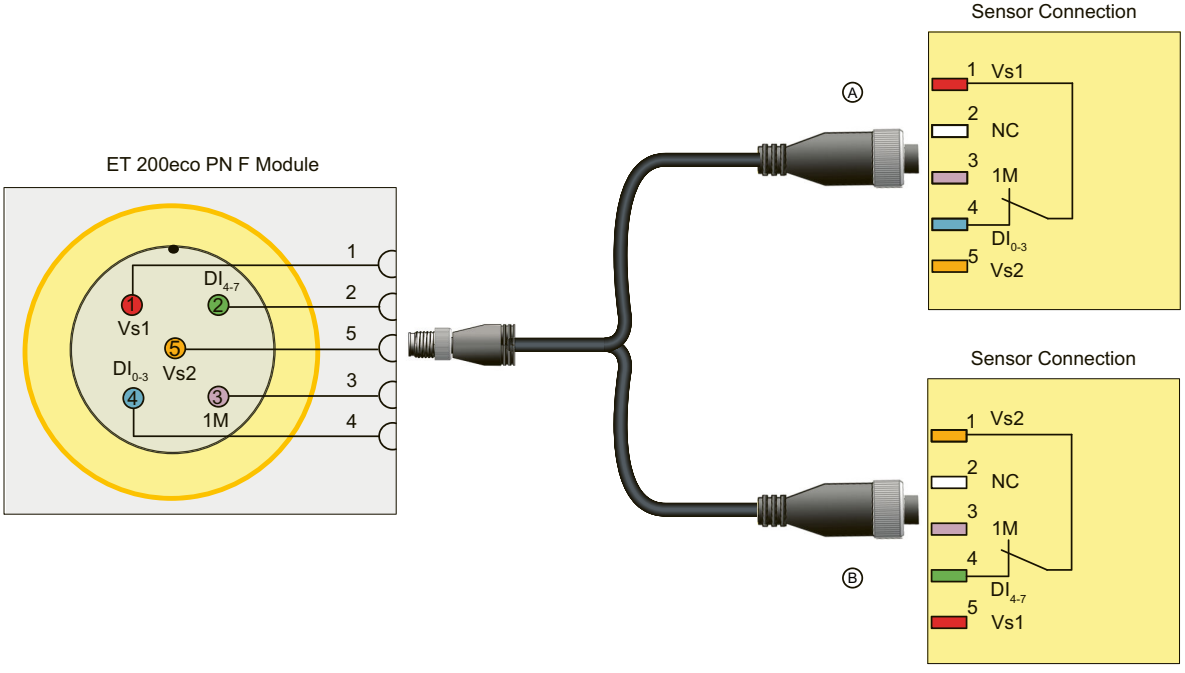


Figure 1-853 F-DI Application Mode 1: Internal sensor supply (1oo1 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 2

This application mode uses single-channel sensors with a 1oo1 evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

NOTICE
To incorporate F-DI Application Mode 2 into a SIL 2-rated application, the sensor must be an appropriately qualified device.

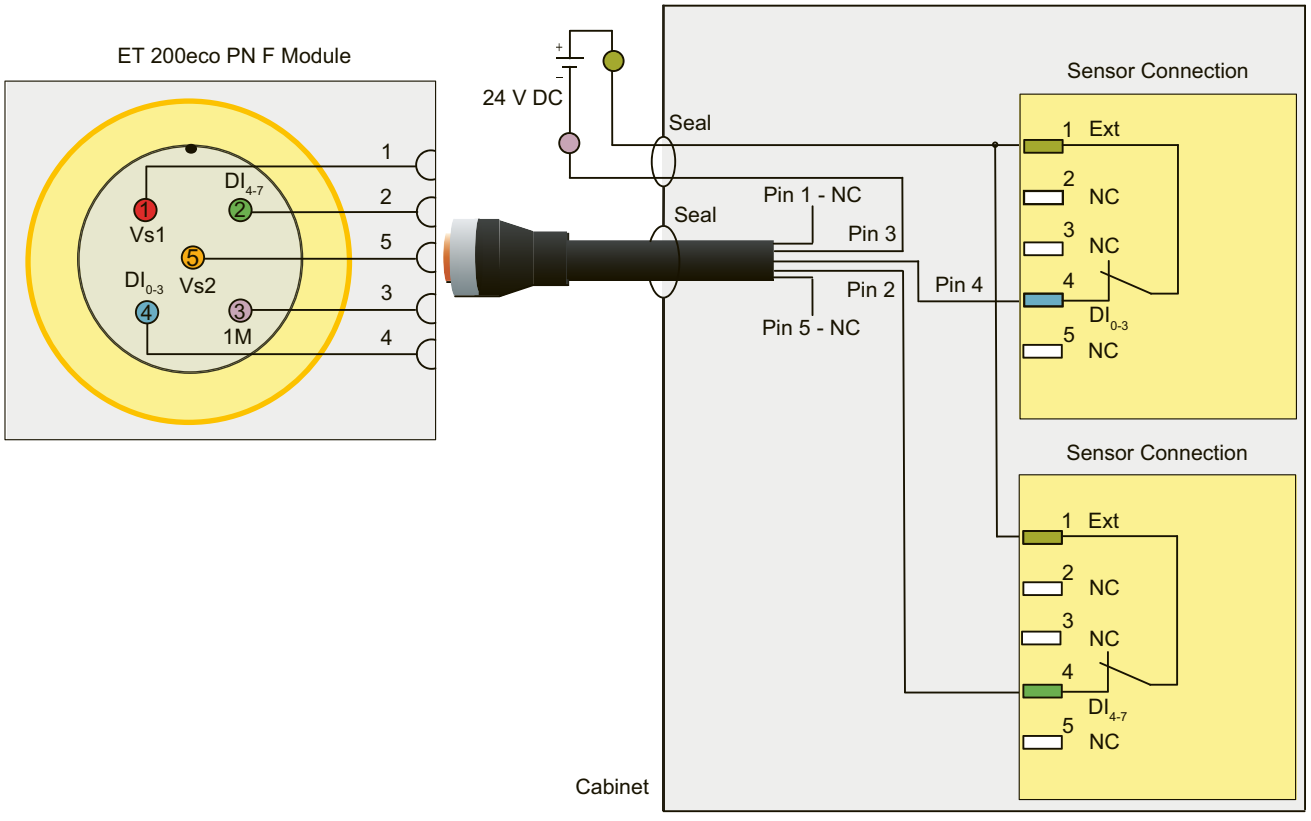


Figure 1-854 F-DI Application Mode 2: External sensor supply (1oo1 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo1 evaluation
Sensor supply	External

See also

SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable (6ES7194-6KB00-0XA0) (Page 115)

3.1.4 F-DI Applications 3 and 4: 1oo2 evaluation of equivalent sensors

F-DI application mode 3

This application mode uses a two-channel sensor in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection.

NOTE

To incorporate F-DI Application Mode 3 into a SIL 3-rated application, the sensor must be an appropriately qualified device.



Figure 1-855 F-DI Application Mode 3: Internal sensor supply (1oo2 evaluation of two-channel sensor shown)

Use Y cable (6ES7194-6KB00-0XA0) for F-DI Application Mode 3 as follows:

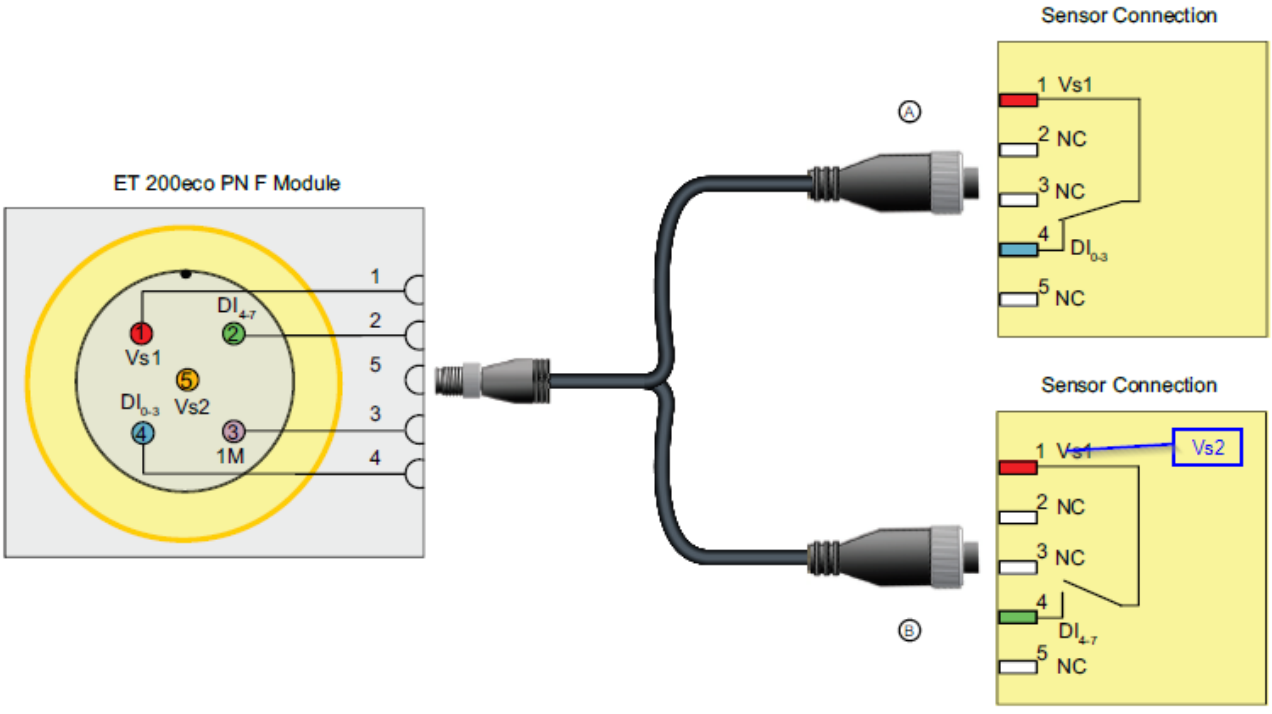


Figure 1-856 F-DI Application Mode 3: Internal sensor supply (1oo2 evaluation of two single-channel sensors shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel equivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 4

This application mode uses a two-channel sensor or two single-channel sensors in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing.

NOTE

To incorporate F-DI Application Mode 4 into a SIL 3-rated application, the sensor must be an appropriately qualified device.

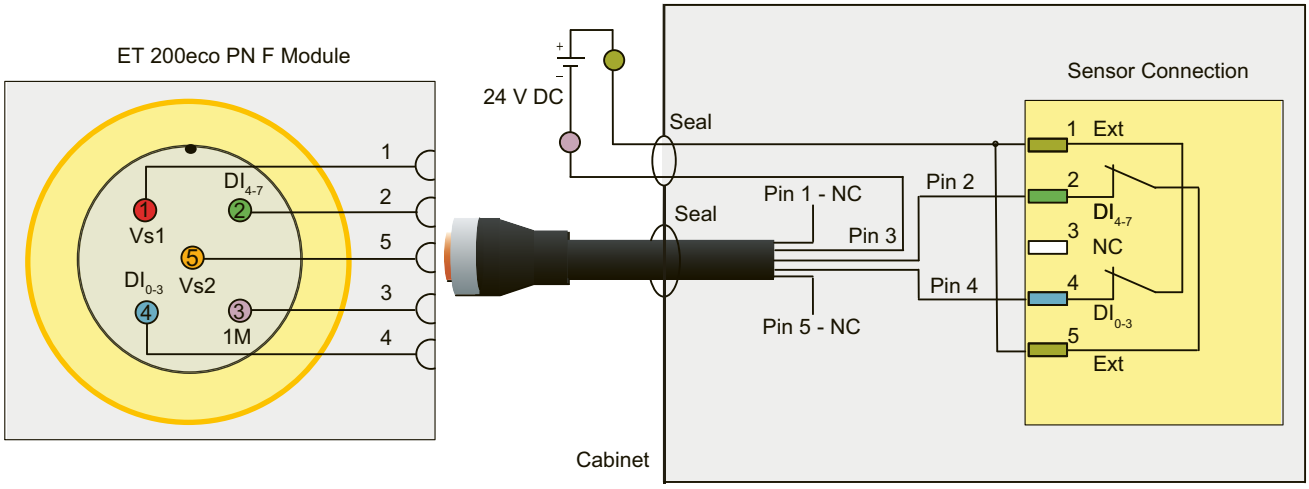


Figure 1-857 F-DI Application Mode 4: External sensor supply (1oo2 evaluation of two-channel sensor shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel equivalent
Sensor supply	External

3.1.5 F-DI Applications 5 and 6: 1oo2 evaluation of 3-wire, nonequivalent sensor circuit

F-DI application mode 5

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 4, 5, 6, and 7) is the inverted input of the nonequivalent configuration.
- Pin 4 (channels 0, 1, 2, and 3) is the non-inverted input of the nonequivalent configuration.

NOTE

To incorporate F-DI Application Mode 5 into a SIL 3-rated application, the sensor must be an appropriately qualified device.



Figure 1-858 F-DI Application Mode 5: Internal sensor supply (1oo2 evaluation of dual-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES714-6KA00-0XA0) for application mode as follows:

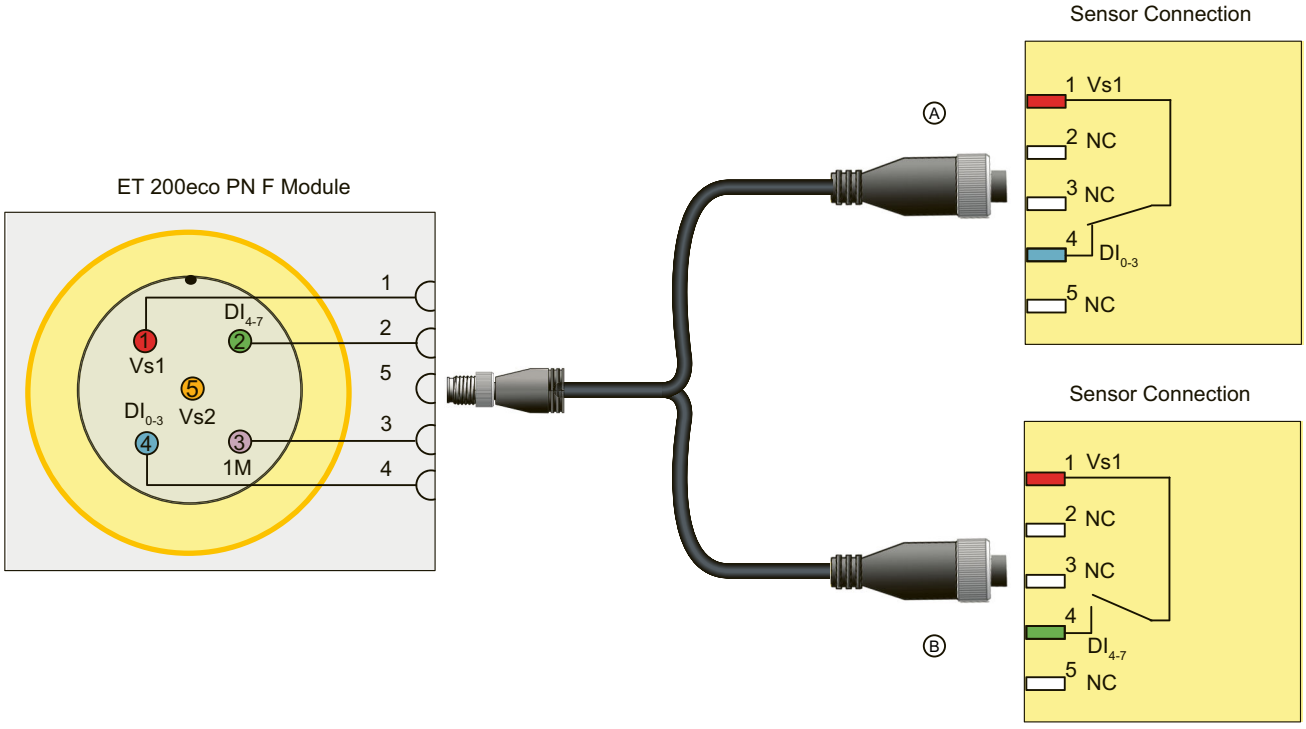


Figure 1-859 F-DI Application Mode 5: Internal sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire nonequivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 6

This application mode uses a two-channel sensor or two single-channel sensors with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 4, 5, 6, and 7) is the inverted input of the nonequivalent configuration.
- Pin 4 (channels 0, 1, 2, and 3) is the non-inverted input of the nonequivalent configuration.

NOTE

To incorporate F-DI Application Mode 6 into a SIL 3-rated application, the sensor must be an appropriately qualified device.

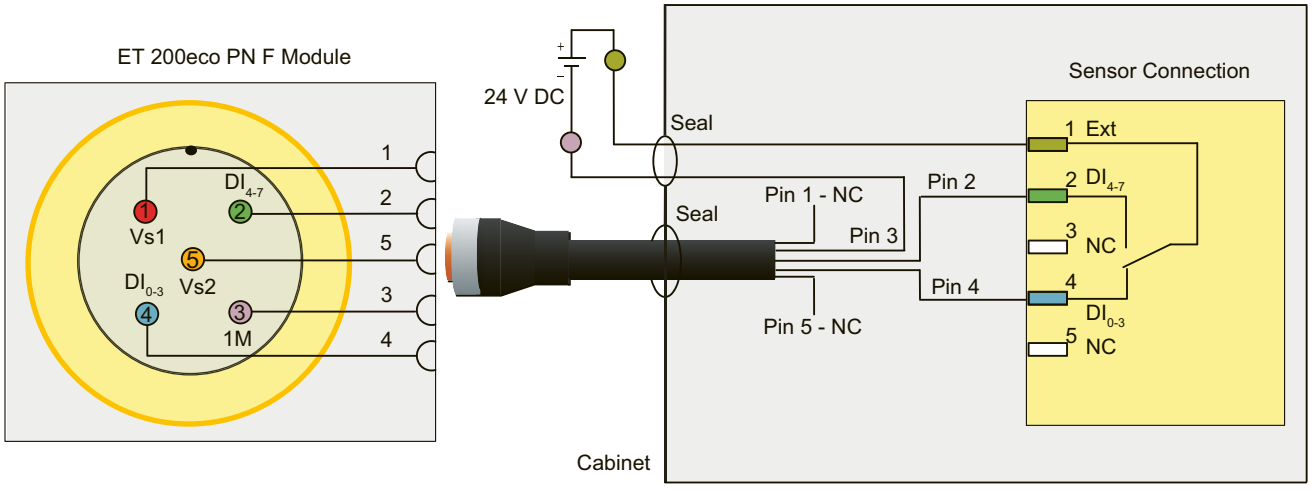


Figure 1-860 F-DI Application Mode 6: External sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 3 wire nonequivalent
Sensor supply	External

See also

SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable (6ES7194-6KA00-0XA0) (Page 116)

3.1.6 F-DI Applications 7 and 8: 1oo2 evaluation of 4-wire nonequivalent sensor circuit

F-DI application mode 7

This application mode uses a two-channel sensor or two single-channel sensors in nonequivalent configuration (4-wire connection) in a 1oo2 voting with discrepancy evaluation. When you use an internal sensor supply, you can successfully perform short-circuit detection. The application mode uses the following pins:

- Pin 2 (channels 4, 5, 6, and 7) is the inverted input of the nonequivalent configuration.
- Pin 4 (channels 0, 1, 2, and 3) is the non-inverted input of the nonequivalent configuration.

NOTE

To incorporate F-DI Application Mode 7 into a SIL 3-rated application, the sensor must be an appropriately qualified device.



Figure 1-861 F-DI Application Mode 7: Straight 5-pin cable with Internal sensor supply (1oo2 evaluation of two-channel sensor with nonequivalent outputs shown)

Use Y cable (6ES7194-6KB00-0XA0) for application mode 7 as follows:

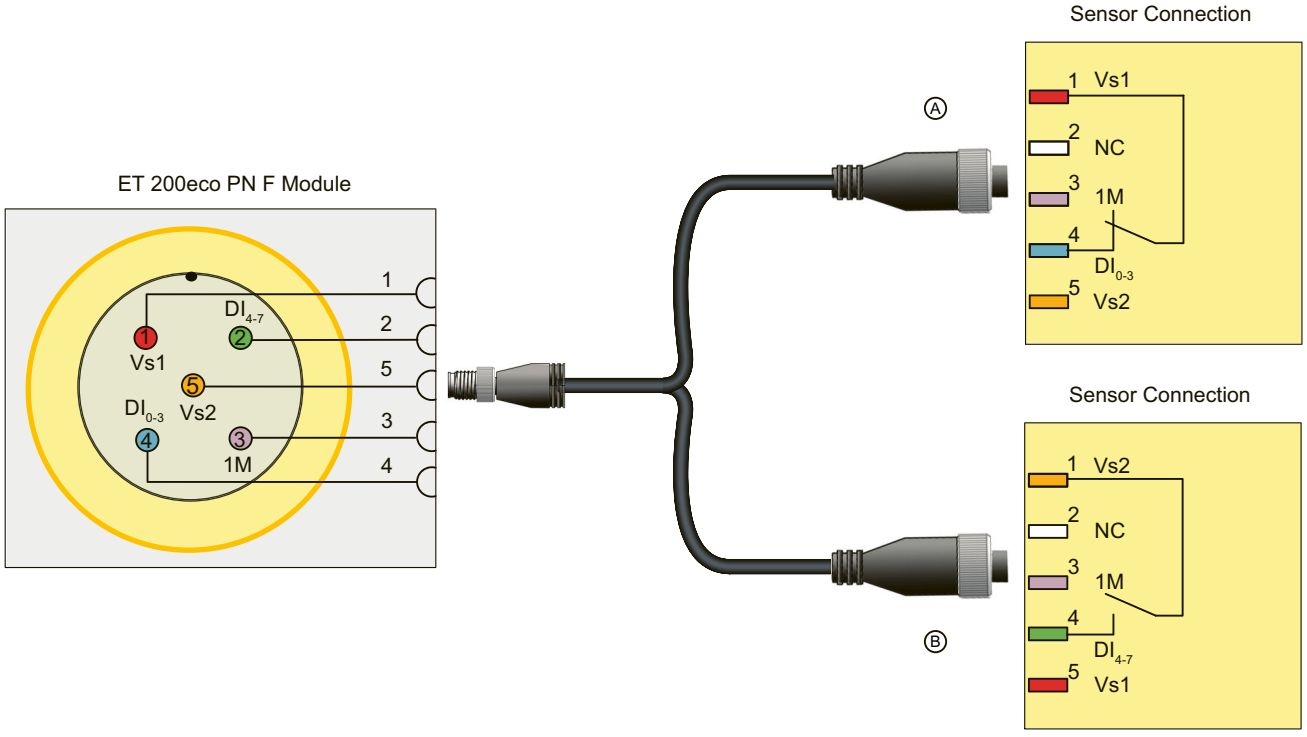


Figure 1-862 F-DI Application Mode 7: Y cable with Internal sensor supply

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire nonequivalent
Sensor supply	Internal
Short-circuit test	Enable

F-DI application mode 8

This application mode uses two single-channel sensorsor a two-channel sensor with two nonequivalent outputs in a 1oo2 voting with discrepancy evaluation. When you use an external sensor supply, the module does not evaluate that channel for short-circuit testing. The application mode uses the following pins:

- Pin 2 (channels 4, 5, 6, and 7) is the inverted input of the nonequivalent configuration.
- Pin 4 (channels 0, 1, 2, and 3) is the non-inverted input of the nonequivalent configuration.

NOTE

To incorporate F-DI Application Mode 8 into a SIL 3-rated application, the sensors must be appropriately qualified devices.

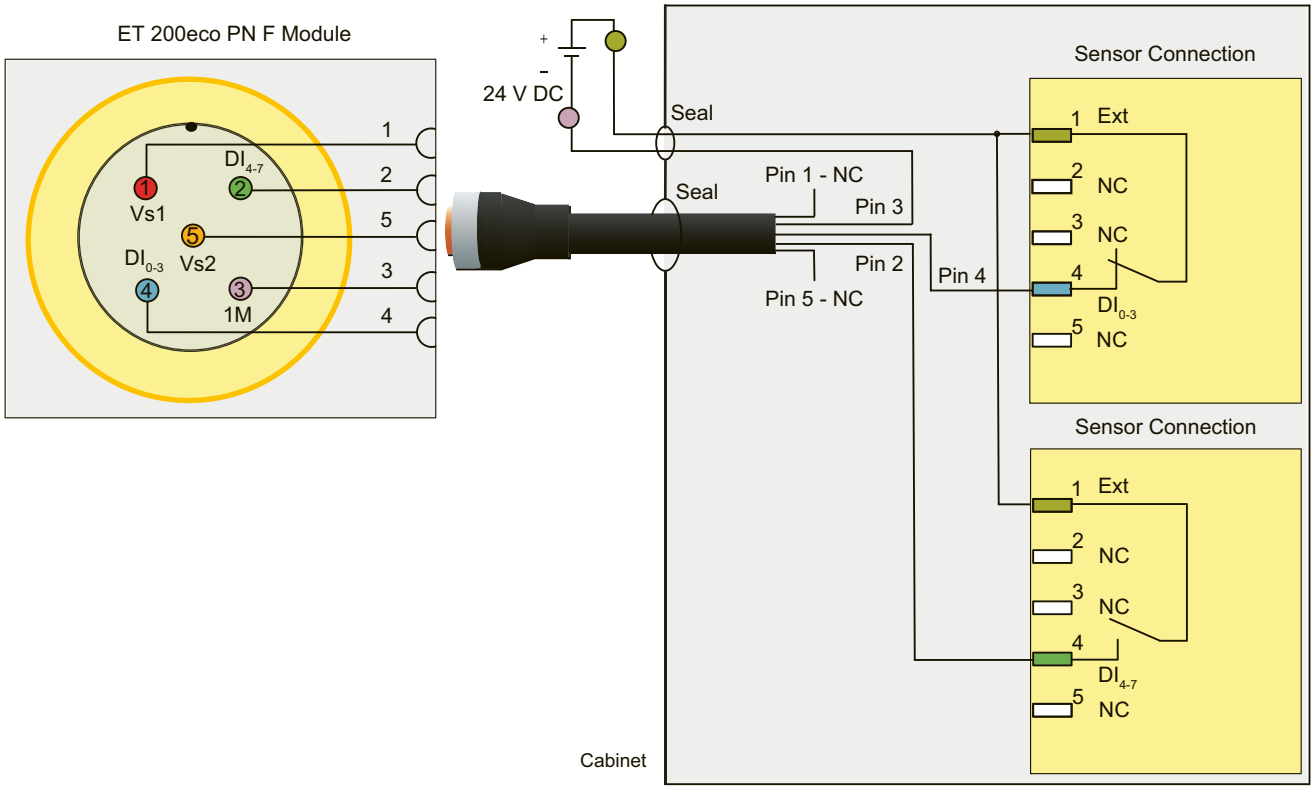


Figure 1-863 F-DI Application Mode 8: External sensor supply (1oo2 evaluation of two single-channel sensors with nonequivalent outputs shown)

Parameter assignment

Parameter name	Parameter value
Sensor evaluation	1oo2 evaluation, 2 channel - 4 wire nonequivalent
Sensor supply	External

See also

SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable (6ES7194-6KB00-0XA0) (Page 115)

3.2 Digital output applications

3.2.1 Overview

You should consider the application modes presented here along with the features of the ET 200eco PN F-DI 8 / F-DQ 3 as described in the overview. Refer to "Fail-Safe digital outputs" (Page 25).

The main features of the digital outputs include the following items:

- The fail-safe module separately controls current flow in the P (24 V DC to load) and M (load to common) sides of the circuit.
- The voltage at P and M outputs is read back to confirm proper state.
- The P and M switches are regularly tested with short ON and OFF pulses to confirm control.
- You must configure readback times that allow the external voltage to respond, but do not cause your load to physically respond.
- Internal current limiting as described in the data sheet may be sufficient in combination with your 24 V DC supply. However, you must consider whether additional current limits or fuses are necessary. Refer to "Specifications" (Page 173).

The module controls all output channels as 1oo2 with cross-diagnostics.

All applications shown are capable of reaching SIL 3/Category 4/PL e.

To reach Category 4, external contactors must be SIL-rated with sense contacts. Read the sense contacts back and confirm the external contactor response in your program. Siemens recommends using an F-DI input for sense contact and other safety diagnostic inputs.

3.2.2 Selecting the digital output application

Application	Description	Achievable SIL/Category/PL
1	Directly-connected SIL-rated actuator	3/4/e
2	External contactors: Separate P and M controlled contactors	3/4/e
3	External contactors: Parallel-connected contactors between P and M	3/4/e
4	External contactors: Separate output channels for each contactor	3/4/e

3.2.3 F-DQ Application 1: Wiring a directly-connected SIL-rated actuator

The module supports Application Mode 1, where there is a direct connection of a load between the P and M outputs of one channel. Both switches are opened when de-energizing the load.

NOTE

This configuration achieves SIL 3/Category 4/PL e.

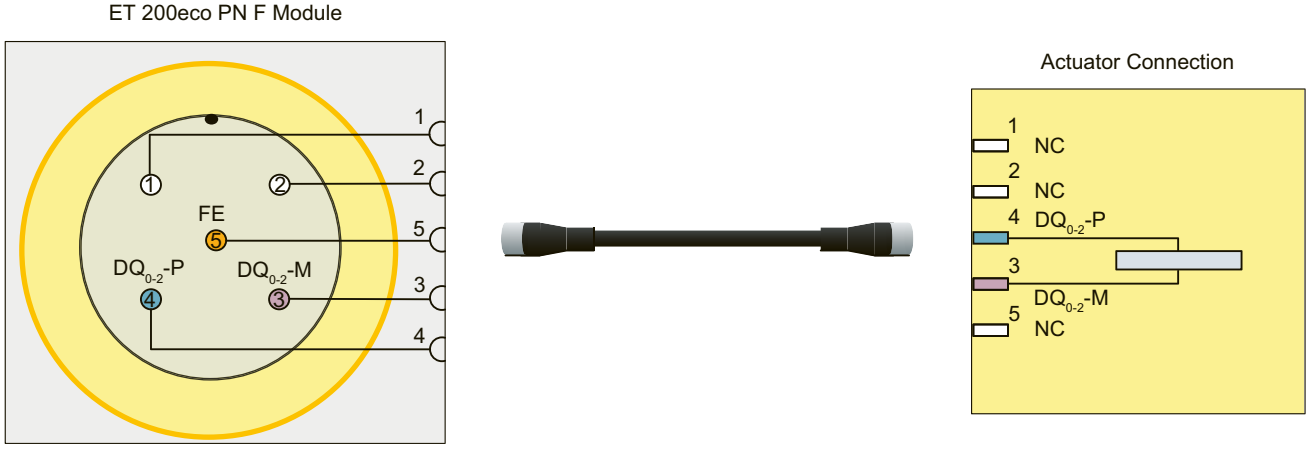


Figure 1-864 F-DQ Application Mode 1

3.2.4 F-DQ Application 2: Wiring external contactors: Separate P and M controlled contactors

The module supports F-DQ Application Mode 2, where the module controls the load using series-connected, normally-open contacts of two relays. The coil of one relay connects the P-output of a channel and M. The coil of the other relay connects the M-output of the same channel and L+.

NOTE

This configuration achieves SIL 3/Category 4/PL e if you fulfill the following conditions:The CPU checks the relay status (feedback) using a separate digital input.You adequately protect the wiring against shorts between the P and M outputs. The CPU cannot switch off the actuator if such a fault occurs.

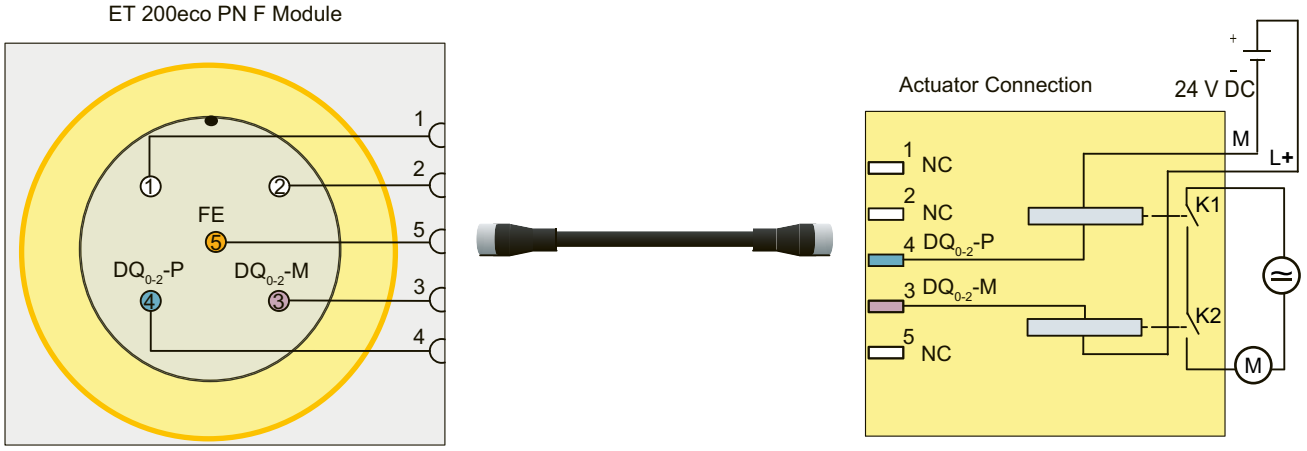


Figure 1-865 F-DQ Application Mode 2

3.2.5 F-DQ Application 3: Wiring external contactors: Parallel connected between P and M

The module supports F-DQ Application Mode 3, where the module controls the load using the series-connected, normally-open contacts of two relays. You connect the coils of both relays, in parallel, across the outputs of one channel.

NOTE

This configuration achieves SIL 3/Category 4/PL e if the CPU checks the relay status (feedback) using a separate digital input. Application Mode 3 is the preferred way of controlling an actuator using relays in a safety-related application. Application Mode 3 avoids the problems mentioned for Application Mode 2, regarding short-circuits between the P and M outputs.

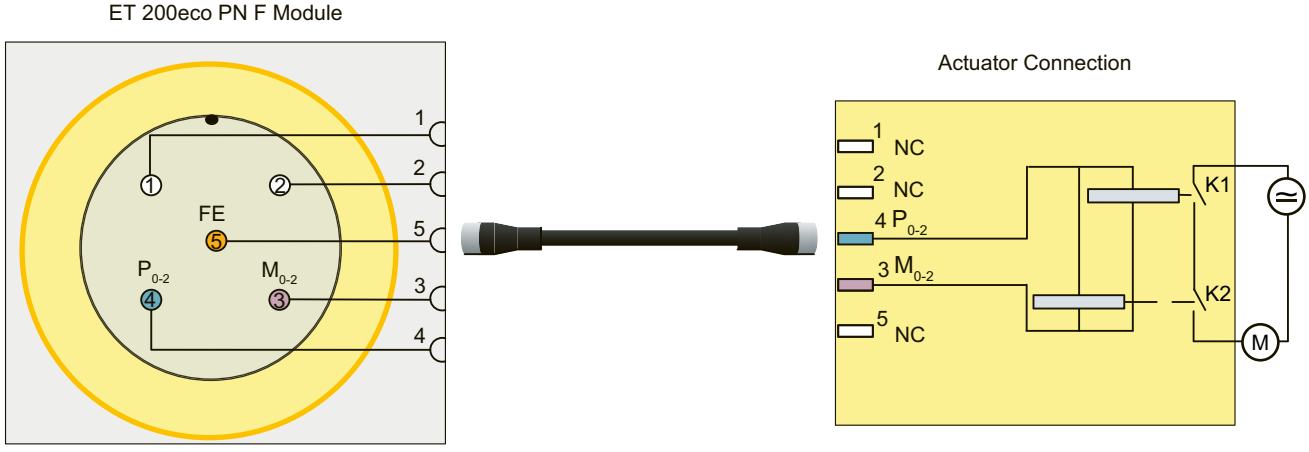


Figure 1-866 F-DQ Application Mode 3

3.2.6 F-DQ Application 4: Wiring external contactors: Separate P and M output channels for each contactor

The module supports F-DQ Application Mode 4, where the module controls the load using the series-connected, normally-open contacts of two relays. Connect the coils of both relays across the outputs of two channels. In the safety program, write the same process value (ON or OFF) to both output channels.

NOTE

The Application Mode 4 configuration achieves SIL 3/Category 4/PL e if the CPU checks the relay status (feedback) using a separate digital input.

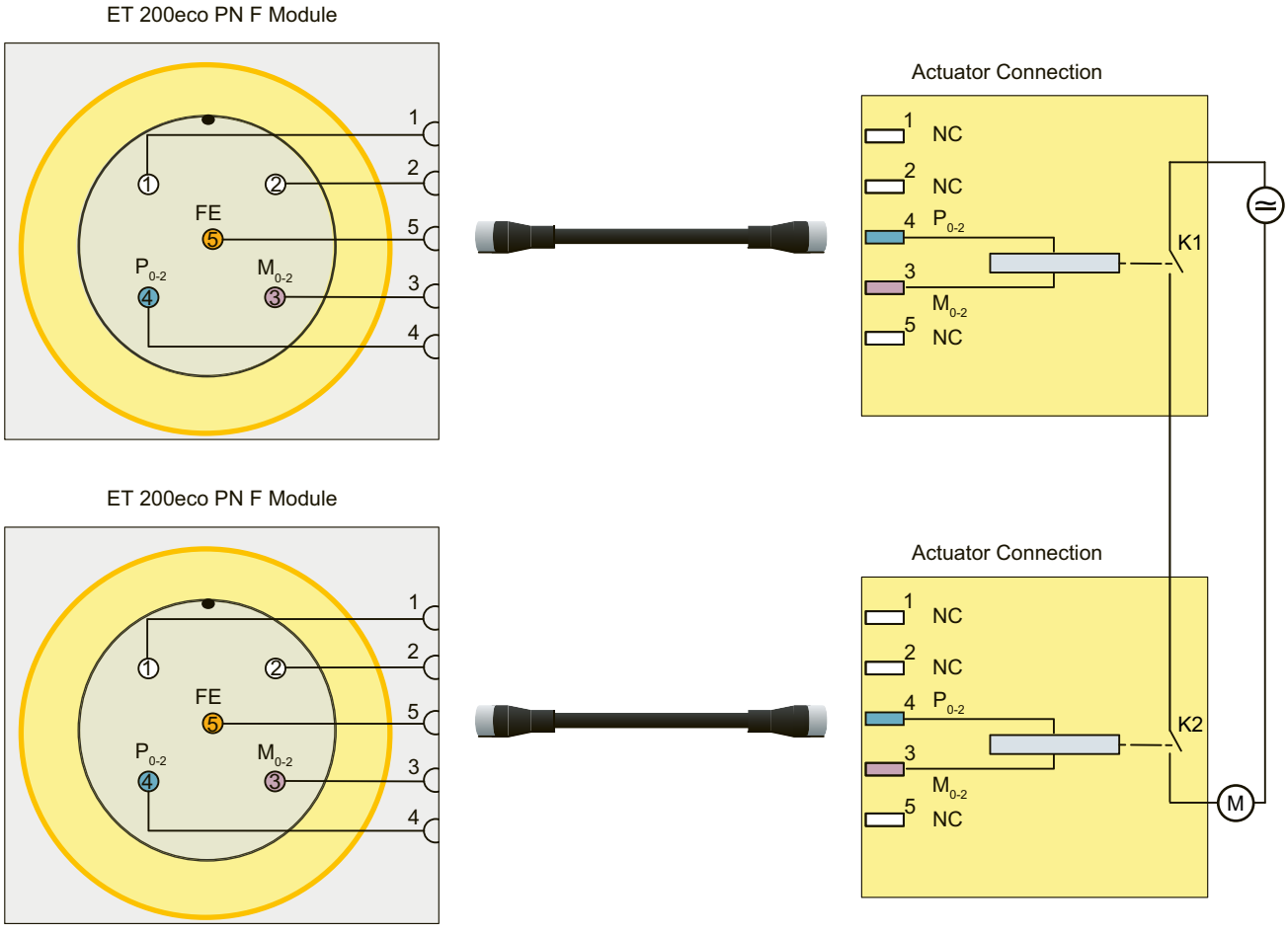


Figure 1-867 F-DQ Application Mode 4

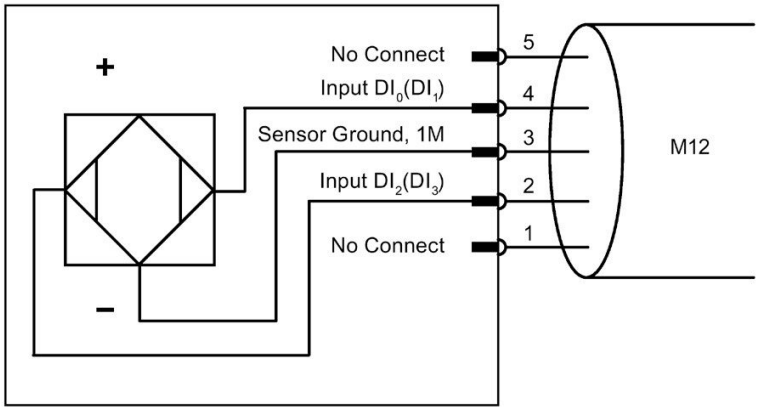
3.3 Examples of application modes for the ET 200eco PN F-DI 8 / F-DQ 3

3.3.1 Examples of application modes for the ET 200eco PN F-DI 8 / F-DQ 3

Laser Scanner (1oo2 evaluation)

For the output signal switching device (OSSD) sensors of a Laser Scanner, use F-DI application mode 4 to conect the Laser Scanner output signal switching device with 1oo2 evaluation to the ET 200eco PN F:

Laser Scanner (1oo2)

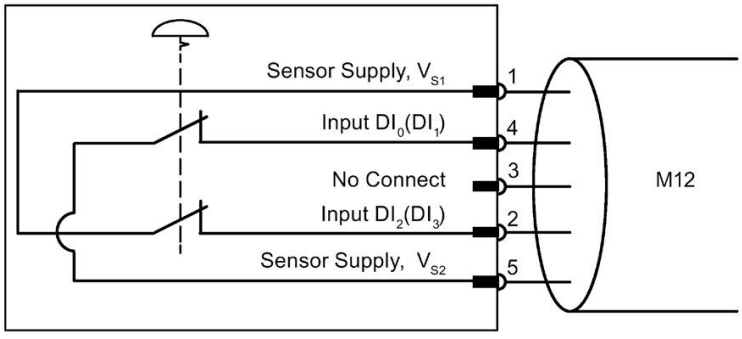


Alternatively, use F-DI application mode 3 and disable the parameter "Short-circuit test" for both sensor supplies.

ESTOP (Emergency Stop) (1oo2 evaluation)

For the ESTOP, use F-DI application mode 3 to connect the ESTOP device with 1oo2 evaluation to the ET 200eco PN F:

ESTOP (1oo2)

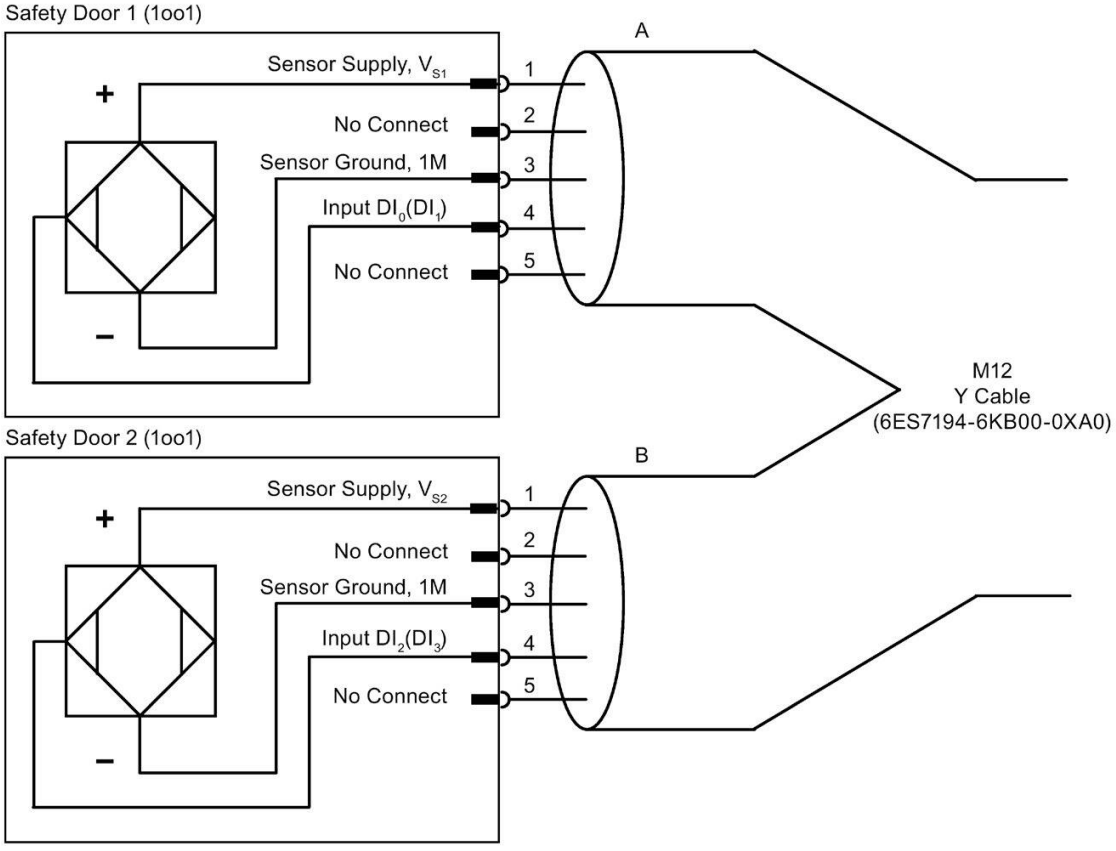


Alternatively, use F-DI applications modes 5 or 7 if nonequivalent evaluation is required for your ESTOP device.

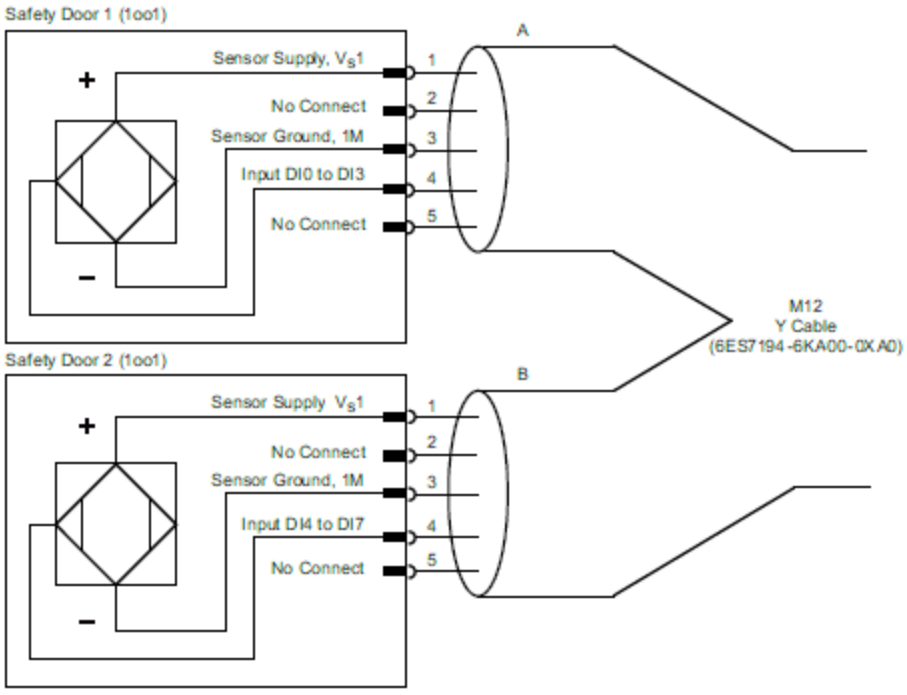
Safety Doors (1oo1 or 1oo2 evaluation)

For the Safety Doors, you can do one of the following:

- Use F-DI application mode 1 with the fail-safe Y cable (6ES7194-6KB00-0XA0) to connect two single-channel sensors with 1oo1 evaluation to one input connection of the ET 200eco PN F as follows:



- Use F-DI application mode 3 (1oo2 evaluation), using two single-channel sensors on the same safety door.
- Alternatively, use F-DI application mode 5 with the fail-safe Y cable (6ES7194-6KA00-0XA0) to connect two nonequivalent single-channel sensors with 1002 evaluation on the same safety door.



SIRIUS Safety position switch with interlock (1oo2 evaluation)

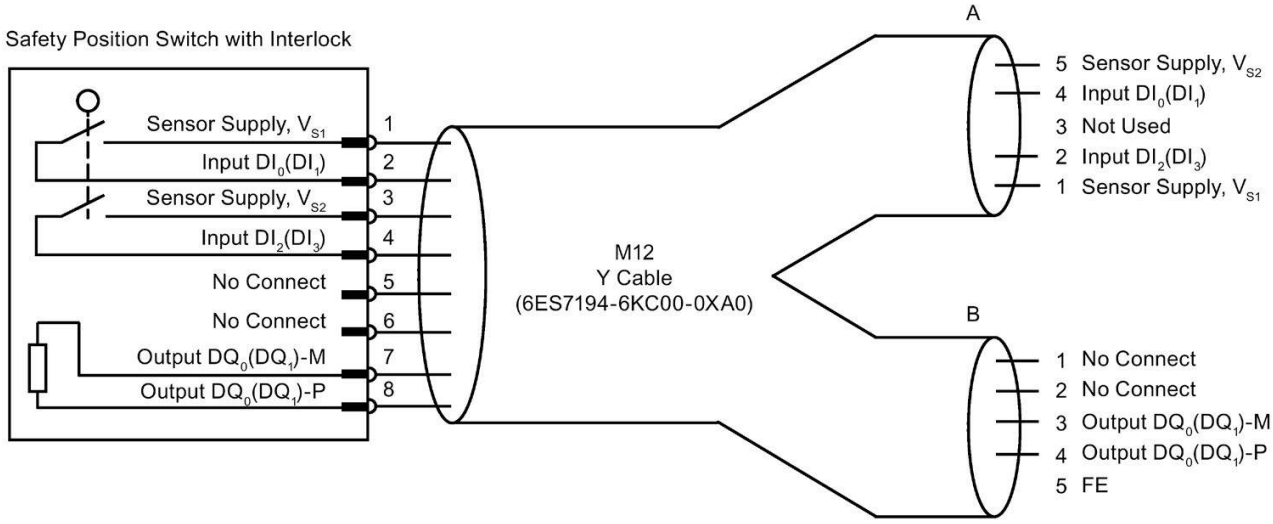
Use F-DI application mode 3 and F-DQ application mode 1 to connect the safety position switch with interlock to the ET 200eco PN F-DI 8 / F-DQ 3.

Use inverted Y cable (6ES7194-6KC00-0XA0) for a safety position switch with interlock. The inverted Y cable is designed to properly connect the fail-safe module F-inputs and F-ouput to the safety position switch.

NOTE

To incorporate this application into a SIL 3-rated application, ensure the sensors are appropriately qualified devices: either SIL 3 or SIL 2 with the Systematic Capability rules defined in the SIRIUS documenation.

For further information, refer to the "Industrial Controls, Detecting devices SIRIUS 3SE5/3SF1/3SE66/3SE67 position switches configuration manual" on the Internet.

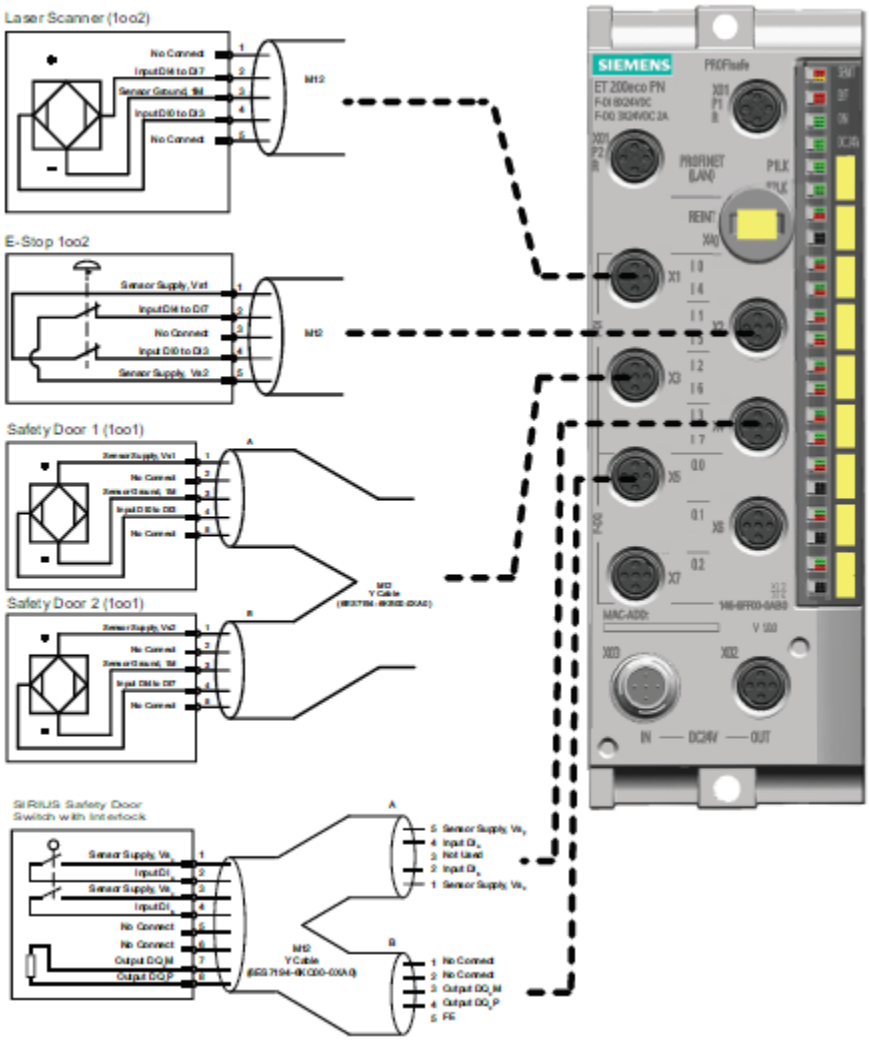


The table below shows the pin assignments for the inputs and outputs of the ET 200eco PN F:

Connector A	**DI_a**	**DI_b**	**Vs_x**	**Vs_y**
X1	0	4	1	2
X2	1	5	1	2
X3	2	6	1	2
X4	3	7	1	2
Connector B	**DQ_a**			
X5	0			
X6	1			
X7	2			

Connect devices to the ET 200eco PN F

The figure below shows examples of field devices connected to the input and output sockets of the ET 200eco PN F as shown below:



See also

SIMATIC DP, Inverted Y cable for distributed I/O for connecting an F-DI and F-DQ with one cable (6ES7194-6KC00-0XA0) (Page 117)
SIRIUS position switches Configuration Manual (https://support.industry.siemens.com/cs/us/en/view/43920150)

Installation

4

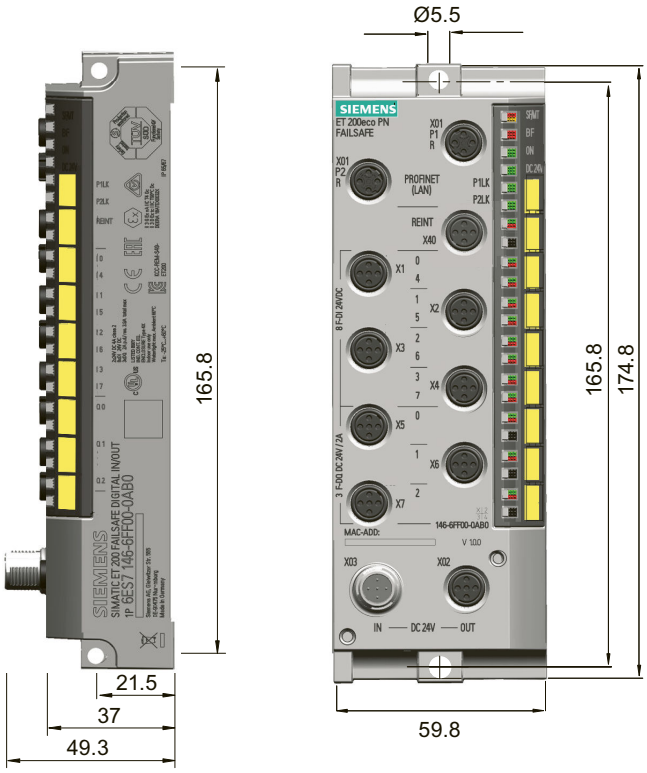
There are two installation variants:

- Without mounting rail (Page 95)
- With mounting rail (Page 96)

4.1 Installation without mounting rail

The ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O device is designed for easy installation. You must mount the I/O device on a solid base. Use the appropriate fasteners to mount the I/O device to the intended material.

The figures below show the dimensional information for mounting:



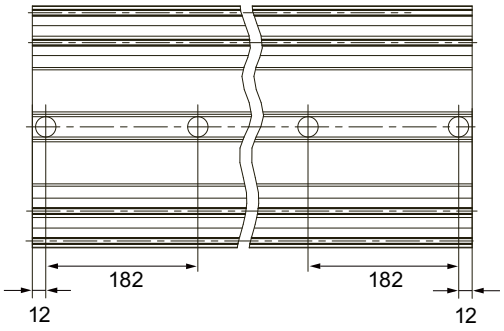
4.2 Installation with mounting rail

The mounting rail is available with a length of 500 mm. Refer to "Ordering information" (Page 185) to find the article number for this item.

Installing the mounting rail

Cut the 500-mm rail to suit your requirements and drill mounting holes for the appropriate fasteners to mount the I/O device to the intended material. You should distribute the mounting holes evenly at a pitch of 182 mm on the rail, starting at a distance of 12 mm from the edge.

Use the rack screw to bolt the I/O devices onto the mounting rail.



NOTE

It is not mandatory that you use this mounting rail.

4.3 Mounting position and dimensions

Mounting position

When the ET 200eco PN F-DI 8 / F-DQ 3 is used in isochronous real-time (IRT) mode, the module should be mounted at the end of the configuration. Do not place the ET 200eco PN F-DI 8 / F-DQ 3 in the middle of the configuration.

NOTE

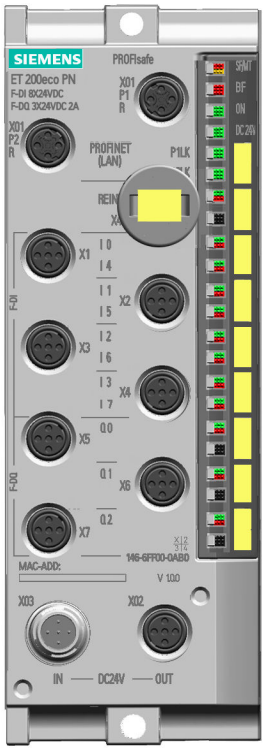
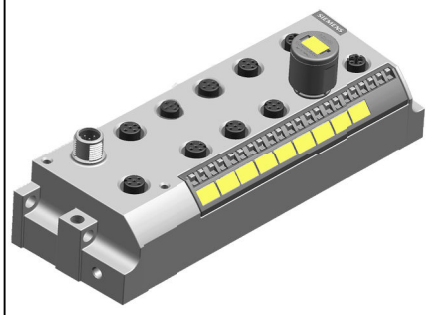
Use 3 m cables when mounting the ET 200eco PN F-DI 8 / F-DQ 3 in IRT mode instead of the 30 cm I/O cables.

Mounting and clearance dimensions

Dimension	Dimensions
Module mounting width	60 mm
Module mounting height	175 mm
Module mounting depth without eCoding Plug	49 mm
Module mounting depth with eCoding Plug	65 mm

4.4 Connecting the M12 eCoding plug

The eCoding plug (Page 185) is a specialized plug that stores the PROFIsafe addresses that you assign to the ET 200eco PN F-DI 8 / F-DQ 3 module.

eCoding Plug (side view)	ET 200eco PN F with eCoding Plug Attached (front view)	ET 200eco PN F with eCoding Plug Attached (side view)
		

The eCoding plug stores assigned PROFIsafe source and destination addresses received from the fail-safe ES into its non-volatile memory. The ecoding plug occupies the X40 M12 connector, utilizing a B-coded plug. You use the eCoding plug to facilitate module replacement.

The module receives PROFIsafe source and destination addresses during parameterization, which are then checked against the PROFIsafe addresses stored in the eCoding plug.

Protection mechanisms prevent you from damaging the eCoding plug or an I/O channel due to attempted plugging of the eCoding plug into an I/O M12 connector port.

Install the eCoding plug into the M12 connector port at X40 with a torque of 1.5 Nm. Do not overtighten the eCoding plug as it could damage the threading of the eCoding plug.

⚠ WARNING

If you remove/insert the eCoding plug with the power connected, this can lead to undefined states in your system.
Death or serious personal injury and damage to the ET 200eco PN F-DI 8 / F-DQ 3 module and associated machines/equipment may result if proper precautions are not taken.
Only remove or replace the eCoding plug when the power is disconnected. Always comply with the required standards and safety guidelines when configuring a system.

⚠ WARNING

When replacing the ET200eco PN F module, transfer the eCoding plug inserted in the failed module to the replacement module to retain the PROFIsafe address stored in the eCoding plug..
Otherwise, it is necessary to use the ES to configure the PROFIsafe address in the replacement module. Ensure that the eCoding plug is not accidentally inserted in a module other than the intended ET200eco PN F module

4.5 Installing the terminal block

The terminal block (6ES7194-6CA00-0AA0) (Page 184) connects the ET 200eco PN F-DI 8 / F-DQ 3 and supplies the I/O device with power.

You can install the terminal block in one of two ways:

- Install the terminal block separately on each module
- Screw the terminal block onto each module

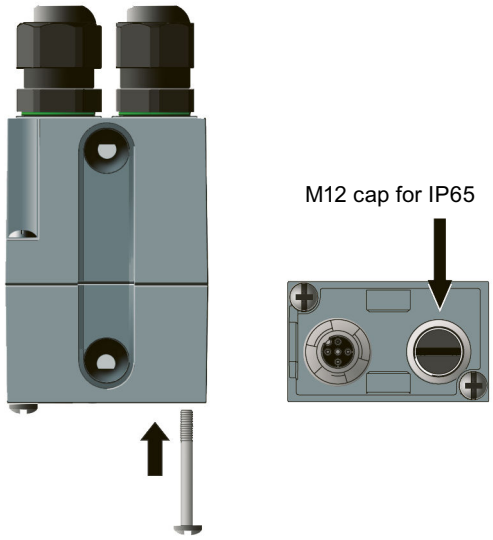
NOTE
You must wire the terminal block before you install it.

Tools required

Recessed head screwdriver, medium size

Installing the terminal block separately

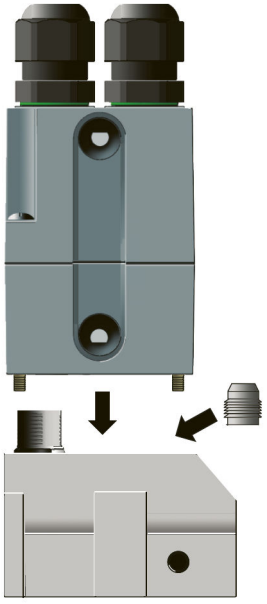
To install the terminal block separately, remove the screws and then screw them in again at the bottom of the housing:



Installing the terminal block on an I/O device

You can install the terminal block horizontally on a housing of 60 mm width.

You can attach an M12 cap to the bottom of the terminal block to implement the corresponding degree of protection. Do not attach the M12 cap to the terminal block connector; mount the M12 cap onto connector X02 of the I/O device. Bolt the terminal block onto the I/O device by tightening the screws.



Refer to the "Terminal block (Page 184)" technical specifications and "Wiring the terminal block" (Page 122) for further information.

4.6 Replacing labels

You can identify the I/O device and the I/O connectors using labels. The module has the following plastic yellow connector labels already clipped into the holder:

- One label for PROFINET device communication
- One label for the eCoding plug
- Seven labels for the I/O connectors

You can order replacement labels.

Tools required

2.5 to 4 mm slotted screwdriver

Replacing labels

1. Push the screwdriver into the small opening of the label at an angle and then pry it out.



2. Push the new label into the holder on the device. The label should snap into place.

Wiring

5

5.1 Fail-Safe system electrical design rules

5.1.1 Safe functional extra low voltage requirement (power supplies and other system components)

⚠ WARNING

Fail-safe modules must be operated with safe functional extra-low voltage (SELV, PELV) power sources.
To maintain safety of the modules' low voltage circuits, external connections to communications ports, analog circuits, 24 V DC nominal supply voltage, and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards.
The external power supply should limit the maximum voltage to 35 V DC even under fault conditions. Please consult the manufacturer's data for the power supplies that you use.

Maximum applied voltage to ET 200eco fail-safe devices

- Operational voltage: The fail-safe module's operational voltage is 20.4 V DC - 28.8 V DC, 35 V DC surge for 0.5 second. Operation of the unit to specifications is assured by design and testing. Defined transients from defined source impedances per EN 61000-4-2, 61000-4-4, 61000-4-6, as specified in the data sheet for each product, may be imposed on this voltage without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 V DC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 V DC. These power supplies must be specified by the manufacturer to limit the output voltage to 35 V DC or less under fault conditions. Otherwise, external protection must be supplied that will reliably open the circuit or limit the output voltage to less than 35 V DC to the modules.
- Surge immunity: Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. This protection must be sufficient to clamp surge voltages and/or open the supply circuit to assure the PLC system is not exposed to voltages greater than 35 V DC. One specification for evaluation of protection from lightning type surges is found in EN 61000-4-5, with operational limits established by EN 61000-6-2. The ET 200eco PN F module requires external protection to maintain safe operation when subject to surge voltages defined by this standard. Refer to Appendix A.1.5.1: "Surge immunity (Page 170)" for further information.

⚠ WARNING

All power supply and fail-safe module circuits must be connected together to a common voltage reference or must be isolated SELV circuits.
The power supply M terminals on the fail-safe CPU and the fail-safe modules must be connected together or isolated as SELV. Failure to do so can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to module isolation boundary.

NOTE

Requirements for power supplies in the event of voltage interruption
To ensure adherence to IEC 61131-2 and NAMUR Recommendation NE 21, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirement in your product standards (for example, 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions. The latest information on PS components is available on the Internet (https://mall.industry.siemens.com).

5.2 Control system electrical rules

5.2.1 General rules and regulations for operating an ET 200eco PN F-DI 8 / F-DQ 3

When operating the ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O device as part of a plant or system, special rules and regulations have to be followed depending on the field of application.

This section provides an overview of the most important rules you have to observe when integrating the ET 200eco PN F distributed I/O device in a plant or system.

EMERGENCY-STOP equipment

EMERGENCY STOP equipment according to IEC 204 (corresponds to DIN VDE 113) must remain effective in all operating modes of the plant or system.

System startup after specific events

The table below identifies situations you must pay attention to when the system starts up after the occurrence of certain events:

If ...	then ...
Startup follows a power dip / failure Startup of the ET 200eco PN F after bus communication has been interrupted	Dangerous operating states must be avoided at all times. If necessary, force an "EMERGENCY OFF"!
Startup after releasing the EMERGENCY OFF equipment	Any uncontrolled or undefined startup must be avoided.

24 V DC supply

The table shows what you have to observe for the 24 V DC supply:

At ...	Requirements ...	
Buildings	External lightning protection	Take lightning protection measures (for example, lightning protection elements)
24 V DC supply lines, signal lines	Internal lightning protection	
24 V DC supply	Safe (electrical) isolation of the extra-low voltage	
Loop-through of supply voltage	Voltage drop in the case of loop-through (Refer to "Looping PROFINET and the supply voltage" (Page 127) for further information.)	

Protection against external electrical interference

The table below shows what to observe in order to protect the system against electrical interference or faults:

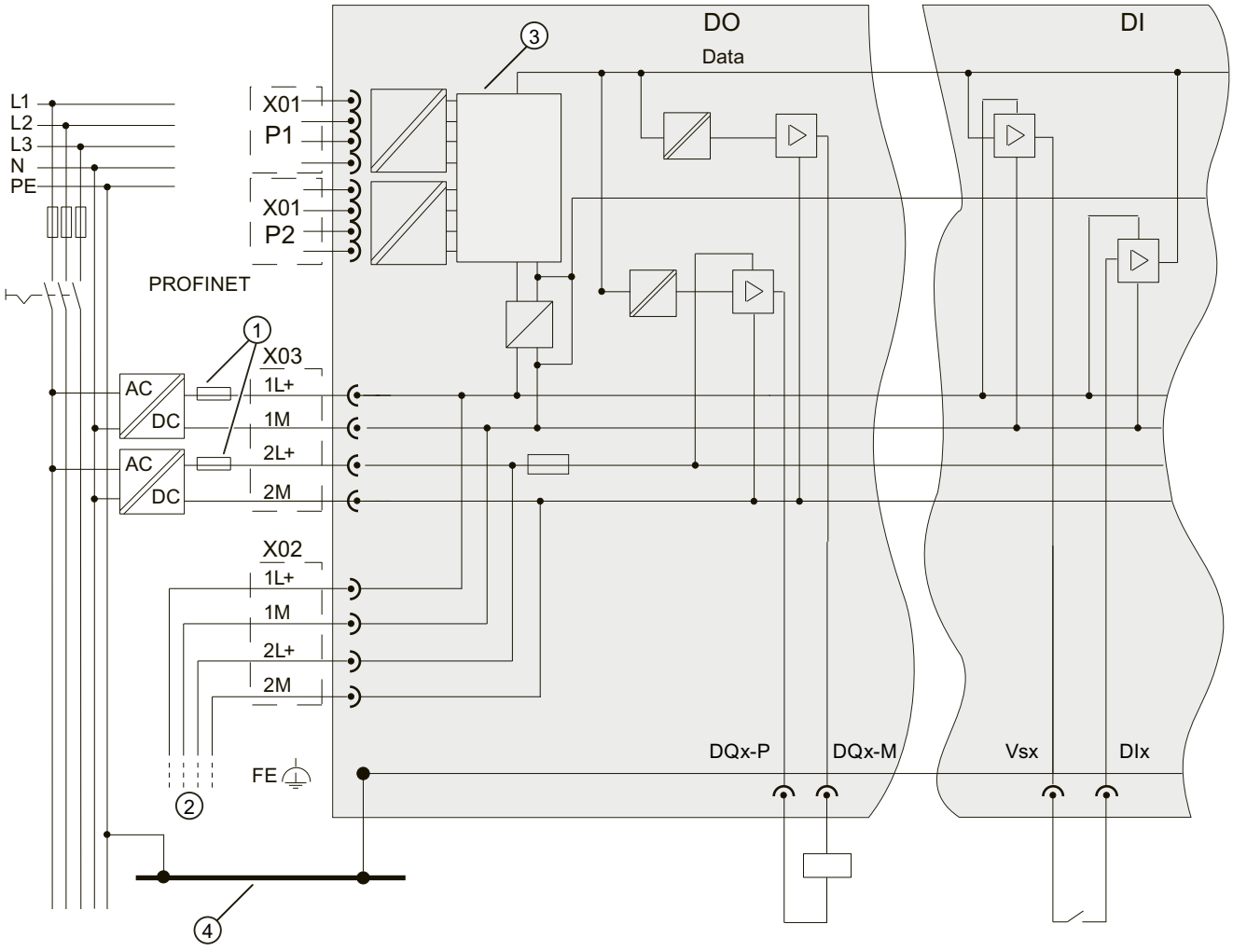
At ...	ensure that ...
all plants or systems in which the ET 200eco PN F is installed	the plant or system is EMC-compatible and properly grounded for the discharge of electromagnetic interference.
supply, signal, and bus lines	the wiring arrangement and installation is correct.
signal and bus lines	a wire break or conductor break does not result in undefined states of the plant or system.

5.2.2 Electrical configuration of the ET 200eco PN F-DI 8 / F-DQ 3

Electrical isolation

The ET 200eco PN F-DI 8 / F-DQ 3 electrical configuration features electrical isolation between:

- 1L+ supply voltage (electronic/sensor supply)
  Electrically isolated from PROFINET IO and 2L+ (load voltage supply)
- 2L+ supply voltage (load voltage supply):
  Electrically isolated from all other circuit components.
- PROFINET IO interface:
  Electrically isolated from all other circuit components.



①	Infeed of supply voltage 1L+ and 2L+ with line protection	③	Microprocessor and switch
②	Loop-through of supply voltage	④	Main ground line

Line protection

Line protection is required in accordance with DIN VDE 0100, that is, you must always provide external fusing.

You must fuse the 1L+ and 2L+ power supplies of the following devices:

- I/O device using a 24 V DC/4.0 A miniature circuit breaker with tripping characteristic type B or C
- Terminal block using a 24 V DC/10.0 A miniature circuit breaker with tripping characteristic type B or C
- Voltage distributor using a 24 V DC/8.0 A miniature circuit breaker with tripping characteristic type B or C

5.2.3 Influence of cable length on the supply voltage

If you are wiring your configuration, then you must take into account the impact of cable gauge and length on the supply voltage to the ET 200eco PN F-DI 8 / F-DQ 3.

Example

A 10 m cable with 0.75 mm^2 has a resistance of 0.5 Ω, which corresponds with a voltage drop of 2 V DC at a load of 4.0 A.

⚠ CAUTION

If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you will risk overheating the cable insulation and contacts resulting in damage to the device.
Electrical faults or unexpected machine operation can result in minor personal injury if proper precautions are not taken.
You must follow all instructions for installation and maintenance of a proper operating environment to ensure the equipment operates safely.

5.2.4 Guidelines for grounding and wiring

Proper grounding and wiring of all electrical equipment is important to provide electrical noise protection for your application and the ET 200eco PN F-DI 8 / F-DQ 3 module. Refer to the technical specifications (Page 173) for the ET 200eco PN F-DI 8 / F-DQ 3 wiring diagrams.

Prerequisites

Before you ground or install wiring to any electrical device, ensure that the power to that equipment has been turned off. Also, ensure that the power to any related equipment has been turned off.

Ensure that you follow all applicable electrical codes when wiring the ET 200eco PN F and related equipment. Install and operate all equipment according to all applicable national and local standards. Contact your local authorities to determine which codes and standards apply to your specific case.

⚠ WARNING

Installing or wiring the ET 200eco PN F or related equipment with power applied could cause electric shock or unexpected operation of equipment.
Failure to disable all power to the ET 200eco PN F and related equipment during installation or removal procedures could result in death, severe personal injury, and damage due to electric shock or unexpected equipment operation.
Always follow appropriate safety precautions and ensure that power to the ET 200eco PN F is disabled before attempting to install or remove the ET 200eco PN F or related equipment.

Always take safety into consideration as you design the grounding and wiring of your ET 200eco PN F system. Electronic control devices, such as the ET 200eco PN F, can fail and cause unexpected operation of the equipment that is being controlled or monitored:

- Fail-safe modules: Internal dangerous failures can occur on these devices with a probability as reflected in the SIL rating, PFD, and PFH as stated in this manual.
- Each control's installation: Common cause failure threats can occur such as overvoltage, over-temperature, electrical faults, EMC interference, and fire, water, or mechanical damage to the installation.

You must evaluate every control point for the threat level and consequences of failure. Your installation can require safeguards that are independent of the ET 200eco PN F to achieve an appropriate level of risk for personal injury or equipment damage.

⚠ WARNING

Control devices can fail in an unsafe condition, resulting in unexpected operation of controlled equipment.
Such unexpected operations could result in death, severe personal injury, and property damage.
When using fail-safe I/O, design safety-related control functions to account for the probability of faults, including redundancy to achieve an appropriate level of risk for the consequences of failure.
When using standard I/O, always include an emergency stop function, electromechanical overrides, or other redundant safeguards when a failure could cause personal injury or significant property damage.

5.2.5 Grounding the ET 200eco PN F-DI 8 / F-DQ 3 module

The best way to ground your application is to ensure that all the common and ground connections of your ET 200eco PN F-DI 8 / F-DQ 3 and related equipment are grounded to a single point. This single point should be connected directly to the earth ground for your system.

All ground wires should be as short as possible and should use a stranded wire of large size, such as 4 mm^2.

When locating grounds, consider safety-grounding requirements and the proper operation of protective interrupting devices.

5.2.6 Operating the ET 200eco PN F-DI 8 / F-DQ 3 on grounded mains

This section provides information about the overall configuration of an ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O device with a grounded infeed (TN-S system). The section focuses on the following topics:

- Disconnecting devices
- Short-circuit and overload protection according to DIN VDE 0100 and DIN EN 60204-1.

Supply voltages of the ET 200eco PN F

There are two supply voltages:

- 1L+: Electronic/sensor supply
- 2L+: Load supply

Definition: Grounded infeed

A TN-S system always bonds the neutral conductor to ground. A simple short-circuit to ground of a live conductor, or of a grounded component of the plant trips the disconnecting devices.

Safe electrical isolation (SELV/PELV according to IEC 60364-4-41)

You can only operate the ET 200eco PN F using power supplies/power supply units with safe electrical isolation.

Components and protective measures

Safety standards stipulate various components and protective measures for plant installation. The type of components and the degree to which the protective measures are mandatory depend on the DIN VDE regulation that applies to your plant configuration. The next table refers to the diagram below:

Compare ...	Reference to the diagram	DIN VDE 0100	DIN EN 60204
Disconnecting device for controller, sensors, and actuators	"Grounding concept for ET 200eco PN F" (See ① in figure below.)	... Part 460: Main switch	... Part 1: Disconnect switch
Short-circuit and overload protection	"Grounding concept for ET 200eco PN F" (See ② in figure below.)	... Part 725: Single-pole protection of circuits	... Part 1: with grounded secondary power circuit: **single-pole** protection
Line protection		... Part 430: Protection of cables and lines against over-current	-

Safe electrical isolation

You require safety isolation for the following items:

- Modules which must be supplied with ≤ 60 V DC or ≤ 25 V AC
- 24 V DC load circuits

Configuring ET 200eco PN F with grounded reference potential

Any interference currents generated within an ET 200eco PN F configuration with grounded reference potential discharge to protective earth. You must connect the terminals externally. Refer to the figure below: Connection between 1M and FE

Configuring ET 200eco PN F with ungrounded reference potential

In an ET 200eco PN F configuration with ungrounded reference potential, any interference currents discharge to protective ground through an internal RC circuit. Refer to the figure below: No connection between 1M and FE

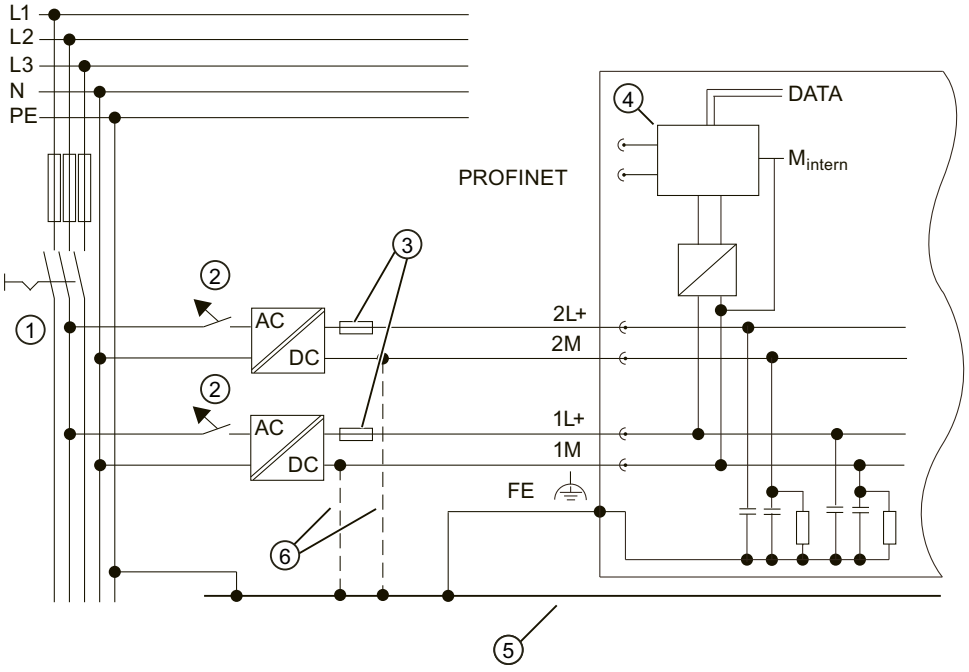
Isolation monitoring

Isolation monitoring must be provided if the following exist:

- Ungrounded ET 200eco PN F configuration
- A repetitive error that is liable to cause dangerous plant states

ET 200eco PN F in its overall configuration

The figure below shows the overall configuration of the ET 200eco PN F distributed I/O device (load voltage supply and grounding concept) with infeed from a TN-S system:



① Disconnecting device for controller, sensors, and actuators
② Short-circuit and overload protection
③ Fuses for line protection
④ Microprocessor and module switch
⑤ Main ground line
⑥ When you configure the ET 200eco PN F with ungrounded reference potential, you eliminate the connection between 1M and FE and 2M and FE.

5.2.7 Wiring the ET 200eco PN F-DI 8 / F-DQ 3

5.2.7.1 Guidelines for wiring the ET 200eco PN F-DI 8 / F-DQ 3

When designing the wiring for your ET 200eco PN F-DI 8 / F-DQ 3, provide a single disconnect switch that simultaneously removes power from all input circuits and from all output circuits. Provide over-current protection, such as a fuse or circuit breaker, to limit fault currents on supply wiring. Consider providing additional protection by placing a fuse or other current limit in each output circuit.

Install appropriate surge suppression devices for any wiring that could be subject to lightning surges.

Do not place low voltage signal wires and communications cables in the same wire tray with AC wires and high energy, rapidly switched DC wires. Always route wires in pairs, with the neutral or common wire paired with the hot or signal-carrying wire.

Use the shortest wire possible and ensure that the wire is sized properly to carry the required current.

Wire and cable should have a temperature rating 30 °C higher than the ambient temperature around the ET 200eco PN F (for example, a minimum of 85 °C-rated conductors for 55 °C ambient temperature). You should determine other wiring type and material requirements from the specific electrical circuit ratings and your installation environment.

Use shielded wires for optimum protection against electrical noise. Typically, grounding the shield at the ET 200eco PN F gives the best results. You should ground communication cable shields to ET 200eco PN F communication connector shells using connectors that engage the cable shield, or by bonding the communication cable shields to a ground.

When wiring input circuits that are powered by an external power supply, include an overcurrent protection device in that circuit.

Refer to "Pin assignment of connectors" (Page 117) for further information on pin assignment for PROFINET, feeding and looping the voltage, digital inputs, and digital outputs connectors.

To help prevent unwanted current flows in your installation, the ET 200eco PN F provides isolation boundaries at certain points. When you plan the wiring for your system, you should consider these isolation boundaries. Refer to the technical specifications (Page 173) for the amount of isolation provided and the location of the isolation boundaries. Circuits rated for AC line voltage include safety isolation to other circuits. Isolation boundaries between 24 V DC circuits are functional only, and you should not depend on these boundaries for safety.

5.2.7.2 Wiring the ET 200eco PN F-DI 8 / F-DQ 3 to functional earth (FE)

All ET 200eco PN I/O devices have a functional earth connection. This connection is used to suppress interference, but not for protective purposes. You establish a direct electrical connection to a point in your plant or a shield using the functional earth connection. EMC interference is discharged directly to earth through this connection. The interference immunity of the entire I/O device is increased by the discharge of the EMC interference.

Installing ET 200eco PN F I/O devices on a conductive base

You require the following items to install ET 200eco PN F I/O devices on a conductive base:

- Conductive base for installation of the I/O device
- Screwdriver to connect to the functional ground
- 2 x M5 x 8 fixing screws and washers to connect to the functional ground

To connect ET 200eco PN F I/O devices to functional earth with a conductive base, follow these steps:

1. Drill two fixing holes.
2. Bolt the I/O device with the M5 fixing screws and washers using a torque of 1.5 Nm.

NOTE

Grounding with a conductive base

When you fasten an I/O device of ET 200eco PN F to a conductive, grounded base, the lower fixing screw creates a conductive connection to the ground potential.

Make sure there is a low-impedance connection between the peripheral device and the conductive substrate and between the conductive substrate and the functional ground.

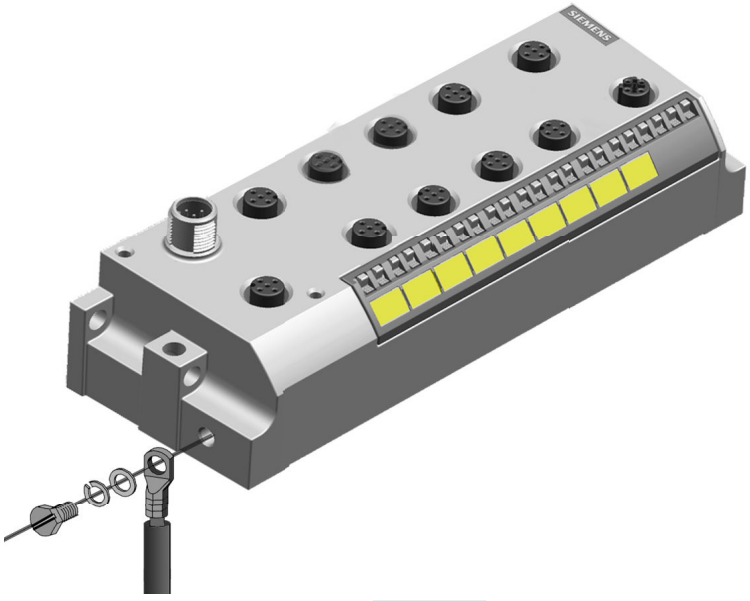
Installing ET 200eco PN F I/O devices on a non-conductive base

You require the following items to install ET 200eco PN F I/O devices on a non-conductive base:

- Non-conductive base for installation of the I/O device
- Tools to connect to the functional ground:
  - Stripping tool
  - Crimp tool
  - Screwdriver
- Accessories to connect to the functional ground:
  - M5 x 8 fixing screw and washers
  - Grounding cable (copper braid cable) with a minimum cross-section of 4 mm^2
  - Cable lug suitable for M5 screws

To connect ET 200eco PN F I/O devices to functional earth with a non-conductive base, follow these steps:

1. Drill 2 fixing holes.
2. Strip the grounding conductor and crimp on the cable lug.
3. Screw the cable lug onto the I/O device and voltage distributor (M5 fixing screw) with a torque of 1.5 Nm.



Refer to Installation "Overview" (Page 95) for further information on installing ET 200eco PN F I/O devices.

5.2.7.3 Wiring I/O devices for 1oo2 evaluation using M12 connecting cables

Connections for the sensors to the 5-pin M12 circular sockets, X1 to X4, are on the front panel of the ET 200eco PN F-DI 8 / F-DQ 3:

- Use M12 connecting cable for 1oo2 evaluation.
- The fail-safe digital input M12 connector cables are black in color.

⚠ WARNING

You may come into contact with live electrical wires connected to the main power supply.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
Shut off the supply voltage before you wire the I/O devices.

Requirements

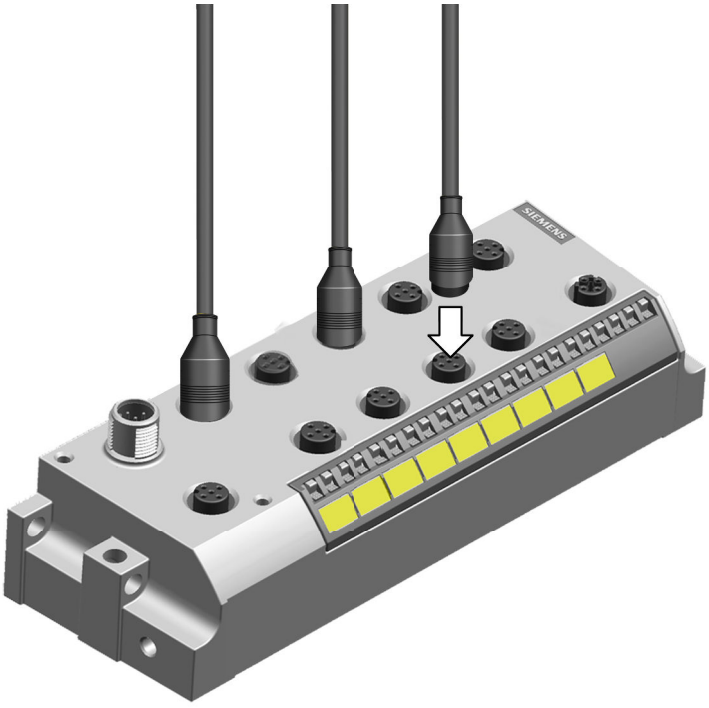
You require the following items to wire the ET 200eco PN F-DI 8 / F-DQ 3:

- Stripping tool and screwdriver for wiring the M12 cable connector, if you do not use prefabricated cables
- One of the following accessories:
  - Prefabricated cable with 5-pin M12 cable connector
  - 3-, 4-, or 5-wire copper cable (conductor cross-section must be ≤0.75 mm^2) with 5-pin M12 cable connector. Refer to "Pin assignment of digital inputs" (Page 120) and "Pin assignment of digital outputs" (Page 121) for further information.
- M12 sealing caps

Refer to "Ordering information" (Page 185) to find the article numbers for these items.

To connect the ET 200eco PN F M12 connectors, follow these steps:

1. Plug the connector into the relevant circular socket connector on the I/O block. Make sure the connectors and sockets are properly interlocked (matched joint).
2. Secure the connector by tightening the knurled ring nut with a torque of 1.5 Nm.



Sealing round sockets not in use

Always seal all unused, round sockets using M12 sealing caps to achieve degree of protection IP65, IP66, or IP67. Refer to "Ordering information" (Page 185) to find the article numbers for these items.

Pin assignment of connectors

Refer to "Pin assignment of connectors" (Page 117) for further information on pin assignment for PROFINET, feeding and looping the voltage, digital input, and digital output connectors.

5.2.7.4 Wiring I/O devices for 1oo1 evaluation or 1oo2 evaluation using M12 Y cables

You can connect two one-channel sensors with 1oo1 evaluation to one input connection of the ET 200eco PN F with a Y cable. The Y cable divides the two channels for two jacks. You can use either Y cable, 6ES7194-6KB00-0XA0 (Page 115)or 6ES7194-6KA00-0XA0 (Page 116), for this application.

You can connect SIRIUS safety position switches with interlock that have M12 8-pin connectors to one input and one output connection of the ET 200eco PN F with an inverted Y cable. You can use the inverted Y cable, 6ES7194-6KC00-0XA0 (Page 117), for this application.

Refer to "Pin assignment of digital inputs" (Page 120) and "Pin assignment of digital outputs" (Page 121) for further information.

⚠ WARNING

You may come into contact with live electrical wires connected to the main power supply.
Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
Shut off the supply voltage before you wire the ET 200eco PN F-DI 8 / F-DQ 3.

Requirements

You require the following items to wire the ET 200eco PN F I/O devices:

- Stripping tool and screwdriver for wiring the M12 cable connector, if you do not use prefabricated cables
- Y cable
- M12 sealing caps

Refer to "Ordering information" (Page 185) to find the article numbers for these items.

Sealing round sockets not in use

Always seal all unused, round sockets using M12 sealing caps to achieve degree of protection IP65, IP66, or IP67. Refer to "Ordering information" (Page 185) to find the article numbers for these items.

Pin assignment of connectors

Refer to "Pin assignment of connectors" (Page 117) for further information on pin assignment for PROFINET, feeding and looping the voltage, digital inputs, and digital outputs connectors.

SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable (6ES7194-6KB00-0XA0)

Use this Y cable (6ES7194-6KB00-0XA0) for applications with the following requirements:

- Sensor connections to the 5-pin M12 circular sockets (X1 to X4) on the front panel of the I/O device
- 1oo1 evaluation (double connection of F-DI with one cable) (See the wiring diagram below.)

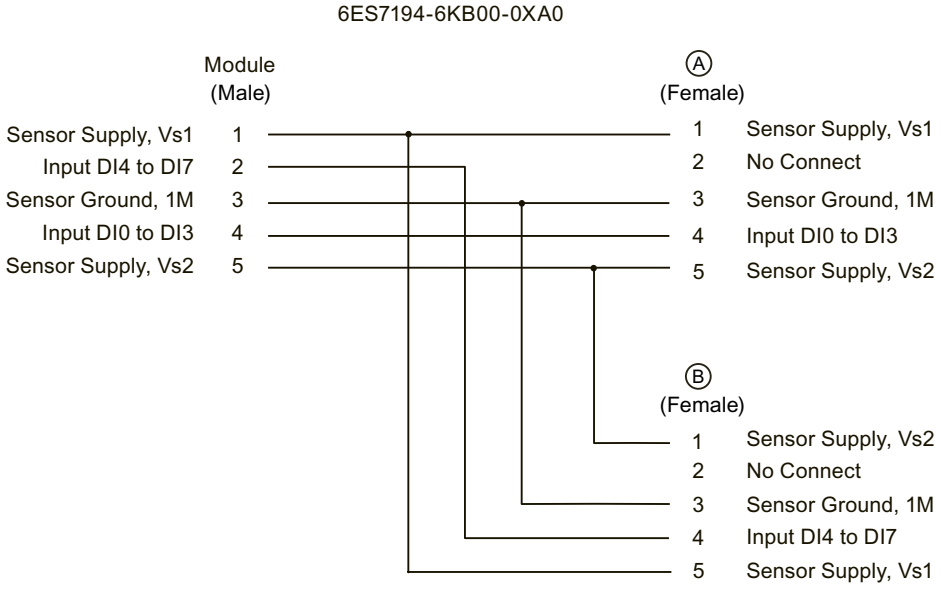
Refer to "Pin assignment of digital inputs" (Page 120) for further information.



Screw into the fail-safe input M12 circular connector on the distributed I/O device

Connection to the input sensors via the M12 circular connectors

The wiring of the Y cable is shown below:

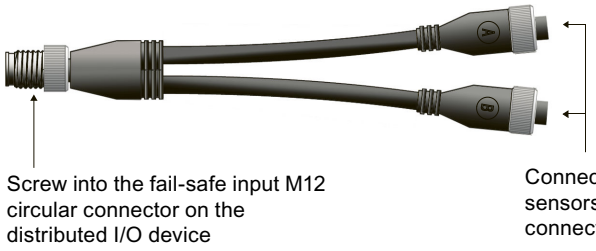


SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable (6ES7194-6KA00-0XA0)

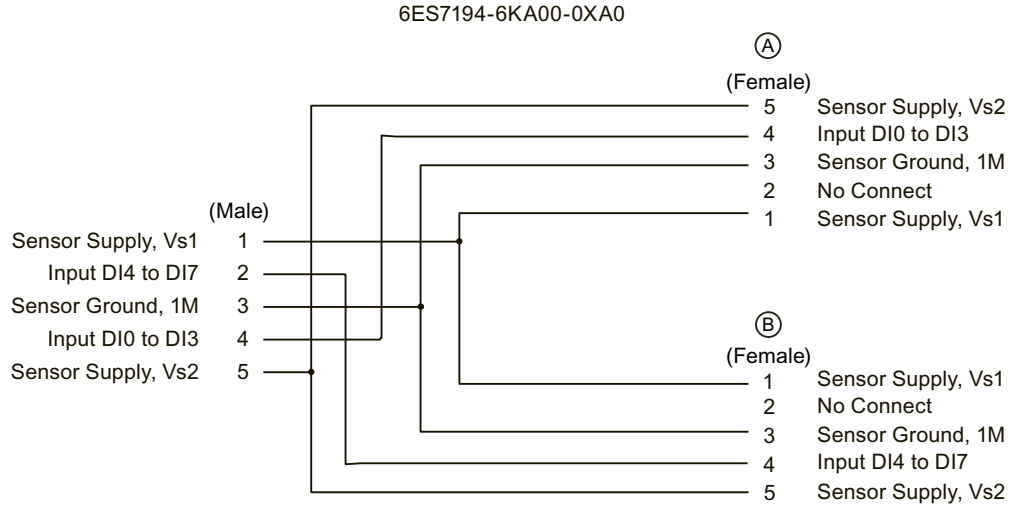
Use this Y cable (6ES7194-6KA00-0XA0) for applications with the following requirements:

- Sensor connections to the 5-pin M12 circular sockets (X1 to X4) on the front panel of the I/O device
- 1oo1 evaluation (double connection of I/O with one cable) (See the wiring diagram below.)

Refer to "Pin assignment of digital inputs" (Page 117) for further information.



The wiring of the Y cable is shown below:

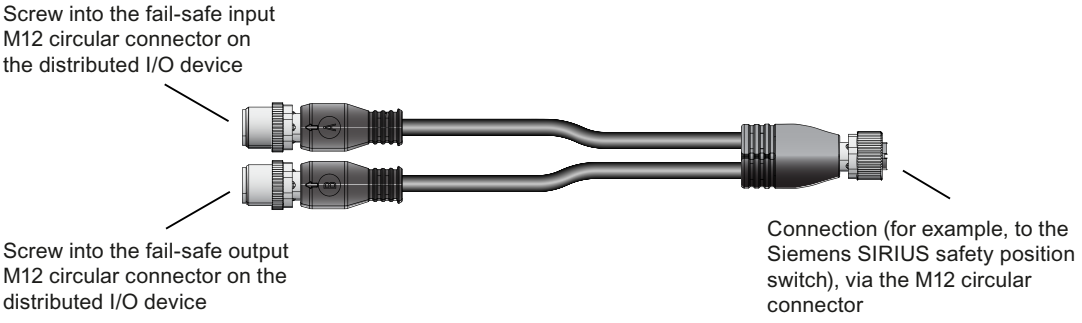


SIMATIC DP, Inverted Y cable for distributed I/O for connecting an F-DI and F-DQ with one cable (6ES7194-6KC00-0XA0)

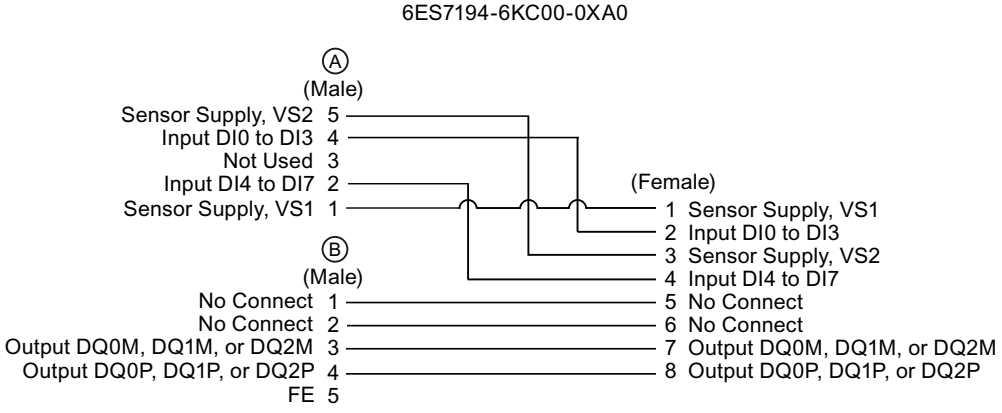
Use this inverted Y cable (6ES7194-6KC00-0XA0) for applications with the following requirements (for example, connecting a SIRIUS safety position switch):

- Sensor connections to the 5-pin M12 circular sockets (X1 to X4) on the front panel of the I/O device
- 1oo1 evaluation (connection of an F-DI and F-DQ with one cable) (See the wiring diagram below.)

Refer to "Pin assignment of digital inputs" (Page 120) and "Pin assignment of digital outputs" (Page 121) for further information.



The wiring of the inverted Y cable is shown below:



5.2.8 Pin assignment of connectors

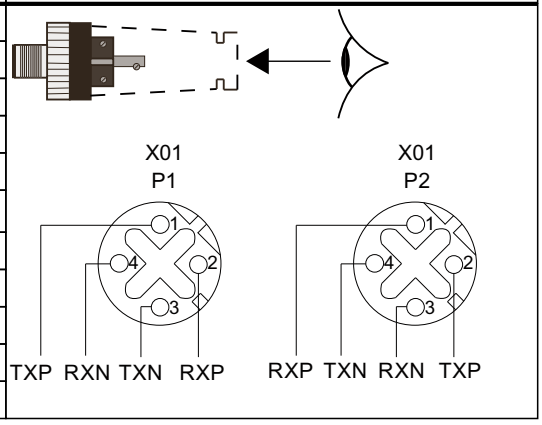
5.2.8.1 Pin assignment of the PROFINET connector

PROFINET connector, X01 connector, port 1 and port 2

The module has a M12 connector with four female pins that are D-coded.

Table 1-1150 Pin assignment of the M12 cable connector for PROFINET connector, ports 1 and 2

Pin	Assignment	View of the cable connector (PROFINET), port 1 and port 2
	Assignment X01 P1	

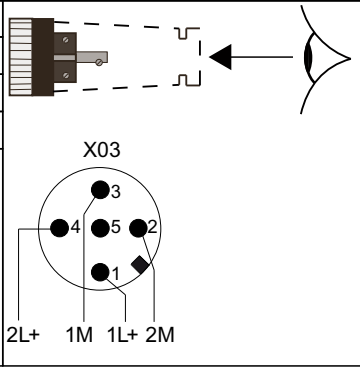
Pin	Assignment	View of the cable connector (PROFINET), port 1 and port 2
1	TXP	
2	RXP	
3	TXN	
4	RXN	
Thread	Functional earth FE	
	Assignment X01 P2	
1	RXP	
2	TXP	
3	RXN	
4	TXN	
Thread	Functional earth FE	

5.2.8.2 Pin assignment for feeding and looping the voltage

Cable connector for supply voltage infeed, X03 connector

The module has an M12 connector with five male pins that are A-coded.

Table 1-1151 Pin assignment of the M12 cable connector for the supply voltage infeed

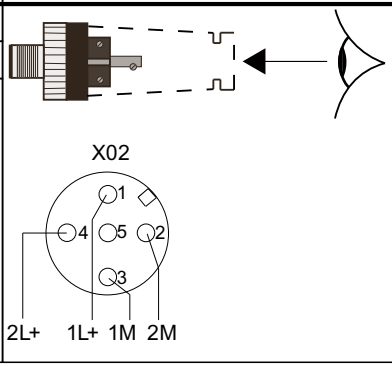
Pin	Assignment	View of the cable connector (wiring side)
1	Supply voltage 1L+	
2	Ground 2M	
3	Ground 1M	
4	Supply voltage 2L+	
5	Reserved	

Cable connector for loop-through of the supply voltage, X02 socket

The module has an M12 connector with five female pins that are A-coded.

Table 1-1152 Pin assignment of the M12 cable connector for loop-through of the voltage

Pin	Assignment	View of the cable connector (wiring side)
1	Supply voltage 1L+	
2	Ground 2M	

Pin	Assignment	View of the cable connector (wiring side)
3	Ground 1M	
4	Supply voltage 2L+	
5	Reserved	

NOTE

The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

NOTE

PROFINET IO

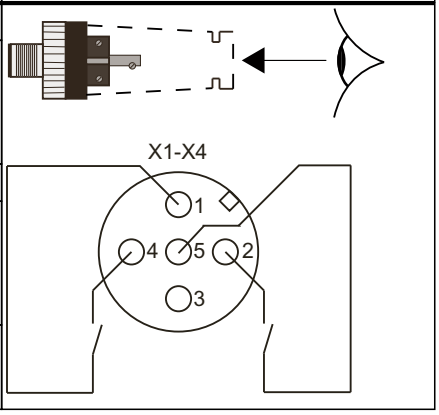
Modules with PROFINET interfaces may only be operated if all of the connected nodes are equipped with SELV/PELV power supplies (or with protection systems of equal quality).

5.2.8.3 Pin assignment of digital inputs

Cable connector for digital inputs, X1 - X4

The module has an M12 connector with five female pins that are A-coded.

Table 1-1153 Pin assignment of digital inputs

Pin	Assignment	View of the cable connector (wiring side)
1	24 V DC sensor supply Vs1	
2	Input signal DI_4: Connector X1 Input signal DI_5: Connector X2 Input signal DI_6: Connector X3 Input signal DI_7: Connector X4	
3	Sensor supply ground 1M	
4	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4	
5	24 V DC sensor supply Vs2	

NOTE

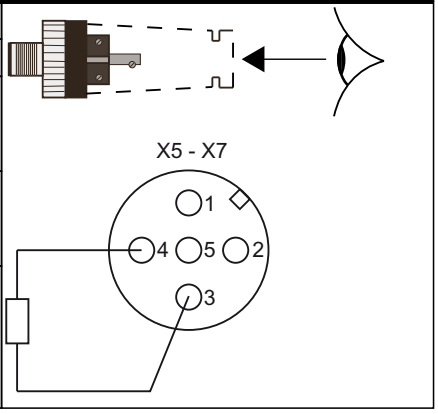
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

5.2.8.4 Pin assignment of digital outputs

Cable connector for digital outputs, X5 - X7

The module has an M12 connector with five female pins that are A-coded.

Table 1-1154 Pin assignment of digital outputs

Pin	Assignment	View of the cable connector (wiring side)
1	Not used	
2	Not used	
3	Output signal DQ_0-M: Connector X5 Output signal DQ_1-M: Connector X6 Output signal DQ_2-M: Connector X7	
4	Output signal DQ_0-P: Connector X5 Output signal DQ_1-P: Connector X6 Output signal DQ_2-P: Connector X7	
5	Functional earth FE	

NOTE

The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

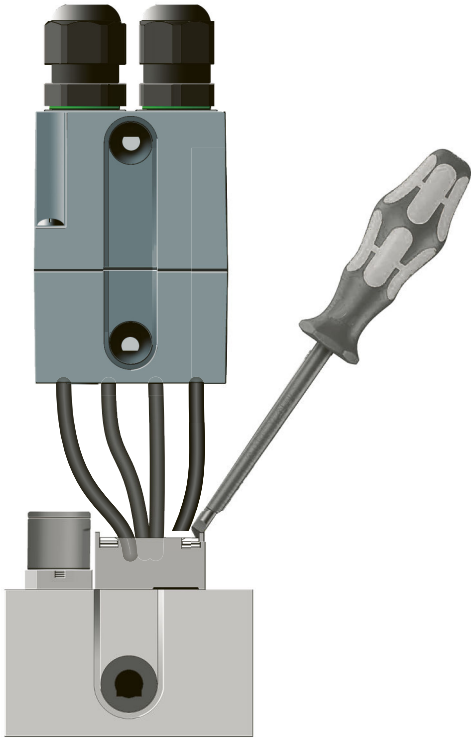
5.2.9 Wiring the terminal block

Tools required

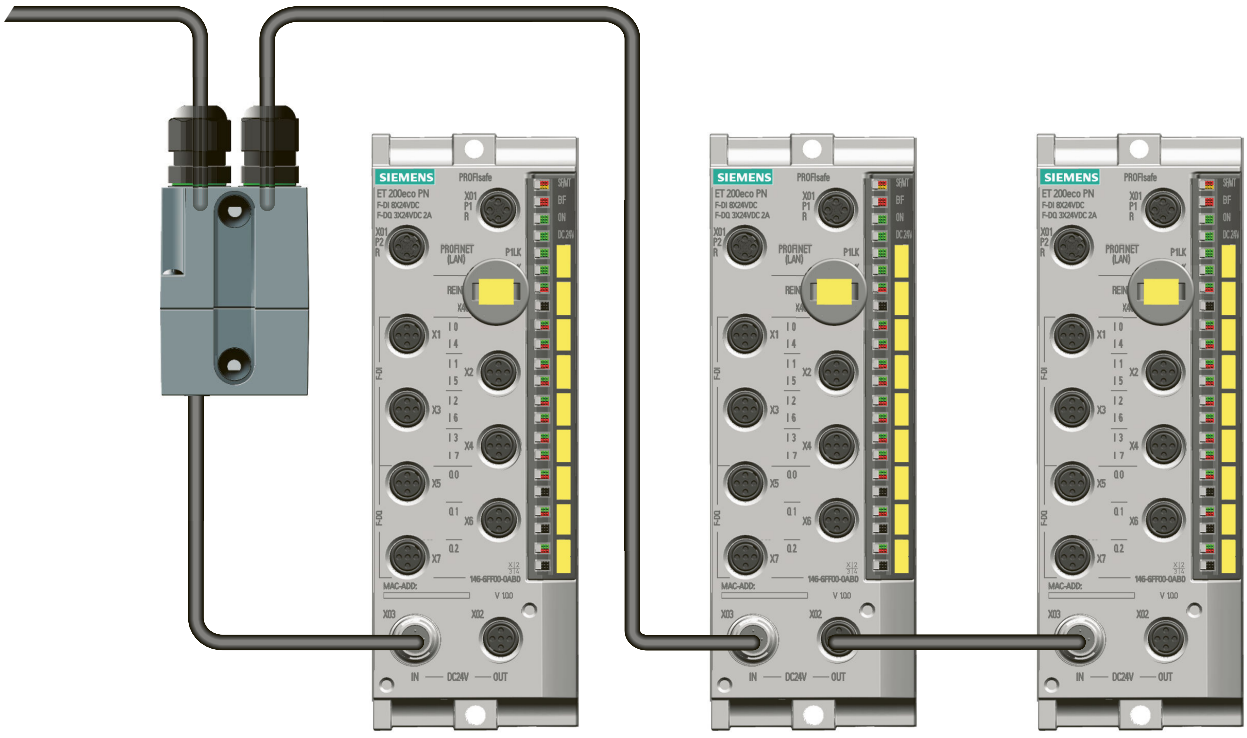
You need a medium-sized cross-tip screwdriver to screw on the terminal block and a slotted screwdriver to press down the insulation displacement terminals.

Wiring the terminal block connectors

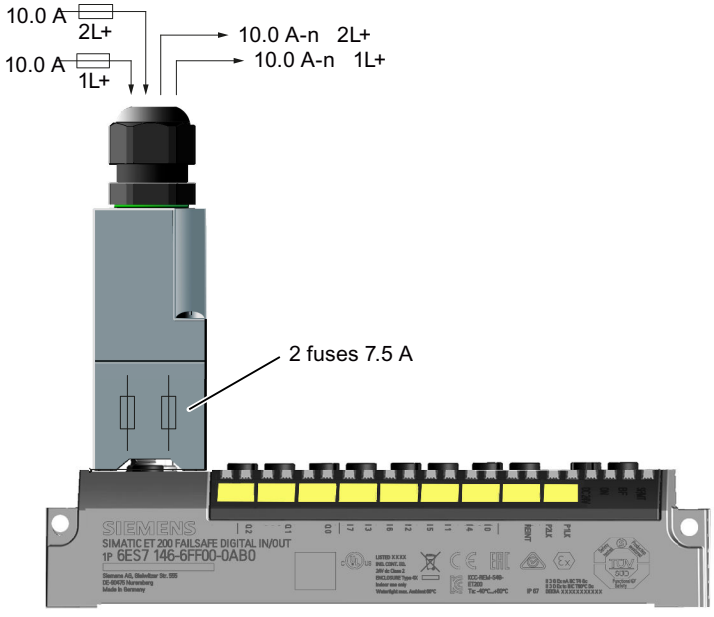
You do not have to strip the cables. You strip the cables automatically when you press down the insulation displacement terminals.



The following figure shows an example of the separate installation of the terminal block and how to wire it to several I/O devices.



You can tap a maximum load of 4.0 A from each supply voltage of the I/O device. You can loop-through the remaining supply voltages.



Pin assignment

The tables below show the terminal block pin assignments:

Table 1-1155 Pin assignment of the insulation displacement terminal block

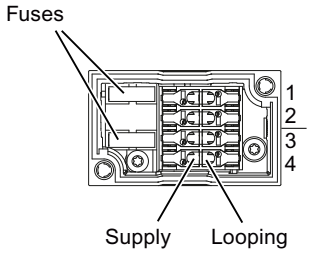
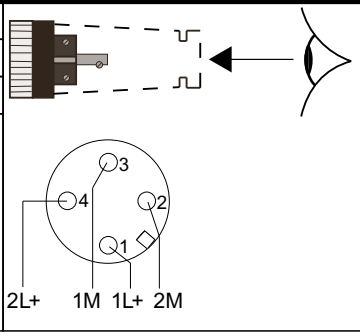
Pin	Assignment	View of the insulation displacement terminal block:
1	24 V DC 1L+	
2	Ground 1M	
3	24 V DC 2L+	
4	Ground 2M	

Table 1-1156 Pin assignment of the M12 connector

Pin	Assignment	View of the cable connector
1	24 V DC 1L+	
2	Ground 2M	
3	Ground 1M	
4	24 V DC 2L+	

Information on wiring

Keep the following considerations in mind when you wire the terminal block:

- If you wire your configuration, you must take into account the impact of cable length on the supply voltage to the ET 200eco PN (permitted tolerance).
- The maximum infeed current of the terminal block is 10.0 A for 1L+ and 10.0 A for 2L+. Do not exceed these values.

⚠ CAUTION

If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you risk overheating the cable insulation and contacts resulting in damage to the device.
Electrical faults or unexpected machine operation can result in minor personal injury if proper precautions are not taken.
You must follow all instructions for installation and maintenance of a proper operating environment to ensure the equipment operates safely.

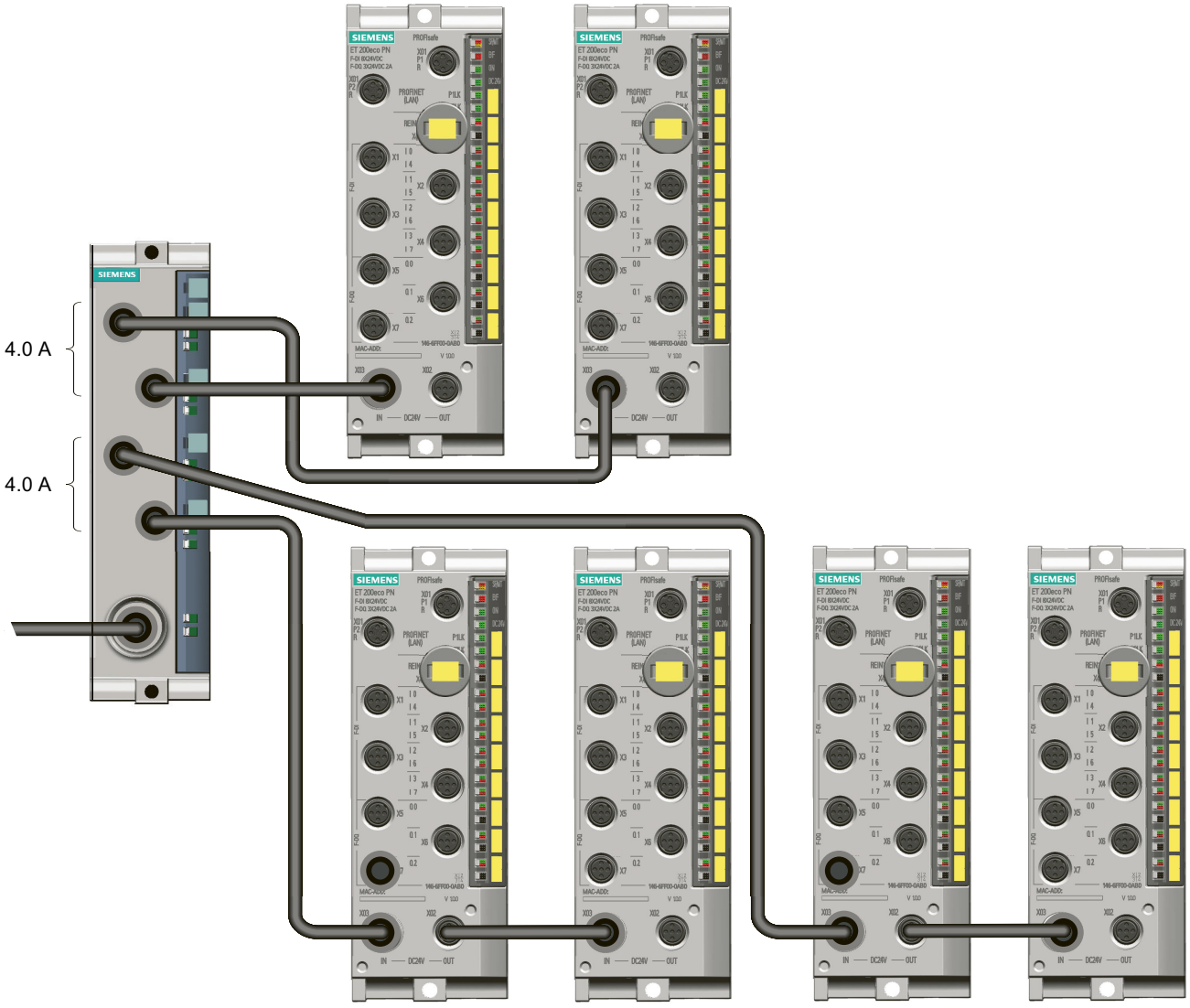
Additional information

Refer to "Installing the terminal block" (Page 98) and "Terminal block" (Page 184) technical specifications for further information.

5.2.10 Wiring the voltage distributor

Wiring the connectors

The following figure shows an example of the configuration of the PD DC 24V 1×7/8" 4×M12 voltage distributor with connected I/O devices:



Pin assignment

The tables below show the pin assignments:

Table 1-1157 Pin assignment of the 7/8" connector at the current input

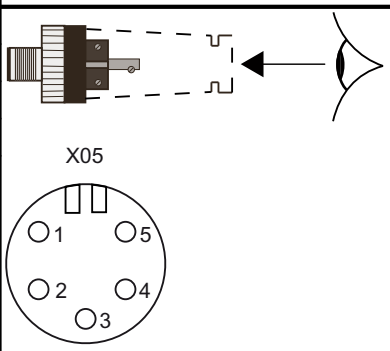
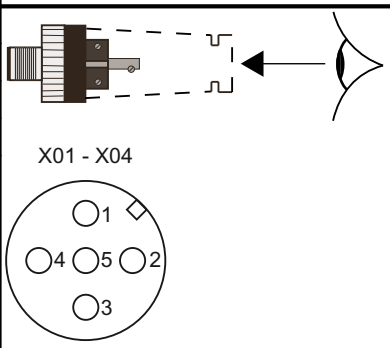
Pin	Assignment	View of the 7/8" cable connector, 24 V DC connection
1	Ground 2M	
2	Ground 1M	
3	Functional earth FE	
4	24 V DC 1L+	
5	24 V DC 2L+	

Table 1-1158 Pin assignment of the M12 connector at the current output

Pin	Assignment	View of the M12 connection plug (front view)
1	24 V DC 1L+	
2	Ground 2M	
3	Ground 1M	
4	24 V DC 2L+	
5	Not used	

Information on wiring

Keep the following considerations in mind when you wire the voltage distributor:

- If you wire your configuration, you must take into account the impact of cable length on the supply voltage to the ET 200eco PN F (permitted tolerance).
- The maximum infeed current of the voltage distributor is 8.0 A for 1L+ and 8.0 A for 2L+. Do not exceed these values.

⚠ CAUTION

If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you risk overheating the cable insulation and contacts resulting in damage to the device.
Electrical faults or unexpected machine operation can result in minor personal injury if proper precautions are not taken.
You must follow all instructions for installation and maintenance of a proper operating environment to ensure the equipment operates safely.

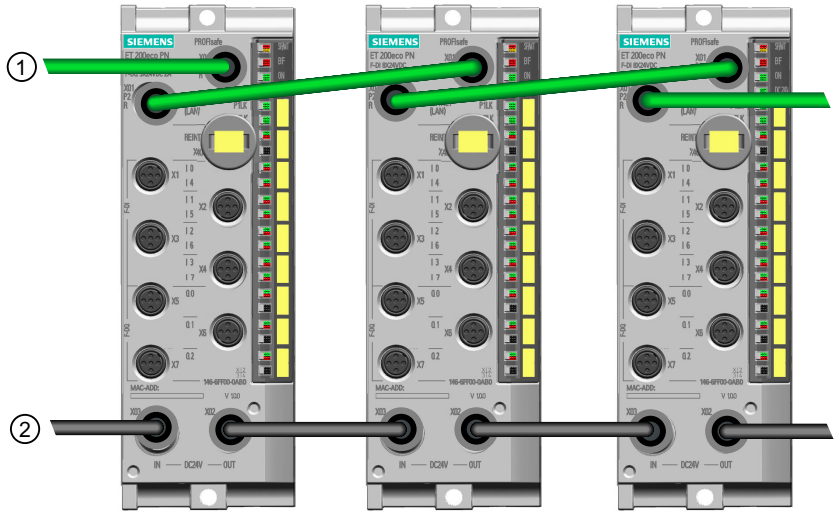
Additional information

Refer to "Voltage distributor" (Page 184) technical specifications for further information.

5.2.11 Looping PROFINET and the supply voltage

The I/O device is equipped with one connector (X03) for the infeed and one socket (X02) for loop-through of the supply voltage. The connector for infeed and the socket for loop-through are interconnected internally.

The I/O device is equipped with two sockets for PROFINET IO (X01 P1 and X01 P2). One socket is available for the infeed and one socket for loop-through of the PROFINET IO.



① PROFINET
② Supply voltage

Information on wiring

Keep the following considerations in mind when you loop PROFINET and the supply voltage:

- If you wire your configuration, you must take into account the impact of cable length on the supply voltage to the ET 200eco PN F (permitted tolerance).
- The maximum infeed current of the I/O device is 4.0 A for 1L+ and 4.0 A for 2L+.

  Do not exceed these values.

⚠ CAUTION

If you do not adhere to the maximum infeed currents and the cable cross-sections required for these currents, you risk overheating the cable insulation and contacts resulting in damage to the device.

Electrical faults or unexpected machine operation can result in minor personal injury if proper precautions are not taken.

You must follow all instructions for installation and maintenance of a proper operating environment to ensure the equipment operates safely.

Reference

Refer to "Pin assignment of connectors" (Page 117) for further information on pin assignment for PROFINET and feeding and looping the voltage connectors.

5.2.12 Guidelines for inductive loads

Guidelines for inductive loads

Use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off. Suppressor circuits protect your outputs from premature failure caused by the high voltage transient that occurs when current flow through an inductive load is interrupted.

In addition, suppressor circuits limit the electrical noise generated when switching inductive loads. High frequency noise from poorly suppressed inductive loads can disrupt the operation of the module. Placing an external suppressor circuit so that it is electrically across the load and physically located near the load is the most effective way to reduce electrical noise.

ET 200eco PN F-DI 8 / F-DQ 3 module DC outputs include internal suppressor circuits that are adequate for inductive loads in most applications.

A good suppressor solution is to use contactors and other inductive loads for which the manufacturer provides suppressor circuits integrated in the load device, or as an optional accessory. However, some manufacturer provided suppressor circuits may be inadequate for your application. An additional suppressor circuit may be necessary for optimal noise reduction.

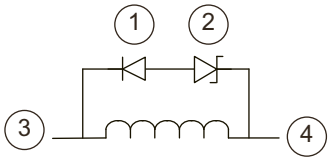
A well-controlled turn-off transient will have a ring frequency of no more than 10KHz, with less than 1KHz preferred. The data sheets list voltage thresholds for the internal suppression circuits on DC outputs. (Refer to Appendix A: "Technical specifications" (Page 173) for further information.) External suppression should limit the transient to less than this threshold to ensure that the internal suppression circuit does not attempt to suppress an excessive load.

An external suppression circuit connected directly across the load also avoids the hazard of energizing the load if suppression circuit components fail short.

NOTE

The effectiveness of a suppressor circuit depends on the application and must be verified for your particular usage. Ensure that all components are correctly rated and use an oscilloscope to observe the turn-off transient.

Typical suppressor circuit for DC outputs that switch DC inductive loads



① Diode

In most applications, the addition of a diode ① across a DC inductive load is suitable, but if your application requires faster turn-off times, then the addition of a Zener diode ② is recommended. Be sure to size your Zener diode properly for the amount of current in your output circuit.

② Zener diode
③ Output channel F-DQ (P-switch)
④ Output channel F-DQ (M-switch)

In most applications, the addition of a diode ① across a DC inductive load is suitable, but if your application requires faster turn-off times, then the addition of a Zener diode ② is recommended. Be sure to size your Zener diode properly for the amount of current in your output circuit.

Configuring

6

All connected fail-safe I/O must have their operating properties configured by the STEP 7 Safety configuration software. You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

6.1 Configuring the ET 200eco PN F-DI 8 / F-DQ 3 module

You configure the ET200eco PN F-DI 8 / F-DQ 3 using the TIA Portal. STEP 7 configuration of the module requires a Hardware Support Package (HSP).

Refer to "Step 3: Configuring the ET 200eco PN F-DI 8 / F-DQ 3" (Page 35) in the Getting Started chapter for step-by-step instructions.

6.2 Configuring the ET 200eco PN F-DI 8 / F-DQ 3 module I/O properties

All connected fail-safe modules must have their operating properties configured by the STEP 7 Safety configuration software. You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

To configure fail-safe module I/O properties, follow these steps:

1. Select "Device configuration" in the project tree.
2. Place fail-safe I/O devices into your project's "Device view".

NOTE

The ET 200eco PN F-DI 8 / F-DQ 3 uses more I and Q memory than required for the physical number of inputs and outputs on the module. The extra bytes carry the PROFIsafe safety status and data integrity information.

The number of input (I) bytes and output (Q) bytes that the ET 200eco PN F-DI 8 / F-DQ 3 requires depends upon which PROFIsafe profile your fail-safe CPU uses. If using PROFIsafe profile V2.4 (with S7-300/S7-400), the module requires 7 input (I) bytes and 5 output (Q) bytes. If using PROFIsafe profile V2.6 (with S7-1200/S7-1500), the module requires 8 input (I) bytes and 6 output (Q) bytes.

Module	PROFIsafe profile	Input (I) bytes required	Output (Q) bytes required
ET 200eco PN F-DI 8 / F-DQ 3	V2.4 (with S7-300/S7-400)	7	5
	V2.6 (with S7-1200/S7-1500	8	6

3. Select the image of a fail-safe I/O device (on the Device view or Device overview) and view the module's "Properties" tab.
4. On the **"Properties"** view, select the **"General"** tab.

5. Click on the module properties tree and expand the branches for an I/O module. You can select a module (for example, "ET 200eco PN F-DI 8 / F-DQ 3") and see all the properties. You can also select a module branch (for example, "F-parameters", "DI-parameters", or "Channel parameters") and see a subset of the properties.
6. Select a property in the left-side property tree and then set values in the right-side property fields.
7. A successful compile and download of your hardware configuration to an S7-1200/1500, S7-300/400, ET 200pro (IP67 compliant), or ET 200S/ET 200SP fail-safe CPU automatically puts your new configuration settings in the I/O modules.

6.3 Configuring F-parameters

The image below shows the F-parameters for the ET 200eco PN F-DI 8 / F-DQ 3:

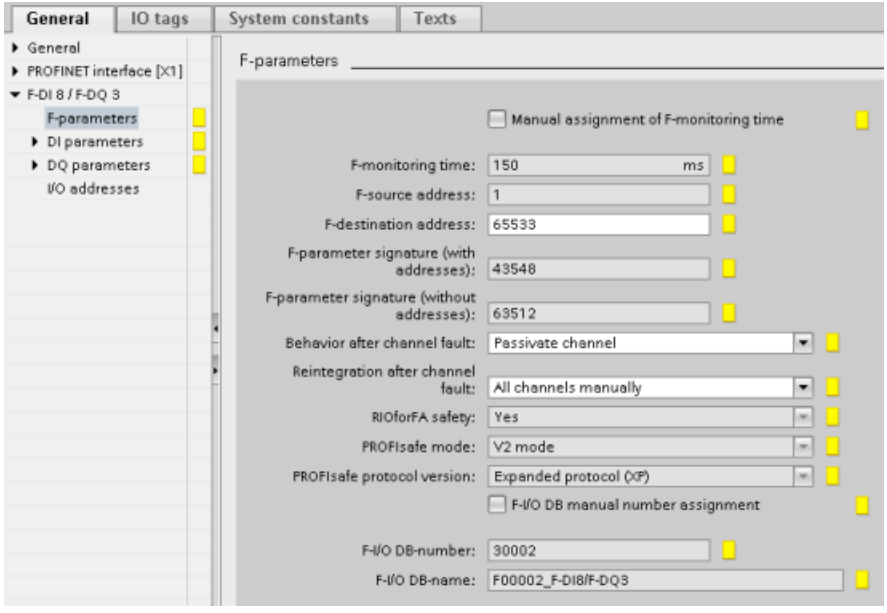


Table 1-1159 F-parameters

F-parameters	Description	Default	Options
Manual assignment of F-monitoring time	You must select the check box to change PROFIsafe F-monitoring time from the central value propagated by the fail-safe CPU.	Check box deselected	Check box: • Selected (manual assignment enabled) • Deselected (manual assignment disabled)
F-monitoring time [1]	Watchdog timer monitoring safety-related communication between the fail-safe CPU and ET 200eco PN F-DI 8 / F-DQ 3 (PROFIsafe monitoring time) Note: Disabled if "Manual assignment of F-monitoring time" check box is deselected.	150 ms	1 to 65535 ms in 1 ms steps

[1] STEP 7 uses this number to set the F-monitoring time in each ET 200eco PN F-DI 8 / F-DQ 3 unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

F-parameters	Description	Default	Options
F-source address	Unique network-wide address for the fail-safe CPU	1 (Always disabled)	1 to 65534 Note: You can configure the F-source address using the fail-safe CPU parameter "Central F-source address".
F-destination address	Unique F-destination address for each fail-safe module (usually in descending order, starting with 65534)	65534 (Always enabled)	1 to 65534
F-parameter signature (with addresses)	Signature for all F-parameters including addresses; used to uniquely identify a given set of parameterization values	Always disabled	
F-parameter signature (without addresses)	Signature for all F-parameters without addresses; used to uniquely identify a given set of parameterization values	Always disabled	
Behavior after channel fault	Passivation response by the ET 200eco PN F-DI 8 / F-DQ 3 to channel faults such as a short-circuit, overload, or discrepancy error	Passivate channel (Always enabled)	• Passivate channel • Passivate the entire module
Reintegration after channel fault	You have two methods, manual and automatic, to reintegrate your ET 200eco PN F-DI 8 / F-DQ 3 channels after a channel fault. You can configure one of the following options: • All channels automatically (no acknowledgement necessary for reintegration) • All channels manually (acknowledgement necessary for reintegration) • Adjustable (reintegration method is selectable (manual or automatic) channel-by-channel)	All channels manually (Always enabled)	• Adjustable • All channels automatically • All channels manually
F-I/O DB manual number assignment	You must select the check box to enable manual assignment of DB numbers.	Check box deselected	Check box: • Selected • Deselected
F-I/O DB number	F I/O block DB number: • Disabled if F-I/O DB manual number assignment check box is deselected (DB number derived from the Engineering Station (ES)) • Enabled if F-I/O DB manual number assignment check box is selected (edited by user)	-	-
F-I/O DB name	F I/O block DB name	Always disabled	-

[1] STEP 7 uses this number to set the F-monitoring time in each ET 200eco PN F-DI 8 / F-DQ 3 unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

Refer to the SIMATIC, Industrial Software, SIMATIC Safety - Configuring and Programming, Programming and Operating Manual (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for further F-parameter information.

6.4 Configuring the ET 200eco PN F-DI 8 / F-DQ 3 module DI and channel parameters

The image below shows the sensor supply parameters for the F-DI on the ET 200eco PN F-DI 8 / F-DQ 3:

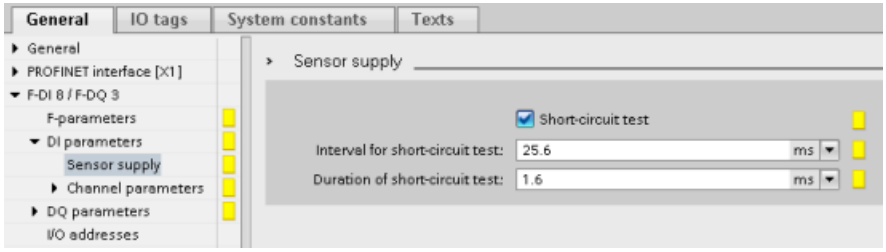
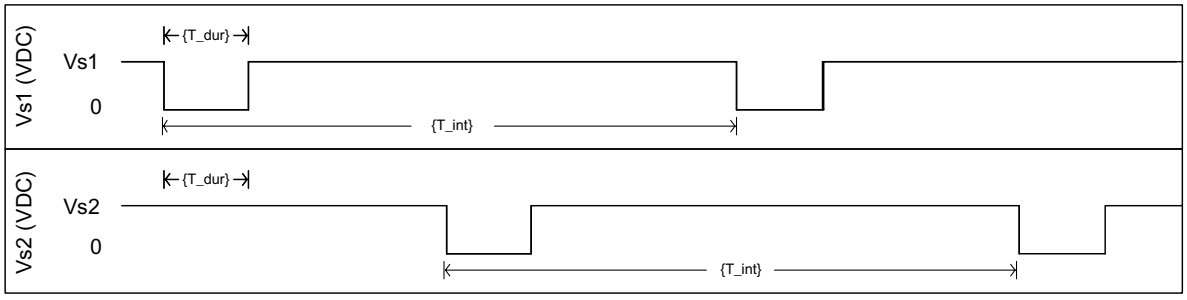


Table 1-1160 ET 200eco PN F-DI 8 / F-DQ 3 DI parameters

DI parameters	Description	Default	Options
Short-circuit test	This test creates short duration OFF pulses on the sensor power supplies. Input circuits powered by Vs1 and Vs2 are expected to be OFF during the sensor OFF time. Failure to detect OFF when a sensor supply is OFF indicates a short-circuit to a power source or another fault that prevents the input from properly detecting a "0". Input channels which fail this test are passivated. During the test, the reported process value will not change, so the configured "Duration of short-circuit test" increases the response time. An actual process "0" occurring near the beginning of a test will not be reported to the user program until after the "Duration of short-circuit test" time has elapsed. Note: The check box must be selected to activate the short-circuit test.	Check box selected	Check box: • Selected (short-circuit test enabled) • Deselected (short-circuit test disabled)
Interval for short-circuit test (see T_int in figure below)	Specifies how often the short circuit test is executed (Interval). It defines the period of time between two consecutive sensor supply off test pulses. This value is the time between the OFF pulses of the sensor supply. Refer to the figure below for further information. Note: The interval must be a minimum of eight times the duration. Note: Disabled if "Short-circuit test" check box is deselected.	25.6 ms	• 12.8 ms • 25.6 ms • 51.2 ms • 102.4 ms • 204.8 ms • 409.6 ms • 819.2 ms

DI parameters	Description	Default	Options
Duration of short-circuit test (see T_dur in figure below)	Specifies the duration of the test pulse generated by the sensor supply. It is the period of time for which the test pulse is applied. This value is the time that the power supply remains off during the test. The short-circuit test OFF pulse must be long enough for the external sensors and wiring to respond and present a "0" to the inputs. Refer to the figure below for further information. Note: The interval must be a minimum of eight times the duration. Note: Disabled if "Short-circuit test" check box is deselected.	1.6 ms	• 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms

Vs1 and Vs2 perform short-circuit testing independently, allowing module circuitry to detect shorts between the two sensor supplies:



Vsx Vs1 or Vs2 sensor supplies (VDC)
T_int Short-circuit test interval (time period) between the OFF pulses of the sensor supply
T_dur Short-circuit test OFF pulse time duration (msec)

The image below shows the channel parameters for the F-DI on the ET 200eco PN F-DI 8 / F-DQ 3:

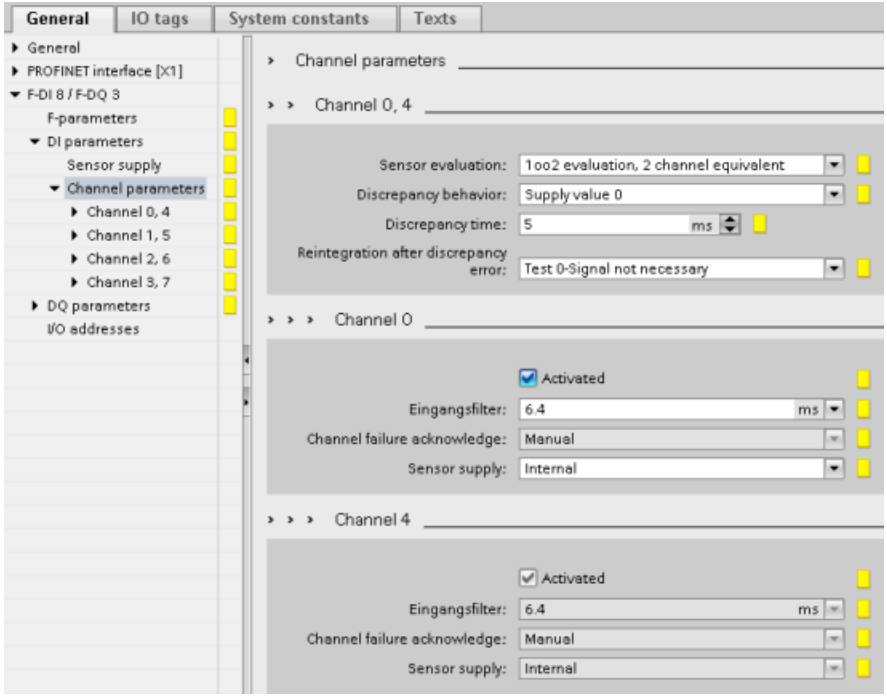


Table 1-1161 ET 200eco PN F-DI 8 / F-DQ 3 DI channel parameters

Channel parameters	Description	Default	Options
F-DI Channel Group Settings			
Sensor evaluation	Assigns whether “channel x” input operates individually (1oo1) or is paired with its companion channel "x+4" input (1oo2). Defines signal evaluation and wiring definitions. These selections correspond with the various application mode wiring examples. **1oo1 evaluation:** One sensor is connected to the module on a single channel. **1oo2 evaluation:** Two input channels are occupied by either: • **2 channel equivalent** (with equivalent signals): One two-channel equivalent sensor or two single-channel equivalent sensors are connected to the two channels, in a channel pair. • **2 channel - 3 wire nonequivalent**: One two-channel nonequivalent sensor is connected to the two channels, in a channel pair. • **2 channel - 4 wire nonequivalent** One two-channel nonequivalent sensor or two single-channel nonequivalent sensors are connected to the two channels, in a channel pair. If 1oo2 is selected, you must assign the discrepancy properties. Note: Refer to "Digital input applications" (Page 72) for illustrations of connection modes.	1oo2 evaluation, 2 channel equivalent	• 1oo1 evaluation • 1oo2 evaluation: – 2 channel equivalent – 2 channel - 3 wire nonequivalent – 2 channel - 4 wire nonequivalent

Channel parameters	Description	Default	Options
Discrepancy behavior	A 1oo2 input configuration allows a logical difference between the two signals, without error, for the configured discrepancy time. You can choose whether the reported process value should be "0" or the last valid value during the configured discrepancy time while the signals do not match. If a logical difference in 1oo2 inputs persists for more than the configured discrepancy time, the module or channel will become passivated with process value(s) set to 0.	Supply value 0	• Supply value 0 • Supply last valid value
Discrepancy time	The two signals in a 1oo2 input configuration will not change exactly at the same time, due to differences in sensors, contacts, and wiring. The discrepancy time parameter allows you to configure a normally expected duration for a mismatch between signals during transition.	5 ms	5 ms to 30000 ms in 1 ms steps
Reintegration after discrepancy error	Assigns whether a zero state must be detected on both 1oo2 inputs before a previously declared discrepancy can be cleared. A channel cannot be reintegrated until a zero has been detected on both 1oo2 signals.	Test 0-Signal not necessary	• Test 0-Signal necessary Note: The test 0-signal must be applied for at least 100 ms. • Test 0-Signal not necessary
F-DI Channel Settings			
Activated	Select the check box to activate the channel. Deselect the check box and the unused channel is deactivated. If you deactivate a channel, you also deactivate its diagnostic function.	Check box selected	Check box: • Selected (channel activated) • Deselected (channel deactivated)
Input filter	The module filters the digital inputs to remove contact bounce and short duration noise. This parameter assigns the duration of the filter time.	6.4 ms	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms
Channel failure acknowledge	Controls whether the channel is automatically reintegrated after a fault clears, or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults" (Page 148) for the reintegration procedure.	Manual	• Automatic • Manual Note: The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can override the "Channel failure acknowledge" parameter's selection.
Sensor supply	You can assign whether to supply 24 V DC power to sensors from a sensor supply output of the module (internal) or from an external power supply (external). Note: Short-circuit tests are not performed for any channel where external power is selected.	Internal	• Internal • External

NOTE

When you select the channel group as 1oo2, the module enables the parameters in the first channel of the group and completely disables the parameters in the second channel of the group. The second channel derives its parameter values from the first channel's parameter values.

When you select the channel group as 1oo1, the module enables all of the parameters in both channels.

NOTE

Safety program access to 1oo2 input data

For 1oo2 evaluation, two paired input channels (for example, F-DI 0 and F-DI 4) are connected to one or two sensors. The F-DI performs the discrepancy analysis and sends the result to the safety program, **at the input address of the low-numbered channel** (F-DI 0, in the example).

Sensor-actuator response time is increased when you add more input discrepancy time

The discrepancy time adds directly to the maximum response time of a 1oo2 evaluation if the two signals do not agree in logical state. If you select the "Supply value 0" option, then the F-DI does not delay a transition from "1" to "0", but can delay the transition from "0" to "1". If you select the "Supply last valid value" option, then the F-DI can delay both transitions from "1" to "0' and "0" to "1". The discrepancy time is influenced by sensor specifications, installation tolerances, and wiring. For best response time, select the smallest discrepancy time that provides reliable normal operation. Refer to "Response time parameters for the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs" (Page 190) for further information.

Discrepancy time variation with short circuit test

If your process input changes near a short-circuit test, a discrepancy is detected in less time than your configured discrepancy time.

With:

Tdisc = configured discrepancy time

Tsct = configured short circuit test duration

Tfilter = configured input filter time

Tda = actual discrepancy time, time between process signal changes that can be detected as a fault

The range of detected discrepancy time is:

If Tfilter < Tsct: {Tdisc - (Tfilter + Tsct)} <= Tda <= Tdisc

If Tfilter >= Tsct: {Tdisc - (2 x Tsct)} <= Tda <= Tdisc

Your configured discrepancy time should account for this variation to avoid unexpected passivations.

6.5 Configuring the ET 200eco PN F-DI 8 / F-DQ 3 module DQ and channel parameters

The image below shows the parameters for the F-DQ on the ET 200eco PN F-DI 8 / F-DQ 3:

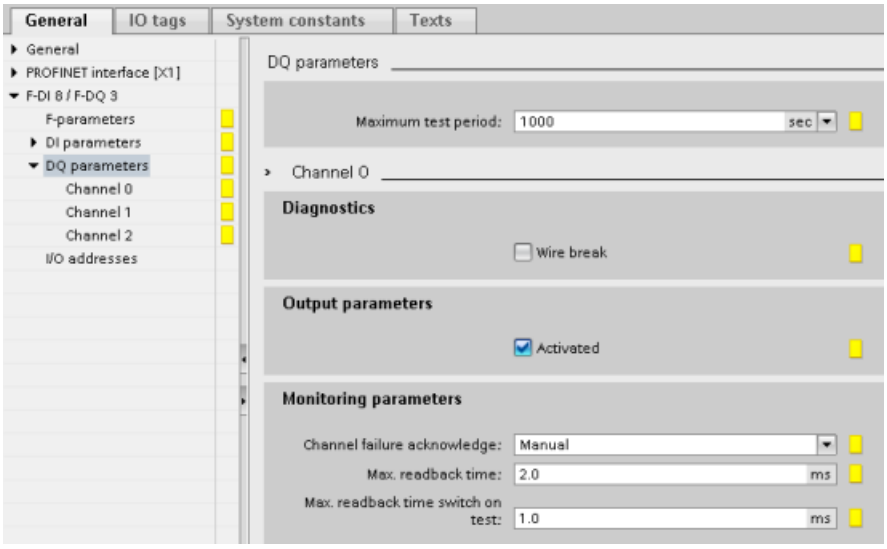


Table 1-1162 ET 200eco PN F-DI 8 / F-DQ 3 DQ parameters

DQ parameters	Description	Default	Options
Maximum test period	Assign the time interval between bit pattern tests for F-DQ DC output faults. Functional bit pattern tests are applied to the output switches. These tests detect faulted P- or M- output switches and wiring faults. Short circuits to other signals or power rails can be detected. Open circuits between the wiring terminals and the load are not detected. If an error is detected on a channel, the test interval is shortened to approx. 1 min. If an error is no longer detected, the configured test interval is used again. A persistent fault is reported to the fail-safe CPU and the affected channels are passivated.	1000 sec	• 100 sec • 1000 sec

Table 1-1163 ET 200eco PN F-DI 8 / F-DQ 3 DQ channel parameters

Channel parameters	Description	Default	Options
Wire break	You can activate or deactivate wire break testing.	Check box deselected	Check box: • Selected (wire break activated) • Deselected (wire break deactivated)
Activated	Select the check box to activate the channel. Deselect the check box and the unused channel is deactivated. If you deactivate a channel, you also deactivate its diagnostic function.	Check box selected	Check box: • Selected (channel activated) • Deselected (channel deactivated)

Channel parameters	Description	Default	Options
Channel failure acknowledge	Controls whether the channel is automatically reintegrated after a fault clears, or requires an acknowledgement (manual) in the user program. Refer to "Reactions to faults" (Page 148) for the reintegration procedure.	Manual	• Automatic • Manual Note: The configuration of the "F-Parameters": "Reintegration after channel fault" parameter can override the "Channel failure acknowledge" parameter's selection.
Maximum readback time	The maximum readback time is a user-configured parameter that assigns the maximum time allowed for an output to reach the new state (ON or OFF) due to a process value change without generating an error. Also, this is the maximum width of a diagnostic test pulse applied to verify that an output can be turned OFF while it is ON. The time of the OFF pulse should be as long as possible, but short enough so that the actuator cannot react.	2.0 ms	1.0 ms to 400.0 ms, in 0.1 ms increments
Maximum readback time switch on test	The maximum readback time switch on test is a user-configured parameter that assigns the maximum time for which the P-switch or the M-switch of a channel that is currently in OFF state can be switched ON during a bit pattern test step. This action tests the P- and M-switches on a channel such that only one switch is turned on at a time. Unless there is a fault in the system (for example, actuator shorted to ground), the actuator is not energized during either the P- or M-switch on tests. Under single fault conditions (either internal or external to the module), test pulses applied to either the P- or the M-switch of channels in the OFF state can repeatedly energize the actuator. You must select the parameter so that the duration of such pulses is too short to cause the actuator to react and, therefore, cannot have a hazardous effect on the equipment under control.	1.0 ms	0.5 ms to 5.0 ms, in 0.1 ms increments

⚠ WARNING

In the presence of a single fault, the bit pattern tests can apply energy to the load for a duration up to the configured "Maximum readback time switch on test".
If the load can respond dangerously within the configured readback time, it can respond to bit pattern tests in the presence of a single fault, resulting in death or serious injury to personnel and/or property damage.
Always choose a maximum readback configuration time that is guaranteed not to activate the load.

6.6 Assigning PROFIsafe addresses

Fail-safe ET 200eco PN modules, fail-safe ET 200SP modules, fail-safe S7-1500/ET 200MP modules, and fail-safe S7-1200 modules do not have a DIP switch that allows you to set the unique F-destination address for each module. Instead, you assign the PROFIsafe address consisting of the F-source address and the F-destination address directly from STEP 7 Safety for fail-safe ET 200eco PN modules, fail-safe ET 200SP modules, and fail-safe S7-1500/ET 200MP modules.

The S7-1200 CPU automatically assigns the PROFIsafe address consisting of the F-source address and the F-destination address to the fail-safe S7-1200 modules.

6.6.1 Basic PROFIsafe address assignment steps

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address and F-source address in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the ET 200eco PN F modules to which you want to assign the configured F-destination and F-source addresses.
3. Assign the PROFIsafe addresses to the fail-safe modules.

NOTE

Refer to "Step 5: Assigning PROFIsafe addresses" (Page 42) in the Getting Started chapter for step-by-step instructions.

NOTE

Refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en) for further information about PROFIsafe address identification and assignment.

6.6.2 Identifying the ET 200eco PN F modules

6.6.2.1 Identification requirements

Ensure that you download the current hardware configuration before you assign the PROFIsafe addresses.

6.6.2.2 Identification procedure

You identify the ET 200eco PN F modules using the following steps:

1. In the network view, select the ET 200eco PN F module to which you want to assign the PROFIsafe address.
2. Right-click the ET 200eco PN F module, and select "Assign PROFIsafe address" from the context menu to display the "Assign PROFIsafe address" dialog.
3. In the "Identification" field, select the method to be used for identifying the ET 200eco PN F module:
   - "By LED flashing": This is the default setting. Channel Status LEDs of the ET 200eco PN F module that you want to identify flash upon identification.
   - "By serial number": If you cannot see the ET 200eco PN F module directly, you can identify the module by the serial number of the module.
4. In the "Assign" column, select the check box for the ET 200eco PN F module to which you want to assign the PROFIsafe address.
5. Click the "Identification" button, and compare the reaction of the fail-safe module to that in the table:
   - If you identify using LED flashing, check whether the Channel Status LEDs of the ET 200eco PN F module whose PROFIsafe address you want to assign are flashing green.
   - If you identify using the serial number, compare the displayed serial number to the serial number of the module.
6. In the "Confirm" column, select the check box for the ET 200eco PN F module for which you want to confirm the reaction of the fail-safe module in the table.

6.6.3 Assigning PROFIsafe addresses

6.6.3.1 Assignment requirements

In order to assign PROFIsafe addresses, you must have successfully identified your ET 200eco PN F modules and installed an eCoding plug on each module.

6.6.3.2 Assignment procedure

To assign the PROFIsafe addresses, proceed as follows:

1. Use the "Assign PROFIsafe addr..." button to assign the PROFIsafe address to the ET 200eco PN F modules. You may have to enter the password of the fail-safe CPU.
2. You must answer "yes" to the "Confirm PROFIsafe address assignment" dialog within 60 seconds to assign the PROFIsafe address.

6.7 Using the eCoding plug for PROFIsafe address assignment storage

The ET 200eco PN F-DI 8 / F-DQ 3 uses an eCoding plug to store the module's PROFIsafe addresses (F-source address and F-destination address).

⚠ WARNING

If you remove/insert the eCoding plug with the power connected, this can lead to undefined states in your system.
Death or serious personal injury and damage to the ET 200eco PN F-DI 8 / F-DQ 3 module and associated machines/equipment may result if proper precautions are not taken.
Only remove or replace the eCoding plug when the power is disconnected. Always comply with the required standards and safety guidelines when configuring a system.

NOTE

When replacing the ET200eco PN F module, transfer the eCoding plug inserted in the failed module to the replacement module to retain the PROFIsafe address stored in the eCoding plug. Otherwise, it is necessary to use the Engineering System to configure the PROFIsafe address in the replacement module. Ensure that eCoding plug in not accidentally inserted in a module other than the intended ET200eco PN F module.

Commissioning

7

7.1 PROFINET IO

7.1.1 Commissioning the ET 200eco PN F-DI 8 / F-DQ 3 on PROFINET IO

The commissioning of your distributed I/O system depends on the system configuration. The following procedure describes the commissioning of the ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O system on an IO controller.

Requirements for the ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O system on the PROFINET IO

NOTE

You must ensure the safety of your plant. To do so, you need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant. Plan the tests to include any possible foreseeable errors. This allows you to prevent people or plants from being placed in danger during operation.

Procedure

The following table shows the chapters in which the required actions are described:

Table 1-1164 Requirements for the ET 200eco PN F-DI 8 / F-DQ 3 distributed I/O system on the PROFINET IO

Step	Procedure	See...
1	Installing the ET 200eco PN F-DI 8 / F-DQ 3 module	"Installation" (Page 95)
2	Wiring the ET 200eco PN F-DI 8 / F-DQ 3 module	"Wiring" (Page 101)
3	Configuring the ET 200eco PN F-DI 8 / F-DQ 3 module	"Configuring" (Page 130)
4	Turning on the supply voltage for the ET 200eco PN F-DI 8 / F-DQ 3 module	"Wiring" (Page 101)

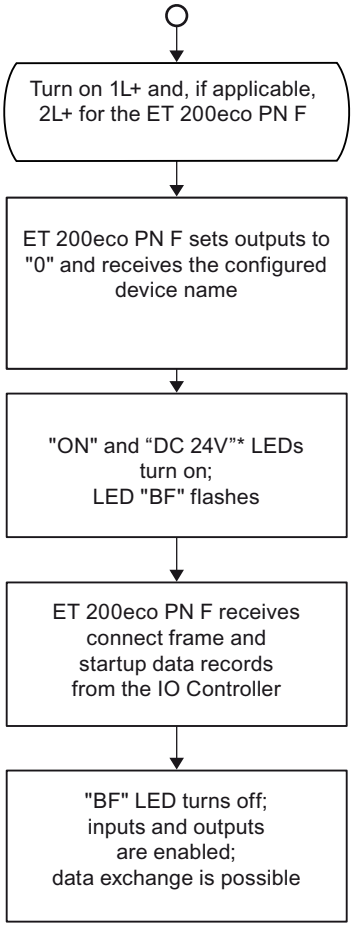
Reference

You can find additional information on assigning the PROFINET IO parameters in the PROFINET with STEP 7 V15 Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

7.1.2 Startup on PROFINET IO

Principle of operation

The diagram below illustrates the startup of the ET 200eco PN F-DI 8 / F-DQ 3 on PROFINET IO:



* "DC 24V" only for digital output and if 2L+ is connected

7.2 Identification and maintenance (I&M) data

7.2.1 Reading out and entering I&M data

Identification and maintenance (I&M) data is information that is saved either as read-only or read/write on the ET 200eco PN F-DI 8 / F-DQ 3 module.

Identification data (I&M0): Manufacturer information on the module that is read-only and in some cases is also printed on the module housing (for example, article number, serial number, and firmware version).

Maintenance data (I&M1, 2, 3): Plant-dependent information (for example, installation location). You create maintenance data during configuration and write that data to the module.

The ET 200eco PN F distributed I/O module supports I&M0 to I&M3.

The I&M data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a system
- Correcting errors in a system

With the I&M identification data, you have the option of clearly identifying modules online.

STEP 7 displays the identification data in the "Properties..." tabs (see STEP 7 online help).

Options for reading out I&M data

You have the following options for reading the I&M data:

- Using the user program
- Using STEP 7 or HMI devices

Procedure for reading I&M data by means of the user program

To read the I&M data of the ET 200eco PN F module in the user program, use the instruction "RDREC".

Procedure for reading the I&M data using STEP 7

NOTE

You must have an online connection to the ET 200eco PN F module.

1. In the project navigation, under "Distributed I/O", select the I/O device (for example, "ET 200eco PN F-DI 8 / F-DQ 3").
2. Select: **Go to device > Online & Diagnostics > Diagnostics** > **General** > "Module information" field

Procedure for input of maintenance data using STEP 7

STEP 7 assigns the default module name. You have the option to enter the following data:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)

To enter the data, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the ET 200eco PN F-DI 8 / F-DQ 3 module.
2. In the module Properties, select: **General** > "Identification & Maintenance" field
3. Enter your I&M data.

NOTE

You must select an Options setting before you can edit and download I&M1 to 3 data. Select: **Options** > **Settings** > **Hardware configuration** > **Compile & download** > "Download" field > "Download Identification & Maintenance (I&M) data" check box

STEP 7 downloads the I&M data during the downloading of the hardware configuration.

Reference

You can find additional information on ET 200eco PN F-DI 8 / F-DQ 3 I&M data in the "Distributed I/O ET 200eco PN Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW).

7.2.2 Data record structure for I&M data

Reading I&M data records (distributed using PROFINET IO)

You can directly access specific identification data by selecting the **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the associated data record index.

The following table shows the principle behind the structure of data records:

Table 1-1165 Basic structure of data records with I&M identification data

Contents	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	54 54 16 54	I&M0/Index $AFF0_H$ I&M1/Index $AFF1_H$ I&M2/Index $AFF2_H$ I&M3/Index $AFF3_H$

The following table shows the structure of data records for I&M identification data:

Table 1-1166 Data record structure for I&M identification data

Identification and maintenance data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
DEVICE_MAN_ID	read (1 Word)	0x002A	Name of the manufacturer ($2A_H$ = SIEMENS AG).
DEVICE_ID	read (20 Char)	6ES7146-6FF00-0AB0	Information to order the module
DEVICE_SER_NUM	read (16 Char)	Serial number	Serial number (device-specific)
HARDWARE_REVISION	read (2 Bytes)	0x0001	Corresponding hardware version
SOFTWARE_REVISION	read (1 Char, 3 Bytes)	V01.00.00	Provides information about the firmware version of the module
MODUL_REVISION_COUNTER	read (1 Word)	0x0000	Provides information about configured changes on the module
Profile_ID	read (1 Word)	0x0000 (PROFIsafe)	Generic device
Profile_Specific_Type	read (1 Word)	0x0005 (I/O Module)	Interface modules
IM_Version	read (2 Bytes)	0x0101 (Version 1.1)	Provides information about the version of the identification data
IM_Supported	read (1 Word)	0x000E	Provides information about the existing identification data (I&M1 though I&M3)
Maintenance data 1: (data record index AFF1 hex)			
TAG_FUNCTION	read/write (32 Bytes)	Initialized with 0x20 (Blank)	Enter an identifier for the module here that is unique plant-wide.
TAG_LOCATION	read/write (22 Bytes)	Initialized with 0x20 (Blank)	Enter the installation location of the module here.
Maintenance data 2: (data record index AFF2 hex)			
INSTALLATION_DATE	read/write (16 bytes)	Initialized with 0x20 (Blank)	Enter the installation date of the module here (YYYY-MM-DD HH:MM).
Maintenance data 3: (data record index AFF3 hex)			
DESCRIPTOR	read/write (54 bytes)	Initialized with 0x20 (Blank)	Enter a comment describing the module.

Diagnostics

8

8.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables. The value "0" (de-energized) represents this safe state for digital fail-safe modules. This applies to both sensors and actuators.

The safety function requires that safe state values be applied to the fail-safe channel(s) instead of process values (passivation of the fail-safe module or channel(s)) in the following situations:

- When the fail-safe system is started up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, short-circuit and discrepancy errors)

The fail-safe CPU enters detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-Safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, the modules detect any faults still existing again. The exception to this is a permanent deactivation fault such as "sustained over-voltage".

Fail-Safe value for fail-safe modules

If digital input channels are passivated , the fail-safe system always provides safe state values ("0") for the safety program instead of the process values applied to the fail-safe inputs.

If digital output channels are passivated in the fail-safe module digital outputs, the fail-safe system always transfers safe state values "0" to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized.

The passivation safe state value and the output state value in CPU STOP mode are always "0", de-energized. You cannot select or program a default "ON" state for passivation or STOP mode.

Passivation is applied to individual channels when a channel-specific diagnostic failure is detected. Failures that can affect the entire module result in passivation of all channels.

NOTE

In the ET 200eco PN F-DI 8 / F-DQ 3 **Properties** > **4/8 F-DI 3 F-DQ** > **F-parameter**s > "Behavior after channel fault" field, if you select "Passivate the entire module", a single channel fault can result in passivation of all channels.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates all module channels.

Table 1-1167 Module signal type and passivation result

Module signal type	Passivation result
Fail-safe digital inputs	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective inputs. • If a channel fault occurs for a 1oo1 configuration, depending on your configuration, only the affected channel or all channels may be passivated. For a 1oo2, the channel group of two inputs in the 1oo2 configuration are passivated.
Fail-safe module digital outputs	• Tests are evaluated per channel, in order to allow channel-granular passivation of defective outputs. • Diagnostic evaluations are performed separately for each of the two switches of a channel. Depending on your configuration, failure detection for one switch may lead to passivation of only the affected channel or all channels.

Response to faults in the fail-safe system

You should prepare maintenance procedures for your system to assure that return to operation after a detected fault is controlled and documented.

The following steps must be performed:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe module

A channel or module can be reintegrated after successful diagnostics determine that a fault has cleared.

You can configure reintegration as automatic or manual. You can make this selection on a per channel basis in the Device Configuration. Module wide errors such as PROFIsafe communication errors or supply voltage errors must always be manually reintegrated.

Channels that you select to be automatically reintegrated are immediately reintegrated when the fault has cleared.

Channels that you select to be manually reintegrated must also be acknowledged in your program after the fault has cleared.

The "ACK_REQ" bit for that module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Some fatal diagnostic errors require a power cycle with successful diagnostics to reintegrate.

Reintegration after high stress events

High temperature, high voltage, and excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The PFD and PFH reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future dangerous failure may be increased.

⚠ WARNING

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.
Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.
After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the module, refer to "Fault types, causes, and corrective measures" (Page 157).

At reintegration, the following occurs:

- For a fail-safe module digital input, the process values pending at the fail-safe inputs are provided for the safety program.
- For a fail-safe module digital output, the output values provided in the safety program are again transferred to the fail-safe outputs.

Safety repair time

The repair time used for PFH and PFD calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

Deactivated fail-safe I/O are not being diagnosed and are subject to dangerous failure without warning.

If any channel passivation persists for 100 hours, the entire module is passivated and can only be recovered through power cycle.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

Do not depend on deactivation or lack of configuration to maintain safe state in any circumstances.

Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the "SIMATIC Safety - Configuring and Programming, Programming and Operating Manual" (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

8.2 Fault Diagnostics

8.2.1 Overview

Diagnostics detect faults that can affect the integrity of safety-related I/O. The faults can be in the fail-safe module, communication with the CPU, or external circuits. Diagnostic information is assigned either to a single channel or to the entire fail-safe module.

Most diagnostics operate without user selection. You can configure the following diagnostic options:

- Short-circuit testing using the digital input sensor supply can be enabled. The interval and duration of short-circuit tests is configurable.
- The readback times for 24 V DC digital outputs are configurable.
- The timeout intervals for failures in the safety communication or failure of a safety program to run is configurable.

  Refer to "Configuring" (Page 130) for a complete description of these options.

The safety-critical and validated action of the diagnostics is to passivate I/O when faults are detected. The reporting of status and diagnostic results through the LED displays and diagnostic messages is subject to single point failures in electronics or software. These reports are offered as maintenance and debugging aids, but must be observed and interpreted with caution.

In the presence of single faults, any or all LED indications can be wrong. You should not rely solely on the presence or absence of red or green LED indicators to make safety decisions.

In the presence of single faults, diagnostic messages may fail to be delivered, or the numerical event ID or text message can be wrong. You should not rely solely on the presence, absence, or content of diagnostic reports to make safety decisions.

⚠ WARNING

Diagnostic and status reports through LEDs and text messages are subject to single point failure errors.

Reliance on such reported information to determine that a system or I/O point is in a safely-controlled state can result in death, severe personal injury, or property damage.

If the integrity of your fail-safe system is in doubt, you should use additional measures such as restricted access or power removal to control hazards during maintenance and debug activities.

8.2.2 Diagnostics performed at startup

Each fail-safe module executes self-diagnostics at power-up to assure that the electronics and software meet testable expectations before allowing the module to participate in process control. If tests are not successful, the module passivates individual channels or all channels.

In addition to internal tests, some tests create signal changes at the terminals.

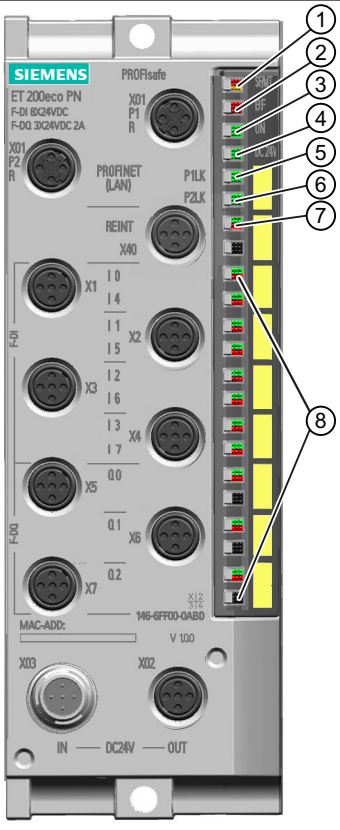
The ET 200eco PN F-DI 8 / F-DQ 3 module executes tests for its digital outputs of the P and M switches as defined by your configured parameters for "Maximum readback time" and "Maximum readback time switch on test" after receiving configuration parameters from the fail-safe CPU at power-up. P and M switch ON tests are sequenced so that normally or in the presence of a single detected fault, there is no complete PM circuit to energize the load.

The ET 200eco PN F-DI 8 / F-DQ 3 module executes tests for its digital inputs of the sensor supply at power up, including ON and OFF pulses, whether or not you have enabled the sensor supply or short-circuit testing in your configuration. If your configuration includes short-circuit testing, the F-DI also executes a short-circuit test according to your configured parameters after receiving the parameters from the fail-safe CPU at power-up.

8.2.3 Diagnostics by LED Display

8.2.3.1 Overview

The ET 200eco PN F-DI 8 / F-DQ 3 module has the following LED position, arrangement, and types:

Module	Location	LED	LED Color	Description
	①	SF/MT	Red/Yellow	System fault/Maintenance
	②	BF	Red	Bus monitoring
	③	ON	Green	Power at 1L+
	④	DC 24V	Green	Power at 2L+
	⑤	P1 LK	Green	Port to Ethernet switch connection
	⑥	P2 LK	Green	Port to Ethernet switch connection
	⑦	REINT	Green/Red	Module reintegration
	⑧	Channel Status	Green	Channel status LED for each channel
	⑧	Channel Fault	Red	Channel fault LED for each channel

NOTE
Each M12 channel connector has two LED light-pipes. F-DI channels use both LED light-pipes, one for each input. F-DQ channels use a single LED light-pipe.

8.2.3.2 Module LED states

Module LED states

The behavior of the module-relevant LEDs follows the definitions in the table below:

LED	LED color	Description
SF/MT (System fault and maintenance)	● On red	The SF LED is controlled by incoming and outgoing diagnostic events. The SF LED is ON whenever at least one incoming event is active.
	○ Off	The SF LED is OFF when all incoming events have been acknowledged by outgoing events.
	● On yellow	The MT LED is ON during a firmware update, once the update procedure commences within the module.
BF (Bus monitoring)	● On red	The BF LED is ON whenever the IO device is not connected to an Ethernet switch.
	✶ Flashing red	The BF LED is flashing whenever there is faulty or absent data exchange between the IO Controller and the ET 200eco PN F IO Device. Faulty or absent data exchange can include the following items: • No connect message frame • Faulty connect message frame • No data exchange between the module and the host, although the module is physically connected to the switch. Possible causes can include the following items: – Incorrect device name – Error in or no configuration – Parameterization errors or no parameterization
	○ Off	The BF LED is OFF whenever the IO device successfully exchanges data with the IO controller.
ON (Power at 1L+)	● On green	The ON LED is ON whenever the 24 V DC supply voltage is present at 1L+.
	○ Off	The ON LED is OFF whenever the 24 V DC supply voltage is too low or not present at 1L+.
DC 24V (Power at 2L+)	● On green	The DC 24V LED is ON whenever the 24 V DC supply voltage is present at 2L+.
	○ Off	The DC 24V LED is OFF whenever the 24 V DC supply voltage is too low or not present at 2L+.
	○ Off	The DC 24V LED is also OFF whenever the 24 V DC supply voltage is too low or not present at 1L+.
P1 LK and P2 LK (Port to Ethernet switch	● On green	The Px LK LED is ON whenever there is a connection to Ethernet switch or IO controller.

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

LED	LED color	Description
connection)	○ Off	The Px LK LED is OFF whenever there is no connection to the Ethernet switch or IO controller.
REINT (Module reintegration)	✶ / ✶ Flashing red and green	The REINT LED flashes Green/Red whenever a reintegratable module-wide diagnostic event has been resolved. This can include the following events: • Reintegratable over-voltage • Reintegratable under-voltage • Module detected PROFIsafe CRC error • Module detected PROFIsafe timeout error
	● On red	The REINT LED is ON red whenever there are compatibility issues between FW or HW revisions.
	○ Off	The REINT LED is otherwise OFF.

○- Off;●- On;✶- Flashing (Flashing frequency: 2.0 Hz)

8.2.3.3 LED states for 1oo1 input channels

The behavior of the 1oo1 input channel LEDs follows the definitions in the table below:

Description	Reintegration LEDs	Input Channel LEDs	
		Fault	Status
LED color	Green / red	Red	Green
Input state 0	○ Off	○ Off	○ Off
Input state 1	○ Off	○ Off	● On green
Channel fault	○ Off	● On red	○ Off
Channel fault resolved, awaiting reintegration	○ Off	✶ / ✶[1] Flashing	

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

[1] Alternating flashing of the separate fault (red) and status (green) LEDs for channels awaiting reintegration (flashing frequency: 2.0 Hz)

8.2.3.4 LED states for 1oo2 input channels

The behavior of the 1oo2 input channel LEDs follows the definitions in the table below:

Description	Reintegration LEDs	Primary input channel LEDs		Secondary input channel LEDs	
		Fault	Status	Fault	Status
LED color	Green / red	Red	Green	Red	Green
Input state 0 (equivalent)	○ Off	○ Off	○ Off	○ Off	○ Off
Input state 1 (equivalent)	○ Off	○ Off	● On green	○ Off	● On green
Input state 0 (nonequivalent)	○ Off	○ Off	○ Off	○ Off	● On green
Input state 1 (nonequivalent)	○ Off	○ Off	● On green	○ Off	○ Off
Discrepancy error	○ Off	● On red	○ Off	● On red	○ Off
Discrepancy error resolved, awaiting reintegration	○ Off	✶ / ✶[1] Flashing		✶ / ✶[1] Flashing	

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 Alternating flashing of the separate fault (red) and status (green) LEDs for channels awaiting reintegration (flashing frequency: 2.0 Hz)

8.2.3.5 LED states for sensor supply behaviors

The behavior of the input LEDs due to sensor supply faults follows the definitions in the table below:

Description	Reintegration LEDs	Input Channel LEDs	
		Fault	Status
LED color	Green / red	Red	Green
Sensor supply fault; for inputs affected by the fault	○ Off	● On red	○ Off
Sensor supply fault; for inputs not affected by the fault	○ Off	○ Off	Input state

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

8.2.3.6 Channel LED states

The behavior of the module and channel-relevant LEDs and reintegration LEDs follows the definitions in the table below:

Description	Reintegration LEDs	Input Channel LEDs		Output Channel LEDs	
		Fault	Status	Fault	Status
LED color	Green / red	Red	Green	Red	Green
Module / System fault	○ Off	● On red	○ Off	● On red	○ Off
Module not configured, includes: under-voltage, over - voltage of 1L+ and 2L+ when not configured	○ Off	○ Off	Input state	○ Off	○ Off
States after the module is successfully configured					
Channel deactivated	○ Off	○ Off	Input state	○ Off	○ Off
No channel faults	○ Off	○ Off	Input state	○ Off	Output state
Channel faults	○ Off	● On red	○ Off	● On red	○ Off
Awaiting manual reintegration after channel fault	○ Off	✶ / ✶[1] Flashing		✶ / ✶[1] Flashing	
Awaiting manual reintegration after 1L+ voltage too high or too low	✶ / ✶ Flashing red and green	✶ / ✶[1] Flashing		✶ / ✶[1] Flashing	
Awaiting automatic reintegration after 1L+ voltage too high or too low	✶ / ✶ Flashing red and green	○ Off	Input state	○ Off	○ Off
Awaiting reintegration after PROFIsafe communication error (detected by host)	✶ / ✶ Flashing red and green	○ Off	Input state	○ Off	○ Off
1L+ supply or 2L+ load voltage too high / too low	○ Off	● On red	○ Off	● On red [3]	○ Off
PROFIsafe communication error (detected by module)	○ Off	○ Off	Input state	○ Off	○ Off
Identification of the F-module when assigning the PROFIsafe address	○ Off	○ Off	✶ Flashing green [2]	○ Off	✶ Flashing green [2]
PROFIsafe address does not match the configured PROFIsafe address	○ Off	● On red	○ Off	● On red	○ Off
Firmware Update (LED indication of FW update activity)	○ Off	○ Off	○ Off	○ Off	○ Off
Inconsistent FW versions and/or HW revisions between TPS and F-µCs	● On red	○ Off	Input state	○ Off	○ Off

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

1 Alternating flashing of the separate fault (red) and status (green) LEDs for channels awaiting reintegration (flashing frequency: 2.0 Hz)

2 Flashing frequency (0.5 Hz)

3 Assuming channels are activated. F-DQ channels can be deactivated. Whenever you deactivate all F-DQ channels, you do not have to power 2L+. When you deactivate all F-DQ channels, you change some F-DQ relevant behaviors (for example, 2L+ under-voltage reporting is suspended).

8.2.3.7 LED states for 24 V DC supply behaviors

The behavior of the 24 V DC LEDs follows the definitions in the table below:

Description	ON (1L+)	DC 24V (2L+)	Reintegration LEDs	Input Channel LEDs		Output Channel LEDs	
				Fault	Status	Fault	Status
LED color	Green	Green	Green / red	Red	Green	Red	Green
24 V DC module 1L+ off; 24 V DC module 2L+ off	○ Off	○ Off	○ Off	○ Off	○ Off	○ Off	○ Off
24 V DC module 1L+ off; 24 V DC module 2L+ on	○ Off	○ Off	○ Off	○ Off	○ Off	○ Off	○ Off
24 V DC module 1L+ on; 24 V DC module 2L+ off (At least one output activated)	● On green	○ Off	○ Off	● On red	○ Off	● On red	○ Off
24 V DC module 1L+ on; [1] 24 V DC module 2L+ off (All outputs deactivated)	● On green	○ Off	○ Off	○ Off	Input state	○ Off	○ Off
24 V DC module 1L+ on; 24 V DC module 2L+ on	● On green	● On green	○ Off	○ Off	Input state	○ Off	Output state

○ - Off;● - On;✶- Flashing (Flashing frequency: 2.0 Hz)

[1] Whenever you deactivate all F-DQ channels, you do not have to power 2L+.

8.2.4 Fault types, causes, and corrective measures

The "Fault types, causes, and corrective measures" table below lists the messages of the ET 200eco PN F-DI 8 / F-DQ 3. These messages are displayed in the TIA Portal under "Online & diagnostics" > "Diagnostics" > "Diagnostic buffer". When you highlight an individual text line in the diagnostic buffer, the Event ID for that text item is displayed, along with module identity and location that generated the message. You may need to expand the window to see all information.

Table 1-1168 Fault types, causes, and corrective measures

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0001	Short-circuit	Digital outputs	A channel problem has been detected where either the P terminal or M terminal is at an unexpected potential.	Short-circuit of the output	Eliminate the short-circuit.
				Short-circuit between channels with different signals	Eliminate the short-circuit.
				Output overload	Eliminate the overload.
				"Maximum readback time switch on test" value is configured too small	Increase "Maximum readback time switch on test" if permissible.
				Short-circuit of output to M	Eliminate the short-circuit.
				Defective output driver	Replace the fail-safe module.

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0005	Overtemperature	Module	• Overtemperature at microcomputer • Overtemperature at I/O	Shutdown due to violation of high temperature limit value in the module case	Check the ambient temperature. Once the fault has been eliminated, the power must be switched off and on.
0x0006	Wire break	Module	WIre break failure. Note: The module detects a wire break. The module can detect a wire break when the channel is wired using a PM load, when the PV=0, and the wire break diagnostic is enabled.	Output is activated: • No load is connected to the PM output. • Output is not wired in a PM configuration. • Too small of a load is detected.	Change the output load characteristics, deactivate unused channels, or disable wire break diagnostic for the offending channels.
0x0009	Hardware revision mismatch	Module	The module detects hardware mismatch. REINT LED is ON red.		Replace module.
0x0010	Parameterization failure (invalid parameters)	Module	On detection of invalid parameters, the module stays in the configured state and signals the rejection of the faulty parameter to the fail-safe CPU. The module LEDs give an immediate indication of this fault.	i-Parameter CRC error	
				Invalid i-parameters (for example, invalid selection, parameter out-of-range, unsupported feature selected, and wrong value of reserved field)	
				Any PROFIsafe parameterization problem detected by the PROFIsafe driver.	
0x0010	Parameterization failure (address assignment failure)	Module	On detection of an address assignment failure that indicates a hardware fault, the module enters the fatal error state. The module performs this fault reaction if the address verification information provided by the F parameters is different than what has been previously assigned to the module.	• Indicates assignment of an incorrect F address to one or more module(s). • Missing eCoding plug	• Reinsert the eCoding plug • Reassign or reinitialize the PROFIsafe F addresses using TIAP • Replace the eCoding plug
0x0010	Parameter error	Module	When the module receives new parameters, the module checks for parameter failures.	Parameter failure detected.	

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0040	Mismatch of safety destination address (F_Dest_Add)	Module	The PROFIsafe driver has detected a destination address mismatch. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective	• Reassign or reinitialize the PROFIsafe F addresses using TIAP • Replace the eCoding plug
0x0041	Safety destination address not valid (F_Dest_Add)	Module	The PROFIsafe driver has detected an invalid destination address. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective	• Reassign or reinitialize the PROFIsafe F addresses using TIAP • Replace the eCoding plug
0x0042	Safety source address not valid (F_Source_Add)	Module	The PROFIsafe driver has detected a source address mismatch or an invalid source address. Checked after new parameters received.	• eCoding plug has been replaced with a different plug • eCoding plug is defective	• Reassign or reinitialize the PROFIsafe F addresses using TIAP • Replace the eCoding plug
0x004D	PROFIsafe communication error (CRC)	Module	Transmission error in data message frame: Data inconsistent (CRC (cyclic redundancy check) error). Checked after new output telegram received.	Communication interference between the fail-safe CPU and the fail-safe module (for example, due to electromagnetic interference in excess of limits or sign-of-life monitoring error)	• Check the communications connection. • Eliminate the interference.
0x004E	PROFIsafe communication failure (timeout)	Module	Monitoring time exceeded for data message frame (timeout). Checked after new output telegram received.	F-monitoring time exceeded. Transmission error: timeout (watchdog time 1 or 2 elapsed)	• Adjust F-monitoring time. • Check Safety program and all other CPU activities for excessive execution or demands: – Interrupts – Ethernet communication – OB scheduling conflicts – Long program paths.
0x0100	Module is defective	Module	Fatal internal error	Fail-Safe module is defective.	Replace the fail-safe module. [2]
0x0103	Watchdog tripped	Module	The watchdog timer in the module communications processor timed out.	Fail-Safe module is defective.	Replace the fail-safe module.
0x0105	Short-circuit to L+	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	Output shorted to P. The fail-safe module detects a channel problem where the	Short-circuit to L+	Eliminate the short-circuit.
				Short-circuit between channels with different signals	Eliminate the short-circuit.

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0105	Short-circuit to L+	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	P-terminal is unexpectedly at L+ potential.	Defective output driver	Replace the fail-safe module.
				"Maximum readback time" value is configured too small.	Increase readback time.
0x0106	Short-circuit to ground	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	The fail-safe module detects a channel problem where the M-switch output terminal is unexpectedly at M potential.	Short-circuit of output to M, ground, or another channel.	Eliminate the short-circuit.
				Defective output driver	Replace the fail-safe module.
				"Maximum readback time" value is configured too small.	Increase readback time.
0x011B	Invalid/inconsistent firmware present	Module	The firmware is inconsistent after a firmware update. Inconsistency between bus ASIC firmware and failsafe firmware. Checked again after firmware update.	Inconsistent firmware version may occur between Network Interface ASIC firmware and failsafe controller firmware if the firmware update is supported.	The firmware update operation should be repeated.
0x013E	Diagnostic event queue overflow	Module	Overflow of the diagnostic events queue has occurred. A newly-occurred diagnostic event could not be queued for transmission to the CPU because the buffer is full.	This can happen if channel errors come and go very quickly (for example, discrepancy errors).	
0x0300	Discrepancy failure, channel state 0/0	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	External discrepancy failure: Channel state 0/0 with 1oo2 non-equivalent configuration	• Process signal faulty, sensor may be defective. • Configured discrepancy time too short • Short-circuit • Sensor mechanical activation or alignment out of tolerance	• Check process signal, replace sensor if necessary. • Check the configured discrepancy time. • Check the wiring. • Check that both sensors are mounted and aligned to be activated together.
0x0301	Discrepancy failure, channel state 0/1	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	External discrepancy failure: Channel state 0/1 with 1oo2 equivalent configuration		
0x0302	Discrepancy failure, channel state 1/0	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	External discrepancy failure: Channel state 1/0 with 1oo2 equivalent configuration		
0x0303	Discrepancy failure, channel state 1/1	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	External discrepancy failure: Channel state 1/1 with 1oo2 non-equivalent configuration		
0x0306	Internal sensor supply	ET 200eco PN F-DI 8 / F-DQ 3	Module-provided sensor supply voltage	Sensor supply shorted to P	Eliminate the short-circuit.

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0306	short-circuit to P	digital inputs	shorted to P	Short-circuit test duration configured too short	Increase short-circuit test duration.
				Failed sensor supply	Replace the fail-safe module.
0x0307	Overload or internal sensor supply short-circuit to ground	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	Internal sensor supply voltage shorted to M, ground, or excessive load on sensor supply. Note: An overload condition is detected if the filtered current measurement of a channel is in the over-current threshold range of 2.4 A and 3.83 A. Overload protection is provided using current measurement of the P outputs. M outputs are short-circuit protected, but not monitored for over-current.	Short-circuit	Eliminate the short-circuit.
				Excessive load on sensor supply	Reduce load on sensor supply.
				Failed sensor supply	Replace the fail-safe module.
0x030B	Channel failure acknowledgement	Module	Channel configured for manual acknowledgement is ready to reintegrate.	Manual acknowledgement required	Manually acknowledge correction of channel fault so that reintegration can occur.
0x030D	F-address memory not accessible	Module	The memory where the F-Address is stored is not accessible.	• eCoding plug is missing • eCoding plug is defective	• Install an eCoding plug into X40 of the module • Replace the defective eCoding plug
0x030E	No valid F-address available	Module	Fail-safe address is not valid (F-address and CRC inconsistent).	• eCoding plug has never been assigned a PROFIsafe address • eCoding plug is defective	• Assign the PROFIsafe Address • Replace the eCoding plug
0x0311	Frequency too high	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	Switching frequency exceeded; readback not in time.	Process value from safety program changing too rapidly for module to follow	• Change Safety program logic to guarantee more time between output changes.
0x0312	Undertemperature	All	• Under-temperature at microcomputers • Under-temperature at I/O	Shutdown due to violation of low temperature limit value in the module case	• Check the ambient temperature. • Once the fault has been eliminated, the power must be switched off and on.

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Event ID	Diagnostic message	ET 200eco PN F-DI 8 / F-DQ 3 module	Description	Possible causes	Corrective measures [1]
0x0313	Failure in the input circuit	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	Internal fault at the read circuit/test circuit	The module digital inputs detect a failure during bit pattern testing of inputs. EMI or module hardware fault.	• If intermittent, probably due to interference. Eliminate interference. • If persistent, or repeats after efforts to eliminate interference, replace the fail-safe module.
0x031C	Input shorted to P	ET 200eco PN F-DI 8 / F-DQ 3 digital inputs	Input shorted to P failure	External wiring or sensor shorts input signal to L+.	Check/correct external short-circuit.
				Input configured for internal sensor supply with short-circuit detection enabled, but wired to external L+	Make wiring and configuration agree.
				Input defective	Replace the fail-safe module.
0x031E	Read back failure	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	The module has detected a channel problem where the expected terminal voltage(s) are not reached.	"Maximum readback time" or "Maximum readback time switch on test" configured value is too small.	Increase readback time.
				Output switch failure	Replace the fail-safe module if output does not respond.
0x0320	Overload	ET 200eco PN F-DI 8 / F-DQ 3 digital outputs	Over load condition at the output driver that leads to passivation of the channel	Over load at output	Eliminate over load.
0x0321	Supply or load voltage too high	Module	Supply voltage (1L+) or load voltage (2L+) maximum exceeded.	Supply or load voltage is set too high.	Adjust supply or load voltage.
0x0322	Supply or load voltage too low	Module	Supply voltage (1L+) or load voltage (2L+) minimum exceeded.	Supply or load voltage is set too low.	Adjust supply or load voltage.

[1] Once the fault is eliminated, the fail-safe module must be reintegrated (returned to normal state) from passivation into the safety program.

Electromagnetic interference and diagnostic reports

Electromagnetic interference can cause communication errors, disturb external and internal signal measurements, and cause processing errors. When error reports do not apparently relate to an identifiable device failure, wiring problem, programming, or configuration error, consider sources of electromagnetic interference and installation and wiring problems that might introduce electromagnetic interference in your installation. Typical problem sources include poor suppression of inductive loads and voltage dips due to excessive load in-rush currents.

Maintenance

9

9.1 Replacing the ET 200eco PN F-DI 8 / F-DQ 3 module

Replacing modules

Replacing a module is not permitted during ongoing operation.

⚠ WARNING

If you remove/insert modules and the eCoding plug with the power connected, this can lead to undefined states in your system.
Death or serious personal injury and damage to the ET 200eco PN F-DI 8 / F-DQ 3 module and associated machines/equipment may result if proper precautions are not taken.
Only remove or replace modules and the eCoding plug when the power is disconnected.
Always comply with the required standards and safety guidelines when configuring a system.

NOTE

When replacing the ET200eco PN F module, transfer the eCoding plug inserted in the failed module to the replacement module to retain the PROFIsafe address stored in the eCoding plug. Otherwise, it is necessary to use the Engineering System to configure the PROFIsafe address in the replacement module. Ensure that eCoding plug in not accidentally inserted in a module other than the intended ET200eco PN F module.

Procedure

To replace a module, proceed as follows:

1. Disconnect the supply and load voltages to the module to be replaced.
2. Remove the eCoding plug.
3. Completely remove all cables connected to the module.
4. Completely remove the fixing screws of the module
5. Replace the module.
6. Fasten the module with a torque of 1.2 Nm.
7. Connect all cables.
8. Connect the eCoding plug to the module.
9. Turn the supply and load voltages on.

Result

The disconnected I/O module and all downstream I/O modules start up again by themselves.

NOTE

Refer to the "Looping PROFINET and the supply voltage" (Page 127) when replacing the ET 200eco PN F module.

9.2 Resetting the ET 200eco PN F-DI 8 / F-DQ 3 module to factory settings (PROFINET)

When you "Reset to factory settings", you reset the ET 200eco PN F-DI 8 / F-DQ 3 module to the delivery state settings. This means that all information that you saved internally on the ET 200eco PN F is deleted.

Result after resetting to factory settings

The following table shows an overview of the contents of the saved items after resetting to factory settings:

Table 1-1169 Result after resetting to factory settings

Memory object	Contents
IP address	Deleted
Device name	Deleted
MAC address	Not deleted
Identification data (I&M0)	Not deleted
Maintenance data (I&M1, 2, 3,)	Deleted (optional)
Firmware version	Not deleted
PROFIsafe addresses stored in eCoding Plug	Not affected

NOTE

When "Resetting to factory settings", the ET 200eco PN F assumes a substitute value behavior (takes on the non-configured state), which means that the module does not enter input data or transmit output data.

Reset options

You can go online with STEP 7 (TIA Portal) to reset an ET 200eco PN F to factory settings

The ET 200eco PN F only works with TIA Portal V15 and later. An HSP is used with TIA Portal V15. Later versions of V15 will not require an HSP.

Requirement

You need an online connection to reset an ET 200eco PN F to factory settings.

Procedure with STEP 7 (TIA Portal)

Connect the PG/PC to the PROFINET IO interface of the ET 200eco PN F distributed I/O system.

Make sure that there is an online connection to the ET 200eco PN F module which is to be reset to factory settings:

1. Navigate to "Devices & Networks" and the "Network view".
2. Right-click on the ET 200eco PN F-DI 8 / F-DQ 3 and select "Online and diagnostics".
3. Go online.
4. In the "Functions" folder, select "Reset to factory settings".
5. Select the "Retain I&M data" option button if you want to retain the I&M data, or the "Reset I&M data" option button if you want to delete the I&M data.
6. Click the "Reset" button.
7. Click "OK" in response to the confirmation prompts.

Result: This command resets the following data:

- PROFINET device name
- IP address
- SNMP parameters
- I&M data (if "Reset I&M data" is selected)

Reference

You will find more information on the procedure in the TIA Portal online help.

9.3 Firmware update

During operation, it can become necessary to update the firmware (for example, for function extensions).

Options for the firmware update

You update the firmware in the ET 200eco PN F-DI 8 / F-DQ 3 module using one of the following:

- TIA Portal
- Embedded web server executing on a SIMATIC CPU
- SIMATIC Automation Tool (SAT)

NOTE

Temporary network interruption
When you perform a firmware update of an ET 200eco PN F-DI 8 / F-DQ 3 I/O module, the module's PROFINET connection is temporarily interrupted due to the restart of the module. All downstream PROFINET devices are interrupted until the firmware update is complete.

Reference

You can find additional information on the procedure in the FAQs on the Internet (https://support.industry.siemens.com/cs/us/en/view/88778936) and in the online help for TIA Portal.

9.4 Cleaning modules

When wired, ET 200eco PN F-DI 8 / F-DQ 3 modules comply with the IP65/IP67 degree of protection and require no cleaning. If you do have to clean the modules, use a dry or damp cloth. Please ensure that you comply with the IP66/67 degree of protection when cleaning with liquids.

Technical specifications

A

A.1 General technical specifications

Table 1-1173 Shipping and storage conditions

Type of conditions	Permissible range
EN 60068-2-2, Test Bb, Dry heat and EN 60068-2-1, Test Ab, Cold	-40 °C to +70 °C
EN 60068-2-30, Test Db, Damp heat	25 °C to 55 °C, 95% humidity
EN 60068-2-14, Test Na, temperature shock	-40 °C to +70 °C, dwell time 3 hours, 5 cycles
EN 60068-2-32, Free fall	0.3 m, 5 times, product packaging
EN 60068-2-6, Sinusoidal Vibration	5 - 8.4 Hz, 3.5 mm 8.4 - 500 Hz, 1 g 10 cycles per axis
EN 60068-2-27, Shock Strain	25 g, 6 ms, 1000 shocks per axis
Barometric pressure	1140 hPa to 660 hPa (corresponding to an altitude of -1000 m to 3500 m)

A.1.1 Standards compliance

The ET 200eco PN F design conforms to the following standards and test specifications. The test criteria for the ET 200eco PN F are based on these standards and test specifications.

Not all ET 200eco PN F models may be certified to these standards, and certification status may change without notification. It is the user's responsibility to determine applicable certifications by referring to the ratings marked on the product. Consult your local Siemens representative if you need additional information related to the latest listing of exact approvals by part number.

Siemens products will generally be in accordance with the latest released standards as of the time of product release. For European Norm (EN) standards, the effective version will be in accordance with listings in the official journal of the European Union. Product certifications including the CE declaration of conformity and certificates from listing agencies cite the exact standards applicable to each certification.

A.1.2 Fail-Safe standards and approvals

The ET 200eco PN F-DI 8 / F-DQ 3 module is certified by TÜV. The fail-safe modules are certified to the IEC 61508, ISO EN 13849, and EN 62061 standards for functional safety. For further information, refer to the current "Report to the Certificate" for the TÜV certificate "SIMATIC Safety" (http://support.automation.siemens.com/WW/view/en/49368678/134200) from the Internet.

A.1.3 PROFIsafe compatibility

- PROFIsafe address type 2
- Supports the RIOforFA-Safety profile
- Supports the PROFIsafe V2.4 profile

A.1.4 Standards and Approvals

A.1.4.1 General certifications

CE approval



The ET 200eco PN F module satisfies requirements and safety-related objectives according to the EC directives listed below and conforms to the harmonized European standards (EN) for the programmable controllers listed in the Official Journals of the European Union.

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
- 2006/42/EC "Machinery Directive" for S7-1200 safety components (fail-safe modules)

The EU Declaration of Conformity is held on file available to competent authorities at:

Siemens AG
Digital Industries
Factory Automation
DI FA AS SYS
Postfach 1963
D-92209 Amberg
Germany

UKCA approval



The ET 200eco PN F module complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The ET 200eco PN F module meets the requirements and protection targets of the following regulations and related amendments:

- Electromagnetic Compatibility Regulations 2016 (EMC)
- Regulations on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2012 (RoHS).
- Supply of Machinery (Safety) Regulations 2008 for S7-1200 safety components (fail-safe modules)

UK Declarations of Conformity for the respective authorities are available from:

Siemens AG
Digital Industries
Factory Automation
P.O. Box 1963
D-92209 Amberg

The UK Declaration of Conformity is also available for download from the Siemens Industry Online Support website under the keyword "Declaration of Conformity".

cULus approval



Underwriters Laboratories Inc. in accordance with:

- UL 61010-1 and UL 61010-2-201
- UL 50 Enclosure Type 1
- CSA C22.2 No. 61010-1 and No. 61010-2-201
- CSA C22.2 No. 94.2-15

NOTE

Class 2 power supply unit

The components must be supplied with a class 2 power supply unit.

Australia and New Zealand - RCM Mark (Regulatory Compliance Mark)



The ET 200eco PN F satisfies requirements of standards to AS/NZS 61000.6.4 and IEC 61000-6-4 (Class A).

Korea Certification



The ET 200eco PN F satisfies the requirements of the Korean Certification (KC Mark). It has been defined as Class A Equipment and is intended for industrial applications and has not been considered for home use.

Eurasian Customs Union approval (Belarus, Kazakhstan, Russian Federation)



EAC (Eurasion Conformity): Declaration of Conformity according to Technical Regulation of Customs Union (TR CU)

A.1.4.2 Industrial environments

The ET 200eco PN F is designed for use in industrial environments.

Table 1-1170 Industrial environments

Application field	Emission requirements	Immunity requirements
Industrial	EN 61000-6-4	EN 61000-6-2

A.1.5 Electromagnetic compatibility

A.1.5.1 Electromagnetic compatibility overview

Electromagnetic Compatibility (EMC) is the ability of an electrical device to operate as intended in an electromagnetic environment and to operate without emitting levels of electromagnetic interference (EMI) that may disturb other electrical devices in the vicinity.

For safety related functions, additional EMC requirements are applied according to IEC 61326-3-1 and IEC 61326-3-2.

Table 1-1171 Immunity per EN 61000-6-2

Electromagnetic compatibility - Immunity per EN 61000-6-2	
EN 61000-4-2 Electrostatic discharge	8 kV air discharge to all surfaces 6 kV contact discharge to exposed conductive surfaces
EN 61000-4-3 Radiated, radio-frequency, electro-magnetic field immunity test	80 to 1000 MHz, 10 V/m, 80% AM at 1 kHz 1.4 to 6.0 GHz, 3 V/m, 80% AM at 1 kHz
EN 61000-4-4 Fast transient bursts	2 kV, 5 kHz with coupling network to AC and DC system power 2 kV, 5 kHz with coupling clamp to I/O
EN 61000-4-5 Surge immunity	AC systems - 2 kV common mode, 1kV differential mode DC systems - 2 kV common mode, 1kV differential mode For DC systems (I/O signals, DC power systems) external protection is required. Refer to "Safe functional extra low voltage requirement (power supplies and other system components)" (Page 101), "Surge immunity" for the recommended protection devices.
EN 61000-4-6 Conducted disturbances	150 kHz to 80 MHz, 10 V RMS, 80% AM at 1kHz

Table 1-1172 Conducted and radiated emissions per EN 61000-6-4

Electromagnetic compatibility - Conducted and radiated emissions per EN 61000-6-4		
Conducted Emissions EN 55016, Class A, Group 1	0.15 MHz to 0.5 MHz	< 79dB (µV) quasi-peak; <66 dB (µV) average
	0.5 MHz to 5 MHz	< 73dB (µV) quasi-peak; <60 dB (µV) average
	5 MHz to 30 MHz	< 73dB (µV) quasi-peak; <60 dB (µV) average
Radiated Emissions EN 55016, Class A, Group 1	30 MHz to 230 MHz	< 40dB (µV/m) quasi-peak; measured at 10 m
	230 MHz to 1 GHz	< 47dB (µV/m) quasi-peak; measured at 10 m
	1 GHz to 6 GHz	< 76dB (uV/m) quasi peak, measured at 10 m

A.1.5.2 Surge immunity

Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. You can find one specification for evaluation of protection from lightning-type surges in EN 61000-4-5, with operational limits established by EN 61000-6-2. The ET 200eco PN F requires external protection to maintain safe operation when subject to surge voltages defined by this standard. The module could issue a channel readback error and passivate the output if you do not appropriately set the "Maximum readback time".

A.1.6 Mechanical and climatic ambient conditions

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions:

Table 1-1174 Test of mechanical ambient conditions

Condition tested	Permissible range
Sinusoidal Vibration, IEC 60068-2-6	
Without mounting rail	10 Hz ≤ f ≤ 58 Hz, constant amplitude 1.5 mm peak 58 Hz ≤ f ≤ 150 Hz, constant acceleration 20 g
With mounting rail	5 Hz ≤ f ≤ 8 Hz, constant amplitude 15 mm peak 8 Hz ≤ f ≤ 150 Hz, constant acceleration 5 g
Vibration (sinusoidal) test in accordance with IEC 60068-2-6	
Shock, IEC 60068-2-27	Type of shock: Half-sine; Shock intensity: 30 g peak value, 18 ms duration, direction of shock: 3 shocks in each +/- direction at each of three vertically-aligned axes

Climatic ambient conditions

The following table shows the permissible climatic ambient conditions for the ET 200eco PN F-DI 8 / F-DQ 3 module:

Table 1-1175 Climatic ambient conditions

Ambient conditions	Permissible range
Ambient temperature range	-25 °C to 60 °C, all mounting positions
Relative humidity	5% to 100% condensing humidity or sprayed water Note: Refer to the ET 200eco PN F-DI 8 / F-DQ 3 "Degree of protection IP65/67" (Page 172) for information on the IP67 rating.
Barometric pressure	1140 hPa to 795 hPa (corresponding to an altitude of -1000 m to 2000 m)
Concentration of contaminants	SO2: < 0.5 ppm with relative humidity < 60% non-condensing H2S: < 0.1 ppm with relative humidity < 60%, non-condensing
EN 60068-2-14, Test Nb, temperature change	-25 °C to 60 °C

Extended environmental conditions for outdoor use: This product does not support outdoor use.

A.1.7 Information on protection class, degree of protection, and rated voltages

A.1.7.1 Contamination level and overvoltage category in accordance with IEC 61010-2-201

The following levels are provided:

- Pollution degree 2
- Overvoltage category: II, unless otherwise noted

A.1.7.2 Protection class in accordance with IEC 61010-2-201

Protection Class II is provided according to IEC 61010-2-201:

- The ET 200eco PN F including only connections to SELV / PELV achieves Protection Class III.
- The ET 200eco PN F does not require a protective earth connection. A functional earth connection is provided and is used for non-safety purposes such as interference immunity improvement.

A.1.7.3 Degree of protection IP65/67

The following degrees of protection in accordance with IEC 60529 is provided for the ET 200eco PN F module:

- Degree of Protection IP 65 (Degree of protection according to IEC 60529):
  - Protection against the ingress of dust and full touch protection
  - Water projected by a nozzle against the module from any direction shall have no harmful effect.
- Degree of Protection IP 66 (Degree of protection according to IEC 60529):
  - Protection against the ingress of dust and full touch protection
  - Water projected by powerful jets against the module from any direction shall have no harmful effect.
- Degree of Protection IP 67 (Degree of protection according to IEC 60529):
  - Protection against the ingress of dust and full touch protection
  - Protection against water when the module is immersed at specified pressures over a specified time period (water must not enter the module in harmful quantities)

A.1.7.4 Rated voltages

Rated voltage	Tolerance	Notes
24 V DC	20.4 V DC to 28.8 V DC	Refer to "Safe functional extra low voltage requirement (power supplies and other system components)" (Page 101) for additional requirements of a 24 V DC power source.

When you suddenly apply 24 V DC power to the ET 200eco PN F modules, short-term current flows can occur which briefly mimic the effect of "1" signals at process outputs and inputs. Digital outputs can trigger to ON state for approximately 50.0 microseconds at power application. The modules deliberately test functional safety P- and M-switch outputs ON at

different times for up to the user-configurable "Maximum readback time switch on test" (0.5 ms to 5.0 ms) during the power up sequence and as a cyclic bit pattern test. This test pulse can energize the load in the presence of a switch or wiring fault on the opposite side of the load circuit. Such short pulses are typically not a hazard for electromechanical loads, but you must consider the effect. High-speed electronic receiver circuits can detect short pulses and improperly interpret the short pulses as deliberate "1" signals.

⚠ WARNING

Short term current and voltage pulses can occur on 24 V DC I/O circuits near the time that power is applied.
Such short term pulses can cause unexpected activation or position changes in machinery, resulting in death or serious injury to personnel and/or property damage.
If your installation includes receivers which can be responsive to short pulses as described above, you should apply measures such as power sequencing or progressive removal of safety lockouts to assure that unexpected machine operations do not occur.

A.2 ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 technical specifications

A.2.1 Overview

Module model	Digital inputs	Digital outputs
ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12	4 x 24 V DC (1oo2), 8 x 24 V DC (1oo1), or a mix	3 x 24 V DC

A.2.2 Specifications

A.2.2.1 ET 200eco PN F technical specifications

Technical Data	Value
Dimensions and weight	
Dimensions W x H x D (mm)	60 x 175 x 49
Weight (without packaging)	940 g
Module-specific data	
Transmission rate	100 Mbps full duplex
Transmission mode	100BASE-TX
Autonegotiation	Yes

[1] Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg

[2] Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH

[3] Maximum useful lifetime of this product

Technical Data	**Value**		
Bus protocol	PROFINET IO: RT • Minimum update time of 250 microseconds Note: No IRT support, but module will participate within an IRT topology		
Supported Ethernet services	PROFINET IO (Device): • ping • ARP • LLDP • Network diagnostics (SNMP)/MIB-2 • DCP • MRP - Media redundancy • I&M0-3 • Port diagnostics • Resetting to factory settings using PROFINET IO • FW update using PROFINET IO • Deactivating of ports (yes) • Device replacement with topological configuration		
PROFINET interface			
Connection socket	2 x M12 D-coded		
Switch function	Yes, internal		
Auto-crossover	Yes, if autonegotiation is enabled		
Manufacturer ID (Vendor ID)	$002A_H$		
Device ID (DeviceID)	0306_H		
Maximum achievable safety class			
Number of channels	1-channel input	2-channel input	Output channel
In accordance with IEC 61508:2010	SIL 2	SIL 3	SIL 3
In accordance with EN ISO 13849-1:2015	Cat 3, PL d	Cat 4, PL e	Cat 4, PL e
Fail-safe performance characteristics			
Safety Integrity Level (SIL)	SIL 2	SIL 3	SIL 3
PFD_avg [1]	≤6e-4	≤1e-5	≤2e-5
PFH [2]	≤1e-8	≤2e-10	≤7e-9
Useful Lifetime (Mission Time) [3]	20 years	20 years	20 years
Safety repair time	100 hours	100 hours	100 hours
Voltages and currents			
Supply voltage 1L+	24 V DC		
• Permissible range	20.4 V DC to 28.8 V DC		
• Surge voltage	35 V DC for 0.5 s		
• Reverse polarity protection	Yes		
• Infeed current 1L+	4.0 A (maximum)		
• Hold up time (loss of power)	0.1 ms at 20.4 V DC		
Supply voltage 2L+	24 V DC		
• Permissible range	20.4 V DC to 28.8 V DC		
• Surge voltage	35 V DC for 0.5 s		
• Reverse polarity protection	Yes		
• Infeed current 2L+	4.0 A (maximum)		
• Hold up time (loss of power)	None for outputs 0.1 ms at 20.4 V DC for internal power		

[1] Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg

[2] Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH

[3] Maximum useful lifetime of this product

Technical Data	Value
Current consumption	
From supply voltage (1L+)	Typical 200 mA (no sensor supply output current)
From supply voltage (2L+)	Typical 70 mA (no digital output activated)
Power loss of the device	9.0 W
Total current of the Sensor Supply outputs: All mounting positions to 60°C	1.6 A through 1L+ (maximum)
Total current of the outputs: All mounting positions to 60°C	3.9 A per 2L+ (maximum)
Insulation	
Insulation test voltage	DC 707 V (type test)
Ethernet interface	1500 V_{RMS} (IEEE802.3)
Electrical isolation	
Between 1L+ and 2L+	Yes
Between 1L+, digital inputs and sensor supply outputs	No
Between input channels	No
Between 2L+ and digital outputs	No
Between output channels	No
Between Ethernet and all other circuit elements	Yes
Status, interrupts, diagnostics	
Interrupts	No
Diagnostic function	
Group error/maintenance	Red/yellow "SF/MT" LED
Bus monitoring PROFINET IO	Red "BF" LED
Monitoring of supply voltage 1L+	Green "ON" LED
Monitoring of supply voltage 2L+	Green "DC 24V" LED
Existing connection to network	Green "P1 LK" and P2 LK" LED; LED for PROFINET IO infeed and loop-through
Host-directed reintegration	Red/green "REINT" LED
Digital input status	Green LED
Fault at digital input	Red LED
Digital output status	Green LED
Fault at digital output	Red LED
Diagnostic information can be read	Yes
Monitoring for	
Failure of 1L+ and 2L+	Yes, under- and over-voltage
Sensor supply short-circuit	Yes
Digital input short-circuit	Yes, per channel
Digital output short-circuit	Yes, per channel
Digital input wire break	No
Digital output wire break	Yes, at PV=0, per channel
Sensor supply	
Number of sensor supplies	2 x 1L+
Voltage range	1L+ minus 2.0 V DC minimum
Load current	800 mA per sensor supply

[1] Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg

[2] Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH

[3] Maximum useful lifetime of this product

Technical Data	Value
Short-circuit protection	Yes, electronic Threshold: 1.4 A to 4.5 A
Sensor selection data / Digital inputs	
Number of inputs	
1oo1 evaluation	8 (maximum)
1oo2 evaluation	4 (maximum)
Type	Sink, Type 1 according to IEC 61131
Rated voltage	24 V DC at 5 mA, typical
Surge voltage	35 V DC for 0.5 s
Logic "1" signal	15 V DC at 3 mA to 30 V DC at 6 mA
Logic "0" signal	-30 V DC to 5 V DC
Connection of 2-wire proximity switch (BERO):	Not possible
• Permissible quiescent current	0.5 mA (maximum)
Filter delay (Configurable) [4]	• 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 12.8 ms
Cable length, shielded	30 m (maximum)
Cable length, unshielded	30 m (maximum)
Number of Inputs that can be controlled simultaneously	8, in all mounting positions
Actuator selection data/ Digital outputs	
Number of outputs	3
Type	P- and M- switching
Logic "1" signal at maximum current	2L+ minus 2.0 V DC (minimum): • P-switch: 2L+ minus 1.5 V DC (maximum) • M-switch: 0.5 V DC (maximum)
Logic "1" current	• 2.0 A (nominal) • 10 mA to 2.4 A
Lamp load	10.0 W (maximum)
Logic 0 current (residual)	• P-switch: 0.5 mA (maximum) • M-switch: 0.5 mA (maximum)
Wire break monitoring	Yes, only when output is off
Output overload protection: [5] • M-switch • P-switch	Yes, electronic in addition to internal non-replaceable fuse. Threshold of 10.0 A to 34.0 A turns M-switch OFF. Threshold of 2.4 A to 4.4 A, 30 ms time constant filter, measured at P-switch, turns both switches OFF. 7.0 A fuse can open for large faults.
Inductive clamp voltage	• P-switch: -26 V DC $_{\text{referenced to 2M}}$ • M-switch: +48 V DC $_{\text{referenced to 2M}}$
Number of Outputs that can be controlled simultaneously	3, in all mounting positions
Parallel connection of 2 outputs	Not possible
Control of a digital input	Not possible
Switching frequency	

[1] Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg

[2] Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH

[3] Maximum useful lifetime of this product

Technical Data	Value
With resistive load	30 Hz symmetrical (maximum)
With inductive load in accordance with IEC 60947-5-1, DC13	0.1 Hz symmetrical (maximum)
With lamp load	10 Hz symmetrical (maximum)
Reverse polarity protection [6]	Yes, except loads connected between M-switch and L+ will conduct if M and L+ are reversed.
Cable length, shielded	30 m (maximum)
Cable length, unshielded	30 m (maximum)

[1] Operation in Low Demand Mode (Average probability of a dangerous failure on demand), PFD_avg

[2] Operation in High Demand or Continuous Mode (Average frequency of a dangerous failure per hour), PFH

[3] Maximum useful lifetime of this product

References

[4] Refer to "Response time parameters for the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs" (Page 190) for further information.

[5] Refer to "Fuse and electronic overload protection" (Page 177) for more information.

[6] Refer to "Digital Output Application Mode 2" (Page 87) for more information.

A.2.2.2 Fuse and electronic overload protection

Overload protection attempts to protect the module from damage from moderate faults in the range of 2.4 A to 15.0 A at the P switch. Above 15.0 A on each P-switch fuse, the internal non-replaceable fuse can open. Supply your ET 200eco PN F-DI 8 / F-DQ 3 digital outputs from a source limited to less than 15.0 A, or use an external fuse or non-shorting load element to prevent opening of the internal fuse.

The internal electronic limiting causes the channel to passivate and reports as an overload. If no damage results, you can reintegrate the channel after removal of the external fault.

A.2.2.3 Switching of loads

Connecting capacitive loads

Load capacitance can delay the voltage response as seen at the P- and M- switches of the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs. For a capacitive load with capacitance C across P and M, and a parallel load resistance R, the "Maximum readback time" needs to be in the range of 2.5 to 3.1 time constant (R * C) of the load. This allows enough time for an appreciable voltage change to be seen when you briefly de-energize an energized load during bit pattern testing. If the resulting "Maximum readback time" is too long for your application, you can reduce this time constant by adding parallel resistance across the load to reduce the realized R * C time constant.

Alternatively, you can add a diode between the P-output and the load (capacitor and resistors) so that when you turn off the output, the voltage on the capacitor is not present at the P-output. Typically, power supplies with input capacitors that have reverse voltage protection have this diode built into the power supply. Using the added diode, you can greatly reduce the "Maximum readback time" to some portion of the hold-up time of the power supply/capacitor. This reduced "Maximum readback time" allows the load to operate normally (load stays ON) during the bit pattern tests.

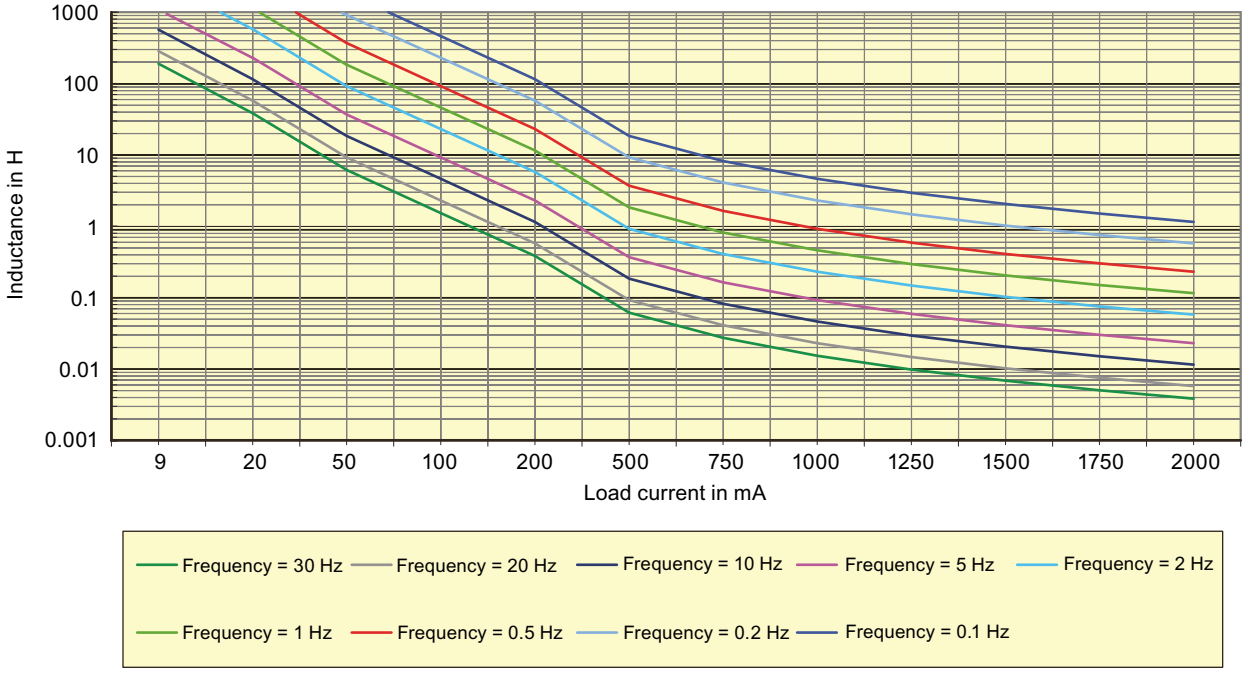
Stray capacitance between the load circuit and ground, M, and P increases the time required for the "Maximum readback time switch on test". When module diagnostics switch "ON" a P or M switch to a de-energized load during bit pattern testing, both sides of the load are driven towards L+ or M, limited by stray capacitance. This effect is typically small.

Your "Maximum readback time switch on test" should be long enough for the load circuit voltage to react, but short enough that if one side of the load faults to P or M, testing of the opposite switch should not cause the load to mechanically react.

Capacitive loads (including power supplies with input capacitors) with low series resistance can have a large inrush current. If you have a large capacitive load, you should add series resistance to reduce the inrush current to reduce the risk of opened fuses or overcurrent fault detection on normal load switch ON events.

Switching of inductive loads

The graph below shows the maximum permitted inductive load and switching frequency allowed using only the internal suppression circuits of the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs. You should equip larger or more frequently switched inductive loads with external suppression circuits to avoid early failure of the ET 200eco PN F-DI 8 / F-DQ 3 digital output switch. The external suppression must conduct the load current at a voltage less than the internal suppression threshold to avoid overloading the internal suppression. Refer to "Guidelines for inductive loads" (Page 128) for more information:



WARNING

Unsuppressed inductive loads can lead to failures.
The following failures can result:

- Unsuppressed inductive loads can lead to early "stuck-on'" failures of the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs.
- Unsuppressed inductive load switching generates an EMI hazard to the PLC system and correct processing of the safety function.

Death or serious personal injury and damage to machines and equipment may result if proper precautions are not taken.
You should use suppressor circuits with inductive loads to limit the voltage rise when a control output turns off and to limit the electrical noise generated when switching inductive loads.

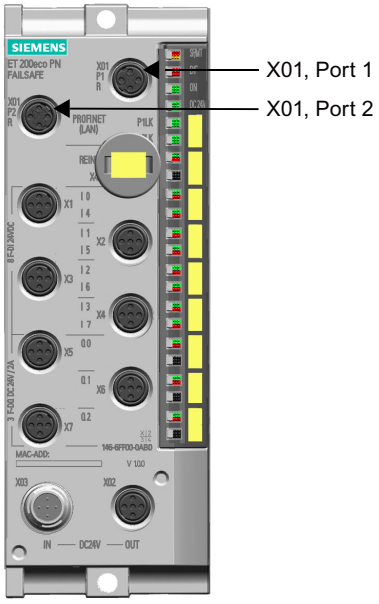
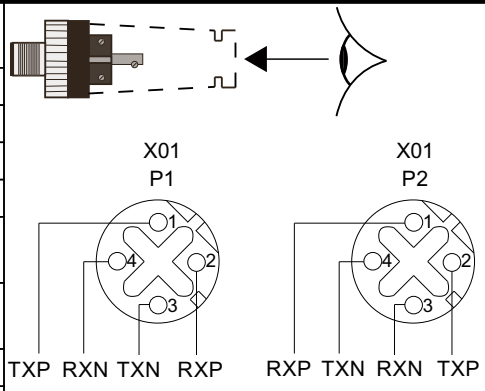
A.2.3 Wiring diagrams

A.2.3.1 Pin assignment of the PROFINET connector

PROFINET connector, X01 connector, port 1 and port 2

The module has a M12 connector with four female pins that are D-coded.

Table 1-1176 Pin assignment of the M12 cable connector for PROFINET connector, ports 1 and 2

ET 200eco PN F	Pin	Assignment	View of the cable connector (PROFINET), port 1 and port 2
		**Assignment X01 P1**	
	1	TXP	
	2	RXP	
	3	TXN	
	4	RXN	
	Thread	Functional earth FE	
		Assignment X01 P2	
	1	RXP	
	2	TXP	
	3	RXN	
	4	TXN	
	Thread	Functional earth FE	

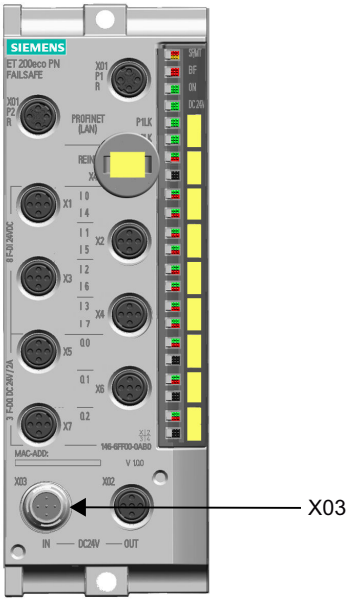
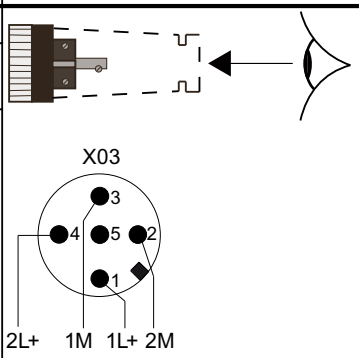
A.2.3.2 Pin assignment for feeding and looping the voltage

Cable connector for supply voltage infeed, X03 connector

The module has an M12 connector with five male pins that are A-coded.

Table 1-1177 Pin assignment of the M12 cable connector for the supply voltage infeed

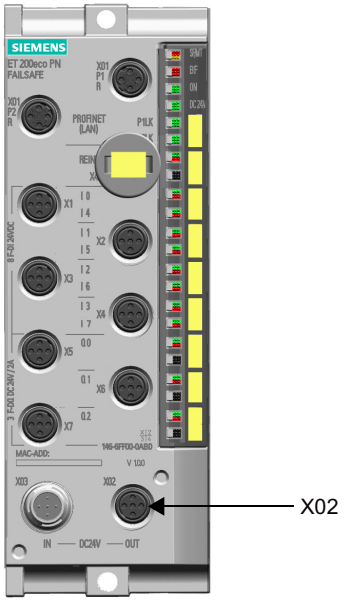
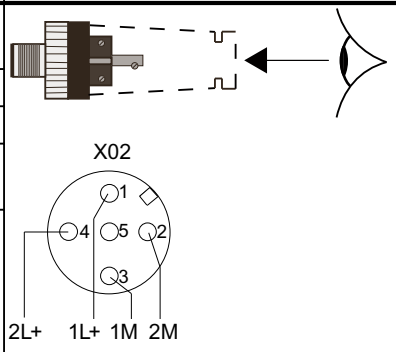
ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	1	Supply voltage 1L+	
	2	Ground 2M	

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	3	Ground 1M	
	4	Supply voltage 2L+	
	5	Reserved	

Cable connector for loop-through of the supply voltage, X02 socket

The module has an M12 connector with five female pins that are A-coded.

Table 1-1178 Pin assignment of the M12 cable connector for loop-through of the voltage

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	1	Supply voltage 1L+	
	2	Ground 2M	
	3	Ground 1M	
	4	Supply voltage 2L+	
	5	Reserved	

NOTE

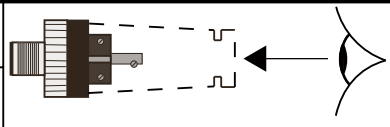
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

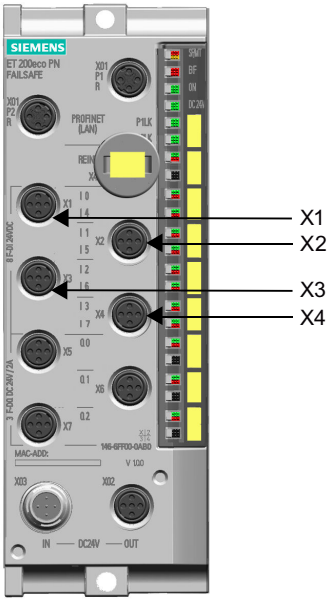
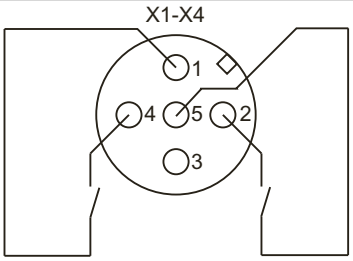
A.2.3.3 Pin assignment of digital inputs

Cable connector for digital inputs, X1 - X4

The module has an M12 connector with five female pins that are A-coded.

Table 1-1179 Pin assignment of digital inputs

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	1	24 V DC sensor supply Vs1	
	2	Input signal DI_4: Connector X1 Input signal DI_5: Connector X2 Input signal DI_6: Connector X3 Input signal DI_7: Connector X4	

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	3	Sensor supply ground 1M	
	4	Input signal DI_0: Connector X1 Input signal DI_1: Connector X2 Input signal DI_2: Connector X3 Input signal DI_3: Connector X4	
	5	24 V DC sensor supply Vs2	

When using the Y cable, pin 4 of the module connector is assigned to pin 4 of the A connector, and pin 2 of the module connector is assigned to pin 4 of the B connector.

NOTE

The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

Refer to "Digital input applications" (Page 74) for alternate applications wiring.

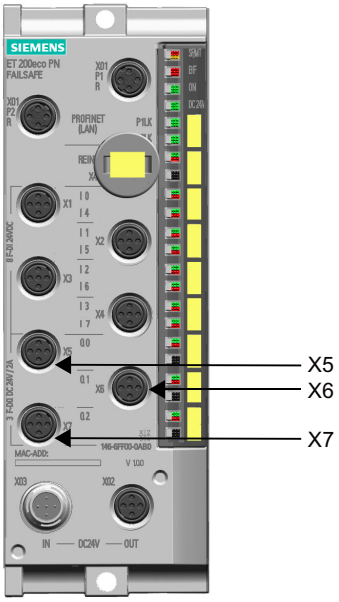
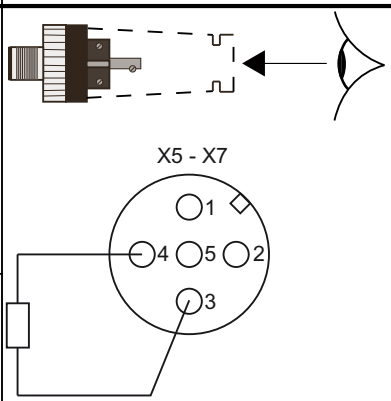
A.2.3.4 Pin assignment of digital outputs

Cable connector for digital outputs, X5 - X7

The module has an M12 connector with five female pins that are A-coded.

Table 1-1180 Pin assignment of digital outputs

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	1	Not used	
	2	Not used	

ET 200eco PN F	Pin	Assignment	View of the cable connector (wiring side)
	3	Output signal DQ0-M: Connector X5 Output signal DQ1-M: Connector X6 Output signal DQ2-M: Connector X7	
	4	Output signal DQ0-P: Connector X5 Output signal DQ1-P: Connector X6 Output signal DQ2-P: Connector X7	
	5	Functional earth FE	

NOTE
The M12 sockets for the supply and I/O have the same coding.
Make sure that you wire the supply and the I/O correctly.

Refer to "Digital output applications" (Page 86) for alternate applications wiring.

A.3 Terminal block

Refer to "Installing the terminal block" (Page 98) and "Wiring the terminal block" (Page 122) for installation and wiring information.

Refer to the "Distributed I/O ET 200eco PN Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW) for ET 200eco PN system terminal block technical specification information.

A.4 Voltage distributor

Refer to "Wiring the voltage distributor" (Page 125) for wiring information.

Refer to the "Distributed I/O ET 200eco PN Operating Instructions" (https://support.industry.siemens.com/cs/document/29999018/simatic-distributed-i-o-et-200eco-pn?dti=0&lc=en-WW) for ET 200eco PN system voltage distributor technical specification information.

Ordering information

B

B.1 ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12

Table 1-1181 ET 200eco PN F-DI 8 / F-DQ 3 module

Item		Article number
Digital inputs and digital outputs	ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12	6ES7146-6FF00-0AB0

B.2 Accessories for the ET 200eco PN F-DI 8 / F-DQ 3 module

⚠ CAUTION

In order to maintain the IP65/67 rating of the ET 200eco PN F-DI 8 / F-DQ 3 module, you can only utilize the appropriately approved accessories, some are listed below, for connection to the ET 200eco PN F-DI 8 / F-DQ 3 module.
Failure to use listed accessories can allow for ingress of water or dust into the ET 200eco PN F-DI 8 / F-DQ 3 module causing damage to the module. Electrical faults or unexpected machine operation can result in minor personal injury if proper precautions are not taken.
You must follow all instructions for installation and maintenance of a proper operating environment to ensure the equipment operates safely.

The table below contains the article numbers for the accessories of the ET 200eco PN F-DI 8 / F-DQ 3 module:

Table 1-1182 Accessories for the ET 200eco PN F-DI 8 / F-DQ 3 module

Designation	Article number
Accessories	
eCoding plug Stores the F-destination and F-source addresses; occupies X40 M12 connector, utilizing a B-coded plug	6ES7194-6KB01-0AA0
Voltage distributor PD 24 V DC 1x7/8" 4×M12	6ES7148-6CB00-0AA0
Terminal block	6ES7194-6CA00-0AA0 *
Mounting rail, 500 mm	6ES7194-6GA00-0AA0
Profile screws, 50 items	6ES7194-6MA00-0AA0
AS interface accessory M12 cover for IP67 devices	3RK1901-1KA00
Labels 10 x 7 mm, yellow, 816 items per pack	6ES7194-6HA00-0AA0

* All of the items with UL certification have an asterisk (*) following their article number.

Designation		Article number
Accessories for the interface "PROFINET M12 connection X1 P1/P2 LAN"		
SIMATIC NET IE M12 Plug pro M12 connector with rugged metal housing and quick connection technology, with 180° cable exit (D-coded), for SCALANCE X208pro and ET 200pro PN	1 pack = 1 units	6GK1901-0DB10-6AA0 *
	1 pack = 8 units	6GK1901-0DB10-6AA8 *
Connector for PROFINET 4-core, shielded		3RK1902-2DA00
SIMATIC NET IE FC M12 plug pro, M12 connector with rugged metal housing and FC connection technology, axial cable exit (D-coded), for SCALANCE X208pro and ET 200pro PN	1 pack = 1 units	6GK1901-0DB20-6AA0 *
	1 pack = 8 units	6GK1901-0DB20-6AA8 *
PROFINET M12 connecting cables		
SIMATIC NET; IE FC TP Standard Cable, GP 2x2 (PROFINET TYPE A), TP installation cable for connection to FC outlet RJ45, for universal usage, 4-wire, shielded CAT 5, sold in meters, delivery unit maximum length of 2000 m, minimum order length 20 m		6XV1840-2AH10
SIMATIC NET; IE FC TP trailing Cable, GP 2x2 (PROFINET TYPE C), TP installation cable for connection to FC outlet RJ45, for drag chain use, 4-wire, shielded CAT 5, sold in meters (5 million bend cycles), delivery unit maximum length of 2000 m, minimum order length 20 m		6XV1840-3AH10
SIMATIC NET; IE FC TP trailing Cable, GP 2x2 (PROFINET TYPE C), TP installation cable for connection to FC outlet RJ45, for drag chain use, 4-wire, CAT 5, sold in meters (1 million bend cycles), delivery unit maximum length of 1000 m, minimum order length 20 m		6XV1870-2D
SIMATIC NET; IE FC TP Marine Cable, TP installation cable for connection to FC outlet RJ45, ratified by ship builders, 4-wire, shielded CAT 5, sold in meters, delivery unit maximum length of 1000 m, minimum order length 20 m		6XV1840-4AH10
SIMATIC NET; IE FC TP Torsion Cable, 2x2 (PROFINET TYPE C), TP installation cable, 4-wire, for use in highly flexible applications (torsion), sold in meters, delivery unit maximum of 1000 m, minimum order amount 20 m		6XV1870-2F
SIMATIC NET, IE Connecting Cable M12-180/M12-180, preassembled IE FC Trailing Cable GP, with 2 x M12 connectors (D-coded)	0.3 m	6XV1870-8AE30 *
	0.5 m	6XV1870-8AE50 *
	1.0 m	6XV1870-8AH10 *
	1.5 m	6XV1870-8AH15 *
	2.0 m	6XV1870-8AH20 *
	3.0 m	6XV1870-8AH30 *
	5.0 m	6XV1870-8AH50 *
	10.0 m	6XV1870-8AN10 *
	15.0 m	6XV1870-8AN15 *
Bus line for PROFINET, converted on both sides, 4-wire, shielded, converted with 2 x M12 D coded, angled	3.0 m	6RK1902-2NB30
	5.0 m	6RK1902-2NB50
	10.0 m	6RK1902-2NC10
Bus line for PROFINET, converted on one side, 4-wire, shielded, converted with 1 x M12 D coded	3.0 m	3RK1902-2HB30
	3.0 m	3RK1902-2HB50
	10.0 m	3RK1902-2HC10
Miscellaneous		
AS interface accessory M12 sealing cap for IP67 modules		3RX9802-0AA00 *

* All of the items with UL certification have an asterisk (*) following their article number.

Designation		Article number
Accessory for the interface "M12-socket X1 to X4/X5 to X7"		
Preassembled cable		
Control cable Pre-assembled at one end M12 connector angled, 5-pole with 1.5 m cable 5 x 0.34 mm^2 A-coded max. 4 A PUR sheath black	1.5 m	3RK1902-4HB15-5AA0 *
Control cable Pre-assembled at one end M12 connector angled, 5-pole with 5 m cable 5 x 0.34 mm^2 A-coded max. 4 A PUR sheath black	5.0 m	3RK1902-4HB50-5AA0 *
Control cable Pre-assembled at one end M12 connector angled, 5-pole with 10 m cable 5 x 0.34 mm^2 A-coded max. 4 A PUR sheath black	10.0 m	3RK1902-4HC01-5AA0 *
Connecting cable M12-M12, 3-pin, PUR cable, 3 × 0.34 mm^2, type E, L, IP67, NO, straight female connector M12 to straight male connector M12	1.5 m	3RK1902-4PB15-3AA0
Y cable		
SIMATIC DP, Y cable for distributed I/O for double connection of standard inputs with one cable, 5-pin M12, 200 mm		6ES7194-6KA00-0XA0
SIMATIC DP, Y cable for distributed I/O for double connection of F-DI with one cable, 5-pin M12, 200 mm		6ES7194-6KB00-0XA0
SIMATIC DP, Inverted Y cable for distributed I/O for connecting an F-DI and F-DQ with one cable, 5-pin M12, 200 mm		6ES7194-6KC00-0XA0
SIRIUS safety position switch		3SE5324-0SD21-1AE4 3SE5324-0SD21-1AE5
Accessories for the interface "DC 24 V IN/OUT M12 (X02/X03)"		
SIMATIC NET, IE Power M12 Cable Connector pro, connection socket for connecting SCALANCE W-700/X208pro for 24 V DC supply voltage, 4-pin, A-coded, with mounting instructions, 3 items		6GK1907-0DC10-6AA3
SIMATIC NET, IE Power M12 Plug pro, plug connector for connecting Power Supply PS791-1 pro for 24 V DC supply voltage, 4-pin, A-coded, with mounting instructions, 3 items		6GK1907-0DB10-6AA3
Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.3 m	6XV1801-5DE30 *
	0.5 m	6XV1801-5DE50 *
	1.0 m	6XV1801-5DH10 *
	1.5 m	6XV1801-5DH15 *
	2.0 m	6XV1801-5DH20 *
	3.0 m	6XV1801-5DH30 *
	5.0 m	6XV1801-5DH50 *
	10.0 m	6XV1801-5DN10 *
	15.0 m	6XV1801-5DN15 *

* All of the items with UL certification have an asterisk (*) following their article number.

B.3 Accessories for voltage distributors

The table below contains the article numbers for the accessories of the voltage distributors:

Table 1-1183 Accessories for voltage distributors

Designation		Article number
Accessories for the interface "DC 24V IN 7/8" (X05)"		
7/8" connector with axial cable exit for field assembly ET 200, female insert		6KG19050FB00
24 V socket - 7/8" angled, 5-pin		3RK1902-3DA00
SIMATIC NET, Energy Cable, 5-wire power cable, stranded wire, 5 × 1.5mm^2, suitable for cable carriers, delivery unit max. 1000 m, minimum order amount 20 m		6XV1830-8AH10
Power Connecting Cable M12-180/M12-180 for power supply of the ET 200, preassembled cable with M12 connector and M12 socket, A-coded, 5-pin	0.3 m	6XV1801-5DE30
SIMATIC NET, 7/8" connector for power supply of the ET200, preassembled cable with 2 7/8" connectors, 5-pin	1.5 m	6XV1822-5BH15
	2.0 m	6XV1822-5BH20
	3.0 m	6XV1822-5BH30
	5.0 m	6XV1822-5BH50
	10.0 m	6XV1822-5BN10
	15.0 m	6XV1822-5BN15
Power cable 7/8" for 24 V, assembled with 2 7/8" both sides angled, 1.5 mm^2, pin - socket 5-pin	1.5 m	(on request)
	2.0 m	(on request)
	3.0 m	3RK1902-3NB30
	5.0 m	3RK1902-3NB50
	10.0 m	3RK1902-3NC10
	15.0 m	(on request)
Power cable 7/8" for 24 V, assembled with 1 7/8" one side angled, 1.5 mm^2, socket, 5-pin	3.0 m	3RK1902-3GB30
	5.0 m	3RK1902-3GB50
	10.0 m	3RK1902-3GC10

B.4 Spare fuses for terminal blocks

The table below contains the article numbers for spare parts:

Table 1-1184 Spare parts: Article numbers

Designation	Article number
Spare fuses for terminal block (miniature copper flat fuse, type FK1, 7.5 A, fast-blow)	6ES7194-6HB00-0AA0

B.5 Documentation

The tables below contain the ISBN or article numbers of additional documentation resources:

PROFINET IO

Technical book	Contents	Article number
Automating with PROFINET - Industrial Communication based on Industrial Ethernet	This book provides an introduction to PROFINET technology.	Commercial book number: ISBN 3-89578-244-0

SIMATIC Manual Collection

Designation	Contents	Article number
SIMATIC Manual Collection	Contains all SIMATIC manuals in electronic format	6ES7998-8XC01-8YE0

Technical Product Data - CD ROM

Designation	Contents	Article number
Technical Product Data for CAx Applications	Contains the following technical product data for CAD/CAE systems: • Technical data according to ECAD component standard V1.2 • Graphical data (drawings) • Circuit-diagram macros	6ES7991-0CC00-0YX0

B.6 Programming software

The table below contains the article numbers for applicable programming and visualization software:

Table 1-1185 Programming and visualization software

SIMATIC software		Article number
Programming software	STEP 7 Professional V15	6ES7822-1AA05-0YA5
	STEP 7 Safety Advanced V15	6ES7833-1FA15-0YA5
Visualization software	WinCC Basic V15	6AV2100-0AA01-0AA0
	WinCC Comfort V15	6AV2101-0AA01-0AA5
	WinCC Advanced V15	6AV2102-0AA01-0AA5
	WinCC Professional 512 PowerTags V15	6AV2103-0DA01-0AA5
	WinCC Professional 4096 PowerTags V15	6AV2103-0HA01-0AA5
	WinCC Professional max. PowerTags V15	6AV2103-0XA01-0AA5

Fail-Safe response times

C

C.1 Maximum response time of the system

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times" (http://support.automation.siemens.com/WW/view/en/49368678/133100).) Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{CYCLE} parameter values given below include an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

C.2 Response time parameters for the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs

Maximum Device Acknowledge Time of the ET 200eco PN F-DI 8 / F-DQ 3 module

T_{DAT_i} 16 ms	Device Acknowledge Time: This is the maximum time for the PROFIsafe message from the fail-safe module's digital inputs to include a response to a new Virtual Monitoring Number. You enter this value in the RT_calculator for a calculation of F-monitoring time.

Maximum response time of the ET 200eco PN F-DI 8 / F-DQ 3 digital inputs

1oo1 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$

$T_{OFDT_i} = T_{WCDT_i} + T_{scf}$

1oo2 evaluation:

$T_{WCDT_i} = T_{filter} + T_{sct} + 2 \times T_{cycle}$

$T_{OFDT_i} = T_{WCDT_i} + MAX (T_{scf}, T_{dis})$

Where:

T_{WCDT_i}	Worst Case Delay Time: Maximum response time of the fail-safe module's digital inputs from a signal transition at the digital input to the reliable availability of the safety message frame available for the fail-safe CPU request.
T_{OFDT_i}	One Fault Delay Time: Maximum response time for the fail-safe module's digital inputs to report a channel as passivated.
T_{filter}	Configured "Input filters" time for the channel
T_{DIS}	Discrepancy time: • Configured "Discrepancy time" for 1oo2 channels changing from "0" to "1" • Configured "Discrepancy time" for 1oo2 channels changing from "1" to "0" and "Supply last valid value" option configured for discrepancy behavior • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "0" for 1oo1 channels You should include the expected discrepancy time between your sensor inputs in your external sensor delay. Your configured T_{DIS} contributes to T_{OFDT_i} as the time delay for the fail-safe module's digital inputs to passivate the channel due to fault case extension of the discrepancy time. This parameter can be listed separately in the RT_calculator. Do not include T_{DIS} in the value of T_{OFDT} that you enter into the RT_calculator if you enter T_{DIS} as a separate item.
T_{sct}	Time delay for short-circuit test duration: • "0" if no short-circuit test configured • "0" for 1oo2 channels changing from "1" to "0" and "Supply value 0" option configured for discrepancy behavior • "Duration of short-circuit test" + "Input filters" time if short-circuit test is configured (Confirmation: "Input filters" can occur twice in equation for T_{WCDT_i} if short-circuit test is configured.)
T_{scf}	Time delay for short-circuit fault detection: • Configured "Interval for short-circuit test", when operating in high demand or continuous mode and depending on the short-circuit test to achieve your required level of safety integrity • "0" when not depending on the short-circuit test to achieve your required level of safety integrity
T_{cycle} 9 ms	Internal cycle time of the fail-safe module

The term "2 x T_{cycle}" allows for other input delays to complete just after the beginning of a cycle. The fail-safe module's digital inputs process and report the changed input data on the next cycle.

C.3 Response time parameters for the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs

Maximum response time of the ET 200eco PN F-DI 8 / F-DQ 3 digital outputs

$T_{WCDT_q} = T_{rb} + MAX (T_{rb}, T_{rb_swon}) + 2 \times T_{cycleq}$

$T_{OFDT_q} = T_{WCDT_q}$

Where:

T_{WCDT_q}	Maximum response time of the fail-safe module's digital outputs from the receipt of a safety message frame from the safety program in the fail-safe CPU to the signal transition at the digital output
T_{OFDT_q}	One Fault Delay Time: Maximum response time for the module's digital outputs to turn an output OFF upon detection of a channel or module fault
T_{rb}	Configured "Maximum readback time" for the channel
T_{rb_swon}	Configured "Maximum readback time switch on test" for the channel
T_{cycleq} 9 ms	Internal cycle time of the fail-safe module

The term "2 x T_{cycleq}" allows for a new process value to be delivered from the fail-safe CPU just after the beginning of a cycle. The fail-safe module's digital outputs process the changed output request and apply new data to the output switches on the next cycle.

After the fail-safe module's digital outputs command the output switch to change, the actual voltage on the load might not be realized until the configured readback time completes. If a bit pattern test is in progress, the new process value cannot be applied to the switches until the applicable readback time completes.

Minimum permissible OFF time for ET 200eco PN F-DI 8 / F-DQ 3 digital outputs

The fail-safe module's digital outputs expect to complete and confirm each ON to OFF transition before receiving a new command to go from OFF to ON. A process value of "0" presented for less than T_{WCDT_q} can cause the channel to passivate.

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Distributed I/O
Update to the ET 200eco PN F-DI 8 / F-DQ 3 Manual, edition 07/2018

Product Information

Overview to Documentation Update for the ET 200eco PN F

In spite of efforts to ensure the accuracy and clarity in the product documentation, some of the pages in the *ET 200eco PN F-DI 8 / F-DQ 3 Manual* contain information that has been identified as being incomplete, incorrect or misleading.

This document contains the following updates

- Corrections and additions to Section 5.1.1: "Safe functional extra low voltage requirement (power supplies and other system components)" (Page 1)
- Corrections to pin notations in wiring diagrams: "Laser Scanner (1oo2 evaluation)" and "ESTOP (1oo2 evaluation)" (Page 2)

Corrections and additions to Section 5.1.1: "Safe functional extra low voltage requirement (power supplies and other system components)"

Section 5.1.1: "Safe functional extra low voltage requirement (power supplies and other system components)" contains the following corrections and additions:

- Maximum voltage is 35 V DC
- Note detailing the requirements for power supplies in the event of voltage interruption (at the end of the section)

5.1.1 Safe functional extra low voltage requirement (power supplies and other system components)

NOTE

Fail-safe modules must be operated with safe functional extra-low voltage (SELV, PELV) power sources.
To maintain safety of the modules' low voltage circuits, external connections to communications ports, analog circuits, 24 V DC nominal supply voltage, and I/O circuits must be powered from approved sources that meet the requirements of SELV, PELV, Class 2, Limited Voltage, or Limited Power according to various standards.
The external power supply should limit the maximum voltage to 35 V DC even under fault conditions. Please consult the manufacturer's data for the power supplies that you use.

Maximum applied voltage to ET 200eco fail-safe devices

- Operational voltage: The fail-safe module's operational voltage is 20.4 V DC - 28.8 V DC, 35 V DC surge for 0.5 second. Operation of the unit to specifications is assured by design and testing. Defined transients from defined source impedances per EN 61000-4-2, 61000-4-4, 61000-4-6, as specified in the data sheet for each product, may be imposed on this voltage without disrupting operation or causing damage. Sustained operation in the range of 28.8 - 35 V DC can result in unacceptable temperature rise and thermal damage, causing the product to become inoperable.
- Absolute maximum rating regarding supply voltage: The absolute maximum rating to prevent module damage and to ensure the functional safety of the modules is 35 V DC. These power supplies must be specified by the manufacturer to limit the output voltage to 35 V DC or less under fault conditions. Otherwise, external protection must be supplied that will reliably open the circuit or limit the output voltage to less than 35 V DC to the modules.

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- Surge immunity: Wiring systems subject to surges from lightning strike coupling must be equipped with external protection. This protection must be sufficient to clamp surge voltages and/or open the supply circuit to assure the PLC system is not exposed to voltages greater than 35 V DC. One specification for evaluation of protection from lightning type surges is found in EN 61000-4-5, with operational limits established by EN 61000-6-2. The ET 200eco PN F module requires external protection to maintain safe operation when subject to surge voltages defined by this standard. Refer to Appendix A.1.5.1: "Surge immunity" for further information.

NOTE

All power supply and fail-safe module circuits must be connected together to a common voltage reference or must be isolated SELV circuits.

The power supply M terminals on the fail-safe CPU and the fail-safe modules must be connected together or isolated as SELV. Failure to do so can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.

Connecting all M terminals together or isolating with approved SELV isolation prevents unwanted current flows in the event of a single fault in the CPU to module isolation boundary.

NOTE

Requirements for power supplies in the event of voltage interruption

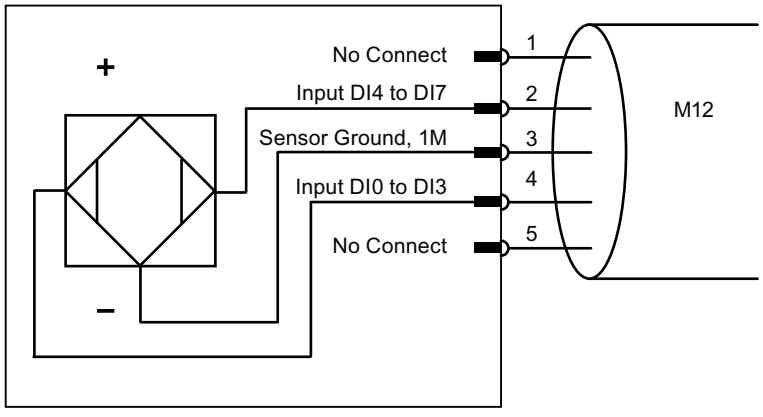
To ensure adherence to IEC 61131-2 and NAMUR Recommendation NE 21, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirement in your product standards (for example, 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions. The latest information on PS components is available on the Internet (https://mall.industry.siemens.com).

Corrections to pin notations in wiring diagrams: "Laser Scanner (1oo2 evaluation)" and "ESTOP (1oo2 evaluation)"

The pin notations for the following wiring diagrams are corrected:

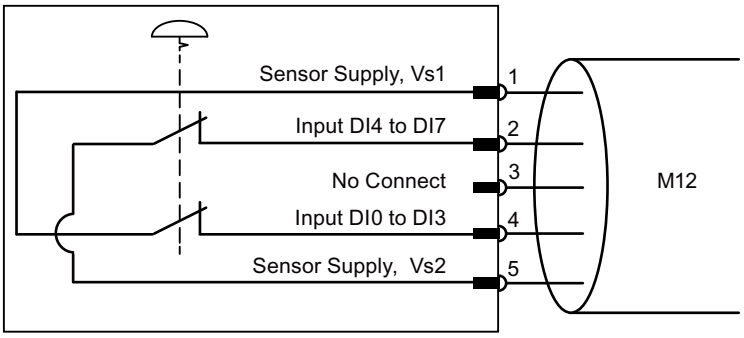
- Laser Scanner (1oo2 evaluation): Located in Section 5.2.7.5: "Configuring 1oo2 and 1oo1 evaluations in the ET 200eco PN F-DI 8 / F-DQ 3" and Section 2.1.4: "Operating the Getting Started example"

Laser Scanner (1oo2)

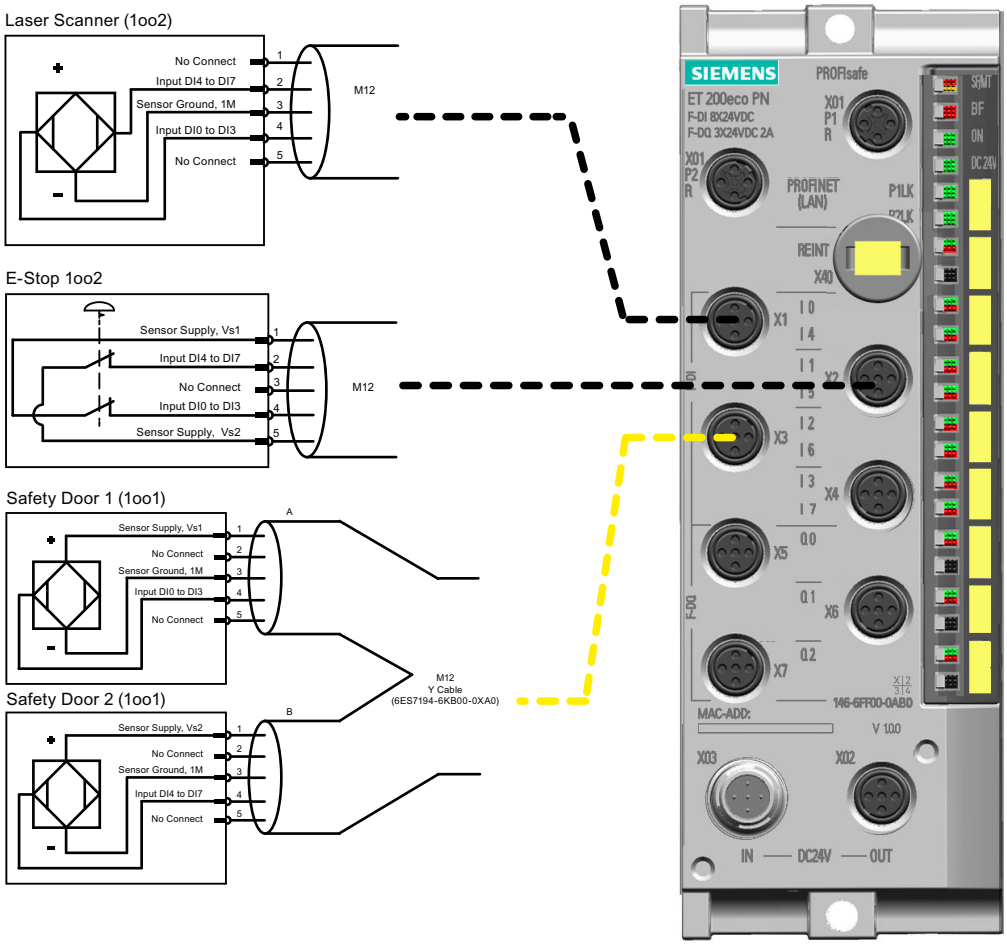


- ESTOP (Emergency Stop) (1oo2 evaluation): Located in Section 5.2.7.5: "Configuring 1oo2 and 1oo1 evaluations in the ET 200eco PN F-DI 8 / F-DQ 3" and Section 2.1.4: "Operating the Getting Started example"

  ESTOP (1oo2)



- Connections to the ET 200eco PN F: Located in Section 5.2.7.5: "Configuring 1oo2 and 1oo1 evaluations in the ET 200eco PN F-DI 8 / F-DQ 3"



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Distributed I/O
M12 Fail-Safe Y cable and M12 Fail-Safe inverted Y cable
Product Information

Introduction
The Y cable allows you to connect two sensors to the inputs with the M12 connection method. Use of the Y cable is recommended when two channels are occupied for each socket of the distributed I/O device. The Y cable distributes the two fail-safe input channels to two circular connectors.
The "inverted" Y cable provides a method of connecting an F-DQ channel and F-DI channel with one cable for use with a Siemens SIRIUS safety position switch with an interlock.
Refer to the respective product user manual for connection details.

Y cable (double connection of F-DI: 6ES7194-6KB00-0XA0)Y cable
The following figure shows the structure of the Y cable:

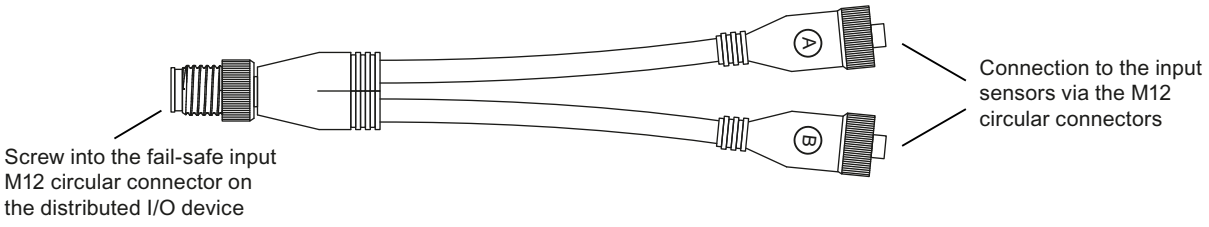


Figure 1 Y cable

Inverted Y cable (double connection of F-DI and F-DQ: 6ES7194-6KC00-0XA0)Inverted Y cable
The following figure shows the structure of the inverted Y cable:

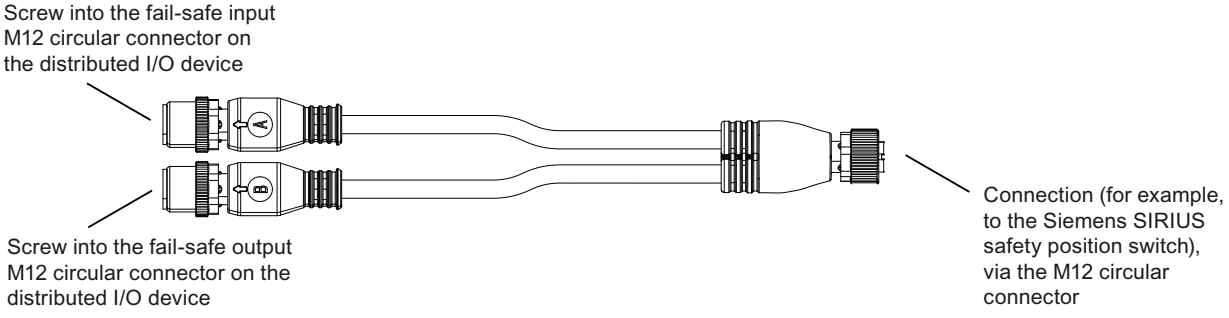
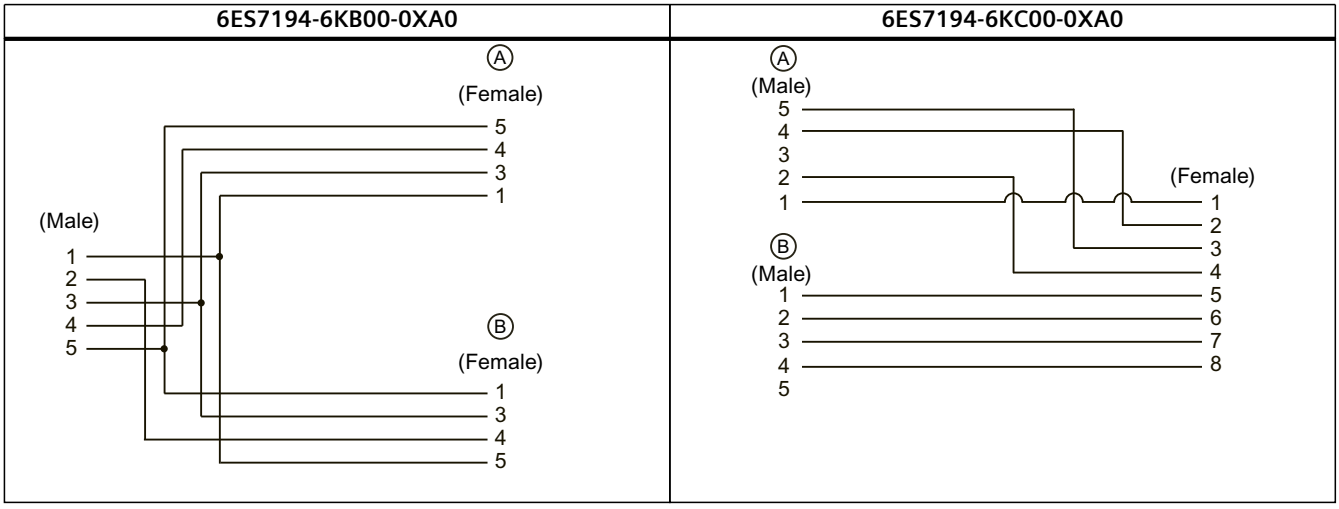


Figure 2 Inverted Y cable

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Wiring
The following figure shows the wiring of the Y cable (6ES7194-6KB00-0XA0) and the inverted Y cable (6ES7194-6KC00-0XA0):



Dimension drawings

The dimension drawings of the Y cable and inverted Y cable are provided below. You must take the dimensions into consideration for installation of your distributed I/O system in cabinets, control rooms, etc.:

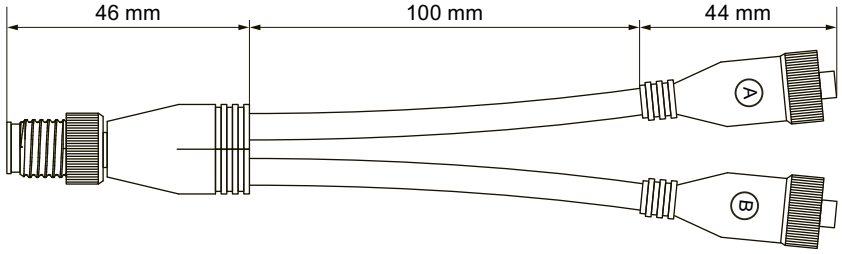


Figure 3 Y cable dimension drawing

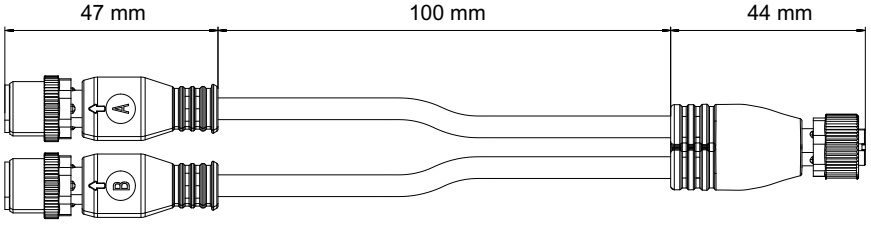


Figure 4 Inverted Y cable dimension drawing

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Distributed I/O fail-safe engineering ET 200pro Distributed I/O System - Fail-Safe Modules

Operating Instructions

Product Overview 1

Configuration 2

Address Assignment and Installation 3

Wiring 4

Diagnostics 5

General Technical Specifications 6

Fail-Safe Connection Modules 7

Fail-Safe Electronic Modules 8

Diagnostic Data of Fail-Safe Modules A

Dimension Drawings B

Accessories and Order Numbers C

Response Times D

Switching of Loads E

07/2013
A5E00394073-03

Preface

Purpose of this Manual

The information in this manual is a reference source for operations, function descriptions, and technical specifications of the fail-safe modules of the ET 200pro distributed I/O system.

Basic Knowledge Requirements

This manual is a supplement to the *ET 200pro Distributed I/O System* manual. Working with this manual requires general knowledge of automation engineering. Knowledge of the *STEP 7* basic software and the ET 200pro distributed I/O system is also required.

Scope of this Manual

Module	Order Number	Release Number and Higher
CM IO 16xM12 fail-safe connection module for EM 8/16 F-DI electronic module	6ES7194-4DD00-0AA0	01
CM IO 12xM12 fail-safe connection module for EM 4/8 F-DI/4 F-DO electronic module	6ES7194-4DC00-0AA0	01
CM F-IO 2×M12 fail-safe connection module for F-Switch PROFIsafe	6ES7194-4DA00-0AA0	01
EM 8/16 F-DI DC24V PROFIsafe fail-safe digital electronic module	6ES7148-4FA00-0AB0	01
EM 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe fail-safe digital electronic module	6ES7148-4FC00-0AB0	01
F-Switch PROFIsafe fail-safe digital electronic module	6ES7148-4FS00-0AB0	01

What's New

Compared with the previous version, this manual includes the following major changes/additions:

- F-Switch PROFIsafe digital electronic module

Approvals

See "Standards and Approvals"

In addition, ET 200pro fail-safe modules are certified for use in safety mode up to the following levels:

- Safety Integrity Level SIL3 in accordance with IEC 61508:2000
- Performance level (PL) e and category 4 in accordance with ISO 13849-1:2006 or EN ISO 13849-1:2008

CE Certification

See "Standards and Approvals"

Certification Mark for Australia (C-Tick Mark)

See "Standards and Approvals"

Standards

See "Standards and Approvals"

Position in the Information Landscape

When working with ET 200pro fail-safe modules and depending on your particular application, you will need to consult the additional documentation listed below.

References to additional documentation are included in this manual where appropriate.

Documentation	Brief Description of Relevant Contents
ET 200pro Distributed I/O System Manual	Describes all generally applicable topics for the ET 200pro hardware (including configuration, installation, and wiring of ET 200pro)
Safety Engineering in SIMATIC S7 System Description	• Provides an overview of the application, configuration, and method of operation of S7 Distributed Safety and S7 F/FH Systems fail-safe automation systems • Contains a summary of detailed technical information concerning fail-safe engineering in S7-300 and S7-400 • Includes monitoring and response time calculations for S7 Distributed Safety and S7 F/FH Systems fail-safe systems
For integration in the S7 Distributed Safety fail-safe system	The following elements are described in the *S7 Distributed Safety Configuring and Programming* Operating Manual and Online Help: • Configuration of the F-CPU and the F-I/O • Programming of the F-CPU in F-FBD or F-LAD
	Depending on which F-CPU you are using, you will need the following documentation: • The *S7-300, CPU 31xC and CPU 31x Operating Instructions: Installation* describes the assembly and wiring of S7-300 systems. • The *CPU 31xC and CPU 31x, Technical Data* Manual describes the standard functions of the CPU 315-2 DP and PN/DP and the CPU 317-2 DP and PN/DP. • The *Automation System S7-400 Hardware and Installation* Installation Manual describes the assembly and wiring of S7-400 systems.

Documentation	Brief Description of Relevant Contents
	• The *Automation System S7-400 CPU Specifications* Reference Manual describes CPU 416-2. • Each applicable F-CPU has its own product information bulletin. These product information bulletins describe only the deviations from the relevant standard CPUs.
STEP 7 manuals	• The *Configuring Hardware and Communication Connections with STEP 7 V5.x* Manual describes the operation of the relevant standard tools of *STEP 7*. • The *System Software for S7-300/400 System and Standard Functions* Reference Manual describes functions for distributed I/O access and diagnostics.
STEP 7 Online Help	• Describes how to operate the standard tools of *STEP 7* • Contains information about how to configure and assign parameters for modules and intelligent slaves with *HW Config* • Contains a description of the FBD and LAD programming languages
PCS 7 manuals	• Describe how to operate the *PCS 7* process control system (required when ET 200pro with fail-safe modules is integrated in a higher-level control system).

The entire SIMATIC S7 documentation is available on CD-ROM.

Guide

This manual describes the fail-safe modules of the ET 200pro distributed I/O system. It consists of instructional sections and reference sections (technical specifications and appendices).

This manual presents the following basic aspects of fail-safe modules:

- Structure and application
- Configuring
- Addressing, installing, and wiring
- Diagnostic evaluation
- Technical Specifications
- Order numbers

Conventions

In this manual, the terms "safety engineering" and "fail-safe engineering" are used synonymously. The same applies to the terms "fail-safe" and "F-".

"When *"S7 Distributed Safety"* appears in italics, it refers to the optional packages for the two "S7 Distributed Safety" fail-safe systems.

Recycling and Disposal

Due to the low levels of pollutants in the fail-safe modules of the ET 200pro, the modules can be recycled. For proper recycling and disposal of your old module (device), consult a certified disposal facility for electronic scrap.

Additional Support

If you have further questions about the use of products presented in this manual, contact your Siemens representative in your local office.
(http://www.siemens.com/automation/partner)

Training Center

We offer courses to help you get started with the S7 automation system. Contact your regional training center or the central training center in D 90327 Nuremberg, Federal Republic of Germany.

Internet: (http://www.sitrain.com)

H/F Competence Center

The H/F Competence Center in Nuremberg offers special workshops on SIMATIC S7 fail-safe and fault-tolerant automation systems. The H/F Competence Center can also provide assistance with onsite configuration, commissioning, and troubleshooting.

For questions about workshops, etc., contact: hf-cc@siemens.com

Technical Support

Technical support for all A&D products can be obtained

- Using the Support Request Web form on the Internet (http://www.siemens.en/automation/support-request)

You can find additional information about our Technical Support on the Internet (http://www.siemens.en/automation/service)

Service & Support on the Internet

In addition to our paper documentation, we offer our complete knowledge base on the Internet (http://www.siemens.com/automation/service&support).

There, you will find the following information:

- Newsletters providing the latest information on your products
- Relevant documentation for your application, which you can access via the search function in Service & Support
- A forum where users and experts from all over the world exchange ideas
- Your local Automation & Drives representative
- Information about local service, repair, and replacement parts and much more can be found under "Services."

Important Note for Maintaining the Operational Safety of Your System

NOTE

Operators of systems with safety-related characteristics are subject to special requirements for operational safety. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish a special newsletter containing information on product developments and product properties that are important (or potentially important) for operation of systems where safety is an issue. By subscribing to the relevant newsletter, you will ensure that you are always up-to-date and able to make changes to your system, when necessary. Please go to the Internet (http://my.ad.siemens.de/myAnD/guiThemes2Select.asp?subjectID=2&lang=en) and register for the following newsletters:

- SIMATIC S7-300
- SIMATIC S7-400
- Distributed I/O
- SIMATIC Industrial Software

To receive these newsletters, select the corresponding check boxes.

See also

Standards and Approvals (Page 36)

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Product Overview

1

Overview

This chapter provides information about the following topics:

- ET 200pro distributed I/O system with fail-safe modules and its place in SIMATIC S7 fail-safe automation systems
- Components comprising the ET 200pro distributed I/O system with fail-safe modules
- The steps you must perform, ranging from selection of the F-modules to commissioning of ET 200S on PROFIBUS DP/PROFINET IO

1.1 ET 200pro Fail-Safe Modules

Fail-Safe Automation System

Fail-safe automation systems (F-systems) are used in systems with increased safety requirements. F-systems are used to control processes that can achieve a safe state immediately as a result of a shutdown. In other words, F-systems control processes where an immediate shutdown will not endanger humans or the environment.

ET 200pro Distributed I/O System

The ET 200pro distributed I/O system is a DP slave/IO device on PROFIBUS DP/PROFINET IO that can contain fail-safe modules in addition to ET 200pro standard modules.

You can use copper cables to assemble the PROFIBUS DP/PROFINET IO lines.

Fail-Safe Modules

The primary difference between fail-safe modules and ET 200pro standard modules is that fail-safe modules have a two-channel internal design. The two integrated processors monitor each other, automatically test the input and output circuits and set the F-module to a safe state in the event of a fault. The F-CPU communicates with the fail-safe module using the PROFIsafe safety-related bus profile.

Fail-safe digital input modules record the signal states of safety-related sensors and send corresponding safety message frames to the F-CPU.

Fail-safe digital output modules are suitable for shutdown operations with short-circuit and cross-circuit monitoring up to the actuator.

Fail-safe switch acquires the signal states of safety-related sensors and sends corresponding safety message frames to the F-CPU and is suitable for connection of frequency converters, motors, and output modules.

Fail-safe connection modules are mounted on the fail-safe electronic modules. They are used to connect sensors and actuators.

1.2 Application of ET 200pro fail-safe modules

Possible Applications of ET 200pro With Fail-Safe Modules

The use of ET 200pro with fail-safe modules enables conventional safety engineering designs to be replaced with PROFIBUS DP/PROFINET IO components. This includes replacement of switching devices for emergency stop, protective door monitors and two-hand operation.

Use in F-Systems

ET 200pro fail-safe modules can be used:

- In the S7 Distributed Safety F-system with the *S7 Distributed Safety* V 5.1 or higher and *F-Configuration Pack* V 5.4 or higher optional packages

The following manuals are applicable to the use of ET 200pro fail-safe modules in F-systems:

- *ET 200pro Distributed I/O Device*
- *Safety Engineering in SIMATIC S7*
- *S7 Distributed Safety, Configuring and Programming*

F-System with ET 200pro

The following figure presents an example configuration for an S7 Distributed Safety F-system including an ET 200pro on PROFIBUS DP/PROFINET IO.

The fail-safe DP master/IO controller exchanges safety-relevant and non-safety-relevant data, for example, with the fail-safe and standard ET 200pro modules.

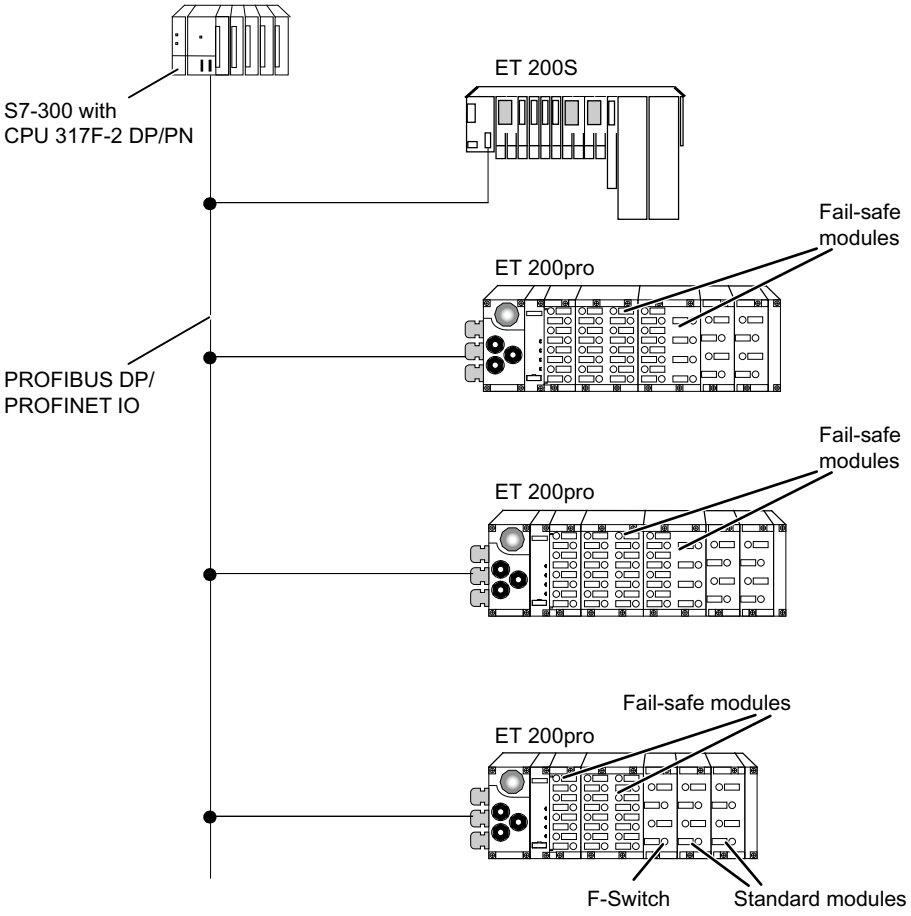


Figure 1-872 S7 Distributed Safety Fail-Safe Automation System

Availability of Fail-Safe Electronic Modules

The following fail-safe electronic modules are available for ET 200pro:

- 8/16 F-DI DC24V PROFIsafe Digital Electronic Module
- 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe digital electronic module; P/M switching (current sourcing/sinking)
- F-Switch PROFIsafe digital electronic module, (one F-switch per potential group allowed)

Fail-safe connection modules are available for the fail-safe electronic modules. A detailed list of these modules is included in this manual.

Application Limited to Safety Mode

You can operate standard and fail-safe modules simultaneously in an ET 200pro.

Fail-safe modules can only be used in safety mode. They cannot be operated in standard mode.

Achievable Safety Classes

Fail-safe modules are equipped with integrated safety functions for safety mode.

The following safety classes can be achieved by assigning applicable parameters to the safety functions in *STEP 7* with the *S7 Distributed Safety* or *S7 F/FH Systems* optional package, combining certain standard and F-modules and arranging the wiring of the sensors and actuators in a specific way:

Table 1-1186 Achievable Safety Classes in Safety Mode

Safety class in safety mode	
According to IEC 61508:2000	**According to ISO 13849-1:2006 or EN ISO 13849-1:2008**
SIL2	Cat. 3/PLe
SIL3	Cat. 4/PLe

See also

Configuration of ET 200pro with Fail-Safe Modules (Page 15)

1.3 Guide for Commissioning of ET 200pro with Fail-Safe Modules

Introduction

The following table lists all important steps required for commissioning ET 200pro distributed I/O systems with fail-safe modules as DP slaves/IO devices on PROFIBUS DP/PROFINET IO.

Sequence of Steps Starting From Selection of F-Modules to Commissioning of ET 200pro

Table 1-1187 Sequence of Steps Starting From Selection of F-Modules to Commissioning of ET 200pro

Step	Procedure	See ...
1.	Select F-modules for ET 200pro configuration.	Chapter "Configuration Options"
2.	Configure and assign parameters for F-modules in *STEP 7*.	Chapter "Configuration and Parameter Assignment" and "Fail-Safe Modules"
3.	Set PROFIsafe addresses on F-modules.	Chapter "Address Assignment and Installation"
4.	Mount ET 200pro.	Chapter "Address Assignment and Installation"
5.	Wire ET 200pro.	Chapter "Wiring and Assembly"
6.	Commission ET 200pro on PROFIBUS DP/PROFINET IO.	*ET 200pro Distributed I/O Device* manual
7.	If commissioning was not successful, perform diagnostics on ET 200pro.	Chapters "Diagnostics" and "Fail-Safe Modules" and *ET 200pro Distributed I/O Device* manual

NOTE

You must configure and assign parameters for the F-modules in *STEP 7* prior to commissioning.

Reason: *STEP 7* automatically assigns the PROFIsafe addresses to the F-modules. You must set these PROFIsafe addresses on each F-module via a switch before mounting the module.

Configuration

2

2.1 Configuration of ET 200pro with Fail-Safe Modules

Introduction

You can configure ET 200pro distributed I/O systems with standard and fail-safe modules. This chapter presents an example configuration.

Configuration Example for ET 200pro with Fail-Safe Modules

The figure below presents a configuration example with standard and fail-safe modules within an ET 200pro.

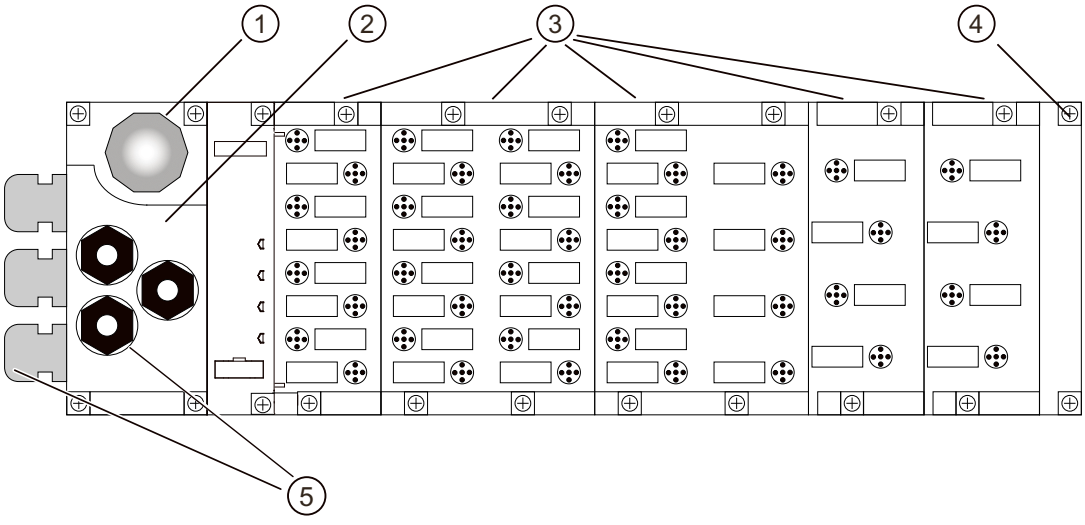


Figure 1-873 Configuration Example for ET 200pro with Fail-Safe Modules

① CM IM DP Direct connection module for the interface module

② IM 154-2 DP HIGH FEATURE (PROFIBUS DP) interface module (6ES7 154-2AA00-0AB0)
IM 154-4 PN HIGH FEATURE (PROFINET IO) interface module (6ES7 154-4AA00-0AB0)

③ Connection modules for the electronic modules

④ Terminating module

⑤ Heavy-gauge threaded joints for cables at the connection module

2.2 Allocation of Modules of an ET 200pro

Introduction

This chapter describes the assignment of F-electronic modules to F-connection modules for ET 200pro.

Assignment of F-Electronic Modules to F-Connection Modules

You can use the following fail-safe electronic modules and connection modules together:

Table 1-1188 Assignment of F-Electronic Modules to F-Connection Modules

F-electronic modules	F-connection modules
8/16 F-DI DC24V PROFIsafe electronic module (6ES7 148-4FA00-0AB0)	CM IO 16×M12 for 8/16 F-DI electronic module (6ES7 194-4DD00-0AA0)
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module (6ES7 148-4FC00-0AB0)	CM IO 12×M12 for 4/8 F-DI/4 F-DO electronic module (6ES7 194-4DC00-0AA0)
F-Switch PROFIsafe electronic module (6ES7 148-4FS00-0AB0)	CM F-IO 2×M12 for F-Switch PROFIsafe electronic module (6ES7 194-4DA00-0AA0)

See also

Properties of 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 51)
Properties of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 79)
Properties of the F-Switch PROFIsafe Electronic Module (Page 96)

2.3 Limitation of Connectable Modules/Maximum Configuration

Maximum Number of Modules

PROFIBUS DP: The maximum number of modules in an ET 200pro depends on the parameter length of the modules. A total of 244 bytes per ET 200pro are possible.

PROFINET IO: A maximum installation width of 1 m must not be exceeded.

Table 1-1189 Parameter Length of F-Modules in Bytes

Fail-Safe Module	Parameter length
8/16 F-DI DC24V PROFIsafe	42 bytes
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe	34 bytes
F-Switch PROFIsafe	26 bytes

Example for PROFIBUS DP

In the following example, modules with a total parameter length of 205 bytes were used in an ET 200pro. There are also 39 bytes available for installation of additional modules.

Number and type of modules	:	1 x IM154-2 HIGH FEATURE	+	2 x 8/16 F-DI	+	2 x 4/8 F-DI/4 F-DO	+	1 x F-Switch PROFIsafe	= 6 modules
Parameter length	:	27 bytes	+	84 bytes	+	68 bytes	+	26 bytes	= 205 bytes

ET 200pro: Limitation and Maximum Configuration

For information on the limitations and maximum configuration of the standard ET 200pro, refer to the *ET 200pro Distributed I/O System* manual.

2.4 Configuration and Parameter Assignment

Requirements

The following are required for configuring and assigning parameters for ET 200pro fail-safe modules:

- *STEP 7*, V 5.3 SP2 or higher; HSP 63 to 68
- *S7 Distributed Safety*, V 5.1 or higher
- *F Configuration Pack*, V 5.5 SP2 or higher

The *F Configuration Pack* V 5.5 SP2 is available for download on the Internet at: http://www.siemens.com/automation/service&support

Configuring

Fail-safe modules are configured in the same way as ET 200pro standard modules with *STEP 7 HW Config*.

Assigning Parameters for Electronic Module Properties

To assign parameters to fail-safe electronic module properties, select the module in *STEP 7 HW Config* and select "Edit > Object Properties".

During a download operation, the parameters are transferred from the programming device (PG) to the F-CPU and stored there. The parameters are then transferred from the F-CPU to the fail-safe module.

Parameter Description

You will find a description of assignable fail-safe electronic module parameters in this manual.

PROFIsafe Address and PROFIsafe Address Assignment

You will find a description of the PROFIsafe address and the procedure for assigning the address in this manual.

See also

Assignment of PROFIsafe Address (Page 20)
Parameters for the 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 54)
Parameters for the 4/8 F-DI/4 F-DO DC24V/2 A PROFIsafe Electronic Module (Page 82)
Parameters for the F-Switch PROFIsafe Electronic Module (Page 98)

Address Assignment and Installation

3

3.1 Address Assignments in the F-CPU

Address Assignment

The fail-safe modules occupy the following address ranges in the F-CPU:

- For S7 Distributed Safety: in the process image area

Table 1-1190 Address Assignment in the F-CPU

F-module	Occupied bytes in the F-CPU:	
	In input range	In output range
8/16 F-DI DC24V PROFIsafe	x + 0 to x + 7	x + 0 to x +3
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe	x + 0 to x +6	x + 0 to x +4
F-Switch PROFIsafe	x + 0 to x + 6	x + 0 to x + 4
x = Module start address		

Addresses Occupied by User Data

Of the assigned fail-safe module addresses in the F-CPU, the user data occupy the following:

Table 1-1191 Addresses Occupied by Input User Data

Bytes in the F-CPU	Occupied bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
8/16 F-DI DC24V PROFIsafe:								
x + 0	Channel 7 or 0 (SIL3)	Channel 6 or 0 (SIL3)	Channel 5 or 0 (SIL3)	Channel 4 or 0 (SIL3)	Channel 3	Channel 2	Channel 1	Channel 0
x +1	Channel 15 or 0 (SIL3)	Channel 14 or 0 (SIL3)	Channel 13 or 0 (SIL3)	Channel 12 or 0 (SIL3)	Channel 11	Channel 10	Channel 9	Channel 8
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe:								
x + 0	Channel 7 or 0 (SIL3)	Channel 6 or 0 (SIL3)	Channel 5 or 0 (SIL3)	Channel 4 or 0 (SIL3)	Channel 3	Channel 2	Channel 1	Channel 0
F-Switch PROFIsafe:								
X + 0	0	0	0	0	0	0	Channel 1	Channel 0
x = Module start address								

Table 1-1192 Addresses Occupied by Output User Data

Bytes in the F-CPU	Occupied bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe:								
x + 0	-	-	-	-	Channel 3	Channel 2	Channel 1	Channel 0

Bytes in the F-CPU	**Occupied bits in F-CPU per F-module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
F-Switch PROFIsafe:								
X + 0	0	0	0	0	0	Channel 2	Channel 1	Channel 0
x = Module start address								

WARNING

You can only access addresses occupied by user data. The other addresses occupied by the F-modules are assigned for functions including safety-related communication between F-modules and the F-CPU in accordance with PROFIsafe.
In 1oo2 sensor evaluation, only the lower-value channel of the channels combined by the 1oo2 sensor evaluation can be accessed in the safety program.

Additional Information

For detailed information about F-I/O access, refer to the *S7 Distributed Safety, Configuring and Programming* manual.

3.2 Assignment of PROFIsafe Address

PROFIsafe Address

Each fail-safe module has its own PROFIsafe address in addition to the PROFIBUS/Industrial Ethernet address. Before installing fail-safe modules, you must set the PROFIsafe address of the F-module on each F-module.

PROFIsafe Address Assignment

The PROFIsafe addresses (F_source_address, F_destination_address) are automatically assigned when the fail-safe modules are configured in *STEP 7*.

The F_destination_address is shown in binary format in the "DIP switch setting" parameter in the object properties for the fail-safe modules in *HW Config*. You must obtain this PROFIsafe address from the parameter assignment dialog box and set it on the fail-safe modules using an address switch.

You can change the configured F_destination_address in *HW Config*. To prevent addressing errors, however, we recommend that you use the automatically assigned F_destination_address.

Address Switch for Setting the PROFIsafe Address

An address switch (10-pin DIP switch) is located on the electronic module. You set the PROFIsafe address (F_destination_address) of the F-module at this address switch.

NOTE

Fail-safe modules in ET 200pro can only be used in safety mode.

Setting the Address Switch

Make sure that the address switch is set properly **before installing** the F-module.

PROFIsafe addresses 1 through 1022 are permitted. The figure below illustrates an example of the switch setting for an address.

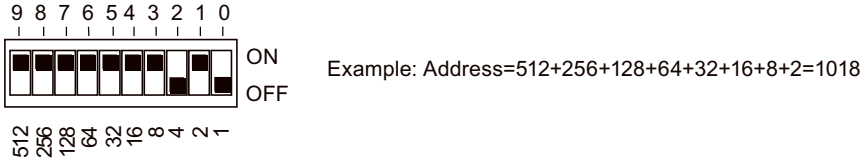


Figure 1-874 Example for Setting the Address Switch (DIP Switch)

NOTE

An address switch of the smallest possible dimensions is installed for reasons of space saving. This makes it sensitive to pressure and objects with sharp edges. Always use a suitable tool to operate the address switch.

Diverse tools suitable for activating the address switch are available on the market, for example, the Grayhill DIPSTICK. A ballpoint pen may be employed if used carefully. It is imperative to avoid any burring which would prevent the switch from reaching its home position. Therefore, DO NOT use screwdrivers or knives to operate the address switch.

Rules for Address Assignment

⚠ WARNING

Observe the following rules when assigning the address:

- Make sure that the address switch setting of the F-I/O matches the PROFIsafe destination address in *STEP 7 HW Config* (Parameter "F_Destination_Address").

3.3 Installing

Installing Fail-Safe Modules

Fail-safe electronic modules and connection modules are part of the ET 200pro range of modules. They are installed in the same way as standard modules in an ET 200pro.

For more information about module installation, refer to the *ET 200pro Distributed I/O Device* manual.

Wiring

4

> **WARNING**
>
> In order to prevent danger to humans or the environment, you must not under any circumstances override safety functions or implement measures that cause safety functions to be bypassed or result in the bypassing of safety functions. The manufacturer is not liable for the consequences of such manipulations or for damage resulting from a failure to heed this warning.

Overview

This chapter presents the specific characteristics involved in wiring fail-safe modules. Generally applicable information about wiring both ET 200pro with fail-safe modules and ET 200pro with standard modules can be found in the *ET 200pro Distributed I/O Device* manual.

4.1 Safe Functional Extra Low Voltage for Fail-Safe Modules

Safe Functional Extra Low Voltage

> **WARNING**
>
> Fail-safe modules must be operated with safe functional extra low voltage (SELV, PELV). This means that only a maximum voltage U_m can ever be applied to these modules, even in the event of a fault. The following applies to all fail-safe modules:
> **U_m < 60.0 V**
> You can find additional information about safe functional extra low voltage, for example, in the data sheets for the applicable power supplies.

All components of the system that are capable of supplying electrical energy in any form must meet this requirement.

Each additional power circuit (24 V DC) installed in the system must be operated with safe functional extra low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer for information.

Note, too, that sensors and actuators with an external power supply can be connected to F-modules. In this context, bear in mind the supply voltage from safe functional extra low voltage. The process signal of a 24 V DC digital module must not exceed a fault voltage U_m, even in the event of a fault.

⚠ WARNING

All voltage sources, for example, internal 24 V DC load voltage supplies, external 24 V DC load voltage supplies and 5 V DC bus voltage, must be electrically connected externally. This prevents voltage additions in the individual voltage sources that would cause the fault voltage U_m to be exceeded, even in the event of potential differences.
Make sure that the cable cross section is sufficient for the electrical connection, in accordance with the ET 200pro configuration guidelines (see *ET 200pro Distributed I/O Device* manual).

Power Supply Requirements for Compliance With the NAMUR Recommendation

NOTE

To comply with NAMUR recommendation NE 21, IEC 61131-2 and EN 298, only power packs or power supplies (230 V AC --> 24 V DC) with a power loss ride-through of at least **20 ms** can be used. The latest information about PS components can be accessed on the Internet at: https://mall.ad.siemens.com
These requirements also apply to power packs or power supplies not produced in ET 200pro or S7-300/400 designs.

4.2 Wiring of Fail-Safe Modules

Same Wiring Procedure as ET 200pro

Fail-safe electronic modules and connection modules are part of the ET 200pro range of modules. They are wired in the same way as standard modules in an ET 200pro.

For more information about wiring modules, refer to the *ET 200pro Distributed I/O Device* manual.

⚠ WARNING

When assigning the F-DI module signals, remember that signals should only be routed within a cable or a non-metallic sheathed cable if:

- A short circuit in the signals does not conceal a serious safety risk.
- Signals are supplied by different sensor supplies of this F-DI module.

Applicable Mounting Rails

Only racks for ET 200pro can be used for installing ET 200pro with fail-safe modules (see *ET 200pro Distributed I/O Device* manual).

Terminal Assignment of Connection Modules

The terminal assignment of the connection modules depends on which electronic module is inserted.

See also

Block Diagram of 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 53)
Use Case 1: Safety Mode SIL2/Category 3 (Page 59)
Use Case 2: Safety Mode SIL3/Category 3 (Page 60)
Use Case 3: Safety Mode SIL3/Category 4 (Page 69)
Wiring of Inputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 86)
Wiring of Outputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 87)
Block Diagram of the F-Switch PROFIsafe Electronic Module (Page 98)
Use Case 1: Safety Mode of F-Switch PROFIsafe (Page 103)
Use Case 2: Safety Mode SIL3/Category 3 (Page 104)
Use Case 3: Safety Mode SIL3/Category 4 (Page 112)

4.3 Inserting and removing fail-safe connection modules and electronic modules

Inserting and Removing Modules

Fail-safe modules in ET 200pro are inserted and removed in the same way as all standard modules in an ET 200pro.

Inserting and Removing Modules During Operation

F-modules can be removed and inserted during operation in exactly the same way as standard modules in ET 200pro.

Follow the instructions in the *"Maintenance and Service"* chapter in the *ET 200pro Distributed I/O Device* manual.

NOTE

Note that replacing fail-safe modules in ET 200pro during operation will generate a communication error in the F-CPU.

You must acknowledge the communication error in your safety program (for information about F-system behavior after communication errors, fail-safe value output and user acknowledgment, refer to the *S7 Distributed Safety, Configuring and Programming* manual).

If the communication error is not acknowledged, the user data of the F-DO modules will remain passivated (outputs at "0").

Remember to Set the PROFIsafe Address

When an F-module is replaced, make sure that the address switch (DIP switch) setting on the electronic module is the same.

See also

Assignment of PROFIsafe Address (Page 20)

4.4 Requirements for Sensors and Actuators

General Requirements for Sensors and Actuators

Note the following important information for the safety-related use of sensors and actuators:

⚠ WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Note that sensors and actuators generally do not withstand a proof-test interval of 10 years according to the IEC 61508:2000 standard without considerable safety degradation.
The probability of dangerous faults and the rate of occurrence of dangerous faults of a safety function must adhere to an SIL-based upper limit. You will find a list of values achieved by F-modules under "Fail-Safe Performance Characteristics" in the technical specifications for the F-modules.
To achieve SIL3 (Category 4), suitably qualified sensors and actuators are necessary.

Requirements for the Duration of Sensor Signals

⚠ WARNING

Note the following requirements for sensor signals:

- In order to guarantee accurate detection of sensor signals by the F-DI/F-DO module inputs, you must ensure that the sensor signals exhibit a certain minimum duration.
- In order for pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable Detection by the F-DI/F-DO Module Inputs

The following table lists the minimum duration of the sensor signals for the F-DI module. The minimum duration depends on the parameter settings for the short-circuit test and the input delay in *STEP 7*.

Table 1-1193 Minimum Duration of Sensor Signals for Proper Detection by an F-DI Module

Electronic module	Short-circuit test parameter	Assigned input delay		
		0.5 ms	3 ms	15 ms
8/16 F-DI	Disabled	10 ms	13 ms	25 ms
	Enabled	10 ms	18 ms	56 ms
4/8 F-DI/4 F-DO	Disabled	11 ms	13 ms	25 ms
	Enabled	11 ms	20 ms	57 ms
F-Switch PROFIsafe	Disabled	-	14 ms	-
	Enabled	-	27 ms	-

Reliable Detection By the Safety Program in the F-CPU

For information about the times for proper detection of sensor signals in the safety program, refer to *"Fail-Safe Modules"* in the *Safety Engineering in SIMATIC S7* system description.

Additional Requirements for Sensors

General rule: A single-channel sensor is sufficient to achieve SIL2/Category 3. However, the sensors must be connected using two channels in order to achieve SIL3/Category 4. However, to achieve SIL2/Category 3 with a single-channel sensor, the sensor itself must be SIL2/Category 3-capable, otherwise the sensors must be connected using two channels in order to achieve this safety level.

Additional Requirements for Actuators

Fail-safe output modules test the outputs at regular intervals. For this purpose, the F-module briefly switches off enabled outputs. The test pulses have the following duration:

- Dark period < 1 ms

Fast-acting actuators can drop out briefly during the test. If your process does not tolerate this, you must use actuators with a sufficient lag (> 1 ms).

⚠ WARNING

If the actuators are operated at voltages greater than 24 V DC (for example, 230 V DC) or if the actuators switch higher voltages, safe isolation must be ensured between the outputs of a fail-safe output module and the components conducting the higher voltage (in accordance with EN 50178).
This is generally the case for relays and contactors. Particular attention must be paid to this requirement for semiconductor switching devices.

See also

Assignment of PROFIsafe Address (Page 20)
Technical Specifications for the 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 76)
Technical Specifications for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 92)
Technical Specifications for the F-Switch PROFIsafe Electronic Module (Page 121)

Diagnostics 5

5.1 Reactions to Faults

Safe State (Safety Concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

NOTE

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators.

Reactions to Faults and F-System Startup

The safety function requires the use of fail-safe values (safe state) instead of process data (**passivation of the fail-safe module**) in the following situations:

- When the F-system starts up
- In the event of errors during safety-related communication between the F-CPU and F-module via the PROFIsafe safety protocol (communication error)
- In the event of F-I/O or channel faults (e.g., wire break, short circuit, discrepancy error)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot store faults retentively. When the system is powered down and then restarted, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

For channels that you have set to "disabled" in *STEP 7*, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group ("Channel enabled/disabled" parameter).

Fail-Safe Value Output for Fail-Safe Modules

In the case of F-DI modules, if channels are passivated, the F-system provides fail-safe values for the safety program instead of the process data pending at the fail-safe inputs:

- For F-DI modules, this is always the fail-safe value (0).

In the case of F-DO modules, if channels are passivated, the F-system transfers fail-safe values (0) to the fail-safe outputs instead of the output values provided by the safety

program. The output channels are set to the zero current and zero voltage state. This also applies when the F-CPU switches to STOP mode. It is not possible to assign fail-safe values.

Depending on which F-system you are using and the type of fault that occurred (F-I/O fault, channel fault or communication error), fail-safe values are used either for the relevant channel only or for all channels of the relevant fail-safe module.

In *S7 Distributed Safety* F-systems up to V 5.3, when a channel fault occurs the entire F-module is passivated (in *S7 Distributed Safety* V 5.4 and higher, the entire module or, alternatively, selected channel(s) are passivated).

Reintegration of a Fail-Safe Module

Switchover from fail-safe values to process data (reintegration of an F-module) occurs automatically or, alternatively, after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in

- the "Diagnostic Messages of 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module, Causes of Faults and Corrective Actions" tables for *"8/16 F-DI DC24V PROFIsafe"* to *"4/8 F-DI/4 F-DO DC24V/2A PROFIsafe"*
- the "Diagnostic Messages of F-Switch PROFIsafe Electronic Module, Causes of Faults and Corrective Actions" tables for *"F-Switch PROFIsafe"*.

After reintegration:

- In the case of a fail-safe DI module, the process data pending at the fail-safe inputs are provided to the safety program
- In the case of a fail-safe DO module, the output values provided in the safety program are again transferred to the fail-safe outputs

Additional Information About Passivation and Reintegration

For additional information about passivation and reintegration of F-I/O, refer to the *S7 Distributed Safety, Configuring and Programming* manual.

Behavior of the F-DI Module When a Communication Error Occurs

The F-DI module responds differently to a communication error than to other faults or errors.

If a communication error occurs, the current process data remain set at the inputs of the F-DI module; the channels are not passivated. The current process data are sent to the F-CPU and are passivated there.

See also

Properties of 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 51)
Diagnostic Functions of the 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 73)
Properties of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 79)
Diagnostic Functions of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 89)
Properties of the F-Switch PROFIsafe Electronic Module (Page 96)
Properties of the F-Switch PROFIsafe Electronic Module (Page 119)

5.2 Error Diagnostics

Purpose of Diagnostics

Diagnostics are used to determine whether fail-safe modules are detecting signals without errors. Diagnostic information is assigned either to one channel or to the entire F-module.

Diagnostic Functions Are Not Safety-Critical

None of the diagnostic functions (displays and messages) are safety-critical. Consequently, they are not implemented as safety-related features, i.e., they are not tested internally.

Diagnostic Options for Fail-Safe Modules in ET 200pro

The following diagnostic options are available for fail-safe modules:

- LED display on the module front panel
- Diagnostic functions of F-modules

Non-Assignable Diagnostic Functions

Fail-safe electronic modules provide non-assignable diagnostic functions. This means that diagnostics are always enabled and are automatically made available by the F-module in *STEP 7* and forwarded to the F-CPU in the event of an error.

Assignable Diagnostic Functions

You can assign (enable) certain diagnostic functions as parameters in *STEP 7*:

- Short-circuit monitoring for the F-DI module
- Wire break detection for the F-DO module
- Short-circuit monitoring for the F-Switch PROFIsafe

WARNING
Diagnostic functions should be enabled or disabled in accordance with the application.

Diagnostics Using LED Display

Every fail-safe connection module indicates faults via its channel LED and SF LED (group fault LED).

The channel LED and SF LED turn red as soon as a diagnostic function is triggered by the F-module. The LEDs go out once all faults have been eliminated.

The SF LED flashes until you acknowledge passivation following a module fault.

Slave Diagnostics

Slave diagnostics comply with IEC 61784-1 Ed3 CP 3/1. The fail-safe electronic modules support slave diagnostics in exactly the same way as standard ET 200pro modules.

For information about the universal structure of the slave diagnostics for ET 200pro and the fail-safe modules, refer to the *ET 200pro Distributed I/O Device* manual. A supplementary description of channel-specific diagnostics for fail-safe modules appears below.

Channel-Specific Diagnostics

As with ET 200pro, there are three bytes available for each channel-specific diagnosis starting at byte 19. A maximum of 10 channel-specific diagnostic messages are possible per distributed I/O device. Channel-specific diagnostics for fail-safe modules are structured as follows:

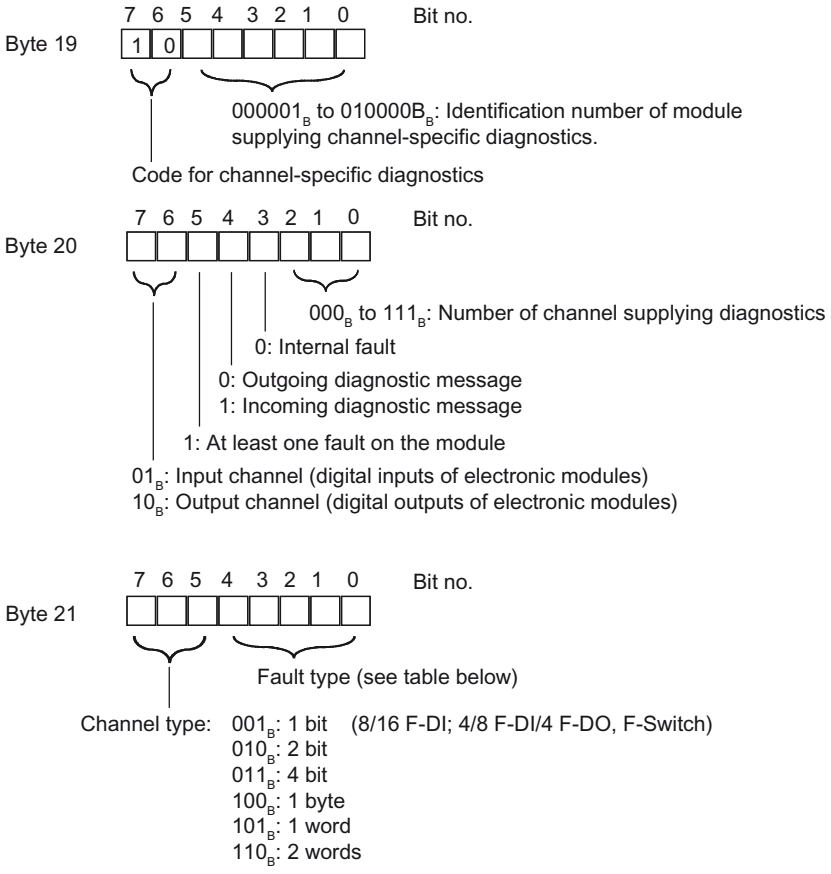


Figure 1-875 Structure of Channel-Specific Diagnostics

NOTE

Channel-specific diagnostics are always updated as far as the current diagnostic function in the diagnostic frame. Subsequent, older diagnostic functions are not deleted.
Remedy: Evaluate the valid current length of the diagnostic frame in *STEP 7* using the RET_VAL parameter of SFC 13.

Possible Fault Types of Fail-Safe Modules

The following table lists the fault types of channel-specific diagnostics. You can obtain detailed diagnostic information via *HW Diagnostics* in *STEP 7*.

Table 1-1194 Fault Types of Channel-Specific Diagnostics

Fault type		Diagnostic function in STEP 7	F-module	Special meaning for F-modules
00001_B	1_D	Short circuit	All	Short circuit to L+ on the unconnected sensor wire Short circuit to L+ sensor supply Ground short circuit or defective sensor supply Internal fault in the read circuit/test circuit
			4/8 F-DI/4 F-DO	P output driver defective Short circuit of output to L+ or output driver M output driver defective Short circuit of output to M or output driver
			F-Switch	Output driver overcurrent P output driver defective Short circuit of output to L+ or output driver Short circuit of output to M or output driver
00100_B	4_D	Overload	4/8 F-DI/4 F-DO	Output driver overcurrent
00101_B	5_D	Overtemperature	All	-
00110_B	6_D	Open circuit	4/8 F-DI/4 F-DO	Wire break
01001_B	9_D	Fault	All	RAM error EPROM error Processor failure (expected DIP switch value/actual DIP switch value) Internal fault in the read circuit/test circuit
10000_B	16_D	Parameter assignment error	All	Parameter assignment error
10001_B	17_D	Sensor voltage or load voltage is missing	All	Module-internal supply voltage
			4/8 F-DI/4 F-DO, F-Switch	Load voltage is defective or not connected
10011_B	19_D	Communication error	All	Cyclic redundancy check (CRC) error in data message frame Monitoring time for data message frame exceeded
11001_B	25_D	Safety-related shutdown	All	Discrepancy error
			4/8 F-DI/4 F-DO, F-Switch	Switching frequency too high

Behavior of F-Modules When a Module Failure Occurs

In the event of a fatal internal fault in the F-module resulting in failure of the F-module, the following occurs:

- The connection to the backplane bus is interrupted and the fail-safe inputs and outputs are passivated.
- Diagnostics are not issued by the F-module and the standard "Module Fault" diagnostics message is issued.
- The SF LED of the relevant F-module illuminates.

Specific Information About Diagnostic Functions

All module-specific diagnostic functions, possible causes, and corrective actions are described in *"8/16 F-DI DC24V PROFIsafe"*, *"4/8 F-DI/4 F-DO DC24V/2A PROFIsafe"* to *"F-Switch PROFIsafe"*.

The status and diagnostic functions indicated by LEDs on the front panel of each F-module are also presented in these sections.

Reading Out Diagnostic Functions

You can have the cause of a fault displayed in the module diagnostics in *STEP 7* (see *STEP 7 online help*).

You can read out diagnostic functions (slave diagnostics) by means of SFC 13 in the standard user program (see *System and Standard Functions* reference manual).

See also

Diagnostic Functions of the 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 73)
Diagnostic Functions of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 89)
Properties of the F-Switch PROFIsafe Electronic Module (Page 119)

General Technical Specifications

6

Overview

This chapter presents the following information about fail-safe modules:

- Information about the most important standards and approvals
- Information about the general technical specifications

General Technical Specifications

The general technical specifications include the standards and test values met by the fail-safe modules when used in an ET 200pro as well as the criteria used to test the fail-safe modules. The transport and storage requirements for the fail-safe modules and the prescribed environmental conditions are also included.

6.1 Standards and Approvals

CE Certification

CE

The ET 200pro fail-safe modules meet the requirements and protection targets of the following EC Directives and comply with the harmonized European Standards (EN) for programmable logic controllers published in the Official Journal of the European Communities:

- 2006/42/EC "Machinery Directive"
- 73/23/EEC "Electrical Equipment for Use within Fixed Voltage Ranges" (Low-Voltage Directive)
- 89/336/EEC "Electromagnetic Compatibility" (EMC Directive)

The EC declarations of conformity are kept available for the responsible authorities at:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A&D AS RD ST Type Test
Postfach 1963
D-92209 Amberg, Germany

UL/CSA Approval



Underwriters Laboratories Inc., in accordance with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

NOTE

The nameplate of the specific module indicates the currently valid approvals.

Certification Mark for Australia



The fail-safe modules of the ET 200pro satisfy the requirements of AS/NZS 2064 (Class A).

IEC 61131

The fail-safe modules of the ET 200pro satisfy the requirements and criteria of IEC 61131-2 (Programmable Controllers - Part 2: Equipment Requirements and Tests).

PROFIBUS/Industrial Ethernet Standard

The ET 200pro distributed I/O device is based on the IEC 61784-1 standard.

Marine approval

Submitted to the following classification organizations
ABS (American Bureau of Shipping)
BV (Bureau Veritas)
DNV (Det Norske Veritas)
GL (Germanischer Lloyd)
LRS (Lloyds Register of Shipping)
Class NK (Nippon Kaiji Kyokai)

Use in Industrial Environment

SIMATIC products are designed for use in industrial environments.

Area of Application	Requirement for	
	Emitted Interference	Interference Immunity
Industry	EN 61000-6-4	EN 61000-6-2

Use in Residential Areas

If you are using the ET 200pro in residential areas, you must ensure compliance with limit class B for emission of radio interference in accordance with EN 61000-6-4.

Suitable measures for achieving a limit class B radio interference level are:

- Installation of the ET 200pro in grounded control cabinets/control boxes
- Use of filters in supply lines

TÜV Certificate and Standards

Fail-safe modules are certified to the following standards. Refer to the report accompanying the TÜV certificate for the current version/edition of the standard.

Standard/Directive	Designation
Standards/Directives for Functional Safety	IEC 61508:2000
	prEN 50159-1 and 2
Standards/Directives for Process Engineering	VDI/VDE 2180-1 to 5
	NE 31
	ISA S 84.01
Standards/Directives Machine Safety	IEC 62061
	98/37/EC
	EN 60204-1
Standards/Directives for Burner Management Systems	DIN VDE 0116, Clause 8.7
	prEN 50156-1
	EN 230, Clause 7.3
	EN 298, Clauses. 7.3, 8, 9, and 10
	DIN V ENV 1954 (stop to position)
Additional Standards/Guidelines	DIN VDE 0110-1
	DIN VDE 0160
	93/68/EEC
	92/31/EEC and 93/68/EEC
	DIN EN 55011 (stop to position)
	EN 50081-2 (stop to position)
	EN 61000-6-2
	DIN EN 61131-2

The current TÜV certificate report is available for downloading on the Internet at https://support.automation.siemens.com under "Product Support".

Requesting TÜV Certificate

You can request copies of the TÜV certificate and the accompanying report at the following address:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A&D AS RD ST Type Test
Postfach 1963
D-92209 Amberg, Germany

6.2 Electromagnetic Compatibility

Introduction

This chapter presents information about the interference immunity of fail-safe modules and information about RFI suppression.

Definition of EMC

Electromagnetic compatibility is the ability of an electrical device to function satisfactorily in its electromagnetic environment without interfering with that environment.

The fail-safe modules meet the requirements of the European Union's EMC law, for example. This requires that the *ET 200pro Distributed I/O System* meets the specifications and directives concerning electrical installation.

Pulse-Shaped Interference

The following table shows the electromagnetic compatibility of the fail-safe modules relative to pulse-shaped interference.

Pulse-shaped interference	Tested with	Degree of severity
Electrostatic discharge in accordance with IEC 61000-4-2 (DIN VDE 0843 Part 2)	8 kV 6 kV	3 (air discharge) 3 (contact discharge)
Burst pulses (rapid transient interference) in accordance with IEC 61000-4-4 (DIN VDE 0843 Part 4)	2 kV (supply line) 2 kV (signal line)	3 4
Surge in accordance with IEC 61000-4-5 (DIN VDE 0839 Part 10) Degrees of severity 2 and 3 require an external protective circuit (see section further down).		
Asymmetrical connection	1 kV (supply line) 1 kV (signal line/data line) 2 kV (supply line)	2
Symmetrical connection	0.5 kV (supply line) 0.5 kV (signal line/data line) 1 kV (supply line) 1 kV (signal line/data line)	3 2 3

Protecting the ET 200pro With Fail-Safe Modules Against Overvoltages

If your equipment makes protection against overvoltage necessary, we recommend that you use an external protective circuit (surge filter) between the load voltage supply and the load voltage input of the terminal modules to ensure surge immunity for the ET 200pro with fail-safe modules.

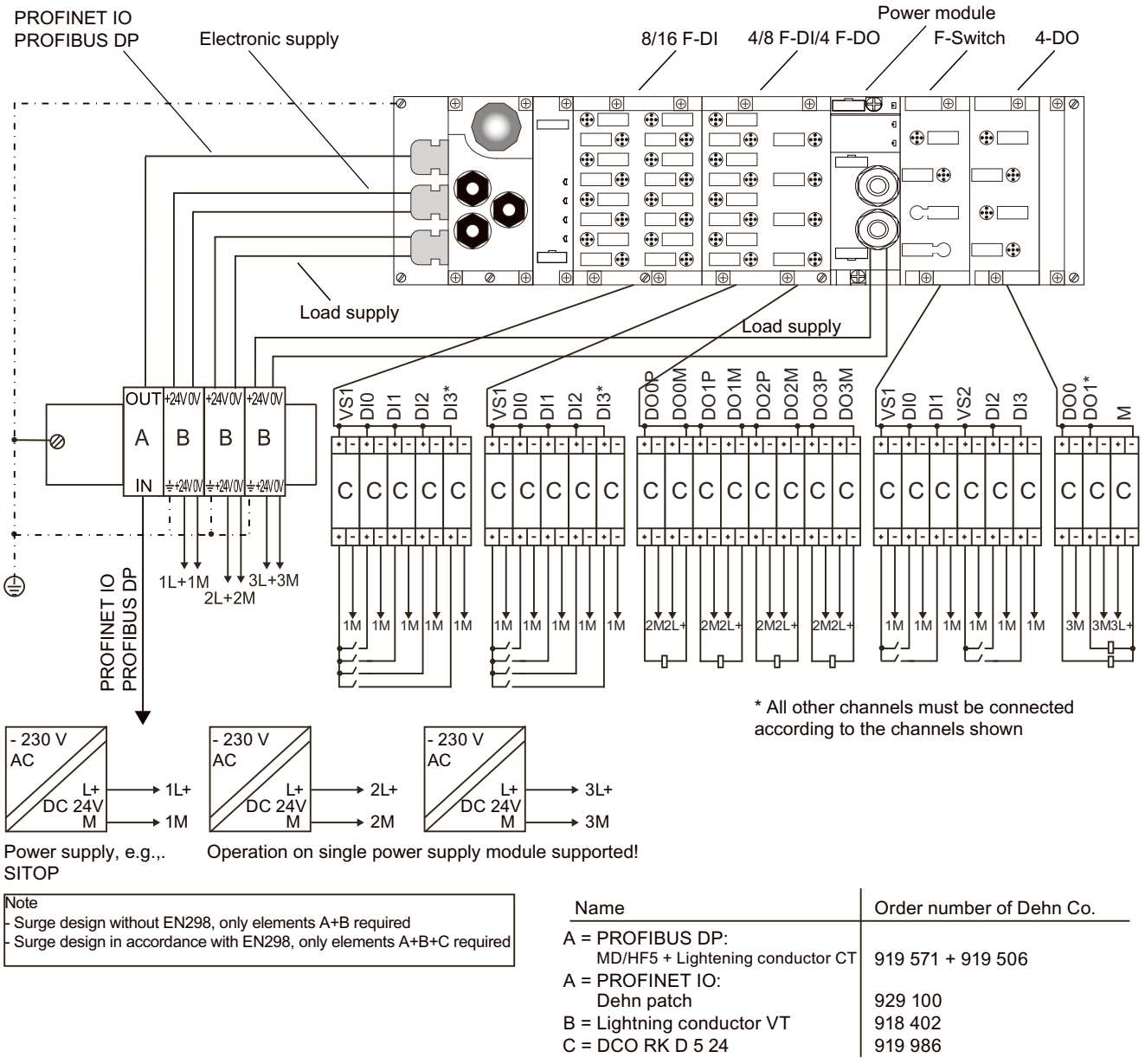
NOTE

Lightning protection measures always require a case-by-case examination of the entire system. Virtually complete protection against overvoltages, however, can only be achieved if the entire building surrounding the system has been designed for protection against overvoltages. In particular, this involves structural measures in the building design phase. Therefore, for detailed information regarding protection against overvoltages, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure illustrates an example configuration with ET 200pro F-modules and standard modules.

You can also use fewer power supplies. However, you must ensure that the total current of the modules fed from one power supply does not exceed the permissible limits.

For additional information about surge protection for standard modules, see the *ET 200pro Distributed I/O System* Manual.



Note
- Surge design without EN298, only elements A+B required
- Surge design in accordance with EN298, only elements A+B+C required

Name	Order number of Dehn Co.
A = PROFIBUS DP: MD/HF5 + Lightening conductor CT	919 571 + 919 506
A = PROFINET IO: Dehn patch	929 100
B = Lightning conductor VT	918 402
C = DCO RK D 5 24	919 986

Figure 1-876 Example Configuration with F Modules and Standard Modules of ET200pro

NOTE

Note for Installation in Accordance with EN928

You must disable the "Load voltage failure diagnostics" for the head-end of the ET 200pro-F.

Sinusoidal Interference

HF radiation:

Tested in accordance with IEC 61000-4-3, "Radiated Electromagnetic Field Requirements"

- Standard test:
  - from 80 MHz through 1 GHz, tested at 10 V/m and 20 V/m; 80 % AM (1 kHz)
  - from 1.4 GHz through 2.7 GHz, tested at 10 V/m; 80 % AM (1 kHz)
- GSM/ISM/UMTS field interferences of different frequencies (Standard: EN 298: 2004, IEC 61326-3-1 (draft))

HF interference on signal and data lines:

Tested in accordance with IEC 61000-4-6, "Testing and measurement techniques – Immunity to conducted disturbances induced by radio-frequency fields"

- Standard test:
  - RF band, asymmetrical, amplitude modulated:
    From 0.15 MHz through 80 MHz, tested at 10 V and 20 V rms; 80 % AM (1 kHz)
- ISM interferences of different frequencies (Standard: EN 298: 2004, IEC 61326-3-1 (draft))

Emission of Radio Interference

Interference transmission of electromagnetic fields in accordance with EN 61000-6-4: Limit class A, group 1 (measured at a distance of 10 m).

Frequency	Emitted Interference
Between 30 MHz and 230 MHz	< 40 dB (µV/m)Q
Between 230 MHz and 1,000 MHz	< 47 dB (µV/m)Q

Interference transmission via supply AC input in accordance with EN 61000-6-4: Limit class A, group 1.

Frequency	Emitted Interference
Between 0.15 MHz and 0.5 MHz	< 79 dB (µV)Q, < 66 dB (µV)M
Between 0.5 MHz and 5 MHz	< 73 dB (µV)Q, < 60 dB (µV)M
Between 5 MHz and 30 MHz	< 73 dB (µV)Q, < 60 dB (µV)M

6.3 Transport and storage conditions

Requirements for Fail-Safe Modules

Fail-safe modules surpass the requirements for transport and storage conditions defined in IEC 61131, Part 2. The following specifications apply to fail-safe modules that are transported and stored in the original packaging.

Type of condition	Permissible range
Free fall	≤ 1 m
Temperature	From -25°C to +70°C

Type of condition	Permissible range
Temperature change	20 K/h
Air pressure	From 1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	From 5% to 95%, without condensation

6.4 Mechanical and Climatic Environmental Conditions

Climatic environmental conditions

The following climatic environmental conditions are applicable:

Environmental Conditions	Areas of Application	Comments
Temperature	From -25 °C to 55 °C	All mounting positions
Temperature change	10 K/h	
Relative humidity	From 5% to a maximum of 100%	With condensation
Air pressure	From 1080 hPa to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Pollutant concentration	SO_2: < 0.5 ppm; Relative humidity < 60%, no condensation H_2S: < 0.1 ppm; Relative humidity < 60%, no condensation	Test: 10 ppm; 4 days 1 ppm; 4 days

Mechanical Environmental Conditions

The requirements for mechanical environmental conditions are presented in the following table in the form of sinusoidal vibrations.

Frequency range	Constant	Intermittent
5 ≤ f ≤ 8 Hz	0.35 mm amplitude	0.75 mm amplitude
8 ≤ f ≤ 150 Hz	5 g constant acceleration	10 g constant acceleration

Testing for Mechanical Environmental Conditions

The following table provides information on the type and scope of tests for mechanical environmental conditions.

Condition	Test Standard	Terminal and Electronic Modules
Vibrations	Vibration test in accordance with IEC 60068-2-6	Type of vibration: Frequency sweeps with a sweep rate of 1 octave/minute. 5 Hz ≤ f ≤ 8 Hz, constant amplitude of 0.75 mm 8 Hz ≤ f ≤ 150 Hz, constant acceleration of 10 g Duration of vibration: 10 frequency sweeps per axis in each of the 3 perpendicular axes

Condition	Test Standard	Terminal and Electronic Modules
Shock	Shock, tested in accordance with IEC 60068-2-27	Type of shock: half sine Force of shock: 30 g peak value, 18 ms duration Direction of shock: 3 shocks each in +/- direction in each of the 3 perpendicular axes
Repetitive shock	Shock, tested in accordance with IEC 60068-29	Type of shock: half sine Force of shock: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks each in +/- direction in each of the three perpendicular axes

Reduction of Vibrations

If fail-safe modules are subjected to greater shocks or vibrations, you must take appropriate measures to reduce acceleration and amplitude.

We recommend that you mount the ET 200pro on damping material (e.g., on a rubber-metal vibration damper).

6.5 Specifications for Dielectric Tests, Protection Class, Degree of Protection, and Rated Voltage

Test Voltage

Dielectric strength is proven during the type test with the following test voltage in accordance with IEC 61131-2:

Circuits with rated voltage U_e to other circuits or to ground	Test voltage
≤ 50V	500 V DC
≤ 150V	2,500 V DC
≤ 250V	4,000 V DC

Pollution Degree/Overvoltage Category in Accordance With IEC 61131

- Pollution degree 2
- Overvoltage category
  - At U_r = 24 V DC: II

Degree of Protection IP65

Degree of protection in accordance with IEC 529

- Protection against the ingress of dust and full protection against physical contact
- Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.

Degrees of Protection IP66 and IP67

Degree of protection in accordance with IEC 529

- Protection against the ingress of dust and full protection against physical contact
- IP66: Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.
- IP67: Protection against water when enclosure is immersed at specified pressures over a specified time period (water must not enter the enclosure in any harmful amount)

Rated Voltage for Operation

The ET 200pro distributed I/O device operates at the following rated voltage and corresponding tolerance.

Rated voltage	Tolerance range
24 V DC	20.4 V DC to 28.8 V DC

Fail-Safe Connection Modules

7

7.1 CM IO 16xM12 Fail-Safe Connection Module for EM 8/16 F-DI DC24V PROFIsafe

Order Number

6ES7 194-4DD00-0AA0

Properties

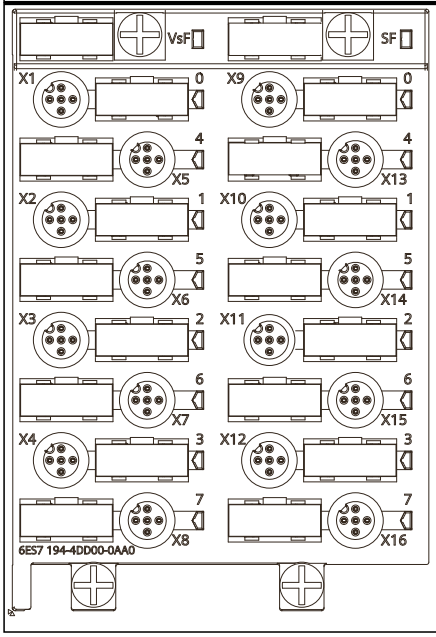
The CM IO 16 x M12 connection module has the following properties:

- Can be plugged in and screwed to the electronic module
- 16 M12 circular socket connectors
- 16 labels and one module label

Terminal assignment

The terminal assignment depends on which electronic module is being used.

View	Terminal	Designation
	X1	1. M12 circular socket connector
	X2	2. M12 circular socket connector
	X3	3. M12 circular socket connector
	X4	4. M12 circular socket connector
	X5	5. M12 circular socket connector
	X6	6. M12 circular socket connector
	X7	7. M12 circular socket connector
	X8	8. M12 circular socket connector
	X9	9. M12 circular socket connector
	X10	10. M12 circular socket connect-or
	X11	11. M12 circular socket connect-or
	X12	12. M12 circular socket connect-or
	X13	13. M12 circular socket connect-or

View	Terminal	Designation
	X14	14. M12 circular socket connector
	X15	15. M12 circular socket connector
	X16	16. M12 circular socket connector

Block Diagram

The following figure presents the block diagram of the CM IO 16 x M12 connection module.

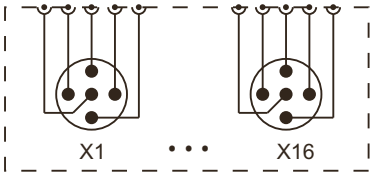


Figure 1-877 Block Diagram of CM IO 16xM12 Connection Module

Technical specifications

Dimensions and Weight	
Dimensions W x H x D (mm)	90 x 130 x 39
Weight	505 g

See also

Properties of 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 51)
Block Diagram of 8/16 F-DI DC24V PROFIsafe Electronic Module (Page 53)

7.2 CM IO 12xM12 Fail-Safe Connection Module for EM 4/8 F-DI/4-DO DC24V/2A PROFIsafe

Order Number

6ES7 194-4DC00-0AA0

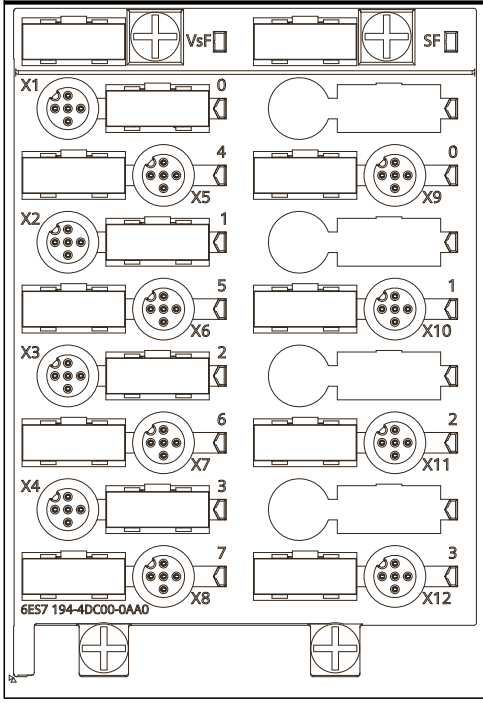
Properties

The CM IO 12 x M12 connection module has the following properties:

- Can be plugged in and screwed to the electronic module
- 12 M12 circular socket connectors
- 12 labels and one module label

Terminal assignment

The terminal assignment depends on which electronic module is being used.

View	Terminal	Designation
	X1	1. M12 circular socket connector
	X2	2. M12 circular socket connector
	X3	3. M12 circular socket connector
	X4	4. M12 circular socket connector
	X5	5. M12 circular socket connector
	X6	6. M12 circular socket connector
	X7	7. M12 circular socket connector
	X8	8. M12 circular socket connector
	X9	9. M12 circular socket connector
	X10	10. M12 circular socket connect-or
	X11	11. M12 circular socket connect-or
	X12	12. M12 circular socket connect-or

Block Diagram

The following figure presents the block diagram of the CM IO 12 x M12 connection module.

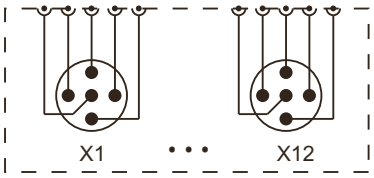


Figure 1-878 Block Diagram of CM IO 12xM12 Connection Module

Technical specifications

Dimensions and Weight	
Dimensions W x H x D (mm)	90 x 130 x 39
Weight	18.70 oz

See also

Properties of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 79)
Block Diagram for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 82)

7.3 CM F-IO 2 × M12 Fail-Safe Connection Module for F-Switch PROFIsafe

Order Number

6ES7 194-4DA00-0AA0

Properties

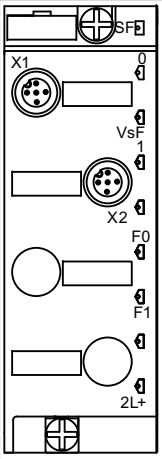
The CM F-IO 2xM12 connection module has the following properties:

- Can be plugged in and screwed to the electronic module
- 2 M12 circular socket connectors
- 2 labels and one module label

Terminal Assignment

The terminal assignment is shown in the following table.

View	Terminal	Designation
	X1	1. M12 circular socket connector

View	Terminal	Designation
	X2	2. M12 circular socket connector

Block Diagram

The following figure presents the block diagram of the CM F-IO 2xM12 connection module.

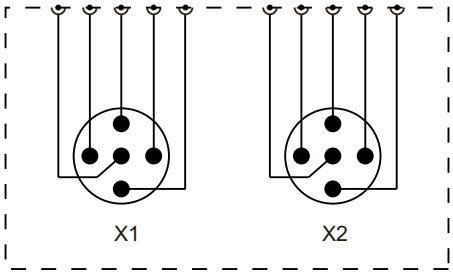


Figure 1-879 Block Diagram of CM F-IO 2xM12 Connection Module

Technical Specifications

Dimensions and Weight	
Dimensions W x H x D in [mm]	45 x 130 x 40
Weight	310 g

See also

Properties of the F-Switch PROFIsafe Electronic Module (Page 96)
Block Diagram of the F-Switch PROFIsafe Electronic Module (Page 98)

Fail-Safe Electronic Modules

8

Overview

Fail-safe digital modules are available for connecting digital sensors or encoders and actuators or loads to ET 200pro. This chapter provides the following information for each fail-safe module:

- Properties and specific characteristics
- Front view, terminal assignment for connection modules and block diagram
- Wiring diagram and assignable parameters
- Diagnostic functions, including corrective actions
- Technical specifications

WARNING

The fail-safe performance characteristics in the technical specifications are applicable to a proof-test interval of 10 years and a mean time to repair of 100 hours.

Description of Applicable Electronic Modules and Connection Modules

The applicable standard electronic modules and standard connection modules are described in the *ET 200pro Distributed I/O Device* manual.

8.1 8/16 F-DI DC24V PROFIsafe Digital Electronic Module

8.1.1 Properties of 8/16 F-DI DC24V PROFIsafe Electronic Module

Order Number

6ES7 148-4FA00-0AB0

Properties

The F-Switch electronic module has the following properties:

- 16 inputs (SIL2/Category 3) or 8 inputs (SIL3/Category 3 or Category 4)
- 24 V DC rated input voltage
- Suitable for switches and 3- or 4-wire proximity switches (BEROs)
- Four short-circuit-proof sensor supplies for each of the four inputs
- External sensor supply possible
- Group fault display (SF; red LED)

- Fault LED for each sensor supply (Vs1F to Vs4F) is mapped to VsF LED and the associated channels
- Status and fault LEDs for each input (two-color green/red LED)
- Identification data (*see ET 200pro Distributed I/O System Standard Manual*)
- Assignable diagnostics
- Can only be operated in safety mode

8.1.2 Terminal Assignment of 8/16 F-DI DC24V PROFIsafe Electronic Module

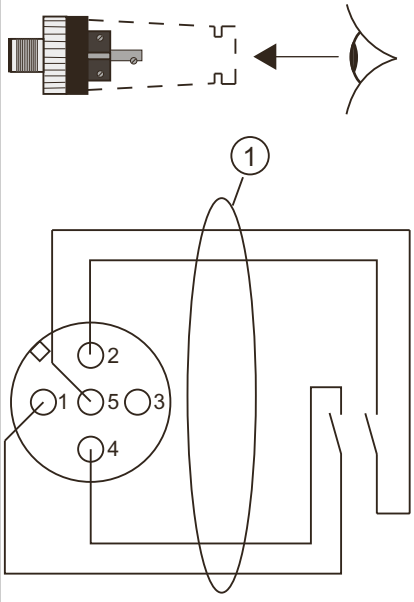
Terminal Assignment on CM IO 16×M12 Connection Module

The following table presents the terminal assignment of the 8/16 F-DI DC24V PROFIsafe electronic module on the CM IO 16×M12 connection module.

Sockets X1 to X4 and X9 to X12 are assigned twice. This enables you to implement a 1oo2 evaluation with one connecting cable, e.g., channels 0 and 4 at connector X1.

The functional ground (FG) is located on the shield.

Table 1-1195 Terminal Assignment on the CM IO 16xM12 Connection Module for 8/16 F-DI DC24V PROFIsafe

Circular connector view	Terminal	Assignment of X1 to X16	
	1	Connectors X1 to X4: 24 V sensor supply 1 (Vs1)[2] Connectors X5 to X8: 24 V sensor supply 2 (Vs2)[2] Connectors X9 to X12: 24 V sensor supply 3 (Vs3)[2] Connectors X13 to X16: 24 V sensor supply 4 (Vs4)[2]	
	2	Input signal:	
		Connector X1: Channel 4[3] Connector X2: Channel 5[3] Connector X3: Channel 6[3] Connector X4: Channel 7[3] Connector X5: Not assigned Connector X6: Not assigned Connector X7: Not assigned Connector X8: Not assigned	Connector X9: Channel 12[3] Connector X10: Channel 13[3] Connector X11: Channel 14[3] Connector X12: Channel 15[3] Connector X13: Not assigned Connector X14: Not assigned Connector X15: Not assigned Connector X16: Not assigned
	3	Sensor supply ground (1M)	
	4	Input signal:	
		Connector X1: Channel 0 Connector X2: Channel 1 Connector X3: Channel 2 Connector X4: Channel 3 Connector X5: Channel 4 Connector X6: Channel 5 Connector X7: Channel 6 Connector X8: Channel 7	Connector X9: Channel 8 Connector X10: Channel 9 Connector X11: Channel 10 Connector X12: Channel 11 Connector X13: Channel 12 Connector X14: Channel 13 Connector X15: Channel 14 Connector X16: Channel 15
	5	Connectors X1 to X4: 24 V sensor supply 2 (Vs2)[3] Connectors X5 to X8: Not assigned Connectors X9 to X12: 24 V sensor supply 4 (Vs4)[3] Connectors X13 to X16: Not assigned	

[1] 3-, 4- or 5-core copper cable
[2] Made available by the ET 200pro for the connected sensor
[3] Relevant only in the case of 1oo2 evaluation via a connecting cable

8.1.3 Block Diagram of 8/16 F-DI DC24V PROFIsafe Electronic Module

Block Diagram

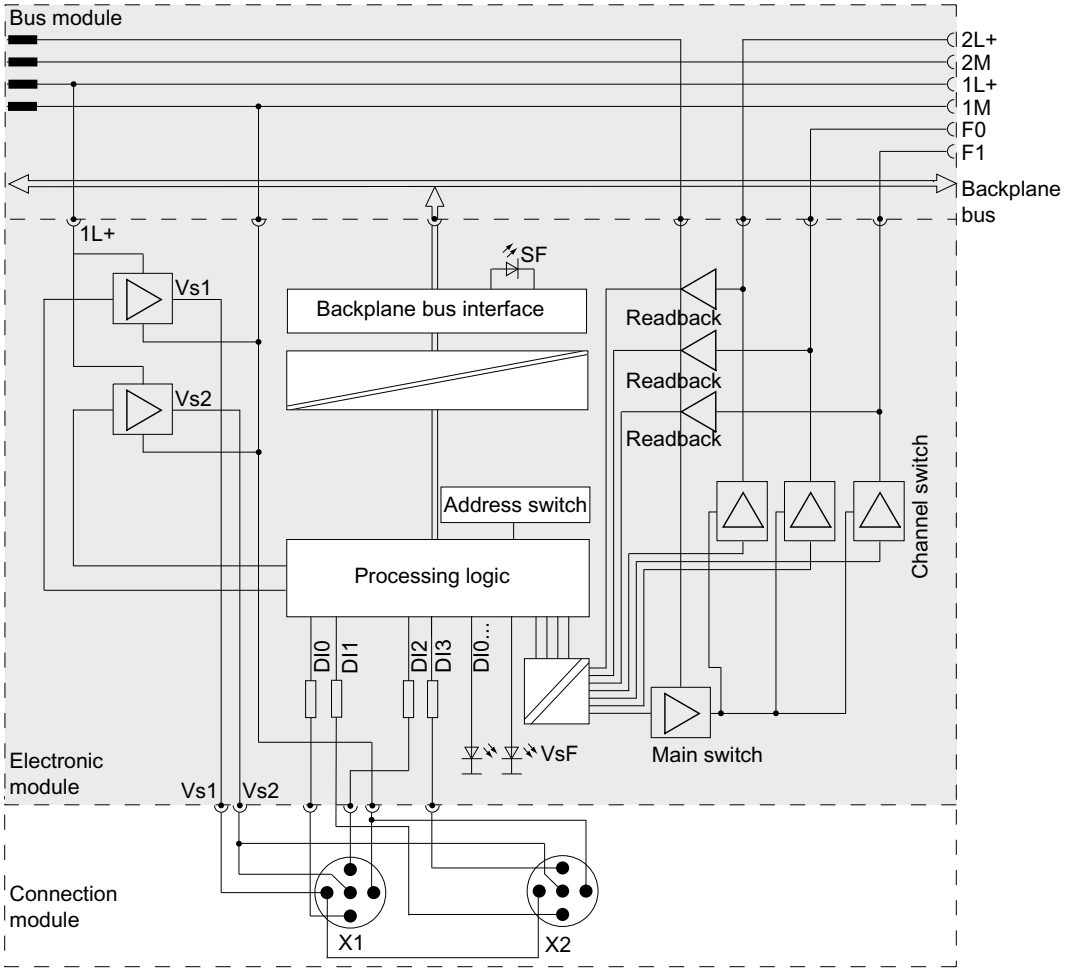


Figure 1-880 Block Diagram of 8/16 F-DI DC24V PROFIsafe Electronic Module

8.1.4 Parameters for the 8/16 F-DI DC24V PROFIsafe Electronic Module

Parameters in *STEP 7*

The following table presents the parameters that can be assigned to the 8/16 F-DI DC24V PROFIsafe electronic module.

Table 1-1196 Parameters for the 8/16 F-DI DC24V PROFIsafe Electronic Module

Parameters	Range	Default	Type of parameter	Range of effectiveness
F-parameters:				
F_destination_address	1 to 1022	Assigned by *STEP 7*	Static	Module
F-monitoring time	10 to 10000 ms	150 ms	Static	Module
Module Parameters:				
Input delay	0.5; 3; 15 ms	3 ms	Static	Module
Short-circuit test	Cyclic/Disable	Cyclic	Static	Module
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
Channel n, n+4	Enabled/disabled	Enabled	Static	Channel group
Evaluation of the sensors	1oo2 evaluation/ 1oo1 evaluation	1oo2 evaluation	Static	Channel group
Type of sensor interconnection	1-channel; 2-channel equivalent; 2-channel nonequivalent	2-channel equivalent	Static	Channel group
Behavior at discrepancy	Provide last valid value; Provide value 0	Provide last valid value	Static	Channel group
Discrepancy time	10 to 30000 ms	10 ms	Static	Channel group
Reintegration after discrepancy error	Test of 0-signal not required/Test of 0-signal required	Test of 0-signal not required	Static	Channel group
* This setting is only relevant when the S7 Distributed Safety V 5.4 or higher optional package is installed.				

Short-Circuit Test Parameter

The cyclic short-circuit test is enabled and disabled using the short-circuit test parameter. The short-circuit test is only useful for simple switches that do not have their own power supply. If the short-circuit test has been enabled, the internal sensor supplies must be used (see also "*Use Cases of the 8/16 F-DI DC24V PROFIsafe Electronic Module*").

Behavior at Discrepancy Parameter

As the "behavior at discrepancy" you assign the value that is made available to the safety program in the F-CPU while there is a discrepancy between the two input channels involved, i.e., during the discrepancy time. You assign the behavior at discrepancy as follows:

- "Provide last valid value", or
- "Provide value 0"

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation"

"Provide last valid value"

The last valid value (old value) before discrepancy occurs is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the two relevant input channel signals. This value is supplied until the discrepancy disappears or until the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is extended by an amount equal to this time.

As a result, the discrepancy time of sensors connected via two channels must be set for fast reactions to short response times. It makes no sense, for example, for a time-critical shutdown to be triggered by sensors connected via two channels with a discrepancy time of 500 ms. In the worst case, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time.

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time that includes a sufficient cushion against false tripping of discrepancy errors.

"Provide value 0"

The value "0" is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two relevant input channels.

If you specified "Provide value 0", the sensor-actuator response time will not be affected by the discrepancy time.

Discrepancy Time Parameter

Here, you can specify the discrepancy time for each channel pair. The entered value is rounded to a multiple of 10 ms.

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation" and
- Type of sensor interconnection: "2-channel equivalent" or "2-channel nonequivalent"

Discrepancy Analysis and Discrepancy Time

If you are using one two-channel sensor, one nonequivalent sensor or two single-channel sensors that are measuring the same physical process variable, the sensors will respond with a time delay due to the limited accuracy of their arrangement.

The discrepancy analysis for equivalence/nonequivalence is used with fail-safe inputs to detect faults based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same voltage levels) are detected at two associated input signals. A test is conducted to determine whether

the difference in levels (when testing for nonequivalence: the consistency) has disappeared within a programmable period known as the discrepancy time. If not, a discrepancy error exists.

In most cases, the discrepancy time starts but does not elapse completely, since the signal differences disappear after a short time.

Select a discrepancy time of sufficient length so that in case of no error, the difference between the two signals (when checking for nonequivalence: the consistency) has definitely disappeared before the discrepancy time expires.

Behavior While Discrepancy Time is Running

While the assigned discrepancy time is running internally on the module, either the **last valid value** or **"0"** is made available to the safety program in the F-CPU by the relevant input channels, depending on the parameter assignment for the behavior at discrepancy.

Behavior After Discrepancy Time Elapses

If the input signals are not equivalent following expiration of the specified discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, the system detects a discrepancy error and generates a "discrepancy" diagnostic message in the diagnostic buffer of the F-I/O module to identify the faulty channels.

Reintegration After Discrepancy Error Parameter

This parameter is used to specify when a discrepancy error is regarded as eliminated and, thus, when the relevant input channels can be reintegrated. The following can be assigned:

- "Test of 0-signal required" or
- "Test of 0-signal not required"

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation"

"Test of 0-signal required"

If you assigned "Test of 0-signal required", a discrepancy error is regarded as eliminated once a 0-signal is present again at both of the relevant input channels.

If you are using nonequivalent sensors, i.e., the "Type of sensor interconnection" is set to "2-channel nonequivalent", a 0-signal must be present again at the channel supplying the wanted signal.

For information about which F-module channels supply the wanted signals, refer to the manual for the F-module you are using.

"Test of 0-signal not required"

If you assigned "Test of 0-signal not required", a discrepancy error is regarded as eliminated once the discrepancy at the two relevant input channels disappears.

F-modules in SIMATIC S7 for which the "Reintegration after discrepancy error" parameter is not available also exhibit this behavior.

8.1.5 Wiring of Inputs of 8/16 F-DI DC24V PROFIsafe Electronic Module

NOTE

The following sections on wiring options and specific *STEP 7* parameters (use cases) apply to the 8/16 F-DI and the inputs of the 4/8 F-DI/4 F-DO.

Use Case Selection

The following figure provides information to help you select the use case that corresponds to your fail-safe requirements. The following sections provide instructions on wiring the F-module and identify the parameters you must assign in *STEP 7* for each use case.

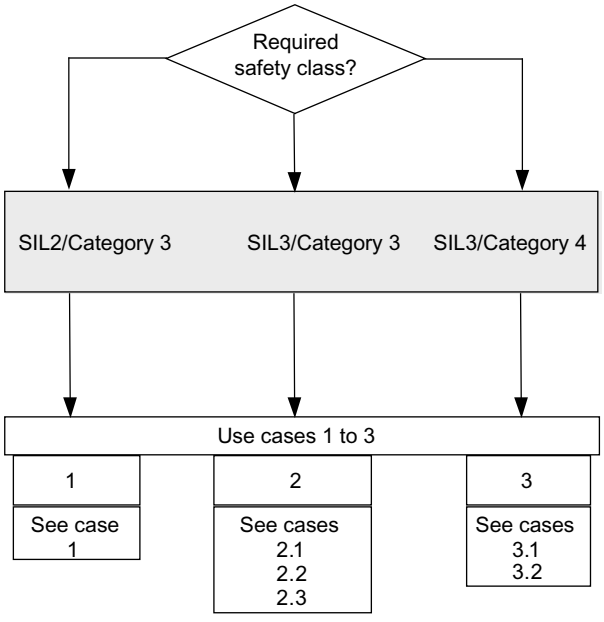


Figure 1-881 Use Case Selection

WARNING

The achievable Safety Integrity Level is determined by the sensor quality and the length of the proof-test interval according to the IEC 61508:2000 standard. If the sensor quality does not meet Safety Integrity Level requirements, always use the sensor in redundant operation and connect it via two channels.

Conditions for Achieving SIL/Category

The conditions for achieving the respective safety requirements are presented in the following table.

Table 1-1197 F-DI Modules: Conditions for Achieving SIL/Category

Use case	Sensors	Evaluation of the sensors	Sensor supply	Achievable SIL/Category
1	1-channel	1oo1	Internal, with short-circuit test	2 / 3
			Internal, without short-circuit test	
			External	
2.1	1-channel	1oo2	Internal, with short-circuit test	3 / 3
			Internal, without short-circuit test	
			External	
2.2	2-channel equivalent	1oo2	Internal, without short-circuit test	
			External	
2.3	2-channel nonequivalent	1oo2	Internal, without short-circuit test	
			External	
3.1	2-channel equivalent	1oo2	Internal, with short-circuit test	3 / 4
3.2	2-channel nonequivalent			

NOTE

You can operate the various inputs of an F-DI module simultaneously in SIL2/Category 3 **and** SIL3/Category 3 or 4. You only have to connect the inputs and assign parameters as shown in the following sections.

Sensor Requirements

Please note the information in *"Requirements for Sensors and Actuators"* when using sensors for safety-related applications.

8.1.6 Use Case 1: Safety Mode SIL2/Category 3

Sensor Supply

The sensors can be powered internally or externally.

Table 1-1198 Use Case 1: Assignment of Sensor Supply to Input Channels

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2 Input channels DI 8 to DI 11: Sensor supply Vs3 Input channels DI 12 to DI 15: Sensor supply Vs4	Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2

Wiring Diagram for Use Case 1 – Connecting One Sensor Via One Channel

One sensor is connected via one channel for each process signal (1oo1 evaluation).
The wiring is carried out at the appropriate connection module.
The figures below illustrate an example wiring diagram for channel groups 1 and 2.

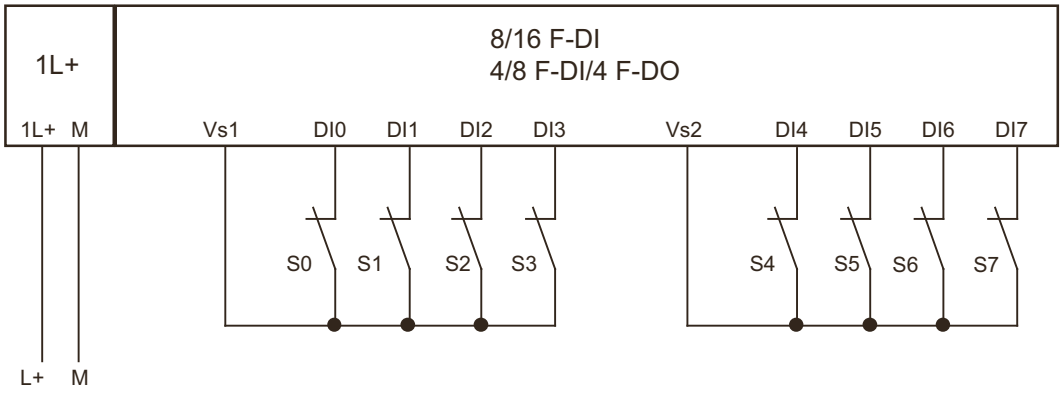


Figure 1-882 Wiring Diagram for F-DI Modules - One Sensor Connected Via One Channel, Internal Sensor Supply

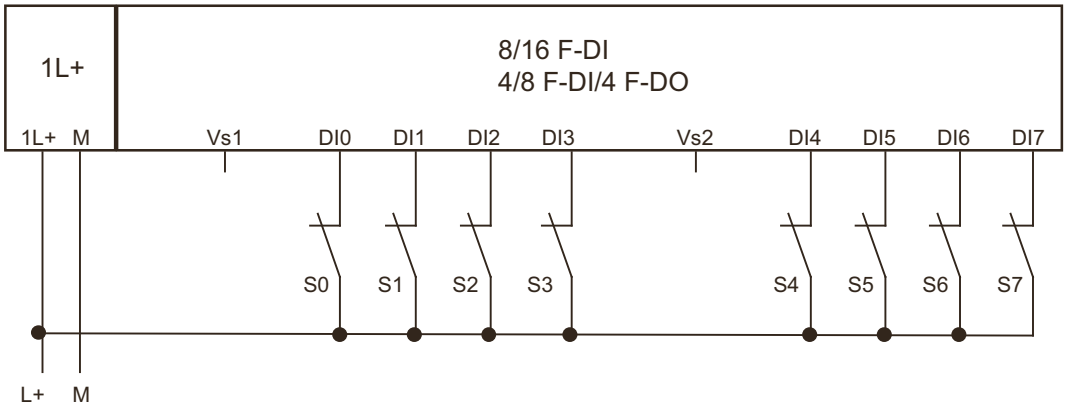


Figure 1-883 Wiring Diagram for F-DI Modules - One Sensor Connected Via One Channel, External Sensor Supply

Assignable Parameters for Use Case 1

Set the "Evaluation of the sensors" parameter to "1oo1 evaluation" for the respective input.

You can enable or disable the "Short-circuit test" parameter. However, you must disable the short-circuit test as soon as at least one fail-safe digital input is **externally** supplied. Otherwise, the "Short circuit" diagnostic is reported.

Specific Characteristics for Fault Detection (Use Case 1)

The following table summarizes fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1199 F-DI Modules: Fault Detection (Use Case 1)

Example of fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	No	No	No
Short circuit of DI 0 with DI 4	Yes*	No	No
P-short circuit of DI 0	Yes	No	No
M-short circuit of DI 0	Yes*	Yes*	No
Discrepancy error	-	-	-
P-short circuit of Vs1	Yes	No	No
M-short circuit of Vs1, or Vs2 defective	Yes	Yes	Yes
Short circuit of Vs1 with Vs2	Yes	No	No
Fault in read/test circuit	Yes	Yes	Yes
Supply voltage fault	Yes	Yes	Yes
*: Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal. If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.			

8.1.7 Use Case 2: Safety Mode SIL3/Category 3

Assigning Inputs to Each Other

The F-DI modules have 2, 8, or 16 fail-safe inputs (SIL2). A pair of these inputs can be used as one input (SIL3). The following assignments apply in this case:

Table 1-1200 Use Case 2: Assignment of Input Channels to Each Other

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channels DI 0 and DI 4 Input channels DI 1 and DI 5 Input channels DI 2 and DI 6 Input channels DI 3 and DI 7 Input channels DI 8 and DI 12 Input channels DI 9 and DI 13	Input channels DI 0 and DI 4 Input channels DI 1 and DI 5 Input channels DI 2 and DI 6 Input channels DI 3 and DI 7

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channels DI 10 and DI 14 Input channels DI 11 and DI 15	

Sensor Supply

The sensor supply can be provided internally or externally.

Table 1-1201 Use Case 2: Assignment of Sensor Supply to Inputs

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2 Input channels DI 8 to DI 11: Sensor supply Vs3 Input channels DI 12 to DI 15: Sensor supply Vs4	Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2

Wiring Diagram for Use Case 2.1 – Connecting One Sensor Via One Channel to Two Inputs

One sensor is connected via one channel to two inputs of the F-module for each process signal (1oo2 evaluation).

NOTE

If the voltage is supplied to the sensor from the F-DI module, you must use the internal sensor supply Vs1. Connection to Vs2 is not possible.

The wiring is carried out at the appropriate connection module.

The figures below illustrate an example wiring diagram for channel groups 1 and 2.

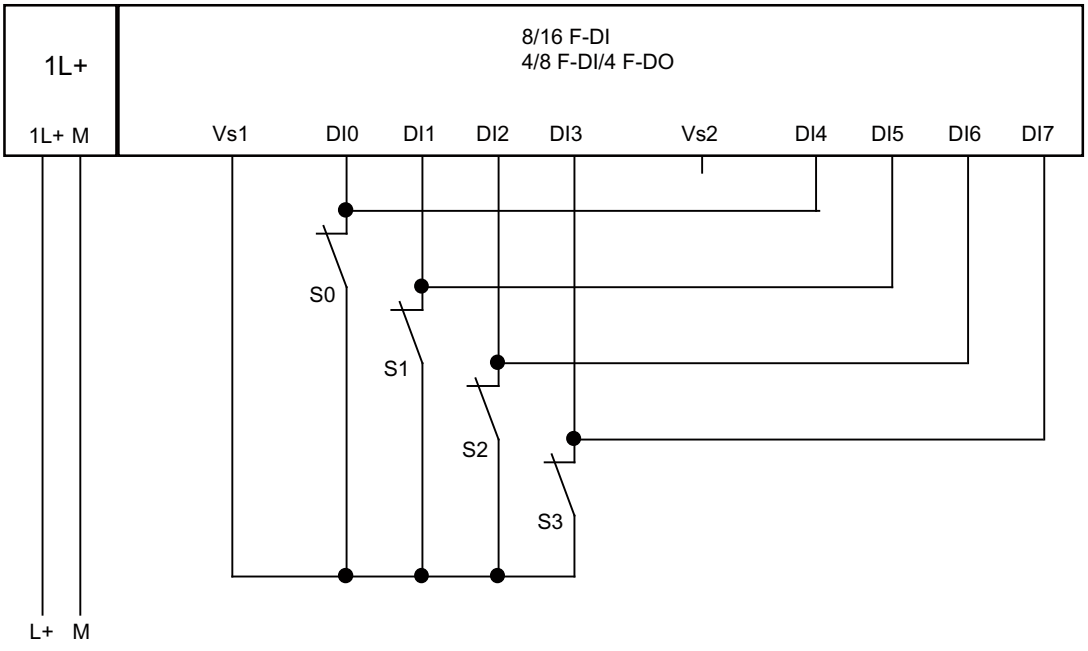


Figure 1-884 Wiring Diagram for F-DI Modules - One Sensor Connected Via One Channel to Two Inputs, Internal Sensor Supply

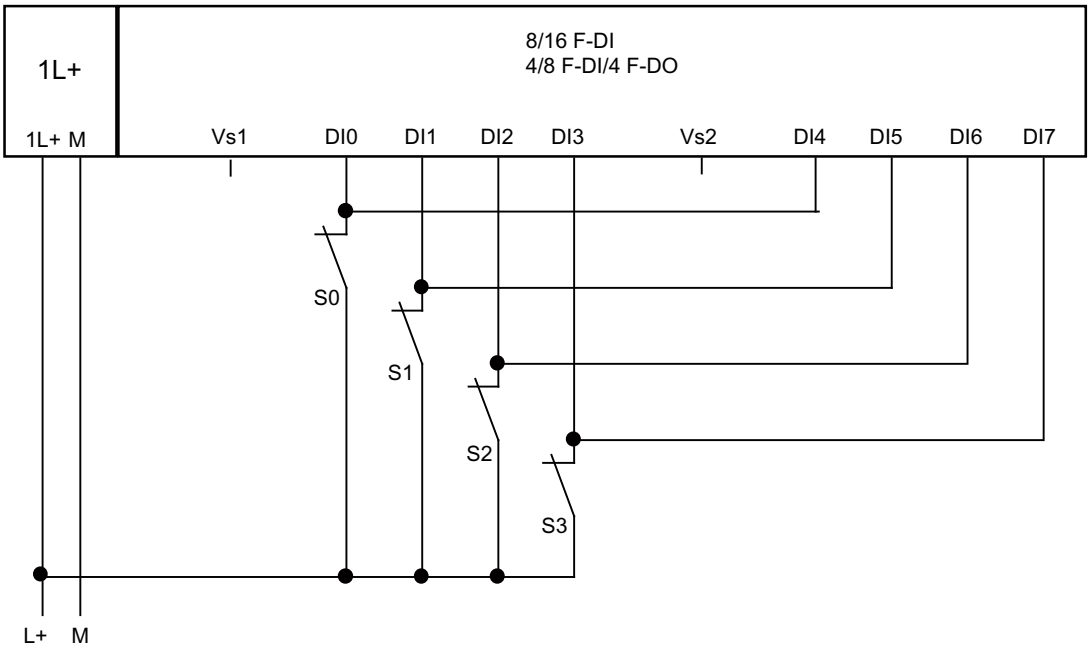


Figure 1-885 Wiring Diagram for F-DI Modules - One Sensor Connected Via One Channel to Two Inputs, External Sensor Supply

WARNING

In order to achieve SIL3/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 2.1

Set the "Evaluation of the sensors" parameter to "1oo2 evaluation" and the "Type of sensor interconnection" parameter to "1-channel" for the relevant input. The discrepancy time is permanently preset to 10 ms and cannot be changed.

You can enable or disable the "Short-circuit test" parameter. However, you must disable the short-circuit test as soon as at least one fail-safe digital input is **externally** supplied. Otherwise, the "Short circuit" diagnostic is reported.

Specific Characteristics for Fault Detection (Use Case 2.1)

The following table summarizes fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1202 8/16 F-DI DC24V PROFIsafe Electronic Module: Fault Detection (Use Case 2.1)

Example of fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	No	No	No
Short circuit of DI 0 with DI 5	No	No	No
P-short circuit of DI 0	Yes	No	No
M-short circuit of DI 0	Yes*	Yes*	No
Discrepancy error	Yes	Yes	Yes
P-short circuit of Vs1	Yes	No	No
M-short circuit of Vs1, or Vs2 defective	Yes	Yes	Yes
Short circuit of Vs1 with Vs2	Yes	No	No
Fault in read/test circuit	Yes	Yes	Yes
Supply voltage fault	Yes	Yes	Yes
***:** Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.			

Wiring Diagram for Use Case 2.2 – Connecting One Two-Channel Sensor Via Two Channels

One two-channel sensor is connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out at the appropriate connection module.

The figures below illustrate an example wiring diagram for channel groups 1 and 2.

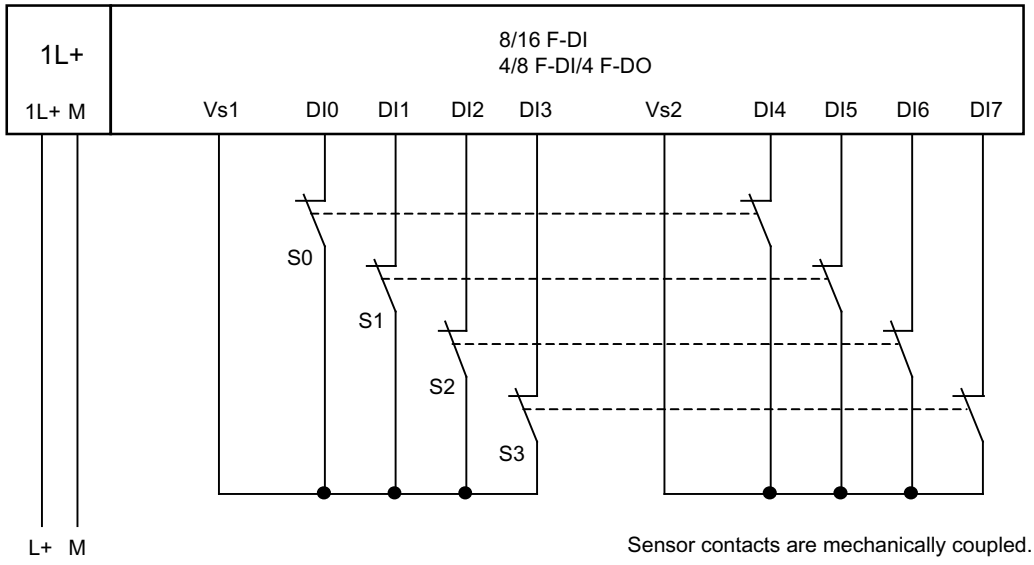


Figure 1-886 Wiring Diagram for F-DI Modules - One Two-Channel Sensor Connected, Internal Sensor Supply

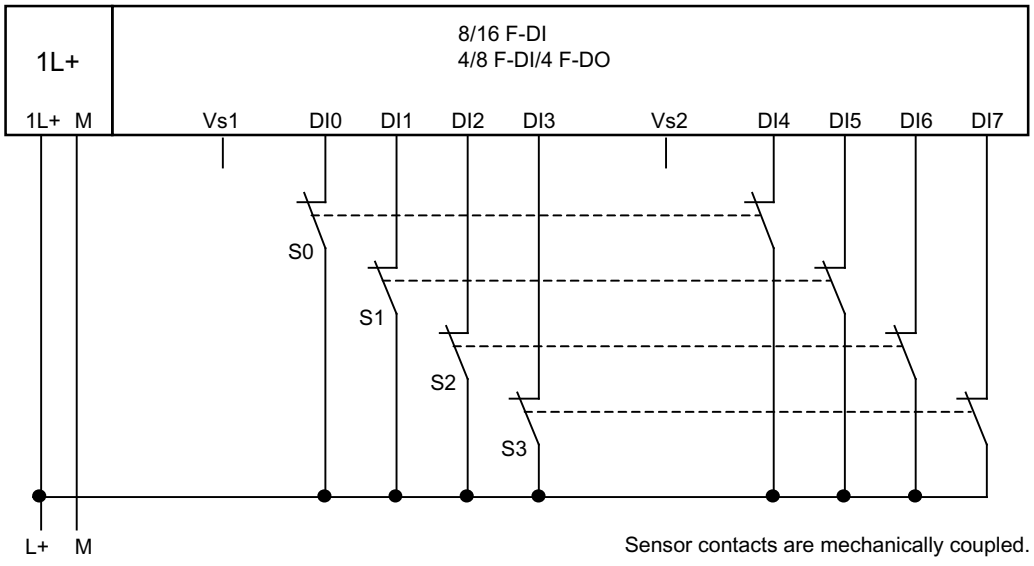


Figure 1-887 Wiring Diagram for F-DI Modules - One Two-Channel Sensor Connected Via Two Channels, External Sensor Supply

Wiring Diagram for Use Case 2.2 – Connecting Two One-Channel Sensors Via Two Channels

Two single-channel sensors are connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation). The sensors can also be supplied via an external sensor supply.

The figure below illustrates an example wiring diagram for channel groups 1 and 2.

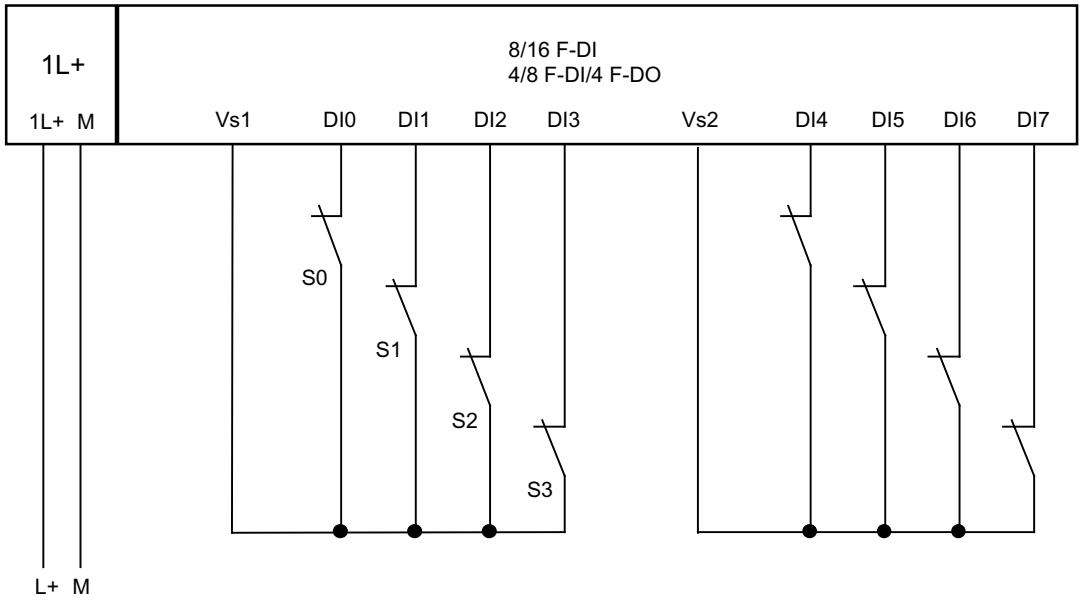


Figure 1-888 Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Via Two Channels, Internal Sensor Supply

WARNING

In order to achieve SIL3/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 2.2

Set the "Evaluation of the sensors" parameter to "1oo2 evaluation" and the "Type of sensor interconnection" parameter to "2-channel equivalent" for the relevant input. Disable the "Short-circuit test" parameter.

Specific Characteristics for Fault Detection (Use Case 2.2)

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1203 F-DI Modules: Fault Detection (Use Case 2.2)

Example of fault	Fault detection in case of ...	
	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	Yes*	Yes*
Short circuit of DI 0 with DI 4	No	No
Short circuit of DI 0 with DI 5	Yes*	Yes*
P-short circuit of DI 0	Yes*	Yes*
M-short circuit of DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit of Vs1	No	No
M-short circuit of Vs1, or Vs2 defective	Yes	Yes
Short circuit of Vs1 with Vs2	No	No
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
***:** Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.		

Wiring Diagram for Use Case 2.3 – Connecting One Nonequivalent Sensor Via Two Channels Nonequivalently

One nonequivalent sensor is connected nonequivalently via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The left channels on the F-module (DI 0 to DI 2, DI 0 to DI 3, or DI 8 to DI 11) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs in the F-CPU.

NOTE

If the voltage is supplied to the sensor from the F-DI module, you must use the internal sensor supply Vs1 (or Vs3). Connection to Vs2 (or Vs4) is not possible.

The wiring is carried out at the appropriate connection module.

The figures below illustrate an example wiring diagram for channel groups 1 and 2.

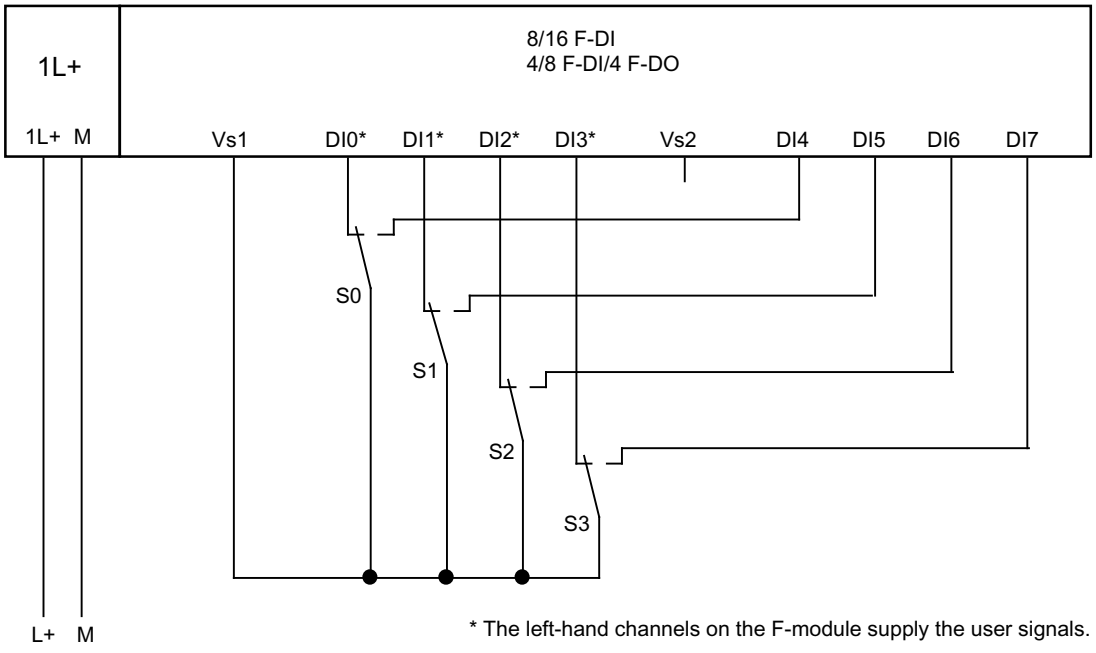


Figure 1-889 Wiring Diagram for F-DI Modules - One Nonequivalent Sensor Connected Nonequivalently Via Two Channels, Internal Sensor Supply

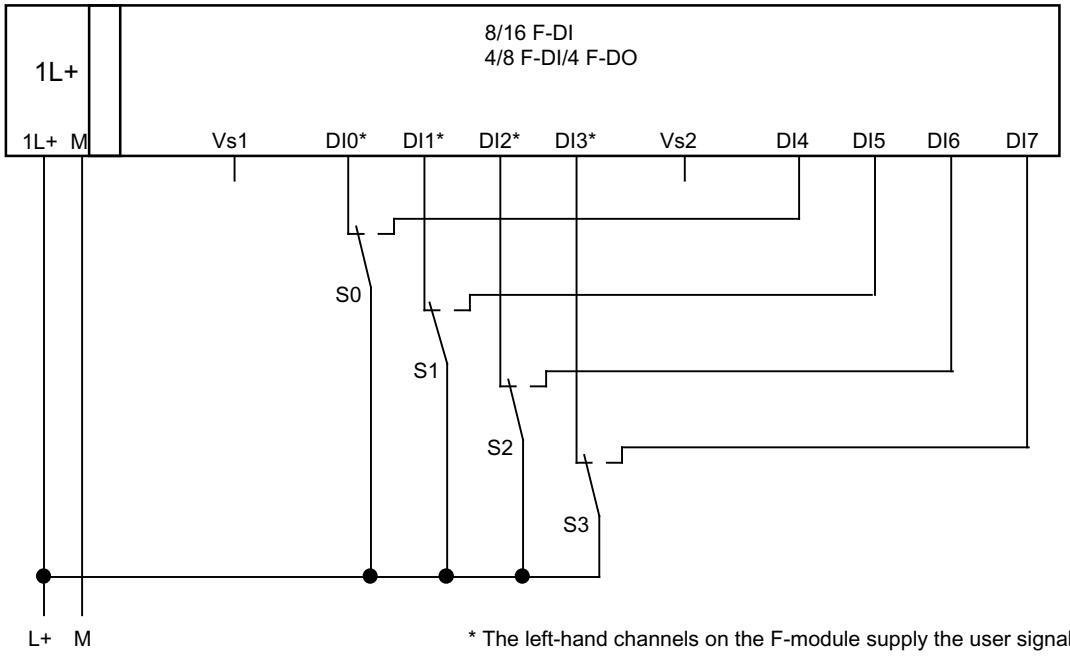


Figure 1-890 Wiring Diagram for F-DI Modules - One Nonequivalent Sensor Connected Nonequivalently Via Two Channels, External Sensor Supply

Wiring Diagram for Use Case 2.3 – Connecting Two One-Channel Sensors Nonequivalently Via Two Channels

Two one-channel sensors are connected nonequivalently via two channels to two inputs of the F-I/O module for each process signal (1oo2 evaluation).

The left channels on the F-module (DI 0 to DI 2, DI 0 to DI 3, or DI 8 to DI 11) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs in the F-CPU.

The sensors can also be supplied via an external sensor supply.

The figure below illustrates an example wiring diagram for channel groups 1 and 2.

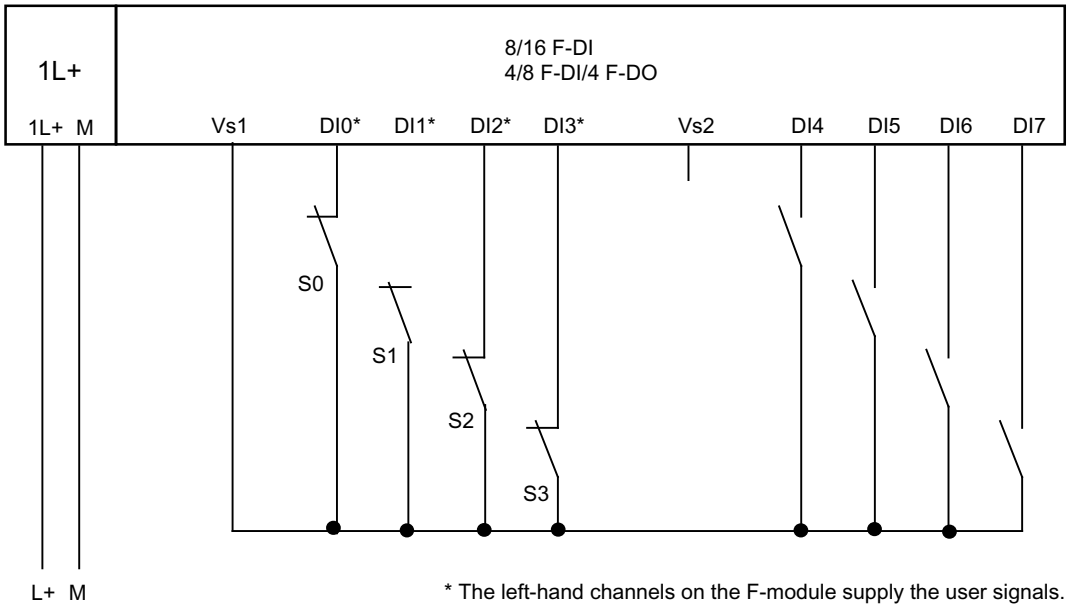


Figure 1-891 Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Nonequivalently Via Two Channels, Internal Sensor Supply

⚠ WARNING

In order to achieve SIL3/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 2.3

Set the "Evaluation of the sensors" parameter to "1oo2 evaluation" and the "Type of sensor interconnection" parameter to "2-channel nonequivalent" for the relevant input. Disable the "Short-circuit test" parameter.

Specific Characteristics for Fault Detection (Use Case 2.3)

The following table summarizes fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1204 F-DI Modules: Fault Detection (Use Case 2.3)

Example of fault	Fault detection in case of ...	
	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	Yes*	Yes*
Short circuit of DI 0 with DI 4	Yes	Yes
Short circuit of DI 0 with DI 5	Yes*	Yes*
P-short circuit of DI 0	Yes*	Yes*
M-short circuit of DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit of Vs1	No	No
M-short circuit of Vs1, or Vs2 defective	Yes	Yes
Short circuit of Vs1 with Vs2	No	No
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
*: Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.		

8.1.8 Use Case 3: Safety Mode SIL3/Category 4

Assigning Inputs to Each Other

The F-DI modules have 2, 8, or 16 fail-safe inputs (SIL2). A pair of these inputs can be used as one input (SIL3). The following assignments apply in this case:

Table 1-1205 Use Case 3: Assignment of Input Channels to Each Other

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channel DI 0 and DI 4	Input channel DI 0 and DI 4
Input channel DI 1 and DI 5	Input channel DI 1 and DI 5
Input channel DI 2 and DI 6	Input channel DI 2 and DI 6
Input channel DI 3 and DI 7	Input channel DI 3 and DI 7
Input channel DI 8 and DI 12	
Input channel DI 9 and DI 13	
Input channel DI 10 and DI 14	
Input channel DI 11 and DI 15	

Sensor supply

The sensor must be supplied internally.

Table 1-1206 Use Case 2: Assignment of Sensor Supply to Inputs

8/16 F-DI DC24V PROFIsafe	4/8 F-DI/4 F-DO DC24V/2A PROFIsafe
Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2 Input channels DI 8 to DI 11: Sensor supply Vs3 Input channels DI 12 to DI 15: Sensor supply Vs4	Input channels DI 0 to DI 3: Sensor supply Vs1 Input channels DI 4 to DI 7: Sensor supply Vs2

Wiring Diagram for Use Case 3.1 – Connecting One Two-Channel Sensor Via Two Channels

One two-channel sensor is connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out at the appropriate connection module.

The figure below illustrates an example wiring diagram for channel groups 1 and 2.

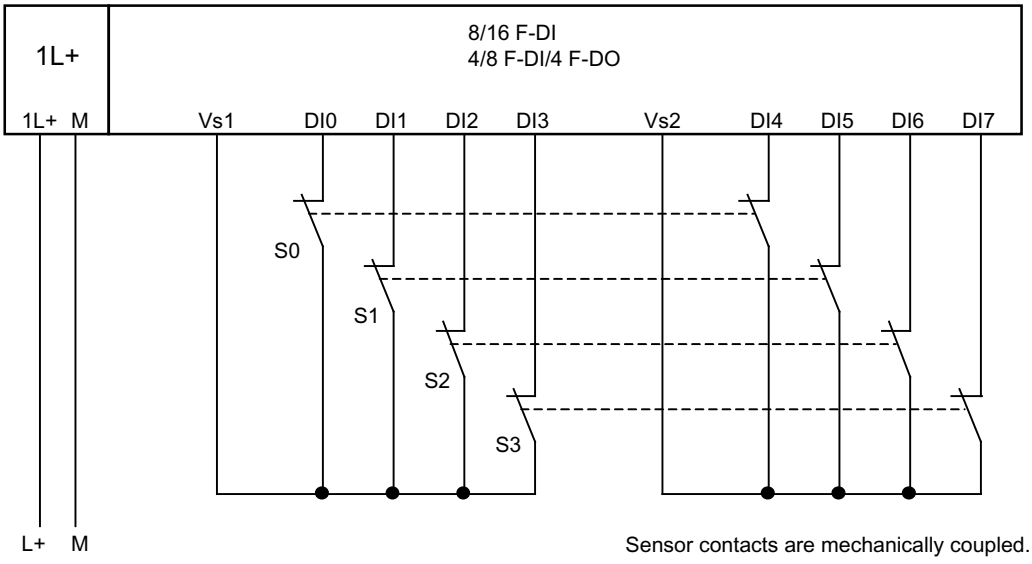


Figure 1-892 Wiring Diagram for F-DI Modules - One Two-Channel Sensor Connected Via Two Channels, Internal Sensor Supply

Alternatively, two one-channel sensors can be connected via two channels (see Figure *"Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Via Two Channels, Internal Sensor Supply"*). In this case, the same process variable is measured with mechanically separated sensors.

⚠ WARNING

In order to achieve SIL3/Category 4 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 3.1

Set the "Evaluation of the sensors" parameter to "1oo2 evaluation" and the "Type of sensor interconnection" parameter to "2-channel equivalent" for the relevant input. Enable the "Short-circuit test" parameter.

Wiring Diagram for Use Case 3.2 – Connecting One Nonequivalent Sensor Via Two Channels Nonequivalently

Eight process signals can be connected to an 8/16 F-DI DC24V PROFIsafe electronic module, 4 process signals to a 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module, and 2 process signals to an F-Switch PROFIsafe. One sensor is connected nonequivalently via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The left channels on the F-module (DI 0 to DI 3 or DI 8 to DI 11) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs in the F-CPU.

NOTE

You must use internal sensor supply Vs1 (or Vs3) to supply voltage to the sensor. Connection to Vs2 (or Vs4) is not possible.

The wiring is carried out at the appropriate connection module.

The figure below illustrates an example wiring diagram for channel groups 1 and 2.

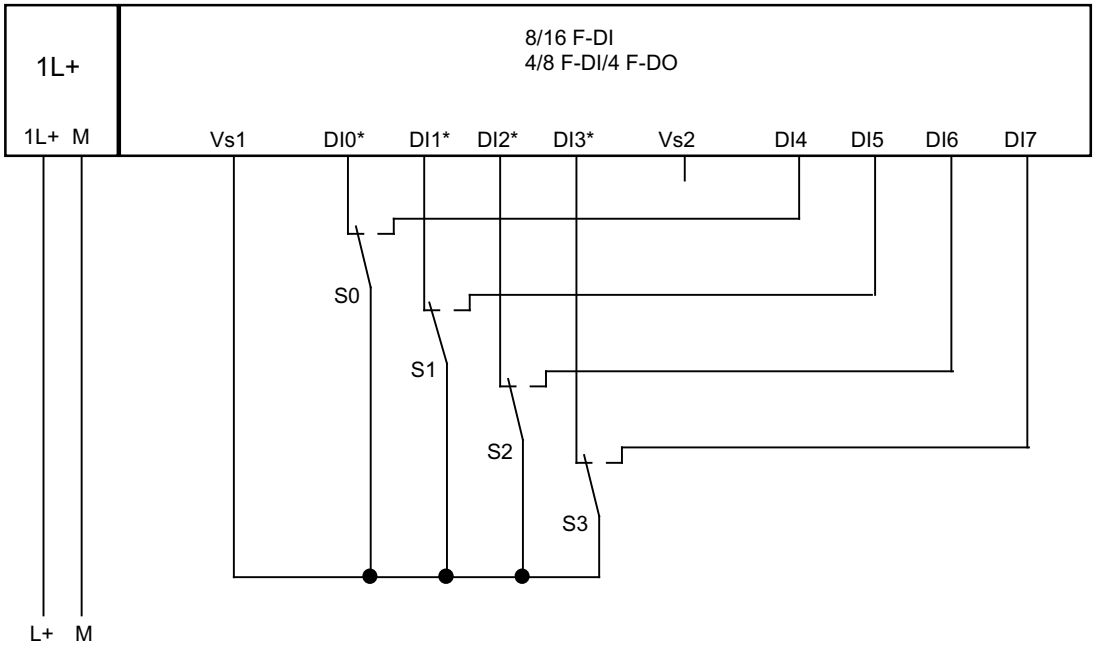


Figure 1-893 Wiring Diagram for F-DI Modules - One Nonequivalent Sensor Connected Nonequivalently Via Two Channels, Internal Sensor Supply

Alternatively, two one-channel sensors can be connected nonequivalently via two channels (see Figure *"Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Nonequivalently Via Two Channels, Internal Sensor Supply"*). In this case, the same process variable is measured with mechanically separated sensors.

⚠ WARNING

In order to achieve SIL3/Category 4 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 3.2

Set the "Evaluation of the sensors" parameter to "1oo2 evaluation" and the "Type of sensor interconnection" parameter to "2-channel nonequivalent" for the relevant input. Enable the "Short-circuit test" parameter.

Specific Characteristics for Fault Detection (Use Cases 3.1 and 3.2)

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1207 F-DI Modules: Fault Detection (Use Cases 3.1 and 3.2)

Example of fault	Fault detection with internal sensor supply and enabled short-circuit test for ...	
	Sensor 2-channel equivalent	Sensor 2-channel nonequivalent
Short circuit of DI 0 with DI 1	Yes*	Yes*
Short circuit of DI 0 with DI 4	Yes*	Yes
Short circuit of DI 0 with DI 5	Yes*	Yes*
P-short circuit of DI 0	Yes	Yes
M-short circuit of DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit of Vs1	Yes	Yes
M-short circuit of Vs1, or Vs2 defective	Yes	Yes
Short circuit of Vs1 with Vs2	Yes	Yes
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes

***:** Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Requirements for Machine Protection Applications With Category 4

The following requirements apply to machine protection applications with Category 4:

- State-of-the-art wiring must be used between the sensors and the automation system or between the automation system and the actuators to prevent short circuits.
- All short circuits listed in the above table are detected. Detection of a short circuit is sufficient in this case, because two faults must exist for the short circuit to occur (both of the short-circuited signal cables exhibit an insulation fault). Thus, a multiple short-circuit analysis is not required.

Processes for detection of all short circuits are also permissible if individual short circuits are not detected, provided:

- The short circuits do not cause corruption of read signals compared to the sensor signals or
- The short circuits cause corruption of read signals compared to the sensor signals, but in the direction that ensures safety.

8.1.9 Diagnostic Functions of the 8/16 F-DI DC24V PROFIsafe Electronic Module

Behavior in Case of Supply Voltage Failure

Failure of sensor supplies Vs1 to Vs4 is indicated by the SF LED, the VsF LED, and the LEDs of the relevant channel group on the F-module. This information is also provided on the module (diagnostic entry). The relevant channel groups or channels (in the case of channel-level passivation) of the module are passivated.

Diagnostic Functions

The following table presents an overview of the diagnostic functions of the 8/16 F-DI DC24V PROFIsafe electronic module. The diagnostic functions are assigned either to one channel or to the entire module.

Table 1-1208 Diagnostic Functions of the 8/16 F-DI DC24V PROFIsafe Electronic Module

Diagnostic Function*	Fault Number	LED	Signaled in Use Case	Range of Effectiveness of Diagnostic	Assignable
Short circuit	1_H	SF	1, 2, 3	Channel	Yes
Overtemperature	5_H	SF	1, 2, 3	Module	No
Fault	9_H	SF	1, 2, 3	Module	No
Parameter assignment error	10_H	SF	1, 2, 3	Module	No
Sensor voltage or load voltage is missing	11_H	VsF VsF	1, 2, 3	Module	No
Communication error	13_H	SF	1, 2, 3	Module	No
Safety-related shutdown	19_H	SF	2.3	Channel	No
*: Specifically for F-modules; display in *STEP 7*, see the "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table					

NOTE

If you have enabled the **short-circuit test** for the F-DI module in *STEP 7* and are using only one of the two internal sensor supplies of the module (Vs1 or Vs2, or Vs3 or Vs4), a channel M-short circuit is detected for each of the four channels whose sensor supply is not used. Four "short-circuit" diagnostic functions are generated in the diagnostic buffer of the F-module.

Specific Characteristics for Fault Detection

Detection of some faults (such as short circuits or discrepancy errors) is dependent on the use case, wiring, and parameter assignment of the short-circuit test. For this reason, tables on fault detection are presented for the use cases in *"Use Case 1: Safety Mode SIL2/Category 3" to "Use Case 3: Safety Mode SIL3/Category 4"*.

Causes of Faults and Corrective Actions

The following table presents the possible causes of faults and corrective actions for the individual diagnostic messages of the 8/16 F-DI DC24V PROFIsafe electronic module.

Table 1-1209 Diagnostic Messages of the 8/16 F-DI DC24V PROFIsafe Electronic Module, Causes of Faults and Corrective Actions

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Short circuit	Always	Internal fault	Replace module
	Cyclically during short-circuit test	Short circuit at the sensor Cross circuit at the sensor	Eliminate short circuit/cross circuit on sensor
Overtemperature	Always	Shutdown due to violation of temperature limit values in the module case.	Check ambient temperature. Check whether permissible output current of the sensor power supply is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
Fault	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration	Correct the configuration (compare actual and preset configuration).
		PROFIsafe address set incorrectly on the F-module	Check whether the PROFIsafe address on the module matches the configuration in *STEP 7 HW Config*
Sensor voltage or load voltage is missing	Always	No supply voltage or supply voltage is too low	Check module for proper contact. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
		Voltage dip due to short circuit	Eliminate short circuit/cross circuit.
Communication error	Always	Error in communication between the F-CPU and module, e.g., due to defective PROFIBUS/Industrial Ethernet connection or higher than permissible electromagnetic interferences.	Check the PROFIBUS/Industrial Ethernet connection. Eliminate the interferences.
		PROFIsafe monitoring time set too low	Set a higher value for the "F-monitoring time" parameter for the module in *STEP 7 HW Config*
		Configuration of the F-module does not match the fail-safe program	Recompile the safety program; then reload the configuration and safety program to the F-CPU
Safety-related shutdown	Always	Faulty process signal Defective sensor	Check process signal. Replace sensor if necessary.

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Safety-related shutdown	Always	Short circuit between unconnected sensor cable and the sensor supply cable	Eliminate short circuit
		Wire break in connected sensor cable or sensor supply cable	Eliminate broken wire
		Assigned discrepancy time is too short	Check the assigned discrepancy time. Once the error is eliminated, the F-module must be reintegrated in the safety program.

For more information on passivation and reintegration of F-I/O, refer to *"Diagnostics"* and the *S7 Distributed Safety Configuring and Programming* or *Programmable Controllers S7 F/FH* manuals.

Generally Applicable Information on Diagnostics

For information on diagnostics pertaining to all fail-safe modules (e.g., readout of diagnostic functions; passivation of channels), refer to *"Diagnostics"* in this manual as well as the *S7 Distributed Safety Configuring and Programming* or *Programmable Controllers S7 F/FH* manuals.

8.1.10 Technical Specifications for the 8/16 F-DI DC24V PROFIsafe Electronic Module

Overview

Technical Specifications		
Dimensions and Weight		
Dimensions W x H x D (mm)	90 x 175 x 65.2 (including rack)	
Weight	Approx. 270 g	
Module-Specific Specifications		
Number of inputs		
• 1-channel	Max. 16	
• 2-channel	Max. 8	
Assigned address area		
• I/O area for inputs	8 bytes	
• I/O area for outputs	4 bytes	
Cable length		
• Unshielded	Max. 30 m	
• Shielded	Max. 30 m	
Maximum achievable safety class	1-channel	2-channel
• According to IEC 61508:2000	SIL2	SIL3
• According to ISO 13849-1:2006 or EN ISO 13849-1:2008	Category 3	Category 4

Technical Specifications		
Fail-safe performance characteristics	SIL2	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-03	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-08	< 1.00E-09
Voltages, Currents, Potentials		
Rated supply voltage L+	24 V DC	
• Permissible range	20.4 V to 28.8 V	
• Power loss ride-through of L+	None	
• Power loss ride-through of internal P5	5 ms	
• Reverse polarity protection	Yes	
Number of simultaneously controllable inputs		
• All mounting positions – Up to 40°C – Up to 55°C	 16 (for 28.8 V) 16 (for 24.7 V) or 8 (for 28.8 V)	
Electrical isolation		
• Between channels and backplane bus	Yes	
• Between channels and power supply	No	
• Between channels	No	
• Between channels/power supply and shield	Yes	
Permissible potential difference between		
• Shield and ET 200pro bus connection	75 V DC/60 V AC	
• Shield and I/O (DIs)	75 V DC/60 V AC	
• ET 200pro bus connection and I/O (DIs)	75 V DC/60 V AC	
Insulation tested during type test with		
• Shield and ET 200pro bus connection	350 V AC/1 min	
• Shield and I/O (DIs)	350 V AC/1 min	
• ET 200pro bus connection and I/O (DIs)	350 V AC/1 min	
Current consumption		
• From backplane bus	Typ. 20 mA	
• From load voltage L+ (without sensor)	Typ. 120 mA	
Power loss of module	Typ. 4.5 W	
Status, Interrupts, Diagnostics		
Status displays		
• Inputs	Two-color red/green LED per channel	
• Sensor supply	LED VsF and display via channel LEDs of channel groups	
Diagnostic functions		
Interrupts		
• Diagnostic interrupt	Channel LED red	
• Group fault display	Red LED (SF)	
• Diagnostic information can be read out	Possible	
• I&M functionality *	See "ET 200pro Distributed I/O" Manual	

Technical Specifications		
Sensor Supply Outputs		
Number of outputs	4	
Output voltage		
• Loaded	Min. L+ (-1.5 V)	
Output current		
• Rated value	200 mA	
• Permissible range	0 mA to 200 mA	
Permissible aggregate current of outputs	800 mA	
Short-circuit protection	Yes, electronic	
• Operating value	0.7 A to 2.1 A	
Data for Selecting a Sensor **		
Input voltage		
• Rated value	24 V DC	
• At signal "1"	15 V to 30 V	
• At signal "0"	-30 V to 5 V	
Input current		
• At signal "1"	Typ. 3.7 mA	
Input delay	Assignable (for all inputs together)	
• At "0" after "1"	Typ. 0.5 ms	(0.3 ms to 0.7 ms)
	Typ. 3 ms	(2.6 ms to 3.4 ms)
	Typ. 15 ms	(13 ms to 17 ms)
• At "1" after "0"	Typ. 0.5 ms	(0.3 ms to 0.7 ms)
	Typ. 3 ms	(2.6 ms to 3.4 ms)
	Typ. 15 ms	(13 ms to 17 ms)
Input characteristic	In accordance with IEC 61131-2, Type 1	
Connection of 2-wire BERO	Not possible	
• Permissible quiescent current	Max. 0.6 mA	
Time, Frequency		
Internal preprocessing times	See *"Response Times"*	
Acknowledgment time in safety mode		
• Short-circuit test enabled With input delay of 0.5 ms: With input delay of 3 ms: With input delay of 15 ms:	 Min. 4 ms / max. 7 ms Min. 4 ms / max. 12 ms Min. 4 ms / max. 9 ms	
• Short-circuit test disabled	Min. 4 ms / max. 6 ms	
Minimum sensor signal duration	See *"Minimum Duration of Sensor Signals for Proper Detection by F-DI Module"* table in *"Wiring"*	
Protection against Overvoltage		
Protection of supply voltage L+ from surge in accordance with IEC 61000-4-5 with external protection elements only		
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs	
• Asymmetrical (L+ to PE, M to PE)	+ 2 kV; 1.2/50 µs	

Technical Specifications	
Protection of inputs and outputs from surge in accordance with IEC 61000-4-5 with external protection elements only	Not required since cable length is < 30 m
Protection of supply voltage 1L+ from overvoltages	Internal fuse tripped
*: Identification sets are described in the "ET200 pro Distributed I/O System" manual.	
**: For requirements for sensors and actuators, see "*Requirements for Sensors and Actuators*"	

8.2 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Digital Electronic Module

8.2.1 Properties of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Order Number

6ES7 148-4FC00-0AB0

Properties

The 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module has the following properties:

- Inputs
  - 8 inputs (SIL2/Category 3) or four inputs (SIL3/Category 3 or Category 4)
  - 24 V DC rated input voltage
  - Suitable for switches and 3- or 4-wire proximity switches (BEROs)
  - Two short-circuit-proof sensor supplies for each of the four inputs
  - External sensor supply possible
- Outputs
  - Four outputs, P/M switching (current sourcing/sinking)
  - 2 A output current
  - 24 V DC rated load voltage
  - Suitable for solenoid valves, DC contactors and indicator lights
- Group fault display (SF; red LED)
- Fault LED for each sensor supply (Vs1F to Vs2F) is mapped to VsF LED and the associated channels.
- Status and fault LEDs for each input/output (two-color green/red LED)
- Identification data (*see ET 200pro Distributed I/O System Standard Manual*)
- Assignable diagnostics
- Safety class SIL3 achievable
- Can only be operated in safety mode

Switching of Grounded Loads

If the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module switches loads that have a connection between the chassis and ground (e.g., to improve the EMC properties) **and** if the chassis and ground are connected in the power supply, a "short circuit" will be detected.

From the perspective of the F-module, the M-switch (current sinking) is bridged by the chassis-ground connection (refer to the following figure for an example for a 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module).

Remedy:

The resistance (R) between the chassis and ground on the load side must be greater than 100 kΩ.

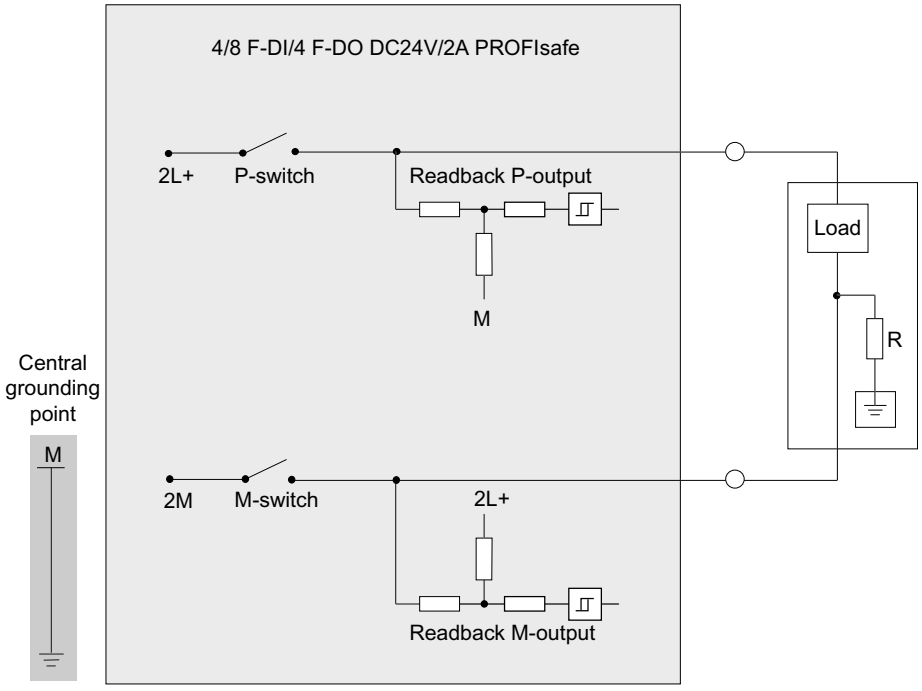


Figure 1-894 Switching Grounded Loads (Resistance Between Chassis and Ground)

8.2.2 Terminal Assignment of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

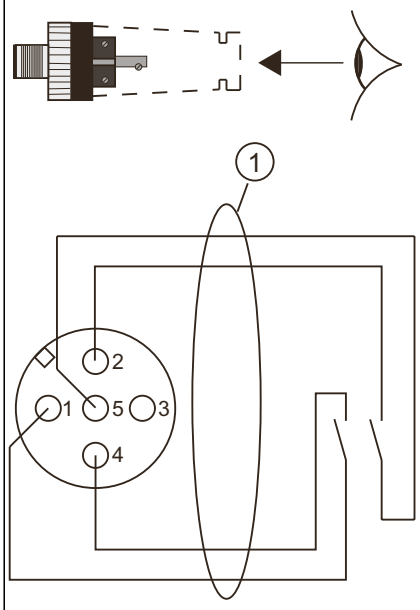
Terminal Assignment on CM IO 12×M12 Connection Module

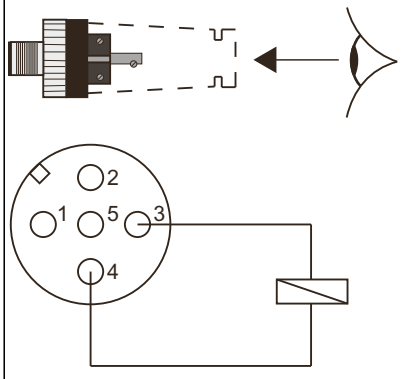
The following table presents the terminal assignment of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module on the CM IO 12×M12 connection module.

Sockets X1 to X4 are assigned twice. This enables you to implement a 1oo2 evaluation with one connecting cable, e.g., channels 0 and 4 at connector X1.

Table 1-1210 Terminal Assignment on the CM IO 12xM12 Connection Module for 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe

Circular connector view	Terminal	Assignment of X1 to X12
Digital inputs	1	Connectors X1 to X4: 24 V sensor supply 1 (Vs1) Connectors X5 to X8: 24 V sensor supply 2 (Vs2) Connectors X9 to X12: Not assigned
	2	Input signal:

<table>
<tr><th>Circular connector view</th><th>Terminal</th><th colspan="2">Assignment of X1 to X12</th></tr>
<tr><td rowspan="4">

Digital outputs

</td><td>2</td><td>Connector X1: Input channel 4[2]
Connector X2: Input channel 5[2]
Connector X3: Input channel 6[2]
Connector X4: Input channel 7[2]</td><td>Connector X5: Not assigned
Connector X6: Not assigned
Connector X7: Not assigned
Connector X8: Not assigned
Connector X9: Not assigned
Connector X10: Not assigned
Connector X11: Not assigned
Connector X12: Not assigned</td></tr>
<tr><td>3</td><td colspan="2">Connectors X1 to X8: Sensor supply ground (1M)
Connector X9: Output channel M0
Connector X10: Output channel M1
Connector X11: Output channel M2
Connector X12: Output channel M3</td></tr>
<tr><td>4</td><td colspan="2">Input signal:</td></tr>
<tr><td></td><td>Connector X1: Input channel 0
Connector X2: Input channel 1
Connector X3: Input channel 2
Connector X4: Input channel 3
Connector X5: Input channel 4
Connector X6: Input channel 5
Connector X7: Input channel 6
Connector X8: Input channel 7</td><td>Connector X9: Output channel P0
Connector X10: Output channel P1
Connector X11: Output channel P2
Connector X12: Output channel P3</td></tr>
<tr><td>5</td><td colspan="2">Connectors X1 to X4: 24 V sensor supply 2 (Vs2)
Connectors X5 to X8: Not assigned
Connectors X9 to X12: Functional ground (FG)</td></tr>
<tr><td colspan="4">[1] 3-, 4- or 5-core copper cable
[2] Only relevant for 1oo2 evaluation via a connecting cable</td></tr>
</table>

8.2.3 Block Diagram for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Block Diagram

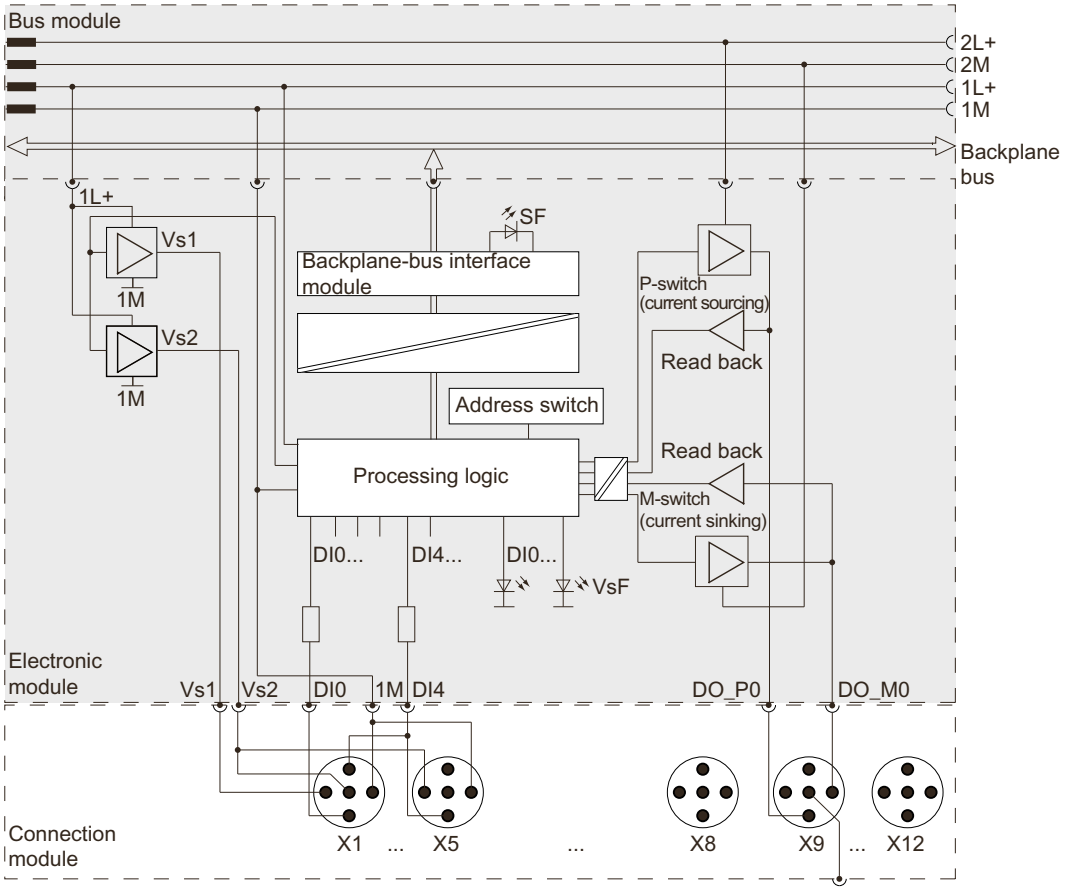


Figure 1-895 Block Diagram for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

8.2.4 Parameters for the 4/8 F-DI/4 F-DO DC24V/2 A PROFIsafe Electronic Module

Parameters in *STEP 7*

The following table shows the parameters that can be set for the F-DI/F-DO module (see also *"Configuration and Parameter Assignment"*).

Table 1-1211 Parameters of the F-DI/DO Module

Parameters	Range	Default	Type of parameter	Range of effectiveness
F-parameters:				
F_destination_address	1 to 1022	Assigned by *STEP 7*	Static	Module
F-monitoring time	10 to 10000 ms	150 ms	Static	Module

Parameters	Range	Default	Type of parameter	Range of effectiveness
Module Parameters:				
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
Module Parameter Inputs:				
Input delay	0.5; 3; 15 ms	3 ms	Static	Module
Short-circuit test	Cyclic/Disable	Cyclic	Static	Module
Channel n, n+4	Enabled/disabled	Enabled	Static	Channel group
Evaluation of the sensors	1oo2 evaluation/ 1oo1 evaluation	1oo2 evaluation	Static	Channel group
Type of sensor interconnection	1-channel; 2-channel equivalent; 2-channel nonequivalent	2-channel equivalent	Static	Channel group
Behavior at discrepancy	Provide last valid value; Provide value 0	Provide last valid value	Static	Channel group
Discrepancy time	10 to 30000 ms	10 ms	Static	Channel group
Reintegration after discrepancy error	Test of 0-signal not required/Test of 0-signal required	Test of 0-signal not required	Static	Channel group
Module Parameter Outputs:				
DO channel n	Enabled/disabled	Enabled	Static	Channel
Readback time	1 to 400 ms	1 ms	Static	Channel
Diagnostics: Wire break	Enabled/disabled	Disabled	Static	Channel
* This setting is only relevant when the *S7 Distributed Safety* V 5.4 or higher optional package is installed.				

Short-Circuit Test Parameter

The cyclic short-circuit test is enabled and disabled using the short-circuit test parameter. The short-circuit test is only useful for simple switches that do not have their own power supply. If the short-circuit test has been enabled, the internal sensor supplies must be used (see also *"Use Cases of the 8/16 F-DI DC24V PROFIsafe Electronic Module"*).

Behavior at Discrepancy Parameter

As the "behavior at discrepancy" you assign the value that is made available to the safety program in the F-CPU while there is a discrepancy between the two input channels involved, i.e., during the discrepancy time. You assign the behavior at discrepancy as follows:

- "Provide last valid value", or
- "Provide value 0"

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation"

"Provide last valid value"

The last valid value (old value) before discrepancy occurs is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the two relevant input channel signals. This value is supplied until the discrepancy disappears or until the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is extended by an amount equal to this time.

As a result, the discrepancy time of sensors connected via two channels must be set for fast reactions to short response times. It makes no sense, for example, for a time-critical shutdown to be triggered by sensors connected via two channels with a discrepancy time of 500 ms. In the worst case, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time.

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time that includes a sufficient cushion against false tripping of discrepancy errors.

"Provide value 0"

The value "0" is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two relevant input channels.

If you specified "Provide value 0", the sensor-actuator response time is not affected by the discrepancy time.

Discrepancy Time Parameter

Here, you can specify the discrepancy time for each channel pair. The entered value is rounded to a multiple of 10 ms.

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation" and
- Type of sensor interconnection: "2-channel equivalent" or "2-channel nonequivalent"

Discrepancy Analysis and Discrepancy Time

If you are using one two-channel sensor, one nonequivalent sensor or two single-channel sensors that are measuring the same physical process variable, the sensors will respond with a time delay due to the limited accuracy of their arrangement.

The discrepancy analysis for equivalence/nonequivalence is used with fail-safe inputs to detect faults based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same voltage levels) are detected at two associated input signals. A test is conducted to determine whether the difference in levels (when testing for nonequivalence: the consistency) has disappeared within a programmable period known as the discrepancy time. If not, a discrepancy error exists.

In most cases, the discrepancy time starts but does not elapse completely, since the signal differences disappear after a short time.

Select a discrepancy time of sufficient length so that in case of no error, the difference between the two signals (when checking for nonequivalence: the consistency) has definitely disappeared before the discrepancy time expires.

Behavior While Discrepancy Time is Running

While the assigned discrepancy time is running internally on the module, either the **last valid value** or **"0"** is made available to the safety program in the F-CPU by the relevant input channels, depending on the parameter assignment for the behavior at discrepancy.

Behavior After Discrepancy Time Elapses

If the input signals are not equivalent following expiration of the specified discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, the system detects a discrepancy error and generates a "discrepancy" diagnostic message in the diagnostic buffer of the F-I/O module to identify the faulty channels.

Reintegration After Discrepancy Error Parameter

This parameter is used to specify when a discrepancy error is regarded as eliminated and, thus, when the relevant input channels can be reintegrated. The following can be assigned:

- "Test of 0-signal required" or
- "Test of 0-signal not required"

Requirements

You have assigned the following:

- Evaluation of the sensors: "1oo2 evaluation"

"Test of 0-signal required"

If you assigned "Test of 0-signal required", a discrepancy error is regarded as eliminated once a 0-signal is present again at both of the relevant input channels.

If you are using nonequivalent sensors, i.e., the "Type of sensor interconnection" is set to "2-channel nonequivalent", a 0-signal must be present again at the channel supplying the wanted signal.

For information about which F-module channels supply the wanted signals, refer to the manual for the F-module you are using.

"Test of 0-signal not required"

If you assigned "Test of 0-signal not required", a discrepancy error is regarded as eliminated once the discrepancy at the two relevant input channels disappears.

F-modules in SIMATIC S7 for which the "Reintegration after discrepancy error" parameter is not available also exhibit this behavior.

Readback Time Parameter

Each output channel has its own assignable readback time. This time specifies the maximum duration of the switch-off test for the corresponding channel and, thus, also the readback time for the switch-off operation of the channel.

The following readback times can be assigned: 1 ms, 5 ms, 10 ms, 50 ms, 100 ms, 200 ms, and 400 ms.

You should set a sufficiently long readback time if the relevant channel switches high-capacitive loads. If the readback time for a controlled capacitive load is set too low, the output channel is passivated because the discharge of the capacitance does not take place within the switch-off test.

In the event of false readback signals, an amount of time equivalent to the readback time is permitted to elapse before the "short circuit" fault causes the output channel to become passivated.

8.2.5 Wiring of Inputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Use cases

NOTE

The use cases for the digital input modules apply to all digital inputs of the ET 200pro fail-safe modules.
For this reason, the wiring diagrams for the inputs are presented for the 8/16 F-DI DC24V PROFIsafe digital electronic module.

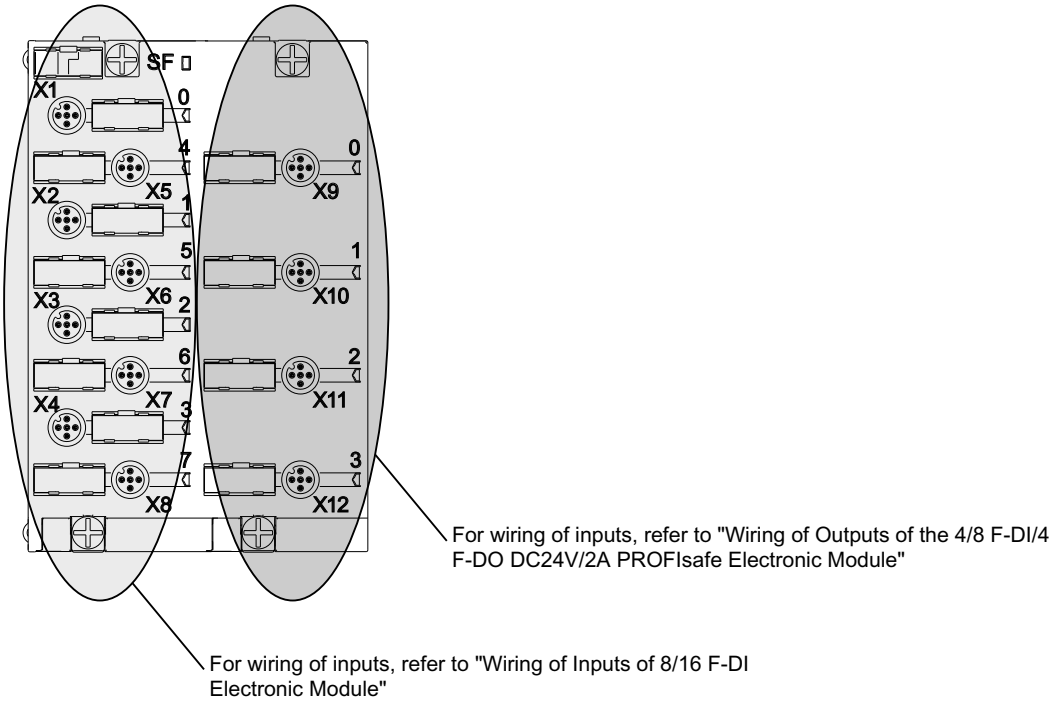


Figure 1-896 Wiring of Inputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

See also

Use Case 1: Safety Mode SIL2/Category 3 (Page 59)
Use Case 2: Safety Mode SIL3/Category 3 (Page 60)
Use Case 3: Safety Mode SIL3/Category 4 (Page 69)
Wiring of Outputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 87)

8.2.6 Wiring of Outputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Use Case 1: Wiring a Load to Each Digital Output

Each of the four fail-safe digital outputs consists of one DOx P P-switch (current sourcing) and one DOx M M-switch (current sinking). They connect the load between the P- and M-switches. The two switches are always controlled so that voltage is applied to the load.

The wiring is carried out at the connection module.

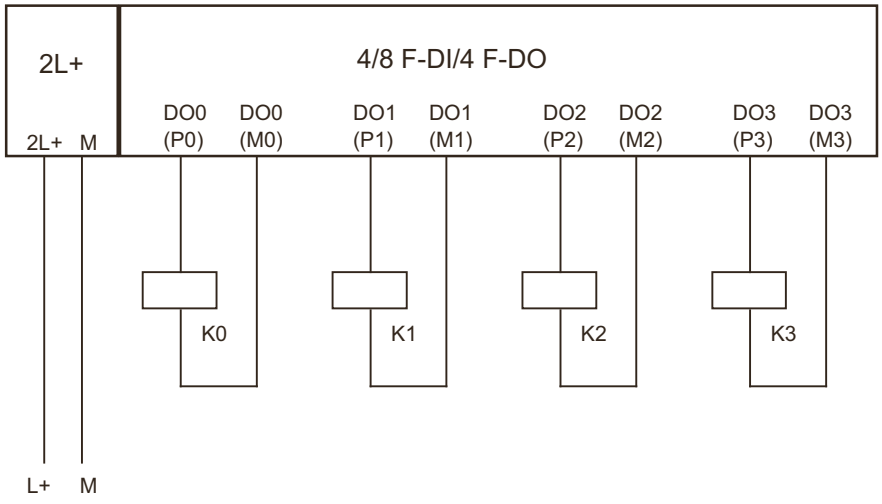


Figure 1-897 Wiring Diagram for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Use Case 2: Wiring Loads to L+ and M at Each Digital Output

You can switch two relays with one fail-safe digital output. The following conditions should be kept in mind:

- L+ and M of the relays must be connected with L+ and M of the F-DO module (reference potential must be equal).
- The normally open contacts of the two relays must be switched in series.

A connection to each of the four digital outputs is possible. The following figure shows an example of the connection at DO 0. This circuit achieves SIL3/Category 4.

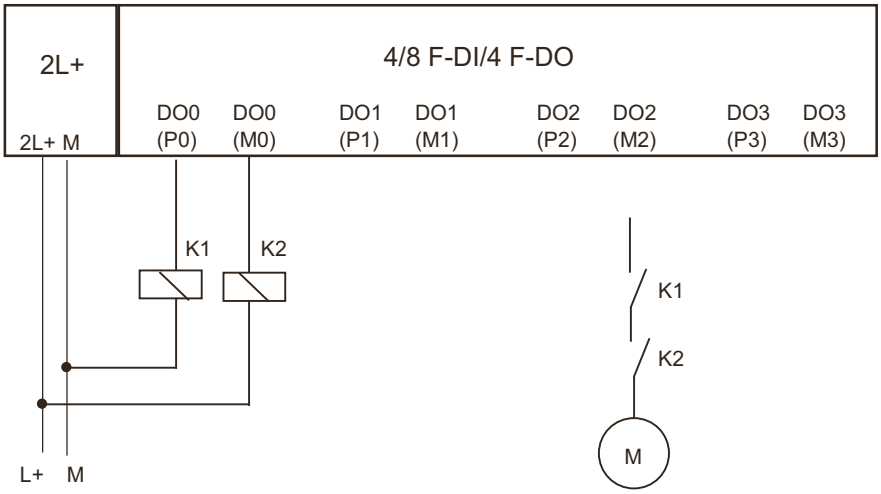


Figure 1-898 Wiring Diagram for Each of Two Relays at One F-DO of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

WARNING

When two relays are connected at one digital output (as shown in the figure above), "wire break" and "overload" faults are detected only at the P-switch of the output (not at the M-switch).
The controlled actuator can no longer be switched off in the event of a cross circuit between the P- and M-switches of the output.

WARNING

To avoid cross circuits between P- and M-switches of a fail-safe digital output, you must route the cables for the relay connection at the P- and M-switches to protect against cross circuits (e.g., as separately sheathed cables or in separate cable ducts).

Use Case 3: Wiring Two Loads in Parallel to Each Digital Output

Avoiding/Managing Cross Circuits:

To protect against cross circuits between P- and M-switches of a fail-safe digital output, we recommend the following wiring schemes:

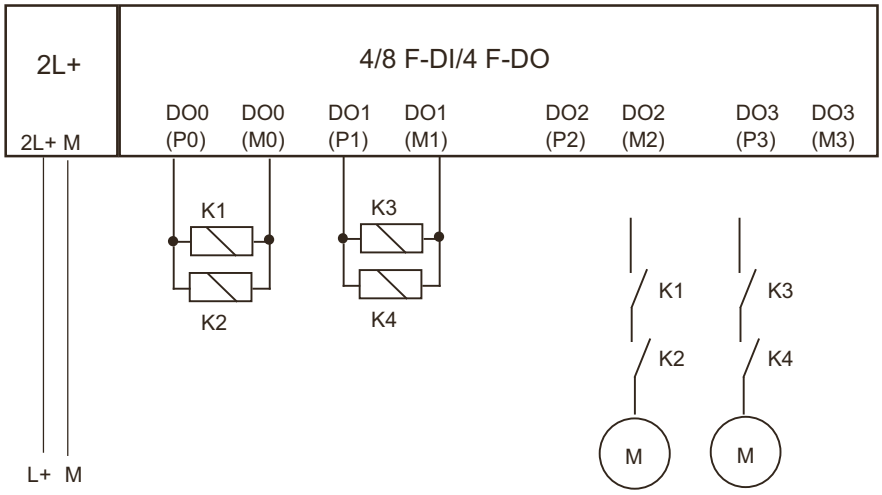


Figure 1-899 Wiring Diagram for Each of Two Relays Parallel at One F-DO of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

See also

Block Diagram for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module (Page 82)

8.2.7 Diagnostic Functions of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Behavior in Case of Supply Voltage Failure

Failure of sensor supplies Vs1 and Vs2 is indicated by the SF LED, VsF LED, and the LEDs of the relevant channel group on the F-module. This information is also provided on the module (diagnostic entry). All channels of the module are passivated.

Diagnostic Functions

The following table presents an overview of the diagnostic functions of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module. The diagnostic functions are assigned either to one channel or to the entire module.

Table 1-1212 Diagnostic Functions of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Diagnostic Function*	Fault Number	LED	Range of Effectiveness of Diagnostic	Assignable
Short circuit	1_H	SF	Channel	No
Overload	4_H	SF	Channel	No
Overtemperature	5_H	SF	Module	No
Wire break	6_H	SF	Channel	Yes
Fault	9_H	SF	Module	No

Diagnostic Function*	Fault Number	LED	Range of Effectiveness of Diagnostic	Assignable
Parameter assignment error	10_H	SF	Module	No
Sensor voltage or load voltage is missing	11_H	SF	Module	No
Communication error	13_H	SF	Module	No
Safety-related shutdown	19_H	SF	Channel	No
*: Specifically for F-modules; display in *STEP 7*, see the "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

Causes of Faults and Corrective Actions

The following table presents the possible causes of faults and corrective actions for the individual diagnostic messages of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module.

Table 1-1213 Diagnostic Messages of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module, Causes of Faults and Corrective Actions

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Short circuit	Always	Short circuit in the actuator	Eliminate short circuit/cross circuit on actuator Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
		Cross-circuit in the actuator	
		Internal fault	Replace module
Short circuit	Cyclically during short-circuit test	Short circuit at the sensor Cross circuit at the sensor	Eliminate short circuit/cross circuit on sensor
Overload	For "1" output signal only	Output stage is overloaded and becomes too hot	Eliminate overload.
Overtemperature	Always	Shutdown due to violation of temperature limit values in the module case.	Check load wiring. Check ambient temperature. Check whether permissible output current (aggregate current) is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
Open circuit	For "1" output signal only	Open circuit	Correct the wire break. Ensure specified minimum load (see *"Technical Specifications of the 4/8 F-DO/4 F-DO DC24V/2A PROFIsafe Electronic Module"*).
Fault	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration; incorrect parameter assignment	Correct the configuration (compare actual and preset configuration). Check communication paths. Correct the configuration.
		PROFIsafe address set incorrectly on the F-module	Check whether the PROFIsafe address on the module matches the configuration in *STEP 7 HW Config*

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Sensor voltage or load voltage is missing	Always	No supply voltage or supply voltage is too low	Check module for proper contact. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on.
		Voltage dip due to short circuit	Eliminate short circuit/cross circuit.
Communication error	Always	Error in communication between the F-CPU and module due to defective PROFIBUS/Industrial Ethernet connection or higher than permissible electromagnetic interferences, for example	Test PROFIBUS/Industrial Ethernet connection. Eliminate the interferences.
		PROFIsafe monitoring time set too low	Reduce the call interval for F-program, or Set a higher value for the "F-monitoring time" parameter for the module in *STEP 7 HW Config*
		Configuration of the F-module does not match the fail-safe program	Recompile the safety program; then reload the configuration and safety program to the F-CPU
Safety-related shutdown	Always	Process signal is faulty Sensor is defective	Check process signal. Replace sensor if necessary.
		Short circuit between unconnected sensor cable (open switch) and the sensor supply cable	Eliminate short circuit
		Wire break in connected sensor cable (closed switch) or sensor supply cable	Eliminate broken wire
		Assigned discrepancy time is too short	Check the assigned discrepancy time.
			Once the error is eliminated, the F-module must be reintegrated in the safety program.
		Switching frequency exceeded	Reduce the switching frequency

Generally Applicable Information on Diagnostics

For information on diagnostics pertaining to all fail-safe modules (e.g., for reading out diagnostic functions, passivating channels), refer to "*Diagnostics*".

8.2.8 Technical Specifications for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Overview

Technical Specifications		
Dimensions and Weight		
Dimensions W x H x D (mm)	90 x 175 x 65.2 including rack	
Weight	Approx. 280 g	
Module-Specific Specifications		
Number of inputs		
• 1-channel	Max. 8	
• 2-channel	Max. 4	
Number of outputs (P/M switching)	4	
Assigned address area		
• I/O area for inputs	7 bytes	
• I/O area for outputs	5 bytes	
Cable length		
• Unshielded	< 30 m	
• Shielded	< 30 m	
Maximum achievable safety class	1-channel	2-channel
• According to IEC 61508:2000	SIL2	SIL3
• According to ISO 13849-1:2006 or EN ISO 13849-1:2008	Category 3	Category 4
Fail-safe performance characteristics	SIL2	SIL3
• Low demand mode (average probability of failure on demand)	< 1.00E-03	< 1.00E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00E-08	< 1.00E-09
Voltages, Currents, Potentials		
Rated supply voltage L+	24 V DC	
• Permissible range	20.4 V to 28.8 V	
• Power loss ride-through of L+	None	
• Power loss ride-through of internal P5	5 ms	
• Reverse polarity protection (1L/1M)	Yes	
• Reverse polarity protection (2L/2M)	No	
Number of simultaneously controllable inputs		
• All mounting positions – Up to 40 °C – Up to 55 °C	 8 (for 28.8 V) 8 (for 24.8 V) or 4 (for 28.8 V)	
Aggregate current of outputs		
• All mounting positions – Up to 40 °C – Up to 50 °C – Up to 55 °C	 6 A 4 A 3 A	

Technical Specifications	
Electrical isolation	
• Between channels and backplane bus	Yes
• Between channels and power supply	No
• Between DIs	No
• Between DOs	No
• Between DIs and DOs	Yes
• Between channels/power supply and shield	Yes
Permissible potential difference between	
• Shield and ET 200pro bus connection	75 V DC/60 V AC
• Shield and I/O (DIs, DOs)	75 V DC/60 V AC
• ET 200pro bus connection and I/O (DIs, DOs)	75 V DC/60 V AC
• Between DIs and DOs	75 V DC/60 V AC
Insulation tested during type test with	
• Shield and ET 200pro bus connection	350 V AC/1 min
• Shield against I/O (DOs)	350 V AC/1 min
• ET 200pro bus connection against I/O (DOs)	350 V AC/1 min
Current consumption	
• From backplane bus	Max. 20 mA
• From the electronic supply (without load)	Typ. 100 mA
• From load voltage L+ (without load)	Typ. 50 mA
Power loss of module	Typ. 5.8 W
Status, Interrupts, Diagnostics	
Status display	
• Inputs	Two-color red/green LED per channel
• Outputs	Two-color red/green LED per channel
• Sensor supply	LED VsF and display via channel LEDs of channel groups
Interrupts	
• Diagnostic interrupt	Channel LED red
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be read out	Possible
• I&M functionality *	See "ET 200pro Distributed I/O" Manual
Sensor Supply Outputs	
Number of outputs	2
Output voltage	
• Loaded	Min. L+ (-1.5 V)
Output current	
• Rated value	200 mA
• Permissible range	0 mA to 200 mA
• Permissible aggregate current of outputs	400 mA
• Short-circuit protection	Yes, electronic

Technical Specifications		
• Operating value	0.7 A to 2.1 A	
Data for Selecting a Sensor **		
• Input voltage		
• Rated value	24 V DC	
• At signal "1"	15 V to 30 V	
• At signal "0"	-30 V to 5 V	
Input current		
• At signal "1"	Typ. 3.7 mA	
Input delay	Assignable (for all inputs together)	
• At "0" after "1"	Typ. 0.5 ms	(0.3 ms to 0.7 ms)
	Typ. 3 ms	(2.6 ms to 3.4 ms)
	Typ. 15 ms	(13 ms to 17 ms)
• At "1" after "0"	Typ. 0.5 ms	(0.3 ms to 0.7 ms)
	Typ. 3 ms	(2.6 ms to 3.4 ms)
	Typ. 15 ms	(13 ms to 17 ms)
Input characteristic	In accordance with IEC 61131-2, Type 1	
Connection of 2-wire BERO	Not possible	
• Permissible quiescent current	Max. 0.6 mA	
Data for Selecting an Actuator**		
Output voltage		
• At signal "1"	• Min. L+ (-1.5 V) • P-switch: L+ (-1.5 V), minimum; voltage drop at M-switch: 0.5 V, maximum	
Output current for "1" signal		
• Rated value	2 A	
• Permissible range	20 mA to 2.4 A	
For "0" signal (residual current)	Max. 0.5 mA	
Indirect control of load by means of coupling relay:		
For "0" signal (residual current)		
• P-switch	Max. 0.5 mA	
• M-switch	Max. 1 mA	
Load resistance range	12 Ω to 1 kΩ	
Lamp load	Max. 10 W	
Wire break monitoring (open load detection) and overload monitoring		
• Response threshold	I < 4 to 19 mA	
• Fault detection time	Depends on the assigned readback time (see "*Response Times*")	
Parallel switching of 2 outputs	Not possible	
Control of a digital input	Not possible	
Switching frequency		
• With resistive load	Max. 30 Hz	

Technical Specifications	
• With inductive load in accordance with IEC 60947-5-1, DC13	Max. 0.1 Hz
• With lamp load	Max. 10 Hz
Limit on inductive shutdown voltage to	Typ. 2L+ (-2×47 V)
Short-circuit protection of output	Yes, electronic
• Response threshold (short circuit)	5 A to 12 A
• Response threshold (external M-short circuit)	5 A to 12 A
• Response threshold (external P-short circuit)	25 A to 45 A
Overload protection	Yes
• Response threshold	I > 2.8 A to 3.2 A
Time, Frequency	
Internal preprocessing times	See *"Response Times"*
Acknowledgment time in safety mode	Min. 4 ms / max. 8 ms
• Short-circuit test enabled For input delay of 0.5 ms For input delay of 3 ms: For input delay of 15 ms:	 Min. 4 ms / max. 7 ms Min. 4 ms / max. 12 ms Min. 4 ms / max. 9 ms
• Short-circuit test disabled	Min. 4 ms / max. 6 ms
Minimum sensor signal duration	See *"Minimum Duration of Sensor Signals for Proper Detection by F-DI Module"* table in *"Wiring"*.
Protection against Overvoltage	
Protection of supply voltage L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+ 2 kV; 1.2/50 µs
Protection of inputs and outputs from surge in accordance with IEC 61000-4-5 with external protection elements only	Not required since cable length is < 30 m
Protection of supply voltage 1L+ from overvoltage	Internal fuse tripped
*: Identification sets are described in the "ET200 pro Distributed I/O System" manual.	
**: For more information on the requirements for sensors and actuators, refer to *"Wiring"*.	

8.3 F-Switch PROFIsafe Digital Electronic Module

8.3.1 Properties of the F-Switch PROFIsafe Electronic Module

Order Number

6ES7 148-4FS00-0AB0

Properties

The F-Switch PROFIsafe electronic module has the following properties:

- Inputs
  - 2 inputs (SIL3/Category 3 or 4)
  - 24 V DC rated input voltage
  - Suitable for switches and 3- or 4-wire proximity switches (BEROs)
  - Two short-circuit-proof sensor supplies for each pair of inputs
  - External sensor supply possible
  - 1oo2 evaluation only supported
- Outputs
  - 3 outputs, PP-switching
  - Output current 1 A (F0/F1) in SIL3/Category 4, 6 A (2L+) in SIL2/Category 3
  - 24 V DC rated input voltage
  - Suitable for standard output modules (2L+ power bus), frequency converter, and motor starter (F0, F1 power bus)
- Group fault display (SF; red LED)
- Group fault display for the sensor supplies (VsF; red LED)
- Status and fault LEDs for each input/output (two-color green/red LED)
- Identification data (*see ET 200pro Distributed I/O System Standard Manual*)
- Can only be operated in safety mode

8.3.2 Terminal Assignment of the F-Switch PROFIsafe Electronic Module

Terminal Assignment on CM F-IO 2xM12 Connection Module

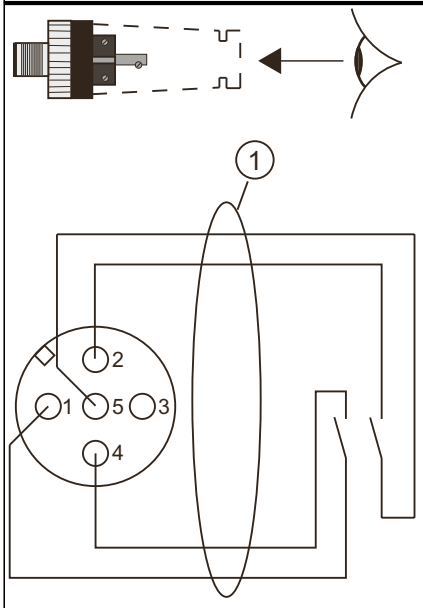
The following table contains the terminal assignment of the F-Switch PROFIsafe on the CM F-IO 2xM12 connection module.

Sockets X1 to X2 are assigned twice. This enables you to implement a 1oo2 evaluation with one connecting cable, e.g., channels 0 and 2 at connector X1.

The functional ground (FG) is located on the shield.

Table 1-1214 Terminal Assignment on CM F-IO 2×M12 Connection Module for F-Switch PROFIsafe

Circular connector view	Terminal	Assignment of X1 to X2
	1	Connectors X1 to X2: 24 V sensor supply 1 (Vs1)[2]
	2	Input signal:

Circular connector view	Terminal	Assignment of X1 to X2
	2	Connector X1: Channel 2 Connector X2: Channel 3
	3	Sensor supply ground (1M)
	4	Input signal:
		Connector X1: Channel 0 Connector X2: Channel 1
	5	Connectors X1 to X2: 24 V sensor supply 2 (Vs2)[2]

[1] 3-, 4- or 5-core copper cable
[2] Provided by the ET 200pro for the connected sensor

8.3.3 Block Diagram of the F-Switch PROFIsafe Electronic Module

Block Diagram

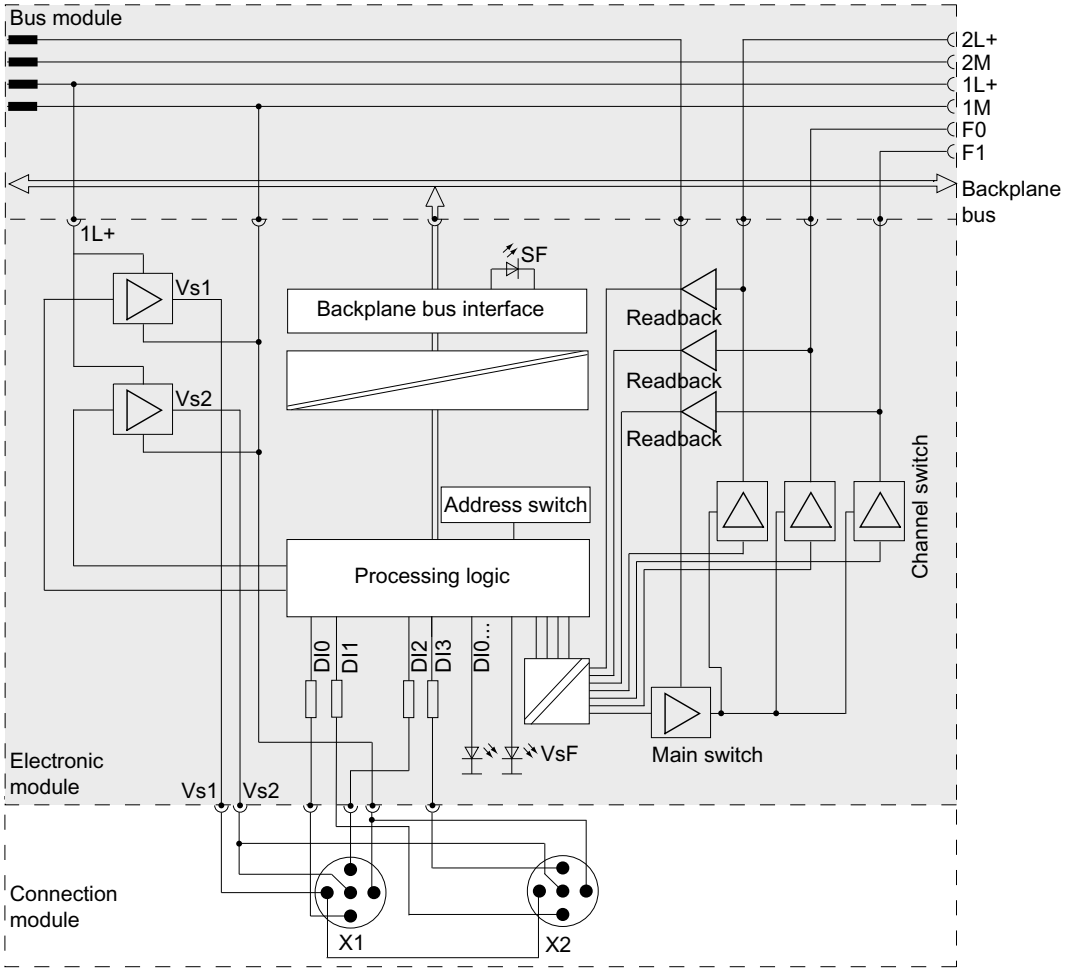


Figure 1-900 Block Diagram of the F-Switch PROFIsafe Electronic Module

8.3.4 Parameters for the F-Switch PROFIsafe Electronic Module

Parameters in *STEP 7*

The table below lists the parameters that can be assigned for the F-Switch PROFIsafe (see also *"Configuration and Parameter Assignment"*).

Table 1-1215 Parameters of the F-Switch PROFIsafe Module

Parameters	Range	Default	Type of Parameter	Range of Effectiveness
F-parameters:				
F_destination_address	1 to 1022	Assigned by *STEP 7*	Static	Module

Parameters	Range	Default	Type of Parameter	Range of Effectiveness
F-monitoring time	10 to 10000 ms	150 ms	Static	Module
Module Parameters:				
Behavior after channel faults*	Passivate the entire module/Passivate the channel	Passivate the entire module	Static	Module
Module Parameter Inputs:				
Input delay	3 ms	3 ms	Static	Module
Short-circuit test	Cyclic/Disable	Cyclic	Static	Module
Channel n, n+2	Enabled/disabled	Enabled	Static	Channel group
Sensor supply	Internal/external	Internal	Static	Module
Evaluation of the sensors	1oo2 evaluation	1oo2 evaluation	Static	Channel group
Type of sensor interconnection	1-channel; 2-channel equivalent; 2-channel nonequivalent	1-channel equivalent 2-channel equivalent	Static	Channel group
Behavior at discrepancy	Provide last valid value; Provide value 0	Provide last valid value	Static	Channel group
Discrepancy time	10 to 30000 ms	10 ms	Static	Channel group
Reintegration after discrepancy error	Test of 0-signal not required/Test of 0-signal required	Test of 0-signal not required	Static	Channel group
Module Parameter Outputs:				
Test of outputs	Enabled/disabled	Enabled	Static	Module
* This setting is only relevant when the *S7 Distributed Safety* V 5.4 or higher optional package is installed.				

Short-circuit test parameter

The cyclic short-circuit test is enabled and disabled using the short-circuit test parameter. The short-circuit test is only useful for simple switches that do not have their own power supply. If the short-circuit test has been enabled, the internal sensor supplies must be used (see also *"Use Cases of the F-Switch PROFIsafe Electronic Module"*).

Sensor Supply Parameter

This parameter can be used to enable the "internal sensor supply" of the F-module. This setting is a prerequisite for using the short-circuit test.

NOTE

When there are different sensor supply parameter settings (internal/external) for the individual channel groups, the use cases presented in the section "Use Cases of the F-Switch PROFIsafe Electronic Module" apply to specific channel groups.

Behavior at Discrepancy Parameter

As the "behavior at discrepancy" you assign the value that is made available to the safety program in the F-CPU while there is a discrepancy between the two input channels involved, i.e., during the discrepancy time. You assign the behavior at discrepancy as follows:

- "Provide last valid value", or
- "Provide value 0"

"Provide last valid value"

The last valid value (old value) before discrepancy occurs is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the two relevant input channel signals. This value is supplied until the discrepancy disappears or until the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is extended by an amount equal to this time.

As a result, the discrepancy time of sensors connected via two channels must be set for fast reactions to short response times. It makes no sense, for example, for a time-critical shutdown to be triggered by sensors connected via two channels with a discrepancy time of 500 ms. In the worst case, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time.

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time that includes a sufficient cushion against false tripping of discrepancy errors.

"Provide value 0"

The value "0" is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two relevant input channels.

If you specified "Provide value 0", the sensor-actuator response time will not be affected by the discrepancy time.

Discrepancy Time Parameter

Here, you can specify the discrepancy time for each channel pair. The entered value is rounded to a multiple of 10 ms.

Requirements

You have assigned the following:

- Type of sensor interconnection: "2-channel equivalent" or "2-channel nonequivalent"

Discrepancy Analysis and Discrepancy Time

If you are using one two-channel sensor, one nonequivalent sensor or two single-channel sensors that are measuring the same physical process variable, the sensors will respond with a time delay due to the limited accuracy of their arrangement.

The discrepancy analysis for equivalence/nonequivalence is used with fail-safe inputs to detect faults based on the timing of two signals with the same functionality. Discrepancy analysis is initiated when different levels (when testing for nonequivalence: same voltage levels) are detected at two associated input signals. A test is conducted to determine whether the difference in levels (when testing for nonequivalence: the consistency) has disappeared within a programmable period known as the discrepancy time. If not, a discrepancy error exists.

In most cases, the discrepancy time starts but does not elapse completely, since the signal differences disappear after a short time.

Select a discrepancy time of sufficient length so that in case of no error, the difference between the two signals (when checking for nonequivalence: the consistency) has definitely disappeared before the discrepancy time expires.

Behavior While Discrepancy Time is Running

While the assigned discrepancy time is running internally on the module, either the **last valid value** or **"0"** is made available to the safety program in the F-CPU by the relevant input channels, depending on the parameter assignment for the behavior at discrepancy.

Behavior After Discrepancy Time Elapses

If the input signals are not equivalent following expiration of the specified discrepancy time (when checking for nonequivalence: no inequality), for example due to wire break at a sensor line, the system detects a discrepancy error and generates a "discrepancy" diagnostic message in the diagnostic buffer of the F-I/O module to identify the faulty channels.

Reintegration After Discrepancy Error Parameter

This parameter is used to specify when a discrepancy error is regarded as eliminated and, thus, when the relevant input channels can be reintegrated. The following can be assigned:

- "Test of 0-signal required" or
- "Test of 0-signal not required"

"Test of 0-signal required"

If you assigned "Test of 0-signal required", a discrepancy error is regarded as eliminated once a 0-signal is present again at both of the relevant input channels.

If you are using nonequivalent sensors, i.e., the "Type of sensor interconnection" is set to "2-channel nonequivalent", a 0-signal must be present again at the channel supplying the wanted signal.

For information about which F-module channels supply the wanted signals, refer to the manual for the F-module you are using.

"Test of 0-signal not required"

If you assigned "Test of 0-signal not required", a discrepancy error is regarded as eliminated once the discrepancy at the two relevant input channels disappears.

F-modules in SIMATIC S7 for which the "Reintegration after discrepancy error" parameter is not available also exhibit this behavior.

8.3.5 Wiring of Inputs of the F-Switch PROFIsafe Electronic Module

NOTE
The information about wiring options and specific parameters in *STEP 7* (use cases) in the following section is applicable to the F-Switch PROFIsafe.

Use Case Selection

The following figure provides information to help you select the use case that corresponds to your fail-safe requirements. The following sections provide instructions on wiring the F-module and identify the parameters you must assign in *STEP 7* for each use case.

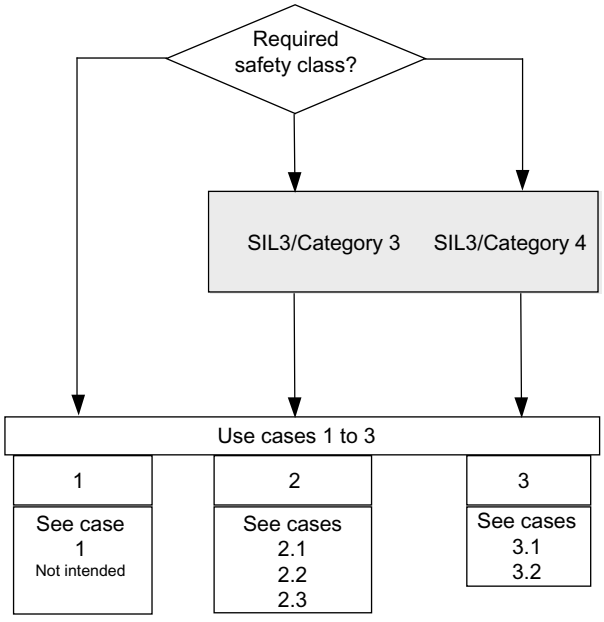


Figure 1-901 Selecting a use case

WARNING

The achievable safety class is dependent on the quality of the sensor and the length of the proof-test interval in accordance with IEC 61508:2000.

Conditions for Achieving SIL/Category

The conditions for achieving the respective safety requirements are presented in the following table.

Table 1-1216 F-DI Modules: Conditions for Achieving SIL/Category

Use case	Sensors	Evaluation of the sensors	Sensor supply	Achievable SIL/Category
2.1	1-channel	1oo2	Internal, with short-circuit test	3 / 3
			Internal, without short-circuit test	
			External	
2.2	2-channel equivalent	1oo2	Internal, without short-circuit test	
			External	
2.3	2-channel nonequivalent	1oo2	Internal, without short-circuit test	
			External	
3.1	2-channel equivalent	1oo2	Internal, with short-circuit test	3 / 4
3.2	2-channel nonequivalent			

NOTE

You can operate the various inputs of an F-Switch PROFIsafe simultaneously in SIL3/Category 3 **and** in SIL3/Category 4. You only have to connect the inputs and assign parameters as shown in the following sections.

Sensor Requirements

Please note the information in "*Requirements for Sensors and Actuators*" when using sensors for safety-related applications.

8.3.6 Use Case 1: Safety Mode of F-Switch PROFIsafe

Use Case 1

NOTE

Use case 1 is not intended for the F-Switch PROFIsafe.

8.3.7 Use Case 2: Safety Mode SIL3/Category 3

Conditions for Achieving SIL/Category

NOTE

For the conditions for achieving the SIL/Category and the requirements for sensors, see "Wiring of Inputs of the F-Switch PROFIsafe Electronic Module".

Assigning Inputs to Each Other

The F-Switch PROFIsafe electronic module has 2 fail-safe inputs (SIL3). The following assignment applies:

F-Switch PROFIsafe
Input channels DI 0 with DI 2
Input channels DI 1 with DI 3

Sensor Supply

The F-Switch PROFIsafe electronic module provides sensor supplies VS1 and VS2 for inputs 0 to 3.

The sensors can be powered internally or externally.

F-Switch PROFIsafe
Input channels DI 0 with DI 1 with sensor supply Vs1
Input channels DI 2 with DI 3 with sensor supply Vs2

Wiring Diagram for Use Case 2.1 – Connecting One Sensor Via One Channel to Two Inputs

One sensor is connected via one channel to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out at the appropriate connection module.

⚠ WARNING

In order to achieve SIL3/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

NOTE

If the voltage is supplied to the sensor from the F-Switch PROFIsafe electronic module, you must use the internal sensor supply Vs1. Connection to Vs2 is not possible.

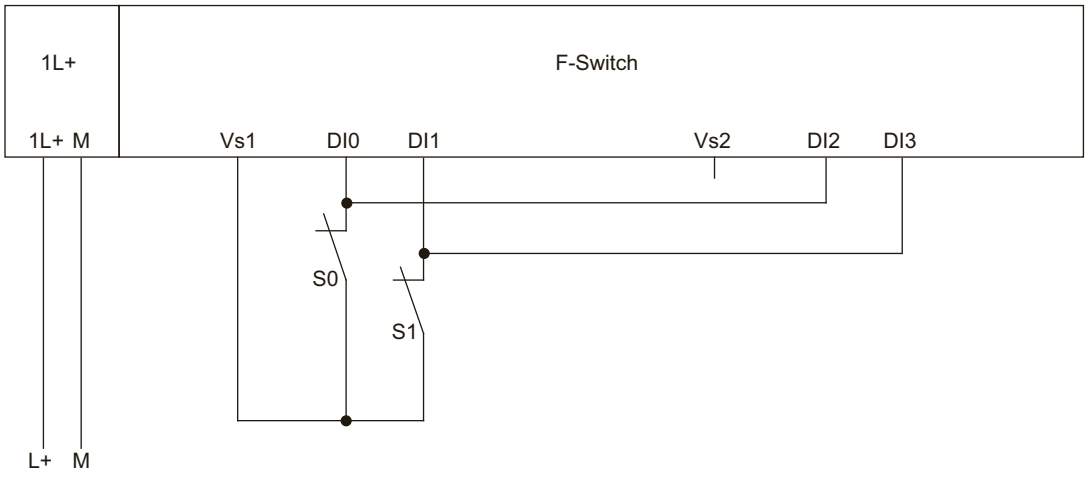


Figure 1-902 Wiring Diagram for F-Switch - One Sensor Connected Via One Channel to Two Inputs, Internal Sensor Supply

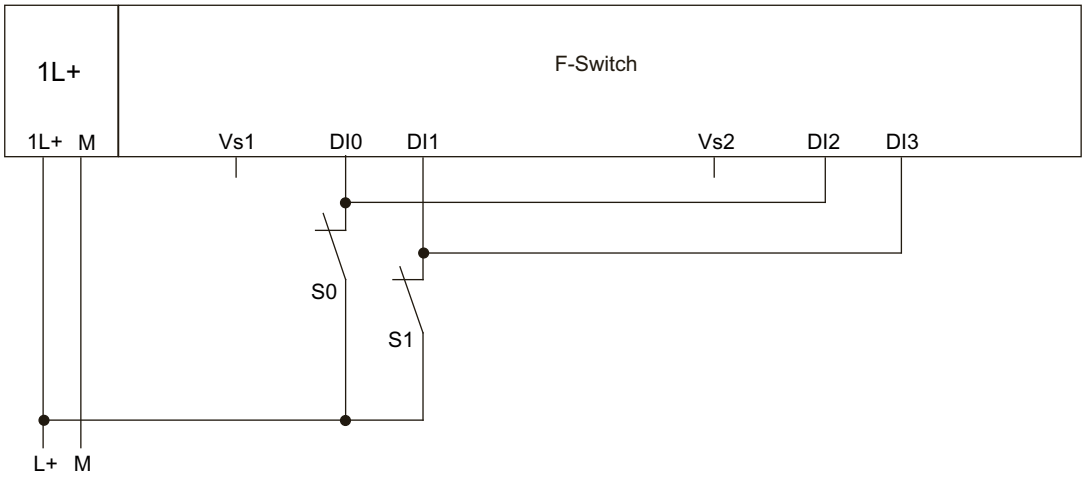


Figure 1-903 Wiring Diagram for F-Switch - One Sensor Connected Via One Channel to Two Inputs, External Sensor Supply

Assignable Parameters for Use Case 2.1

Set the "Type of sensor interconnection" parameter to "1-channel" for the corresponding input. The discrepancy time is permanently preset to 10 ms and cannot be changed.

You can enable or disable the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is enabled.

Special Features for Fault Detection in Use Case 2.1

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1217 F-Switch PROFIsafe Electronic Module: Fault Detection

Example of Fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	**Internal sensor supply and short-circuit test disabled**	**External sensor supply**
Short circuit of DI 0 with DI 1	No	No	No
Short circuit of DI 0 with DI 3	No	No	No
P-short circuit of DI 0	Yes	No	No
M-short circuit of DI 0	Yes*	Yes*	No
Discrepancy error	Yes	Yes	Yes
P-short circuit of sensor supply	Yes	No	No
M-short-circuit in sensor supply or defective	Yes	Yes	Yes
Short-circuit in sensor supply at DI 0	No	No	No
Supply voltage fault	Yes	Yes	Yes
***:** Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.			

WARNING

If the short-circuit test is disabled or cannot be enabled, the wiring between the sensor and input channel must be short circuit-proof.

Wiring Diagram for Use Case 2.2 – Connecting One Two-Channel Sensor Via Two Channels

One two-channel sensor is connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out at the appropriate connection module.

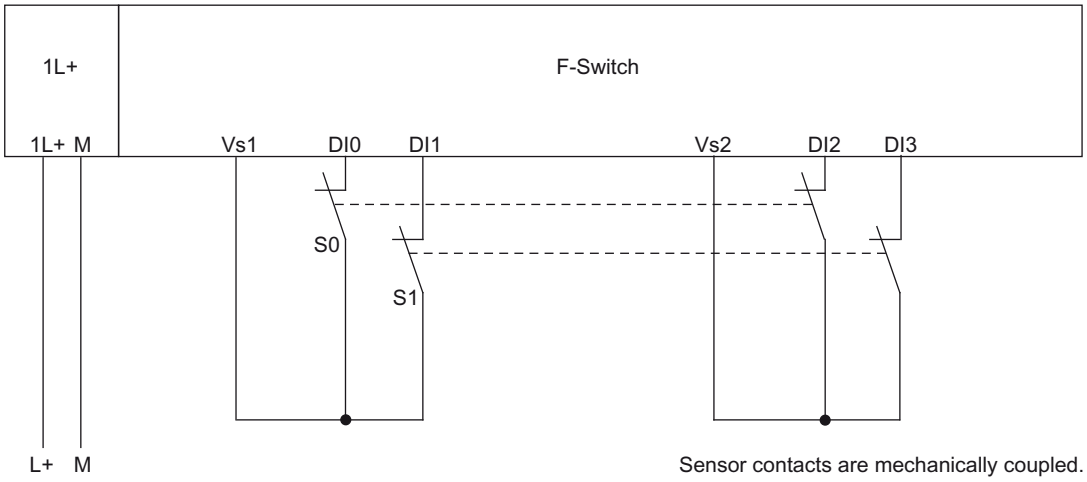


Figure 1-904 Wiring Diagram for F-Switch - One Two-Channel Sensor Connected, Internal Sensor Supply

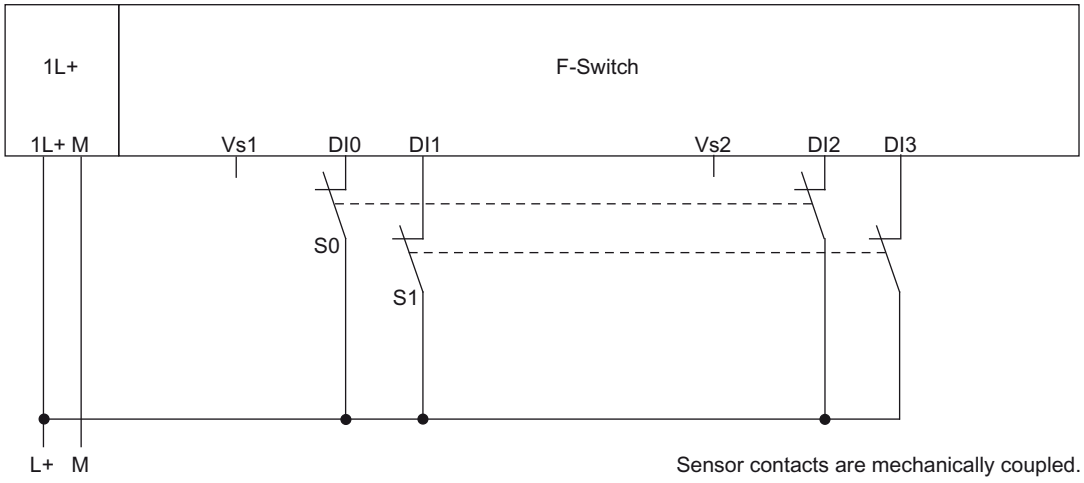


Figure 1-905 Wiring Diagram for F-Switch - One Two-Channel Sensor Connected Via Two Channels, External Sensor Supply

Wiring Diagram of the Connection of Two Single-Channel Sensors to Two Channels

Two single-channel sensors are connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation). The sensors can also be supplied via an external sensor supply.

⚠ WARNING
In order to achieve SIL2/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 2.2

Set the "Type of sensor interconnection" parameter to "2-channel equivalent" for the corresponding input.

You can enable or disable the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is enabled.

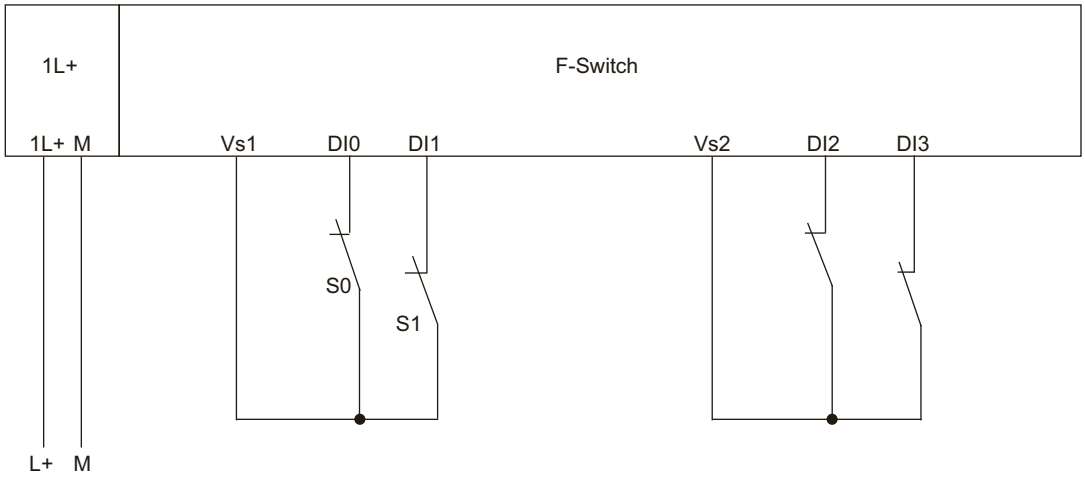


Figure 1-906 Wiring Diagram for F-Switch - Two One-Channel Sensors Connected Via Two Channels, Internal Sensor Supply

Special Features for Fault Detection in Use Case 2.2

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1218 F-Switch PROFIsafe Electronic Module: Fault Detection

Example of Fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	Yes*	Yes*	Yes*
Short circuit of DI 0 with DI 2	No	No	No
Short circuit of DI 0 with DI 3	Yes*	Yes*	Yes*
P-short circuit of DI 0	Yes*	Yes*	Yes*
M-short circuit of DI 0	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
P-short circuit of sensor supply	Yes	No	No
M-short-circuit in sensor supply or defective	Yes	Yes	Yes

Example of Fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	Internal sensor supply and short-circuit test disabled	External sensor supply
Short-circuit in sensor supply at DI 0	Yes*	Yes*	Yes*
Supply voltage fault	Yes	Yes	Yes
*: Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.			

WARNING

If the short-circuit test is not enabled or the sensor supply to digital inputs is set to "external", the wiring between the sensor and the input channel must be short circuit-proof.

Wiring Diagram for Use Case 2.3 – Connecting One Nonequivalent Sensor Via Two Channels Nonequivalently

One nonequivalent sensor is connected nonequivalently via two channels to two inputs of the F-I/O module for each process signal (1oo2 evaluation).

The left channels on the F-module (DI0 through DI1) supply the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

NOTE

If the voltage is supplied to the sensor from the F-Switch PROFIsafe module, you must use the internal sensor supply Vs1. Connection to Vs2 is not possible.

The wiring is carried out at the appropriate connection module.

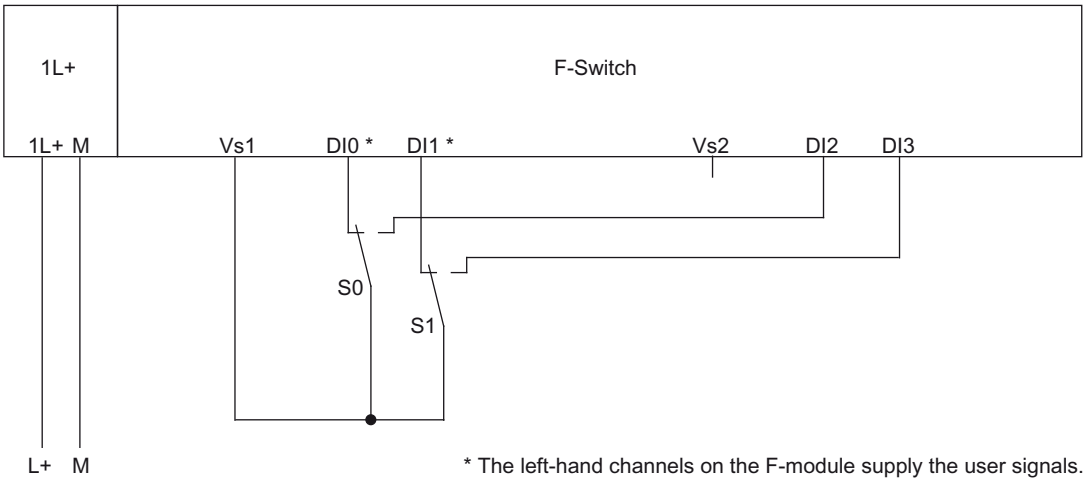


Figure 1-907 Wiring Diagram for F-Switch - One Nonequivalent Sensor Connected Via Two Channels Nonequivalently, Internal Sensor Supply

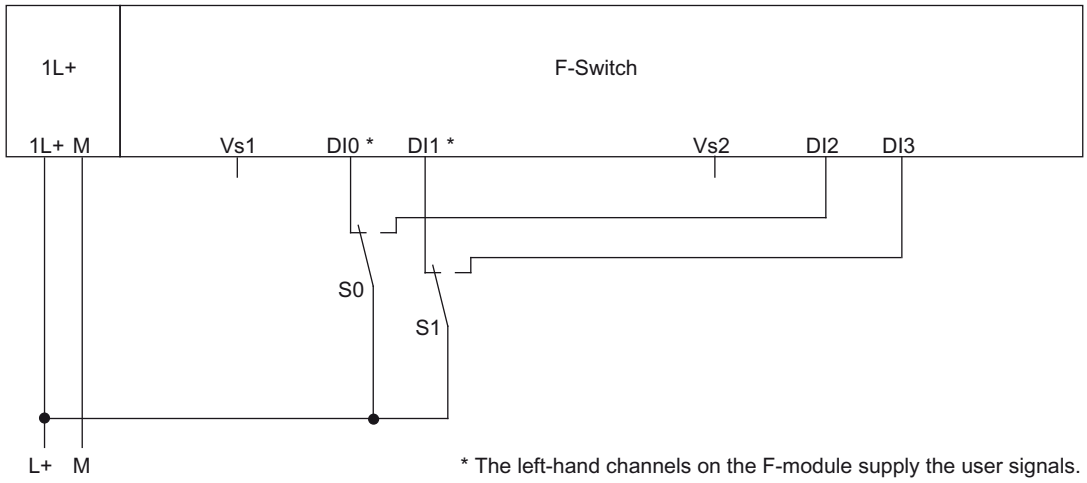


Figure 1-908 Wiring Diagram for F-Switch - One Nonequivalent Sensor Connected Via Two Channels Nonequivalently, External Sensor Supply

Wiring Diagram for Nonequivalent Connection of Two Single-Channel Sensors to Two Channels

Two single-channel sensors are connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The left channels of the F-module (DI 0 through DI 1) return the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

The sensors can also be supplied via an external sensor supply.

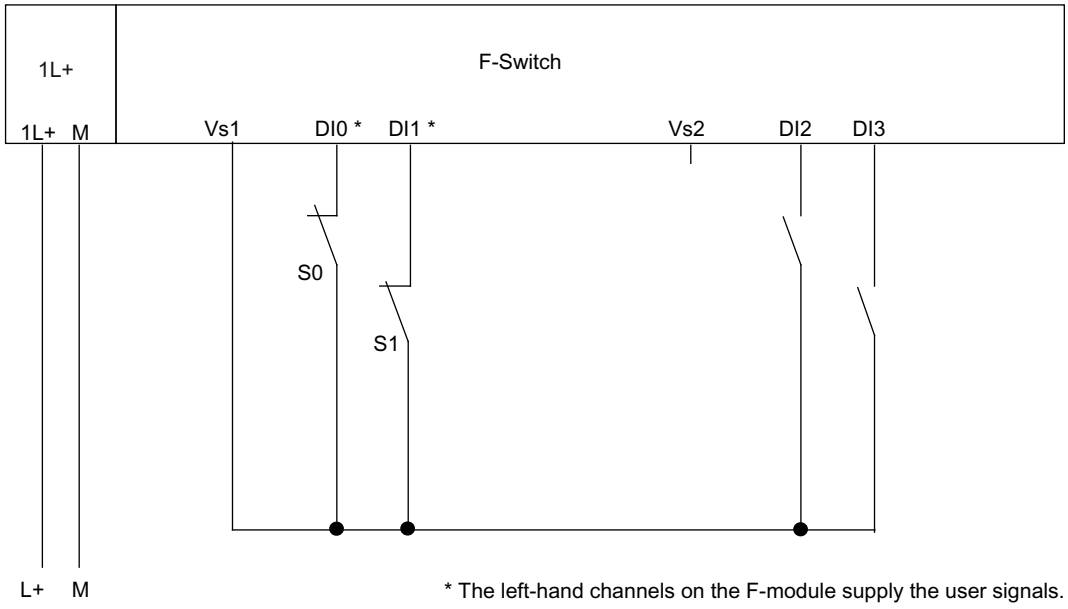


Figure 1-909 Wiring Diagram for F-Switch - Two One-Channel Sensors Connected Via Two Channels Nonequivalently, Internal Sensor Supply

⚠ WARNING

In order to achieve SIL2/Category 3 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 2.3

Set the "Type of sensor interconnection" parameter to "2-channel nonequivalent" for the corresponding input.

You can enable or disable the "short-circuit test" parameter. For digital inputs connected to an external supply, set the "Sensor supply" parameter for the corresponding digital input to "external". The program will otherwise report a "short circuit" diagnostics event if the "short-circuit test" is enabled.

Special Features for Fault Detection in Use Case 2.3

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1219 F-Switch PROFIsafe Electronic Module: Fault Detection (Use Case 2.3)

Example of Fault	Fault detection in case of ...		
	Internal sensor supply and short-circuit test enabled	Internal sensor supply and short-circuit test disabled	External sensor supply
Short circuit of DI 0 with DI 1	Yes*	Yes*	Yes*
Short circuit of DI 0 with DI 2	Yes	Yes	Yes
Short circuit of DI 0 with DI 3	Yes*	Yes*	Yes*
P-short circuit of DI 0	Yes*	Yes*	Yes*
M-short circuit of DI 0	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
P-short circuit of sensor supply	Yes	No	No
M-short circuit of sensor supply or sensor supply defective	Yes	Yes	Yes
Short-circuit in sensor supply at DI 0	Yes*	Yes*	Yes*
Supply voltage fault	Yes	Yes	Yes
*: Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.			

8.3.8 Use Case 3: Safety Mode SIL3/Category 4

Assigning Inputs to Each Other

The F-Switch PROFIsafe has 2 fail-safe inputs (SIL3). The following assignments apply in this case:

Table 1-1220 Use Case 3: Assignment of Input Channels to Each Other

F-Switch PROFIsafe
Input channels DI 0 with DI 2
Input channels DI 1 with DI 3

Sensor Supply

The F-Switch PROFIsafe electronic module provides sensor supplies VS1 and VS2 for inputs 0 to 3.

The sensor must be supplied internally.

Table 1-1221 Use Case 2: Assignment of Sensor Supply to Inputs

F-Switch PROFIsafe
Input channels DI 0 with DI 1 with sensor supply Vs1
Input channels DI 2 with DI 3 with sensor supply Vs2

Wiring Diagram for Use Case 3.1 – Connecting One Two-Channel Sensor Via Two Channels

One two-channel sensor is connected via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The wiring is carried out at the appropriate connection module.

The figure below illustrates an example wiring diagram for channel groups 1 and 2.

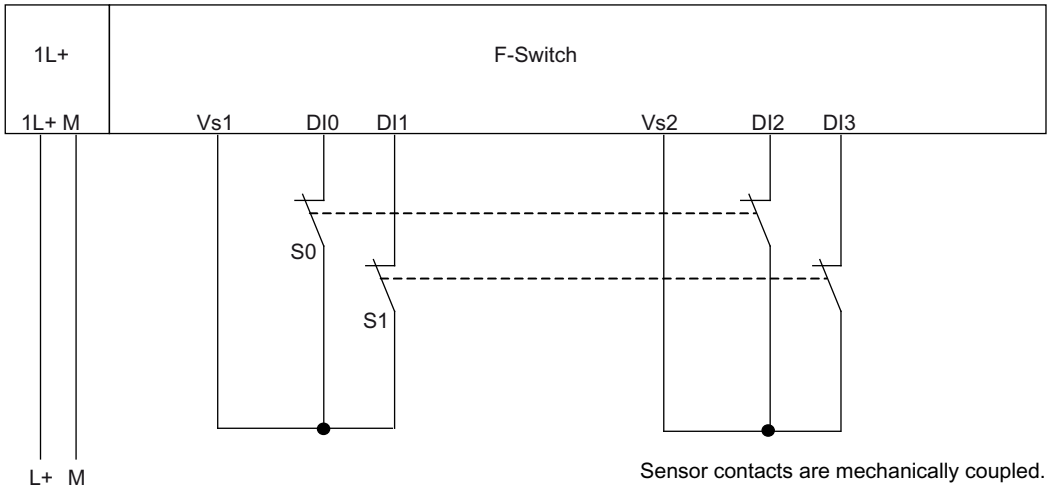


Figure 1-910 Wiring Diagram for F-Switch - One Two-Channel Sensor Connected Via Two Channels, Internal Sensor Supply

Alternatively, two one-channel sensors can be connected via two channels (see Figure *"Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Via Two Channels, Internal Sensor Supply"*). In this case, the same process variable is measured with mechanically separated sensors.

⚠ WARNING

In order to achieve SIL3/Category 4 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 3.1

Set the "Type of sensor interconnection" parameter to "2-channel equivalent" for the corresponding input. Enable the "short-circuit test" parameter and set "internal" at the "sensor supply" parameter.

Wiring Diagram for Use Case 3.2 – Connecting One Nonequivalent Sensor Via Two Channels Nonequivalently

You can connect two process signals to an F-Switch PROFIsafe. One sensor is connected nonequivalently via two channels to two inputs of the F-module for each process signal (1oo2 evaluation).

The left channels of the F-module (DI 0 through DI 1) return the wanted signals. If no faults are detected, these signals will be available in the I/O area for inputs on the F-CPU.

NOTE

You must use the internal sensor supply Vs1 to supply voltage to the sensor. Connection to Vs2 is not possible.

The wiring is carried out at the appropriate connection module.

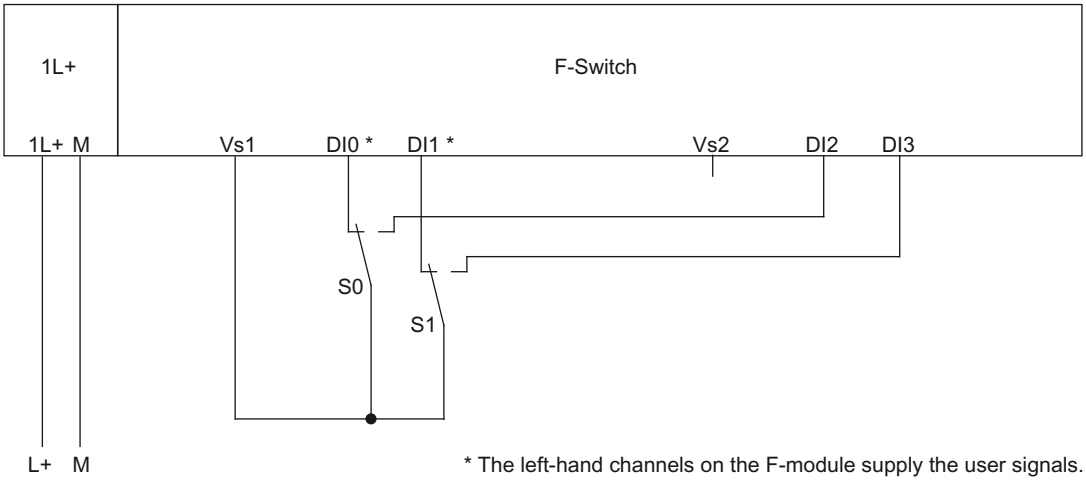


Figure 1-911 Wiring Diagram for F-Switch - One Nonequivalent Sensor Connected Via Two Channels Nonequivalently, Internal Sensor Supply

Alternatively, two one-channel sensors can be connected nonequivalently via two channels (see Figure *"Wiring Diagram for F-DI Modules - Two One-Channel Sensors Connected Nonequivalently Via Two Channels, Internal Sensor Supply*"). In this case, the same process variable is measured with mechanically separated sensors.

⚠ WARNING

In order to achieve SIL3/Category 4 with this wiring, you must install a suitably qualified sensor, for example, in accordance with IEC 60947.

Assignable Parameters for Use Case 3.2

Set the "Type of sensor interconnection" parameter to "2-channel nonequivalent" for the corresponding input. Enable the "short-circuit test" parameter and set "internal" at the "sensor supply" parameter.

Specific Characteristics for Fault Detection (Use Cases 3.1 and 3.2)

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 1-1222 F-Switch PROFIsafe Electronic Module: Fault Detection (Use Cases 3.1 and 3.2)

Example of Fault	Fault detection with internal sensor supply and enabled short-circuit test for ...	
	Sensor 2-channel equivalent	Sensor 2-channel nonequivalent
Short circuit of DI 0 with DI 1	Yes*	Yes*
Short circuit of DI 0 with DI 2	Yes*	Yes
Short circuit of DI 0 with DI 3	Yes*	Yes*
P-short circuit of DI 0	Yes	Yes
M-short circuit of DI 0	Yes*	Yes*
Discrepancy error	Yes	Yes
P-short circuit of Vs1	Yes	Yes
M-short circuit of Vs1, or Vs2 defective	Yes	Yes
Short circuit of Vs1 with Vs2	Yes	Yes
Fault in read/test circuit	Yes	Yes
Supply voltage fault	Yes	Yes
***:** Fault is detected only in case of signal corruption. That is, the signal read differs from the sensor signal (discrepancy error). If there is no signal corruption relative to the sensor signal, fault detection is not possible and is not required from a safety standpoint.		

Requirements for Machine Protection Applications With Category 4

The following requirements apply to machine protection applications with Category 4:

- State-of-the-art wiring must be used between the sensors and the automation system or between the automation system and the actuators to prevent short circuits.
- All short circuits listed in the above table are detected. Detection of a short circuit is sufficient in this case, because two faults must exist for the short circuit to occur (both of the short-circuited signal cables exhibit an insulation fault). Thus, a multiple short-circuit analysis is not required.

Processes for detection of all short circuits are also permissible if individual short circuits are not detected, provided:

- The short circuits do not cause corruption of read signals compared to the sensor signals or
- The short circuits cause corruption of read signals compared to the sensor signals, but in the direction that ensures safety.

8.3.9 Wiring of Outputs of the F-Switch PROFIsafe Electronic Module

Assignment of Channels

Channel	Power bus
DO0	F0
DO1	F1
DO2	2L+

A list of the modules operated behind the F-Switch can be obtained on the Internet under ID 25371449.

Actuator Interconnection

The actuators are interconnected via the power bus.

The PP-switching outputs of the F-Switch PROFIsafe are fed to the actuators via the power bus. The power bus is permanently wired within the system. As a result, only limited wiring variations are possible. The power buses can be tapped and routed or conditioned only from modules of the ET 200pro system.

Wiring Diagram of Frequency Converter (SIL2/Category 3)

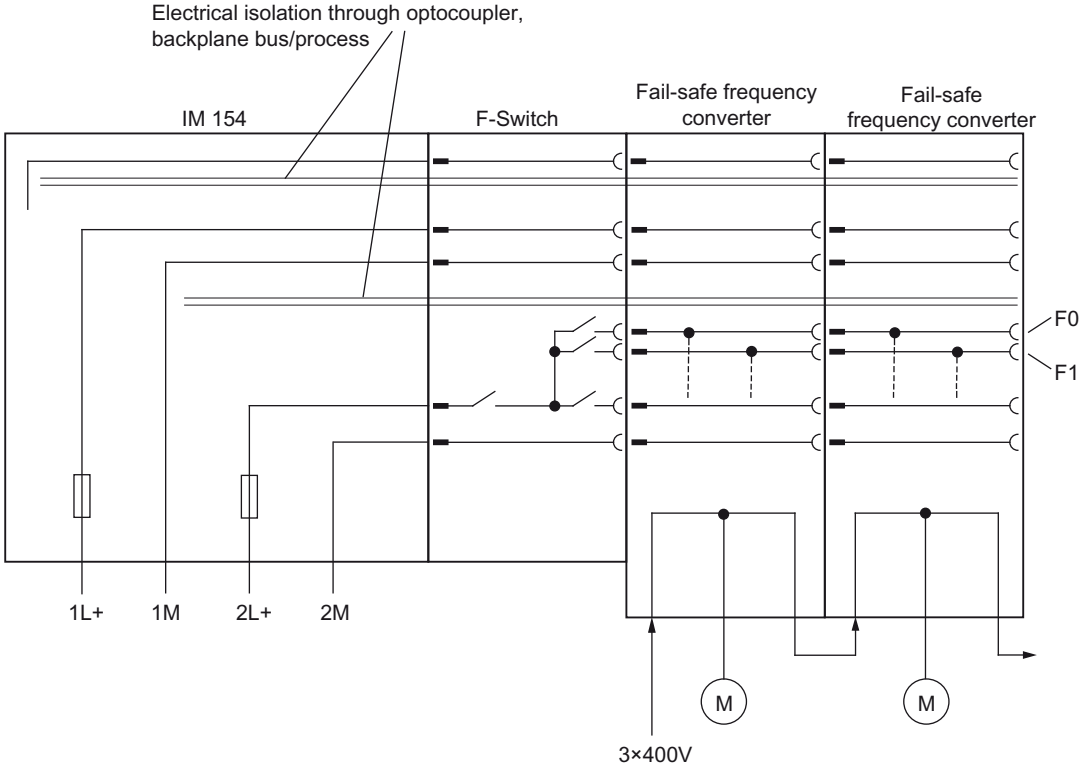


Figure 1-912 Wiring Diagram of F-Switch PROFIsafe - Connection of Frequency Converter

Wiring Diagram of Standard Digital Outputs (SIL2/Category 3)

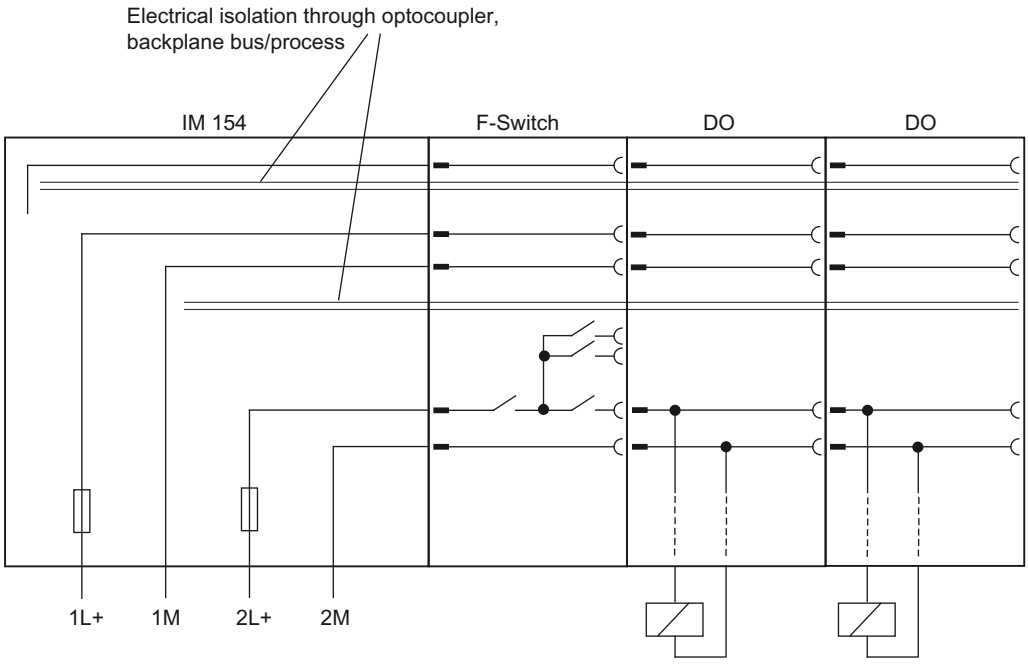


Figure 1-913 Wiring Diagram of F-Switch PROFIsafe - Connection of Digital Outputs

⚠ WARNING

In the event of a cross circuit between 2L+ and DO or an external P-short circuit, the controlled actuator or the 2L+ power bus is no longer switched off. You should always wire the actuators in a cross-circuit-proof and an external P-short-circuit-proof manner, for example, using sheathed cables or separate cable ducts, in order to prevent a cross-circuit or an external P-short circuit.

⚠ WARNING

When supplying power to standard digital output modules, always use the CM modules of these digital output modules to supply the actuators (actuator feedback on the DO module). Otherwise, a residual current can flow for a "0-signal" in the event of a current break.

Wiring Diagram of Shutdown Modules (SIL3/Category 4)

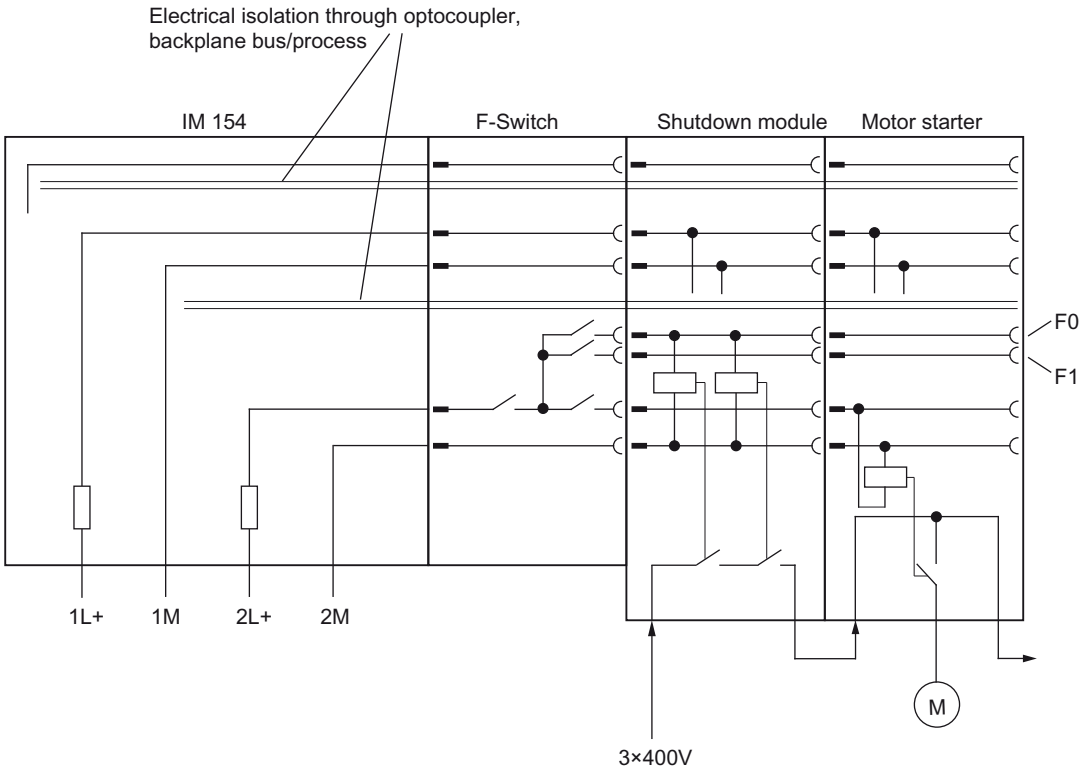


Figure 1-914 Wiring Diagram of F-Switch PROFIsafe - Connection of Shutdown Modules

WARNING

"Test of outputs" must be enabled for this mode for SIL3/Category 4.

Safety-Related Shutdown of Standard Output Modules

WARNING

Safety-related activation of standard DO module outputs is not possible. Only safety-related shutdown is possible. The following issues must therefore be taken into consideration:
In the worst case you must consider all possible faults of the standard DO modules and the program controlling them for which there is no direct fault detection. For example, the FM-Switch PROFIsafe does not detect external short circuits to L+ at the standard DO module outputs.
All faults of the standard DO modules influence the process by means of final controlling elements.
The process status must be made known to the F-CPU by way of sensors and a suitable safety program.
The safety program must react in a safety-related and logically suitable fashion to unwanted or potentially dangerous states in the process using the F-Switch PROFIsafe and fail-safe output modules.

See also

on the Internet (http://www.siemens.com/automation/support-request)

8.3.10 Properties of the F-Switch PROFIsafe Electronic Module

Behavior in Case of Supply Voltage Failure

Failure of sensor supplies Vs1 and Vs2 is indicated by the SF LED, the VsF LED, and the LEDs of the relevant channel group on the F-module. This information is also provided on the F-module (diagnostic entry). All channels of the F-module are passivated.

Diagnostic Functions

The following table shows an overview of the diagnostic functions of the F-Switch PROFIsafe electronic module. The diagnostic functions are assigned either to one channel or to the entire module.

Table 1-1223 Properties of the F-Switch PROFIsafe Electronic Module

Diagnostic Function*	Fault Number	LED	Range of Effectiveness of Diagnostic	Assignable
Short circuit	1_H	SF	Channel	Yes
Overtemperature	5_H	SF	Module	No
Fault	9_H	SF	Module	No
Parameter assignment error	10_H	SF	Module	No
Sensor voltage or load voltage is missing	11_H	SF	Module	No
Communication error	13_H	SF	Module	No
Safety-related shutdown	19_H	SF	Channel	No
*: Specifically for F-modules; display in *STEP 7*, see the "Channel-Specific Diagnostics, Fault Types of Fail-Safe Modules" table				

Causes of Faults and Corrective Actions

The following table lists the possible causes of faults and corrective measures for the individual diagnostic messages of the F-Switch PROFIsafe electronic module.

Table 1-1224 Causes of Faults and Corrective Measures for Diagnostic Messages of the F-Switch PROFIsafe Electronic Module

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Short circuit	Always	Short circuit in the actuator	Eliminate short circuit/cross circuit on actuator Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on
		Cross-circuit in the actuator	
		Internal fault	Replace module
	For output signal "1" only	Overload: output stage is overloaded and becomes too hot.	Eliminate overload.

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Short circuit	Cyclically during short-circuit test	Short circuit at the sensor Cross circuit at the sensor	Eliminate short circuit/cross circuit on sensor
Overtemperature	Always	Shutdown due to violation of temperature limit values in the module case.	Check load wiring. Check ambient temperature. Check whether permissible output current (aggregate current) is exceeded for the ambient temperature. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on
Fault	Always	Internal module fault has occurred	Replace module
Parameter assignment error	Always	Inserted module does not match configuration; incorrect parameter assignment	Correct the configuration (compare actual and preset configuration). Check communication paths. Correct the configuration.
		PROFIsafe address set incorrectly on the F-module	Check whether the PROFIsafe address on the module matches the configuration in *STEP 7 HW Config*
Sensor voltage or load voltage is missing	Always	No supply voltage or supply voltage is too low	Check module for proper contact. Once the fault has been eliminated, the module must be removed and inserted, or the power switched off and on
		Voltage dip due to short circuit	Eliminate short circuit/cross circuit.
Communication error	Always	Error in communication between the F-CPU and module, e.g., due to defective PROFIBUS/Industrial Ethernet connection or higher than permissible electromagnetic interferences	Test PROFIBUS/Industrial Ethernet connection. Eliminate the interferences.
		PROFIsafe monitoring time set too low	Reduce the call interval for F-program, or Set a higher value for the "F-monitoring time" parameter for the module in *STEP 7 HW Config*
		Configuration of the F-module does not match the safety program	Recompile the safety program; then reload the configuration and safety program to the F-CPU
Safety-related shutdown	Always	Process signal is faulty Sensor is defective	Check process signal. Replace sensor if necessary.
		Short circuit between unconnected sensor cable (open switch) and the sensor supply cable	Eliminate short circuit
		Wire break in connected sensor cable (closed switch) or sensor supply cable	Eliminate broken wire

Diagnostic Message	Fault Detection	Possible Causes	Corrective Actions
Safety-related shutdown	Always	Assigned discrepancy time is too short	Check the assigned discrepancy time.
			Once the error is eliminated, the F-module must be reintegrated in the safety program.
		Switching frequency exceeded	Reduce the switching frequency

Generally Applicable Information on Diagnostics

For information on diagnostics pertaining to all fail-safe modules (e.g., for reading out diagnostic functions, passivating channels), refer to "*Diagnostics*".

8.3.11 Technical Specifications for the F-Switch PROFIsafe Electronic Module

Overview

Technical Specifications	
Dimensions and Weight	
Dimensions W x H x D (mm)	45 x 130 x 65.2 (including rack)
Weight	Approx. 170 g
Module-Specific Specifications	
Number of inputs	
• 2-channel	Max. 2
Number of outputs (P/P switching)	Max. 3
Assigned address area	
• I/O area for inputs	7 bytes
• I/O area for outputs	5 bytes
Cable length	
• Unshielded	< 30 m
• Shielded	< 30 m
Maximum achievable safety class	2-channel
• According to IEC 61508:2000	SIL3
• According to ISO 13849-1:2006 or EN ISO 13849-1:2008	Category 4
Fail-safe performance characteristics	SIL2 / SIL3
• Low demand mode (average probability of failure on demand)	< 1.00 E-05
• High demand/continuous mode (probability of a dangerous failure per hour)	< 1.00 E-09
Voltages, Currents, Potentials	
Rated supply voltage L+	24 V DC
• Permissible range	20.4 V to 28.8 V

Technical Specifications	
• Power loss ride-through of L+	None
• Power loss ride-through of internal P5	5 ms
• Reverse polarity protection	Yes: electronics, No: load supply (reverse polarity causes fuse to trip (12.5 A quick-response) in the head module)
Electrical isolation	
• Shield and ET 200pro bus connection	Yes
• ET 200pro bus connection and I/O	Yes
• Shield and I/O (DIs, DOs)	Yes
• Between DIs and DOs	Yes
Permissible potential difference between:	
• Shield and ET 200pro bus connection	75 V DC/60 V AC
• ET 200pro bus connection and I/O	75 V DC/60 V AC
• Shield and I/O (DIs, DOs)	75 V DC/60 V AC
• Between DIs and DOs	75 V DC/60 V AC
Insulation tested during type test with	
• Shield and ET 200pro bus connection	370 V AC / 1 min or 520 V DC / 1 min
• ET 200pro bus connection and I/O	370 V AC / 1 min or 520 V DC / 1 min
• Shield and I/O (DIs, DOs)	370 V AC / 1 min or 520 V DC / 1 min
• Between DIs and DOs	370 V AC / 1 min or 520 V DC / 1 min
Current consumption	
• From backplane bus	Max. 40 mA
• From the electronic supply (without load)	50 mA
• From load voltage L+ (without load)	Typ. 25 mA
Power loss of module	3 W
Status, Interrupts, Diagnostics	
Status displays	
• Inputs	Two-color red/green LED per channel
• Outputs	Two-color red/green LED per channel
• Sensor supply	LED VsF and display via channel LEDs of channel group
Interrupts	
• Diagnostic interrupt	Channel LED red
Diagnostic functions	
• Group fault display	Red LED (SF)
• Diagnostic information can be read out	Possible
• I&M functionality *	See "ET 200pro Distributed I/O" Manual
Sensor Supply Outputs	
Number of outputs	2
Output voltage	
• Loaded	Min. L+ (-1.5 V)
Output current	
• Rated value	200 mA

Technical Specifications		
• Permissible range	0 mA to 200 mA	
• Permissible aggregate current of outputs	400 mA	
• Short-circuit protection	Yes, electronic	
• Operating value	4 A to 9 A	
Data for Selecting a Sensor **		
Input voltage		
• Rated value	24 V DC	
• At signal "1"	15 V to 30 V	
• At signal "0"	-30 V to 5 V	
Input current		
• At signal "1"	Typ. 3.5 mA	
Input delay	For all inputs together	
• At "0" after "1"	Typ. 3 ms	2.0 ms to 4.5 ms
• At "1" after "0"	Typ. 3 ms	2.0 ms to 4.5 ms
Input characteristic	In accordance with IEC 1131-2, Type 1	
Connection of 2-wire BERO	Not possible	
• Permissible quiescent current	• Max. 0.6 mA	
Data for Selecting an Actuator*		
Output voltage		
• At signal "1"	• L+ -1.5 V (F0 / F1) • L+ -1.5 V (2L+)	
Output current for "1" signal		
• Rated value	• 1 A (F0 / F1) • 6 A (2L+)	
• Permissible range	• Up to 1.2 A (F0 / F1) • 20 mA to 6 A (2L+)	
For "0" signal (residual current)	Max. 0.5 mA	
Indirect control of load by means of coupling relay:		
For "0" signal (residual current)		
P-switch	Max. 0.5 mA	
Lamp load	• Not possible (F0 / F1) • Max. 60 W (2L+)	
Parallel switching of 2 outputs	Not possible	
Control of a digital input	Possible	
Switching frequency		
• With resistive load	• Max. 10 Hz 1 A (F0 / F1) • Max. 2 Hz (2L+)	
• With inductive load in accordance with IEC 60947-5-1, DC13	• Max. 0.1 Hz (F0 / F1) • Max. 0.1 Hz (2L+)	
• With lamp load	Max. 2 Hz (2L+)	
Limit on inductive shutdown voltage to	• -36 V (F0 / F1) • -1 V (2L+)	
Short-circuit protection of output	Yes, electronic	
• Response threshold (short circuit) (FO/FI)	5 A to 12 A	

Technical Specifications	
• Response threshold (short circuit) (2L+)	20 A to 120 A
Time, Frequency	
Internal preprocessing times	See *"Response Times"*
Acknowledgment time in safety mode	Min. 4 ms / max. 8 ms
Short-circuit test enabled • With input delay of 3 ms:	2.0 ms -4.5 ms
Minimum sensor signal duration	See Table *"Minimum Duration of Sensor Signals for Proper Detection by F-DI Module"* in *"Wiring"*
Outputs	
• Safety mode SIL3, Category 4	20 ms
• Safety mode with fault reaction	< 20 ms for signal change < 15 min for static signals
Protection against Overvoltage	
Protection of supply voltage 1L+ and 2L+ from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+ 1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+ 2 kV; 1.2/50 µs
Protection of inputs from surge in accordance with IEC 61000-4-5 with external protection elements only	
• Symmetrical (L+ to M)	+1 kV; 1.2/50 µs
• Asymmetrical (L+ to PE, M to PE)	+2 kV; 1.2/50 µs
Protection of supply voltage 1L+ from overvoltages	Internal fuse tripped
*: Identification sets are described in the "ET200 pro Distributed I/O System" manual.	
**: For requirements for sensors and actuators, see "*Requirements for Sensors and Actuators*"	

Diagnostic Data of Fail-Safe Modules

A

Introduction

This appendix describes the structure of diagnostic data in the system data. You need to know this structure if you want to evaluate diagnostic data of fail-safe modules in the standard user program.

Further Reading

The *System and Standard Functions* reference manual describes in detail the principles of evaluating diagnostic data of F-modules in the standard user program and describes the SFCs used for this.

SFCs for Reading Out Diagnostic Data

The following SFCs are available for reading out diagnostic data of fail-safe modules in the standard user program:

Table 1-1225 SFCs for Reading Out Diagnostic Data

SFC Number	Identifier	Application
59	RD_REC	Reading out data records of S7 diagnostics (storing in data area of the standard user program)
13	DPNRM_DG	Reading out slave diagnostics (storing in data area of the standard user program)

Position in the Diagnostic Frame of the Slave Diagnostics

When fail-safe modules are being used in the ET 200pro and a diagnostic interrupt occurs, data records 0 and 1 are entered in the slave diagnostics of the ET 200pro (= interrupt section).

The position of the interrupt section in the slave diagnostics depends on the structure of the diagnostic frame and the length of the channel-specific diagnostics.

You will find a detailed description of the structure of the diagnostic frame and the position of the interrupt section in accordance with the PROFIBUS standard in the section on "Commissioning and Diagnostics" in the *ET 200pro Distributed I/O System* Manual.

Data Records 0 and 1 of the System Data

The diagnostic data of a module can be up to 44 bytes long and is located in data records 0 and 1 of the system data area:

- Data record 0 contains 4 bytes of diagnostic data that describe the state of the F-module.
- Data record 1 contains
  - The 4 bytes of diagnostic data of the F-module that are also in data record 0 and
  - Up to 40 bytes of channel-specific diagnostic data depending on the F-module (see "*Channel-Specific Diagnostics Starting at Byte 8*").

Description

The structure and content of the individual diagnostic data bytes are described below.
In general, the following applies: If a fault occurs, the corresponding bit is set to "1".

Bytes 0 and 1

The following figure shows the content of bytes 0 and 1 of the diagnostic data.

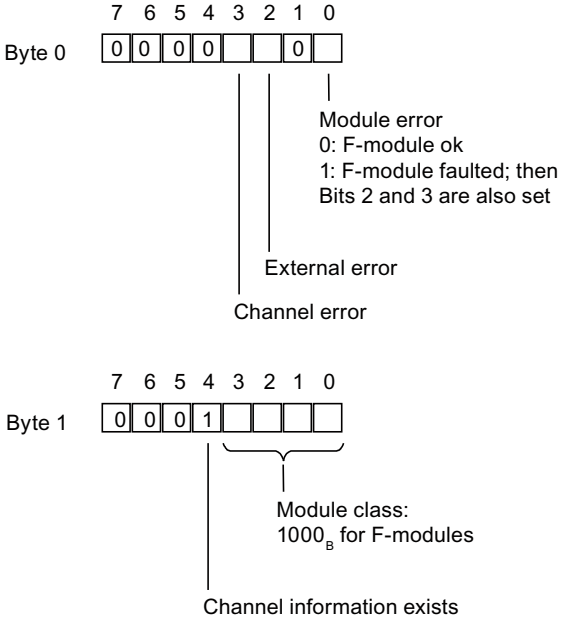


Figure 1-915 Bytes 0 and 1 of Diagnostic Data

Bytes 2 and 3

The following figure shows the content of bytes 2 and 3 of the diagnostic data.

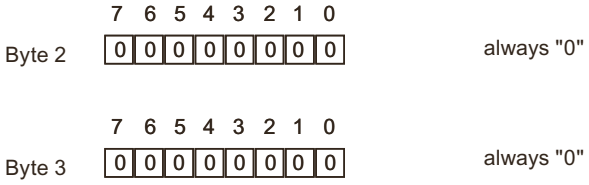


Figure 1-916 Bytes 2 and 3 of Diagnostic Data

Bytes 4 to 6

The following figure shows the content of bytes 4 to 6 of the diagnostic data.

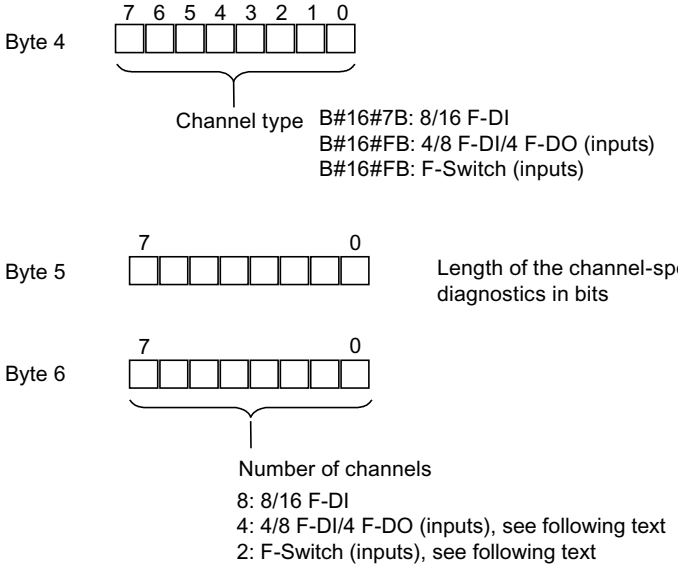


Figure 1-917 Bytes 4 to 6 of Diagnostic Data

4/8 F-DI/4 F-DO:

For the 4/8 F-DI/4 F-DO module, the diagnostic data are separated according to inputs and outputs. The diagnostic data for the inputs are in bytes 4 to 23 and the diagnostic data for outputs are in bytes 24 to 43.

You can determine whether the module has diagnostic data in bytes 24 to 43 by evaluating bit 7 in byte 4.

F-Switch:

For the F-Switch electronic module, the diagnostic data are divided according to inputs and outputs. The diagnostic data for the inputs are in bytes 4 to 15, and the diagnostic data for outputs are in bytes 16 to 31.

Byte 7 for 8/16 F-DI and 4/8 F-DI/4 F-DO (Inputs)

The figure below shows the content of byte 7 of the diagnostic data for the 8/16 F-DI and the inputs of 4/8 F-DI/4 F-DO.

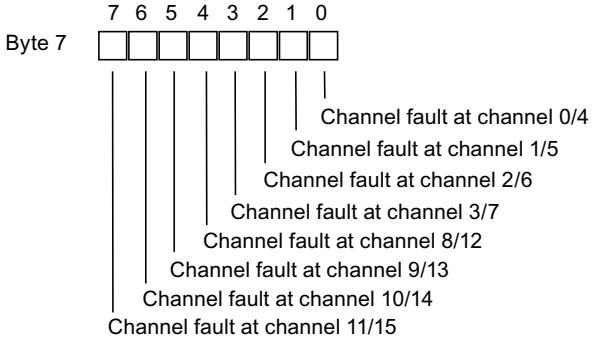


Figure 1-918 Byte 7 of the Diagnostic Data for 8/16 F-DI and Inputs of 4/8 F-DI/4 F-DO

Byte 7 for F-Switch

The figure below shows the content of byte 7 of the diagnostic data for the inputs of the F-Switch electronic module.

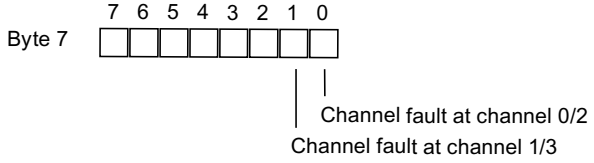


Figure 1-919 Byte 7 of the Diagnostic Data for the Inputs of the F-Switch

Channel-Specific Diagnostics Starting at Byte 8 to Byte 23

The channel-specific diagnostics start in byte 8 of the diagnostic data. Four bytes of diagnostic information are provided per channel.

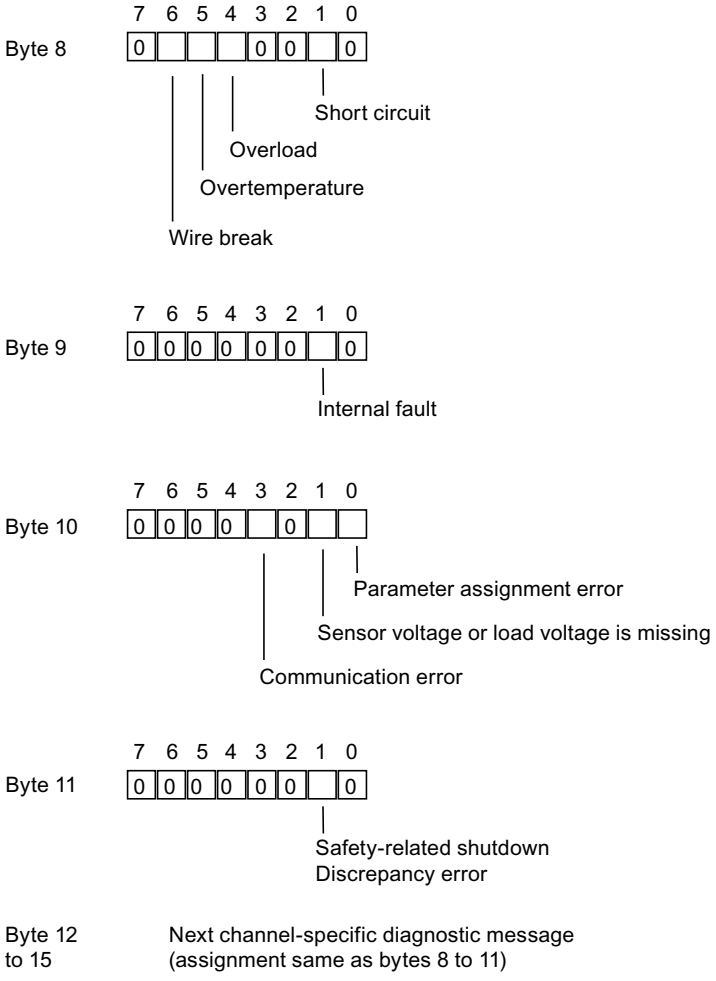


Figure 1-920 Channel-Specific Diagnostics Starting in Byte 8 of the Diagnostic Data

Bytes 24 to 26 for 4/8 F-DI/4 F-DO

The following figure shows the content of bytes 24 to 26 of the diagnostic data.

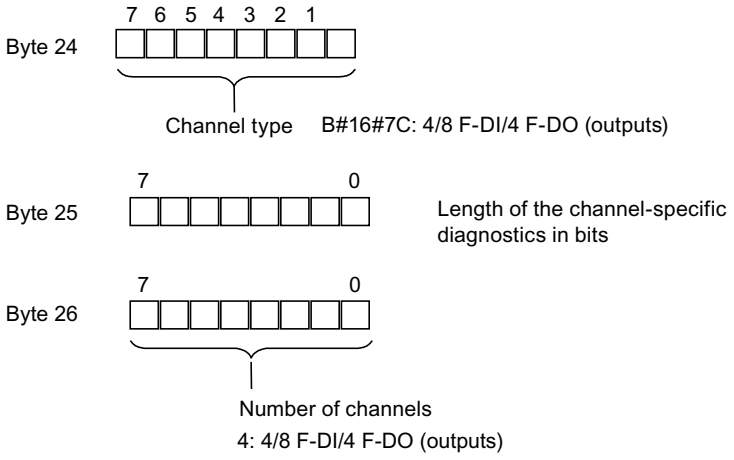


Figure 1-921 Bytes 24 to 26 of Diagnostic Data

Bytes 16 to 18 for F-Switch

The following figure shows the content of bytes 16 to 18 of the diagnostic data of the F-Switch.

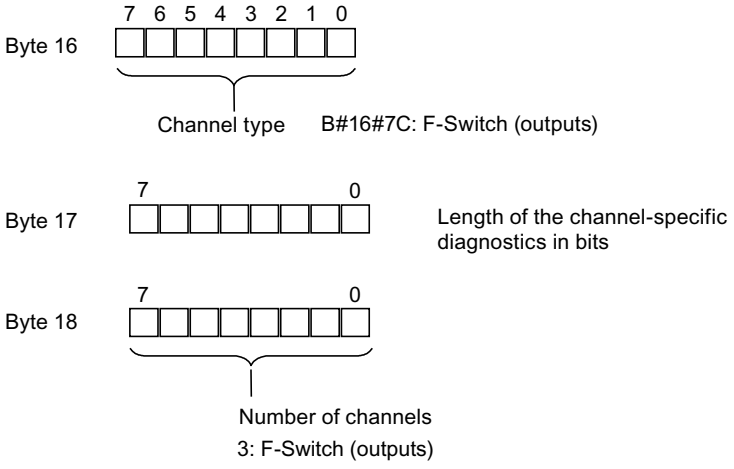


Figure 1-922 Bytes 16 to 18 of the Diagnostic Data of the F-Switch

Byte 27 for 4/8 F-DI/4 F-DO (Outputs)

The following figure shows the content of byte 27 of the diagnostic data for the outputs of 4/8 F-DI/4 F-DO.

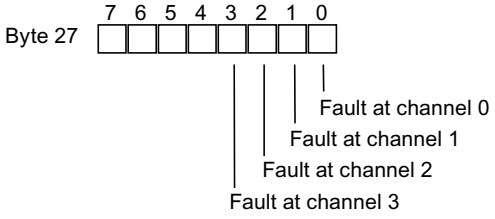


Figure 1-923 Byte 27 of Diagnostic Data for the Outputs of 4/8 F-DI/4 F-DO

Byte 19 for F-Switch (Outputs)

The figure below shows the content of byte 19 of the diagnostic data for the outputs of the F-Switch.

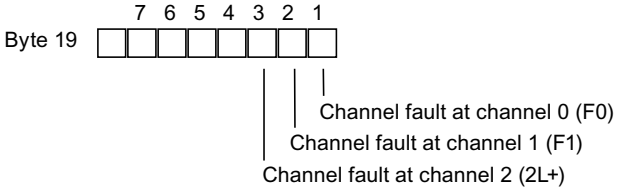


Figure 1-924 Byte 19 of the Diagnostic Data for the Outputs of the F-Switch

Channel-Specific Diagnostics Starting at Byte 28 to Byte 43 for 4/8 F-DI/4 F-DO

The channel-specific diagnostics start in byte 28 of the diagnostic data. Four bytes of diagnostic information are provided per channel.

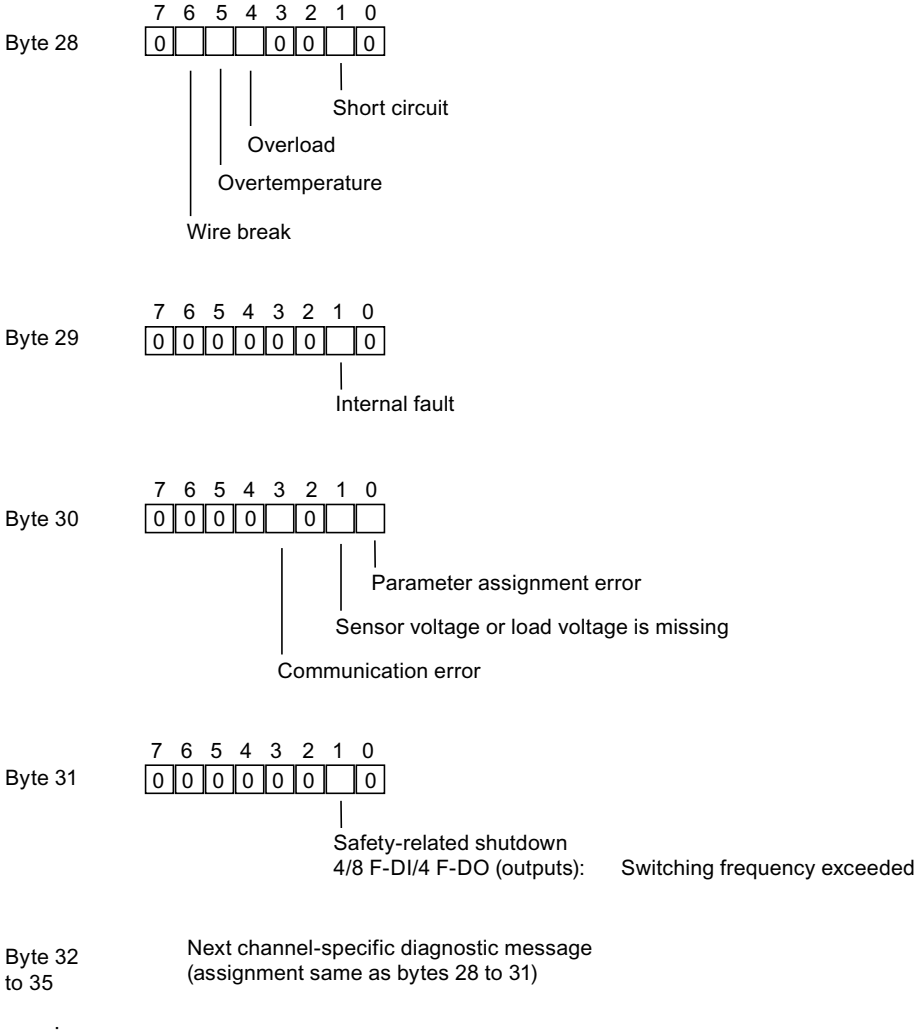


Figure 1-925 Channel-Specific Diagnostics Starting in Byte 28 of the Diagnostic Data

Channel-Specific Diagnostics Starting at Byte 20 to Byte 31 for F-Switch

The channel-specific diagnostics start in byte 20 of the diagnostic data. Four bytes of diagnostic information are provided per channel.

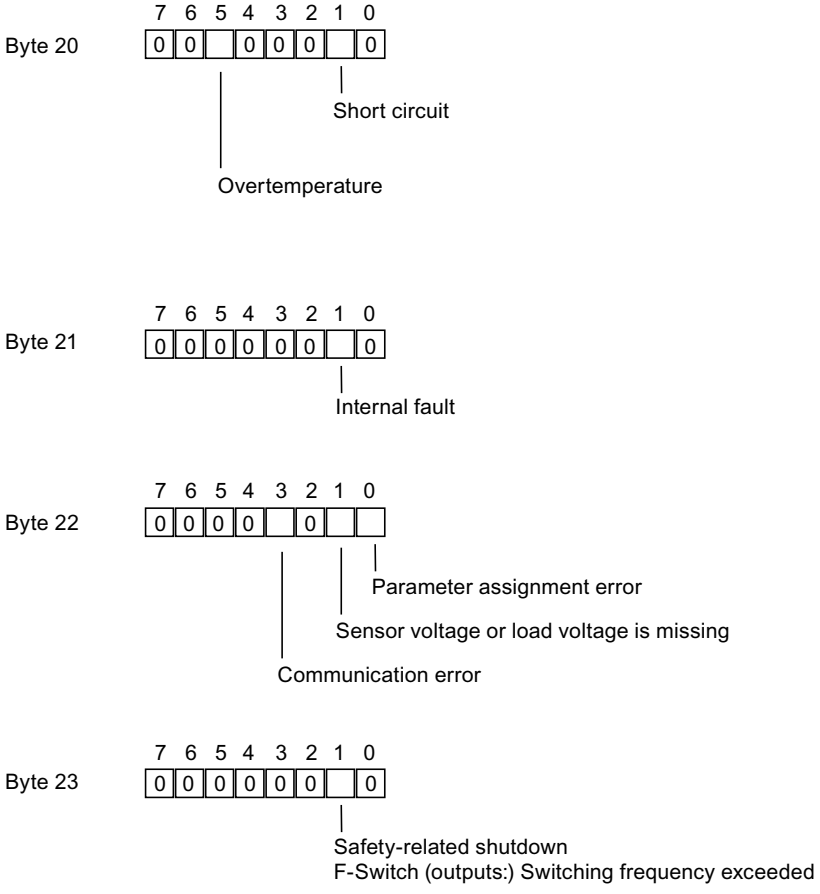


Figure 1-926 Channel-Specific Diagnostics Starting at Byte 20 of the Diagnostic Data of the F-Switch

Due to the different numbers of channels of the F-modules, data record 1 has differing lengths:

8/16 F-DI	40 bytes
4/8 F-DI/4 F-DO	44 bytes
F-Switch	32 bytes

Dimension Drawings

B

F-Connection Module With Inserted F-Module

A dimension drawing for an F-connection module with inserted F-electronic module is shown below. The upper figure shows a narrow rack, while the lower figure shows a compact rack.

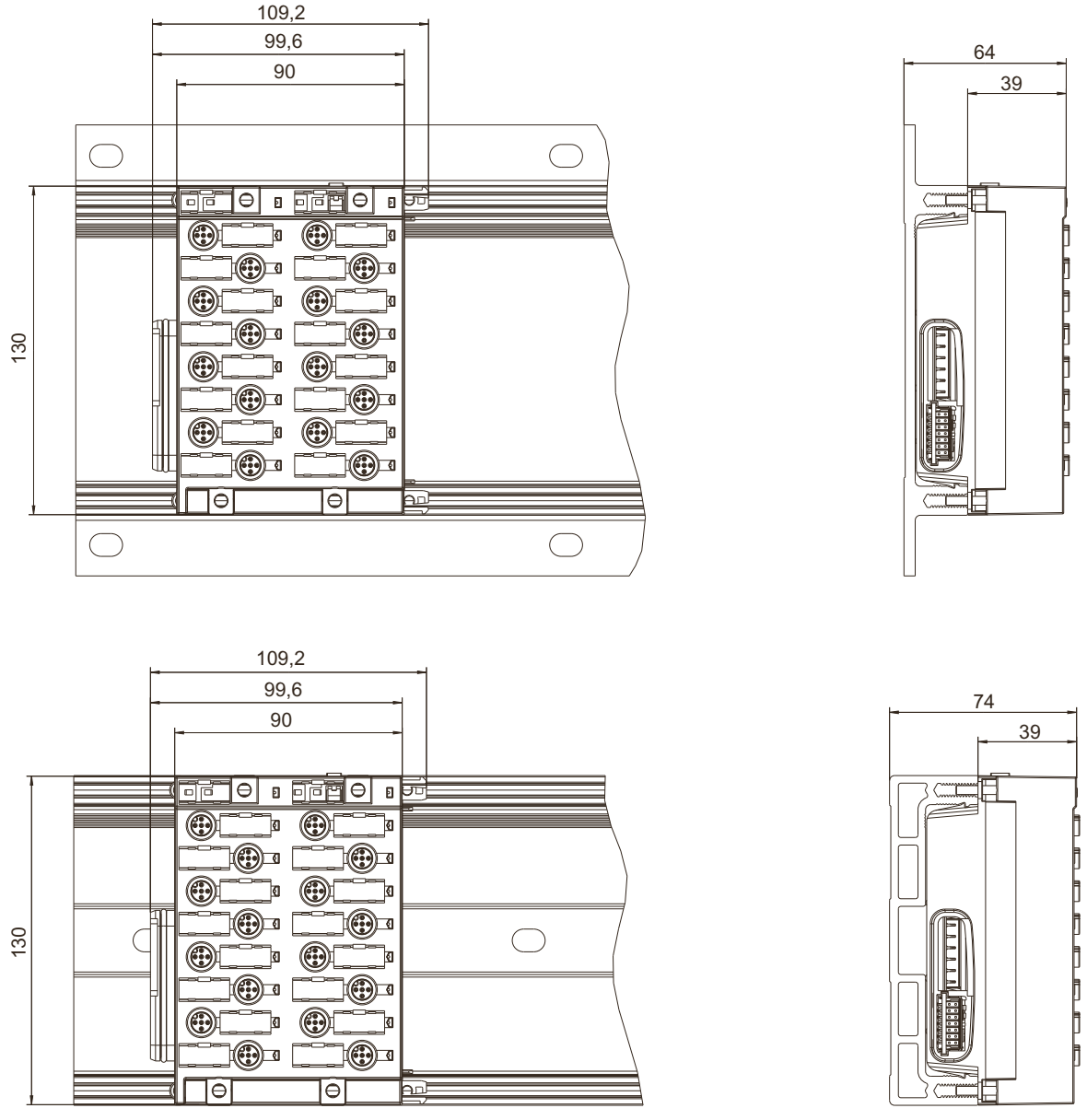


Figure 1-927 Dimension Drawing of F-Connection Module With Inserted F-Electronic Module

CM F-IO 2×M12 Fail-Safe Connection Module with Inserted F-Switch PROFIsafe

A dimension drawing for a CM F-IO 2×M12 fail-safe connection module with inserted F-Switch PROFIsafe is shown below. The upper figure shows a narrow rack, while the lower figure shows a compact rack.

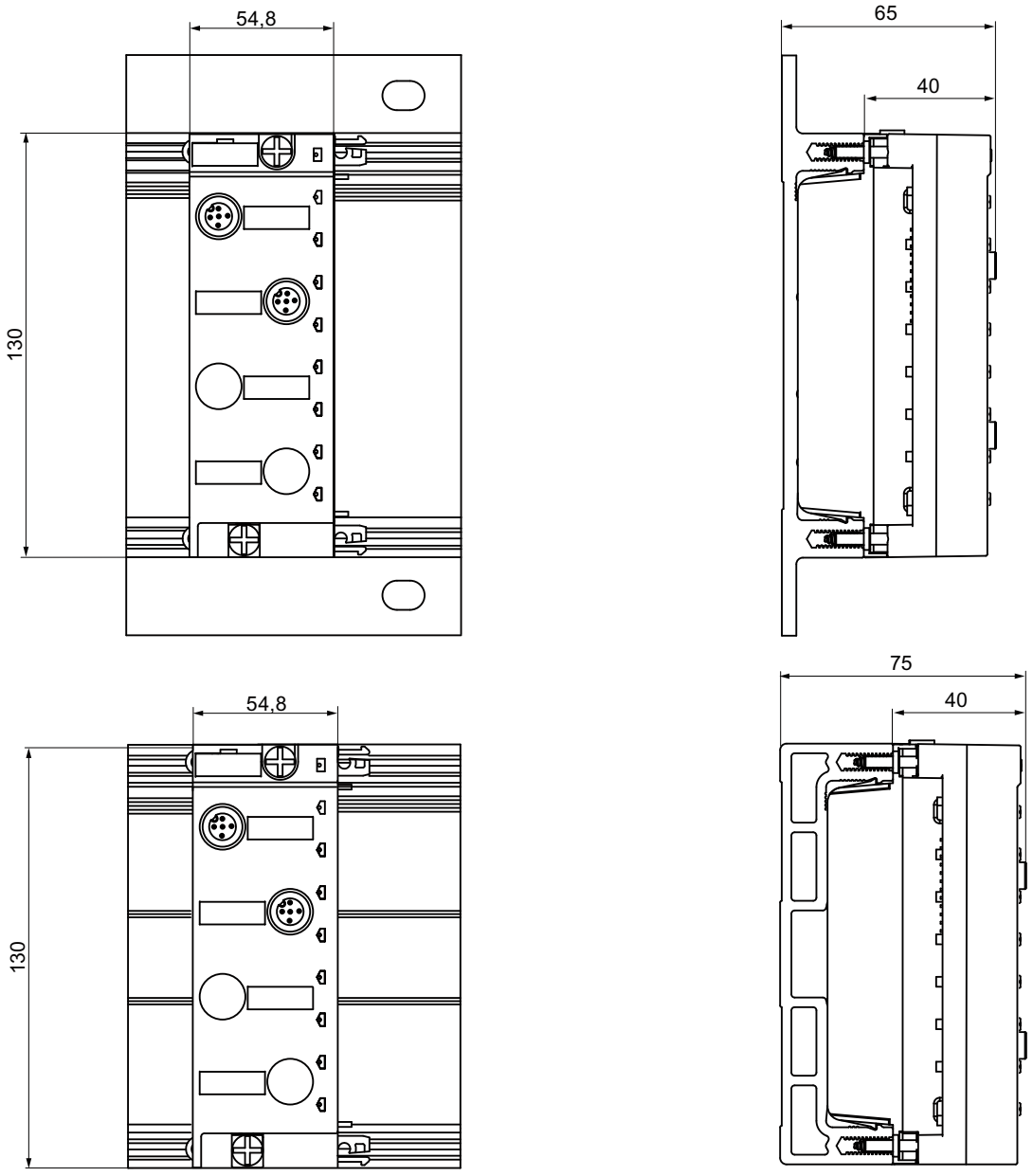


Figure 1-928 Electronic Module with CM F-IO 2xM12 Connection Module

Accessories and Order Numbers

C

C.1 Accessories and Order Numbers

Accessories and Order Numbers

The order numbers and accessories are found in the appendix of the *ET 200pro Distributed I/O Device* manual.

Component	Order Number
8/16 F-DI DC24V PROFIsafe	6ES7 148-4FA00-0AB0
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe	6ES7 148-4FC00-0AB0
F-Switch PROFIsafe	6ES7 148-4FS00-0AB0
CM 16×M12 for 8/16 F-DI	6ES7 194-4DD00-0AA0
CM 12×M12 for 4/8 F-DI/4 F-DO	6ES7 194-4DC00-0AA0
CM F-IO 2×M12 for F-Switch PROFIsafe	6ES7 194-4DA00-0AA0

Response Times

D

D.1 Response Times

Introduction

The response times of the ET 200pro fail-safe modules are presented below. The response times of the fail-safe modules enter into the calculation of the F-system response time.

For information on calculating the F-system response time, refer to the *Safety Engineering in SIMATIC S7* system description.

Definition of Response Time

The response time is the time between detection of an input signal and a change in the gated output signal.

The actual response time lies somewhere between a minimum and maximum response time. The maximum response time must always be anticipated when configuring a system.

For fail-safe digital inputs: The response time is the time between a signal change at the digital input and safe loading of the -> safety message frame on the backplane bus.

For fail-safe digital outputs: The response time is the time between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Maximum Response Time of the 8/16 F-DI DC24V PROFIsafe, the Inputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe, and the F-Switch PROFIsafe

In the case of problem-free operation:

Table 1-1226 In the Case of Problem-Free Operation

Electronic module	Short-circuit test parameter	Assigned input delay		
		0.5 ms	3 ms	15 ms
8/16 F-DI	Disabled	10 ms	13 ms	25 ms
	Enabled	10 ms	18 ms	56 ms
4/8 F-DI/4 F-DO	Disabled	11 ms	13 ms	25 ms
	Enabled	11 ms	20 ms	57 ms
F-Switch PROFIsafe	Disabled	-	14 ms	-
	Enabled	-	27 ms	-

Table 1-1227 8/16 F-DI DC24V PROFIsafe Electronic Module, Inputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe, and F-Switch PROFIsafe: Internal Preprocessing Times

Electronic module	Evaluation of the sensors	Minimum internal preprocessing time T_{min}	Maximum internal preprocessing time T_{max}
8/16 F-DI	1oo1 and 1oo2	3 ms	12 ms
4/8 F-DI/4 F-DO	1oo1 and 1oo2	4 ms	7 ms
F-Switch PROFIsafe	1oo2	4 ms	8 ms

Maximum response time if a fault occurs:

The following table shows the maximum response time of the F-DI module when a fault occurs, depending on the parameter assignment in *STEP 7* and the evaluation of the sensors.

Table 1-1228 Electronic Modules: Maximum Response Time if a Fault Occurs

Electronic module	Input delay	1oo1 evaluation			1oo2 evaluation**		
		0.5 ms	3 ms	15 ms	0.5 ms	3 ms	15 ms
8/16 F-DI	Short-circuit test disabled	15 ms	15 ms	15 ms	10 ms	10 ms	10 ms
	Short-circuit test enabled	37 ms	58 ms	161 ms	10 ms	15 ms	41 ms
4/8 F-DI/4 F-DO	Short-circuit test disabled	19 ms	19 ms	19 ms	10 ms	10 ms	10 ms
	Short-circuit test enabled	30 ms	40 ms	90 ms	10 ms	18 ms	42 ms
F-Switch PROFIsafe	Short-circuit test disabled	-			-	10 ms	-
	Short-circuit test enabled	-			-	23 ms	-

: With **1oo2 evaluation, the response times also depend on the assigned behavior at discrepancy:
Provide value 0: The times in the above table apply.
Provide last valid value: The times in the above table are extended by the amount of the assigned discrepancy time.

NOTE

Please note that the Excel file for calculation of the maximum response times provided with the *S7 Distributed Safety* optional package already supports calculation of the extension of the "Maximum response time if a fault occurs" by the assigned discrepancy time.

Maximum Response Time of the Outputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

The maximum response time of the outputs of the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe electronic module (in the fault-free case and when a fault occurs) corresponds to the maximum internal preprocessing time T_{max}.

The internal preprocessing times depend on the assigned readback time (see table below).

Table 1-1229 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module: Internal Preprocessing Times

4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module			
Assigned Read-back Time	**Limit Frequency**	**Minimum Internal Preprocessing Time T_{min}**	**Maximum Internal Preprocessing Time T_{max}**
1 ms	62.5 Hz	4 ms	13 ms
5 ms	50.0 Hz	4 ms	14 ms
10 ms	40.0 Hz	4 ms	17 ms
50 ms	15.4 Hz	4 ms	30 ms
100 ms	8.7 Hz	4 ms	46 ms
200 ms	4.6 Hz	4 ms	71 ms
400 ms	2.4 Hz	4 ms	135 ms

Maximum Response Time of Outputs of the F-Switch PROFIsafe Electronic Module

The maximum response time of the outputs of the F-Switch PROFIsafe electronic module (with or without fault) is equivalent to the maximum internal preprocessing time T_{max}.

The internal preprocessing times depend on the assigned readback time (see table below).

Table 1-1230 F-Switch PROFIsafe Electronic Module: Internal Preprocessing Time

F-Switch PROFIsafe Electronic Module			
Assigned Read-back Time	**Limit Frequency**	**Minimum Internal Preprocessing Time T_{min}**	**Maximum Internal Preprocessing Time T_{max}**
3 ms	45.4 Hz	4 ms	11 ms

Switching of Loads

E

E.1 Switching of Capacitive Loads

Switching of Capacitive Loads

If the electronic outputs of the 4/8 F-DI/4F-DO DC24V/2A PROFIsafe electronic module are interconnected with loads that draw little current and have capacitance, the "short circuit" error message can result. Reason: capacitances are not sufficiently discharged within the assigned readback time during the self-test.

The following figure shows typical curves indicating the relationship between the load current and switchable load capacitance for the assignable readback times.

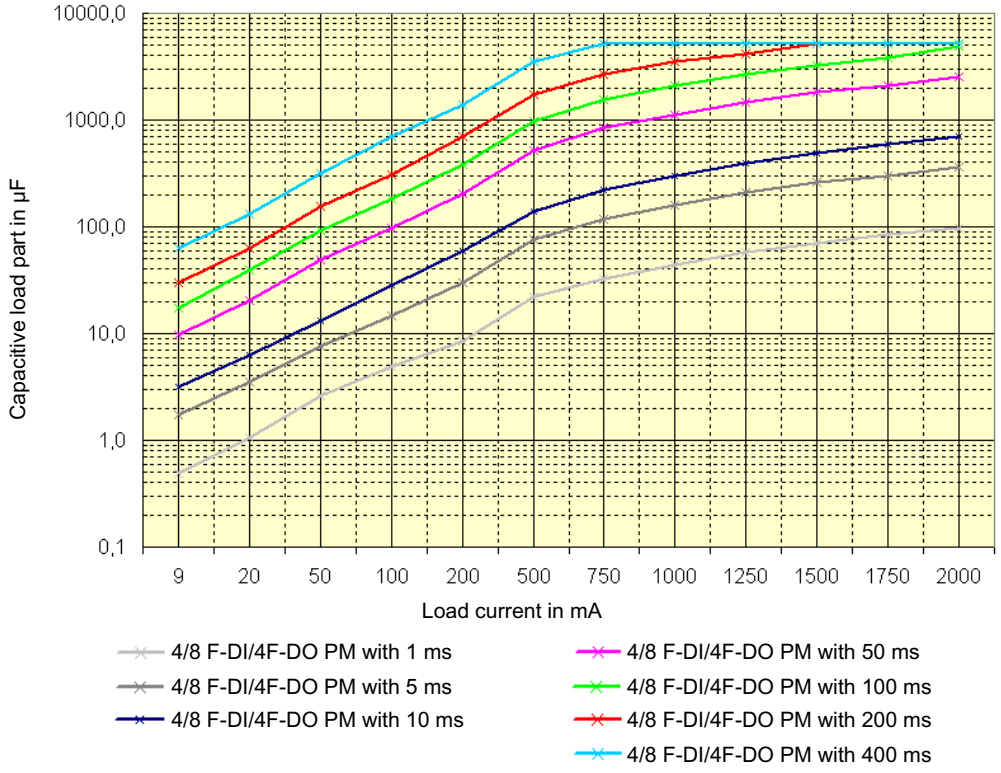


Figure 1-929 Relationship Between Load Current and Switchable Load Capacity for the 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe Electronic Module

Remedy:

1. Determine the load current and capacitance of the load.
2. Determine the operating point in the figure above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

Switching of Capacitive Loads for the F-Switch PROFIsafe

The figure below shows the typical curves indicating the relationship between load resistance and switchable load capacitance.

Behavior is as described above.

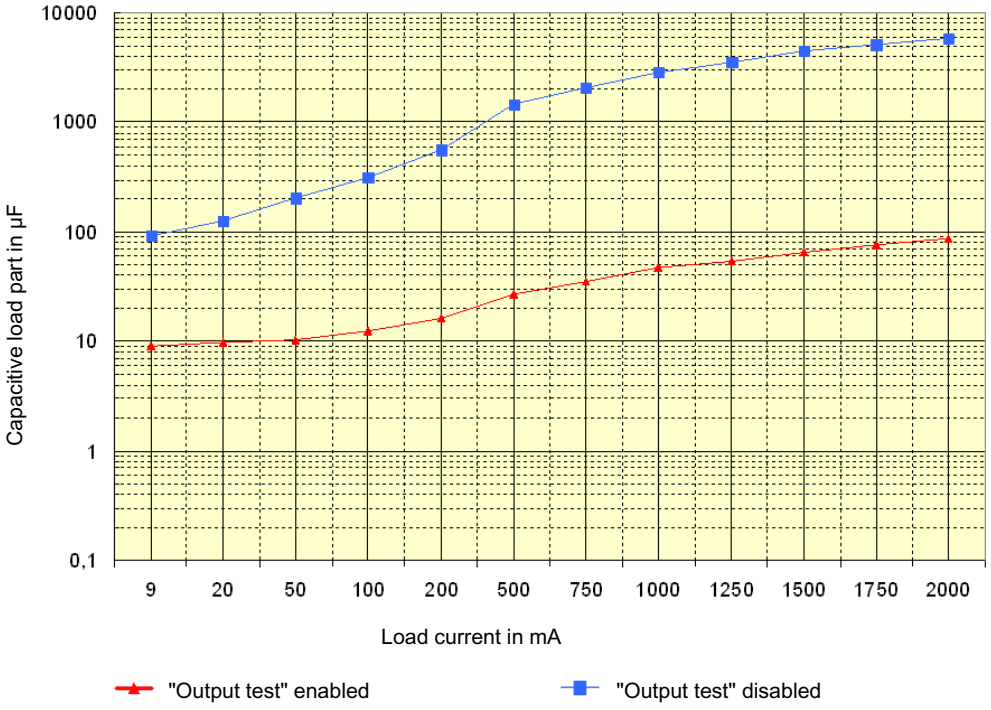


Figure 1-930 Comparison of Maximum Switchable Capacitive Loads for the F-Switch PROFIsafe

E.2 Switching of Inductive Loads

Switching of Inductive Loads for EM 4/8 F-DI/4 F-DO DC24V/2A PROFIsafe

The diagram below shows the maximum permitted inductive load as a function of the load current and switching frequency.

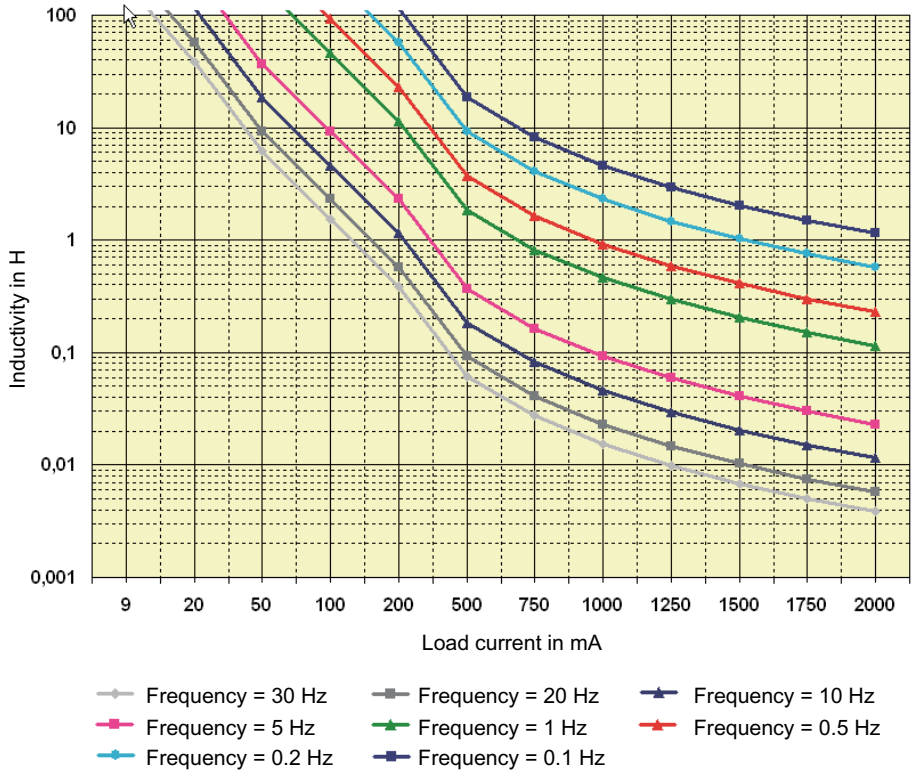


Figure 1-931 Relationship between Load Resistance and Inductive Loads

SIEMENS
SIMATIC

Distributed I/O system ET 200pro
Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function
SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity

- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14218/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14218/cert?ct=444&ci=5596).

Firmware
You can find the latest firmware versions for the I/O system (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/search?t=all&search=et%20200pro&type=Download&lc=en-WW).

Documentation
The complete documentation for the I/O system consists of product information, operating instructions, equipment manuals and function manuals. You will find these on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748221).

Retention of the documentation
Retain this documentation for later use.

1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation
The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use
SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.
The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

⚠ WARNING

Intended use
SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).
If third-party products and components are used, these have to be recommended or approved by Siemens.
Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.
Non-observance may result in death or serious physical injury.
Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

⚠ WARNING

Connection of the power supply
The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221) and on the nameplate of the device.

NOTE
The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

⚠ WARNING

Danger from voltage/current!
Only perform assembly and disassembly work when the device is de-energized.
Install products with degree of protection IP65/67 according to IEC 60529 weatherproof and stationary indoors.

⚠ WARNING

Electric shock due to externally supplied plant units
Even if the main supply to the plant is disconnected, externally supplied plant units can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.
Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

⚠ WARNING

Safety functional extra low voltage
The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221) of the fail-safe I/O and in the data sheets of the power supplies to be used.
Use a power supply unit with output voltage that does not exceed 36 V DC even in the event of a fault.
Follow the notes and warnings in the respective manual.

Electromagnetic Compatibility
The I/O system is intended for operation in the EMC environment class Industry.
Ensure an EMC-compliant design of your automation system as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221) for the I/O system.

NOTICE

Interference emission / Interference immunity
The operation of the I/O system can cause radio interference in residential areas.
If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

Cleaning
When wired, the product complies with degree of protection IP65/IP67 and does not require any cleaning.
If you do have to clean the product, then use a dry or damp cloth. Take care to comply with the conditions of degree of protection IP65/IP67 when cleaning with liquids.

Maintenance and repair
The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal
For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories
You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221).

Functional safety

⚠ WARNING

Danger to humans and the environment
To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components.

For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/109748221).

⚠ WARNING

Check the firmware version for fail-safe approval
When using a new firmware version, check whether the firmware version is approved for the respective fail-safe I/O.
The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.
The PROFIsafe address must be set or assigned for fail-safe I/O.
Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

2 Use of radio devices and cell phones

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones
Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.
If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.
Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.
In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

SIEMENS

SIMATIC

Industrial Software SIMATIC Safety - Configuring and Programming

Programming and Operating Manual

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Industrial Software
SIMATIC Safety - Configuring and Programming

Programming and Operating Manual

Important notes

Purpose of this documentation

The information in this documentation enables you to configure (Page 33) and program (Page 108) SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance (Page 407) of a SIMATIC Safety F-system.

NOTE

The Programming and Operating Manual "SIMATIC Safety - Configuring and Programming" in its latest version (possibly including product information for the manual) is the relevant source of all information on functional safety regarding configuring and programming. This also applies in the event of discrepancies between this manual and other documentation on functional safety regarding configuring and programming of SIMATIC Safety.
You must heed all warnings in the Programming and Operating Manual "SIMATIC Safety - Configuring and Programming".

Basic knowledge requirements

General basic knowledge of automation engineering is needed to understand this documentation. Basic knowledge of the following is also necessary:

- Fail-safe automation systems
- Automation systems
  - S7-300
  - S7-400
  - S7-1200
  - S7-1500
  - S7-1500H
  - S7-1500 Virtual Controller
  - S7-1500 Software Controller
  - SIMATIC Drive Controller
- Distributed I/O systems on
  - PROFIBUS DP
  - PROFINET IO
- Totally Integrated Automation Portal, including:
  - Hardware configuration with the *hardware and network editor*
  - Programming in the LAD and FBD programming languages using the *program editor*.
  - Communication between CPUs
  - OPC UA for communication between CPUs with OPC UA Safety

Scope of this documentation

This documentation is valid for *STEP 7 Safety Advanced V21*.

STEP 7 Safety Advanced V21 is used for configuring and programming the SIMATIC Safety fail-safe system.

In this context, integration of the F-I/O listed below in SIMATIC Safety is also addressed:

- S7-1500/ET 200MP fail-safe modules
- ET 200SP fail-safe modules
- ET 200SP HA fail-safe modules
- ET 200S fail-safe modules
- ET 200eco fail-safe I/O modules
- ET 200eco PN fail-safe I/O modules
- ET 200AL fail-safe I/O modules
- ET 200pro fail-safe modules
- ET 200iSP fail-safe modules
- S7-300 fail-safe signal modules
- S7-1200 fail-safe modules
- Fail-safe GSD based DP slaves
- Fail-safe GSD based I/O devices

Approvals

The SIMATIC Safety F-system is certified for use in safety mode up to:

- Safety Integrity Level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Incorporation in the information landscape

Depending on your application, you will need the following supplementary documentation when working with *STEP 7 Safety*.

This documentation includes references to the supplementary documentation where appropriate.

Documentation	Brief description of relevant content
For the SIMATIC Safety F-system	Depending on which F-CPU you are using, you will need the following documentation: • For the F-CPUs S7-1200/1500, a Product Information (https://support.industry.siemens.com/cs/ww/en/view/109478599) describes all deviations from the respective standard CPUs. • Each F-CPU S7-300/400 that can be used has its own product information. The product information describes the deviations from the respective standard CPUs. • The Device manuals (https://support.industry.siemens.com/cs/ww/en/ps/13717/man) describe the S7-1500 CPUs.

Documentation	Brief description of relevant content
	• The "S7-300, CPU 31xC and CPU 31x: Installation" (https://support.industry.siemens.com/cs/ww/en/view/13008499) operating instructions describe the installation and wiring of S7-300 systems. • The "CPU 31xC and CPU 31x, Technical Data" (https://support.industry.siemens.com/cs/ww/en/view/12996906) device manual describes the CPUs 315-2 DP and PN/DP, the CPU 317-2 DP and PN/DP, and the CPU 319-3 PN/DP. • The "S7-400 Automation System, Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849) installation manual describes the installation and wiring of S7-400 systems. • The "S7-400 Automation System, CPU Data" (https://support.industry.siemens.com/cs/ww/en/view/109818285) reference manual describes the CPUs 414-3 PN/DP, the CPU 416-2, and the CPU 416-3 PN/DP. • The "ET 200S Interface Module IM 151-7 CPU" (https://support.industry.siemens.com/cs/ww/en/view/12714722) manual describes the IM 151-7 CPU. • The "ET 200S, Interface Module IM 151-8 PN/DP CPU" (https://support.industry.siemens.com/cs/ww/en/view/47409312) manual describes the IM 151-8 PN/DP CPU. • The "ET 200S, Interface Module IM 154-8 CPU" (https://support.industry.siemens.com/cs/ww/en/view/44251850) manual describes the IM 154-8 CPU. • The "SIMATIC S7-1500 Software Controller CPU 1505SP (F), CPU 1507S (F) and CPU 1508S (F) SIMATIC Industrial OS Version (https://support.industry.siemens.com/cs/ww/en/view/109808199)" manual describes the SIMATIC S7-1500 Software Controllers CPU 1505SP (F), CPU 1507S (F) and CPU 1508S (F). • The function manuals (https://sieportal.siemens.com/su/blSqW) describe the S7-1500 Virtual Controller.
"S7-1200 Functional Safety manual (https://support.industry.siemens.com/cs/ww/en/view/104547552)" system manual	Describes the F-CPUs S7-1200 and the fail-safe modules S7-1200 (including installation, wiring, and technical specifications)
"S7-1500/ET 200MP system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/29727/man) for the corresponding S7-1500/ET 200MP fail-safe modules	Describes the hardware of the S7-1500 systems and the S7-1500/ET 200MP fail-safe modules (including installation, wiring, and technical specifications)
System manual "Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)"	Describes the hardware of S7-1500R/H systems (including design, wiring and technical specifications)
"SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665)" system manual and "SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766666)" equipment manual	Describes the hardware of the SIMATIC Drive Controller (including design, wiring and technical specifications)

Documentation	Brief description of relevant content
"SIMATIC S7-1500 S7-PLCSIM Advanced (https://support.industry.siemens.com/cs/ww/en/view/109955578)" function manual	Describes the operation of S7-PLCSIM Advanced
"ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/14059/man) for the corresponding ET 200SP fail-safe modules	Describes the hardware of the ET 200SP fail-safe modules (including installation, wiring, and technical specifications)
System manual "Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109817158)" and the equipment manuals (https://support.industry.siemens.com/cs/ww/en/ps/28940/man) for the respective ET 200SP HA fail-safe modules	Describes the hardware of the ET 200SP HA fail-safe modules (including setup, wiring and technical specifications).
"ET 200eco Distributed I/O Station Fail-safe I/O Block (https://support.industry.siemens.com/cs/ww/en/view19033850)" manual	Describes the hardware of the ET 200eco fail-safe I/O module (including installation, wiring, and technical specifications)
Manual "ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 (https://support.industry.siemens.com/cs/ww/en/view/109765611)"	Describes the hardware of the ET 200eco PN fail-safe I/O module (including installation, wiring, and technical specifications)
System manual "ET 200AL system manual (https://support.industry.siemens.com/cs/ww/en/view/89254965)" and equipment manual "Digital I/O Module F-DI 4+F-DQ 2x24VDC/2A, 4xM12" (https://support.industry.siemens.com/cs/ww/en/view/109798489)	Describes the hardware of the ET 200AL fail-safe I/O module (including installation, wiring, and technical specifications)
"Distributed I/O System ET 200S, Fail-Safe Modules (https://support.industry.siemens.com/cs/ww/en/view/27235629)" operating instructions	Describes the hardware of the ET 200S fail-safe modules (including installation, wiring, and technical specifications)
"S7-300 Automation System, ET 200M Distributed I/O System, Fail-safe Signal Modules (https://support.industry.siemens.com/cs/ww/en/view/19026151)" manual	Describes the hardware of the S7-300 fail-safe signal modules (including installation, wiring, and technical specifications)
"Distributed I/O system ET 200pro, fail-safe I/O modules (https://support.industry.siemens.com/cs/ww/en/view22098524)" operating instructions	Describes the hardware of the ET 200pro fail-safe modules (including installation, wiring, and technical specifications)

Documentation	Brief description of relevant content
"ET 200iSP distributed I/O device - Fail-safe modules (https://support.industry.siemens.com/cs/ww/en/view/47357221)" operating instructions	Describes the hardware of the ET 200iSP fail-safe modules (including installation, wiring, and technical specifications)
"Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925)" Function Manual	Contains the description of communication with OPC UA
Help on *STEP 7*	• Describes the operation of the standard tools in *STEP 7* • Contains information regarding configuration and parameter assignment of hardware • Contains a description of the programming languages FBD and LAD • Contains the description of communication with OPC UA

Fail-safe modules Manual Collection

The Manual Collection contains all the documentation for the SIMATIC fail-safe modules collected into one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109806400).

Guide

This documentation describes how to work with *STEP 7 Safety*. It includes instructions and reference sections (description of the instructions for the Safety program).

The following topics are addressed:

- Configuration of SIMATIC Safety
- Access protection for SIMATIC Safety
- Programming of the Safety program (safety-related user program)
- Safety-related communication
- Instructions for the Safety program
- Support for the system acceptance
- Operation and maintenance of SIMATIC Safety
- Monitoring and response times

Conventions

The following conventions apply:

- In this documentation, the terms "safety engineering" and "fail-safe engineering" are used synonymously. The same applies to the terms "fail-safe" and "F-".
- "F-systems" include redundant S7-1500HF systems. Special features and restrictions of H systems are described in the system manual "Redundant S7-1500R/H system (https://support.industry.siemens.com/cs/ww/en/view/109754833)" and also apply to the redundant S7-1500HF systems.
- *"STEP 7 Safety V21"* stands for *"STEP 7 Safety Advanced V21"*.
- "(S7-300)" indicates that the section **only** applies to S7-300 F-CPUs. S7-300 F-CPUs also includes the F-CPUs ET 200S and ET 200pro (IM F-CPUs).
- "(S7-400)" indicates that the section **only** applies to S7-400 F-CPUs.
- "(S7-1200 G1)" indicates that the section **only** applies to S7-1200 F-CPUs with article number 6ES721x-1xF**40**....
- "(S7-1200 G2)" indicates that the section **only** applies to S7-1200 F-CPUs with article number 6ES721x-1xF**50**....
- "(S7-1200)" indicates that the section **only** applies to S7-1200 G1 F-CPUs and S7-1200 G2 F-CPUs.
- "(S7-1500)" indicates that the section **only** applies to S7-1500 F-CPUs. S7-1500 F-CPUs also include S7-1500 HF-CPUs, ET 200SP F-CPUs, the CPU 151xpro F-2 PN, the S7-1500 F Software Controller, the SIMATIC Drive Controller and the S7-1500 F Virtual Controller. In the case of exceptions, these are indicated.

The scopes can be combined.

The term **Safety program** refers to the fail-safe portion of the user program and is used instead of "fail-safe user program", "F-program", etc. For purposes of contrast, the non-safety-related part of the user program is referred to as the "standard user program".

The **hardware configuration** includes the configuration of standard CPUs and standard I/Os as well as the configuration of F-CPUs and F-I/Os.

The **safety-related hardware configuration** includes the safety-related parameters of the F-CPUs and F-I/Os.

The **safety-related project data** includes the safety-related hardware configuration as well as the Safety program.

NOTE

Each warning is marked with a unique number at the end of the text. This enables you to easily reference other documents, for example, to obtain an overview of the safety requirements for the system.

Additional support

If you have further questions about the use of products presented in this manual, contact your local Siemens representative.

You can find information on whom to contact on the Web (https://www.automation.siemens.com/aspa_app).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Web (http://www.siemens.com/simatic-tech-doku-portal).

You can find the online catalog and online ordering system on the Web (www.siemens.com/industrymall).

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We offer courses to help you get started with the S7 automation system. To do this, contact your regional training center or the central training center in Nuremberg, Germany.

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Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which could be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in to the Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F/SIMATIC S7-1500HF (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Software Controller (https://support.industry.siemens.com/cs/products?pnid=13911&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=24471&lc=en-WW)
- Virtual Controller (https://support.industry.siemens.com/cs/ww/en/ps/29702)

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

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Product Overview

1

1.1 Overview

SIMATIC Safety fail-safe system

The SIMATIC Safety fail-safe system is available to implement safety concepts in the area of machine and personnel protection (for example, for emergency STOP devices for machining and processing equipment) and in the process industry (for example, for implementation of protection functions for safety devices of instrumentation and controls and of burners).

⚠ WARNING

The SIMATIC Safety F-system is used to control processes that reach their safe state immediately through shutdown. This also applies in particular to redundant S7-1500HF systems.
SIMATIC Safety may only be used for controlling processes in which a shutdown does not pose a danger to humans or the environment.
When realizing safety applications including the creation of the safety-related project data you have to take into consideration the standards, directives and guidelines relevant for your application. In particular include standards in which the software creation process is described (for example IEC 61508-3 or ISO 13849-1). *(S062)*

Achievable safety requirements

SIMATIC Safety F-systems can satisfy the following safety requirements:

- Safety Integrity Level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Functional safety in SIMATIC Safety

Functional safety is implemented primarily in the software. The SIMATIC Safety F-System brings the plant into a safe state in the event of a hazardous event and maintains this state. Safety mechanisms are contained mainly in the following components:

- In the safety-related user program (safety program) in the F-CPU
- In the fail-safe inputs and outputs (F-I/O)

The F-I/O ensure the safe processing of field information (sensors: e.g. emergency STOP pushbutton, light barriers; actuators, e.g. for motor control). They have all of the required hardware and software components for safe processing, in accordance with the required Safety Integrity Level. The user only has to program the user safety function. Functional safety for the process can be provided by a user safety function or a fault reaction function.

The F-system cyclically checks the integrity of the safety program and the safety-related data. This check is generally always performed when safety-related data leaves an F-runtime group via safety-related communication or F-I/O access. If this check detects a fault, the F-system executes the fault reaction function, which switches off the associated outputs and, if necessary, sets the F-CPU to STOP.

NOTE

If the F-CPU switches to STOP mode due to a fault reaction function, with a redundant S7-1500HF system, it leads to the STOP of the primary CPU **and** the backup CPU.

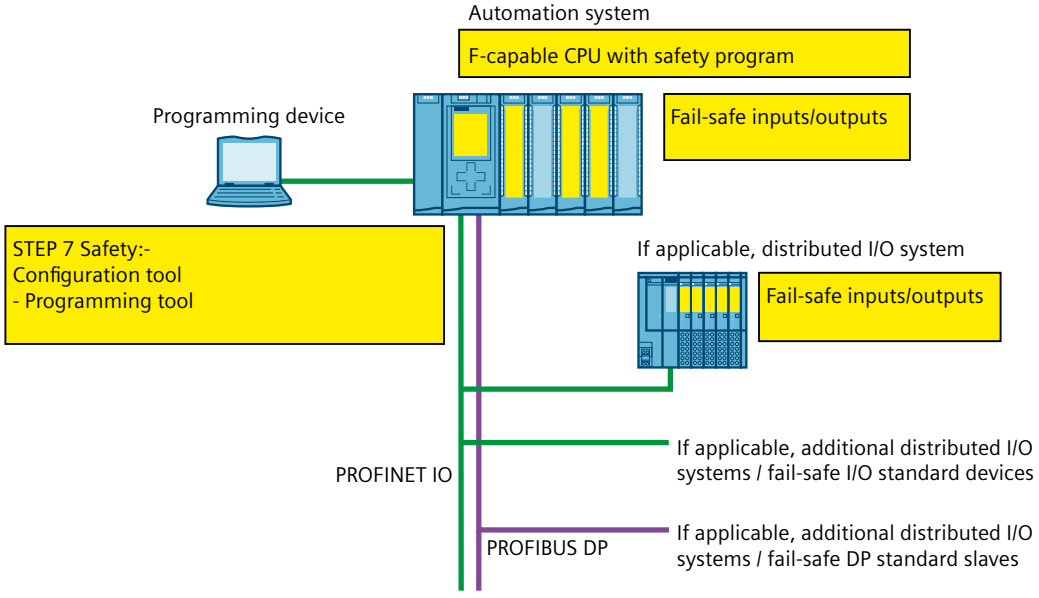
Example of user safety function and fault reaction function

In the event of overpressure, the F-system will open a valve (user safety function). In the event of a hazardous fault in the F-CPU, all outputs are deactivated (fault reaction function), whereby the valve is opened, and the other actuators also attain a safe state. For a non-faulty F-system, only the valve would be opened.

1.2 Hardware and Software Components

Hardware and software components of SIMATIC Safety

The following schematic diagram provides an overview of the hardware and software components required to configure and operate a SIMATIC Safety F-system.



Hardware components for PROFIBUS DP

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFIBUS DP:

- F-CPUs with DP interface, such as CPU 1516F-3 PN/DP
- SIMATIC Drive Controller, for example, CPU 1504D TF
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-safe I/O modules ET 200eco (S7-300, S7-400)
  - Fail-safe GSD based DP slaves (light array, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFIBUS DP for connection to distributed F-I/O:

- CP 443-5 Extended
- CM 1243-5
- CM 1542-5
- CP 1542-5
- SP CM DP

Hardware components for PROFINET IO

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFINET IO:

- F-CPUs with PN interface, e.g. CPU 1214FC DC/DC/DC
- SIMATIC Drive Controller, for example, CPU 1504D TF
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200SP HA fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200eco PN fail-safe I/O modules
  - ET 200AL fail-safe I/O modules
  - Fail-safe GSD based I/O devices (light array, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFINET IO for connection to distributed F-I/O:

- CP 443-1
- CP 443-1 Advanced-IT
- CM 1542-1

Hardware components for central configuration

You can use the following fail-safe components in SIMATIC Safety F-systems centrally on an F-CPU (not HF-CPU):

- S7-300/ET 200M fail-safe signal modules
- S7-1200 fail-safe modules
- S7-1500/ET 200MP fail-safe modules
- ET 200SP fail-safe modules
- ET 200S fail-safe modules
- ET 200pro fail-safe modules (can also be used with CPU 1516proF-2)

You have the option to expand the configuration with standard I/O.

STEP 7 Safety

This documentation describes *STEP 7 Safety Advanced V21*. *STEP 7 Safety* is the configuration and programming software for the SIMATIC Safety F-system. With *STEP 7 Safety*, you receive the following:

- The support for configuring the F-I/O in the *hardware and network editor* of TIA Portal
- The support for creating the Safety program using LAD and FBD and integrating error detection functions into the Safety program
- Instructions for programming your Safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your Safety program in LAD and FBD with special safety functions

Moreover, *STEP 7 Safety* offers functions for comparing Safety programs and for assisting you with the system acceptance.

⚠ WARNING

The configuration of F-CPUs and F-I/Os as well as the programming of F-blocks must be carried out in TIA Portal as described in this documentation. To ensure safe operation with the SIMATIC Safety system, you must comply with the requirements of the relevant standards, such as IEC 61508. The section System acceptance (Page 407) describes procedures and tools of STEP 7 Safety to meet these requirements. *(S056)*

Optional packages

In addition to *STEP 7 Safety*, you can use option packages with F-I/O and F-CPUs and use instructions for programming your Safety program with special safety functions within the SIMATIC Safety F-system, for example SINUMERIK.

The installation, parameter assignment and programming as well as what is important to note during system acceptance, is described in the documentation for the specific optional packages.

Also read the notes in "Configurations supported by the SIMATIC Safety F-system (Page 62)".

TIA Portal Cloud Connector

⚠ WARNING

Use of the TIA Portal Cloud Connector is only intended for engineering work with TIA Portal. This means online access in productive operation (e.g. SCADA) is not permitted. This is particularly true for Safety programs. *(S068)*

Openness

Openness (https://support.industry.siemens.com/cs/ww/en/view/109826886) as part of *STEP 7 Safety* is supported with the functions listed below. The use of Openness in productive operation is not permitted.

As part of *STEP 7 Safety* the following is supported:

- Inserting / removing F-CPUs and F-I/Os
- Copying / deleting F-CPUs and F-I/Os from templates
- Compiling hardware
- Compiling software (incl. Safety program)
- Handling access protection for the safety-related project data (for TIA projects not protected by project protection)
- Reading/configuring F-parameters of the F-CPU (for S7-1500 F-CPUs)
- Reading/configuring F-parameters of F-I/Os
- Reading/configuring i-parameters of F-I/Os (for ET 200SP, ET 200AL, ET 200MP, ET 200eco PN, ET 200pro)
- Downloading safety-related project data to a SIMATIC Memory Card or storing it in a file folder
- Reading, declaring or deleting fail-safe tags in the PLC tag table
- Updating projects to the latest type versions of F-blocks
- Consistent station upload
- Export and import of F-blocks and F-compliant PLC data types (UDT)
- Comparison of hardware and software
- Version control interface (VCI) support
- Reading out PLC online fingerprint for the Safety program
- Storing safety-related project data as a PC System Configuration file

- Reading out the F-signatures and block signatures
- Adding and removing OPC UA Safety configurations (SafetyProvider/SafetyConsumer)

The following are not supported.

- Downloading to device

⚠ WARNING

When using Openness or other tools for operating the TIA Portal in combination with safety-related project data, integrity of the data must be ensured (for example, as part of the save or transfer functions of "Source Code Management" applications). If there is a connection of external tools, the requirements for offline support tools according to IEC 61508-3 must be observed. A violation of the integrity of the safety-related project data either offline or online cannot be detected by *STEP 7 Safety*. A final verification of the correctness of the safety-related project data has to be carried out as described in the section System acceptance (Page 407). *(S070)*

Openness programs can also be integrated into TIA Portal as an add-in. It is also possible to include so-called workflow add-ins, which are automatically called before a Safety program is compiled. See "Extending workflows" in the standard help.
If you have integrated such a workflow add-in, this is output in the safety summary.

Openness service

The Openness interface has been expanded to include the following services:

- `GlobalSettings` (see name area **Siemens.Engineering.Safety**), which provides the following actions:
  - `SafetyModificationsPossible(bool safetyModificationsPossible)`
  - `UsernameForFChangeHistory(string userName)`
  - `bool SafetyModificationsPossible()`
  - `string UsernameForFChangeHistory()`
- `SafetyBaseIdProvider` with the following action in the name area **Siemens.Engineering.Safety**:
  - `void GenerateBaseId()`

  `SafetySignatureProvider` which provides the following actions and properties:
  - `SafetySignatureComposition Signatures`
  - `UInt64 SafetySignature.Value`
  - `SafetySignatureType SafetySignature.Type`

- `SafetyAdministration` with the following actions and properties in the name area **Siemens.Engineering.Safety:**
  - `bool IsSafetyOfflineProgramPasswordSet`
  - `void SetSafetyOfflineProgramPassword(SecureString newPassword)`
  - `void RevokeSafetyOfflineProgramPassword(SecureString currentPassword)`
  - `bool IsLoggedOnToSafetyOfflineProgram`
  - `void LoginToSafetyOfflineProgram(SecureString currentPassword)`
  - `void LogoffFromSafetyOfflineProgram()`
- `Safety Administration`, which can be accessed from the `PLc-DeviceItem`.
  The `SafetyAdministration` service offers the following properties in the **Siemens.Engineering.Safety** namespace. These three properties include additional properties that are listed in the description.
  - `RuntimegroupComposition RuntimeGroups { get; }`
  - `SafetySettings Settings { get; }`
  - `SafetySignatureProvider ProgramSignatures { get; }`
- `SafetyPrintout` with the following action in the name area **Siemens.Engineering.Safety**:
  - `bool Print(SafetyPrintoutFilePrinter filePrinter, FileInfo fullOutputPath, string documentLayout, SafetyPrintoutOption documentationOption);`

More information can be found in the System Manual "SIMATIC TIA Portal Openness: Automating creation of projects (https://support.industry.siemens.com/cs/ww/en/view/109826886)" in the section "F-specific openness".

Virtual environments

⚠ WARNING

Use of virtual environments in the engineering system
Note that a hypervisor or a client software of a hypervisor is not permitted to perform any function that reproduces recorded message frame sequences with correct time response in a network with real F-CPUs and F-I/Os.
Make sure that this condition is met, for example, when using the following functions:

- Reset of captured statuses (snapshots) of the virtual machines (VMs)
- Suspending and resuming the VMs
- Replay of recorded sequences in the VMs
- Moving VMs between hosts in productive operation (e.g. Fault Tolerance (FT))
- Digital twins of VMs in the virtual environment

If in doubt, disable these functions in the settings (Hypervisor administration console). *(S067)*

Operating system installations with S7-150xS(P) F

⚠ WARNING

When using a PC with multiple Windows or Linux operating system installations (e.g. via boot manager), only one S7-150xS(P) F may be installed on this PC. *(S095)*

Safety program

You can create a Safety program using the *program editor*. You can program fail-safe FBs and FCs in the FBD or LAD programming languages using the instructions from *STEP 7 Safety* and create fail-safe DBs.

Safety checks are automatically performed and additional fail-safe blocks for error detection and fault reaction are inserted when the Safety program is compiled. This ensures that failures and errors are detected and appropriate reactions are triggered to maintain the F-system in the safe state or bring it to a safe state.

In addition to the Safety program, a standard user program can be run on the F-CPU. A standard program can coexist with a Safety program in an F-CPU because unintentional influencing of the safety-related data of the Safety program is uncovered by the standard user program.

Data can be exchanged between the safety program and the standard user program in the F-CPU by means of bit memory or data of a standard DB or by accessing the process image input and output.

Note possible restrictions/particularities when using Software Units or a Safety Unit (Page 113).

See also

Data Transfer from the Safety Program to the Standard User Program (Page 192)

1.3 Installing/uninstalling the STEP 7 Safety Advanced V21 license

After installation of the *STEP 7 Safety Advanced V21* license, the range of functions of *STEP 7 Safety Advanced V21* is available to you. This license is not required for S7-1200 F-CPUs.

Software requirements for *STEP 7 Safety Advanced V21*

At a minimum, the following software package must be installed on the programming device or PC:

- *SIMATIC STEP 7 Professional V21*

Installing the *STEP 7 Safety Advanced V21* license

1. Start the *Automation License Manager* on the programming device/PC on which the *"SIMATIC STEP 7 Professional V21"* software package is installed.
2. Install the *STEP 7 Safety Advanced V21* license as described in the *Automation License Manager help*.

Uninstalling the *STEP 7 Safety Advanced V21* license

To uninstall the *STEP 7 Safety Advanced V21* license, proceed as described in the *Automation License Manager help*.

1.4 Migrating projects from S7 Distributed Safety V5.4 SP5 to STEP 7 Safety Advanced

Migration of *S7 Distributed Safety* projects to *STEP 7 Safety Advanced* is no longer supported as of *STEP 7 Safety V21*. Migration is still possible with earlier versions of the *TIA Portal*. The project can then be upgraded from an earlier version to the current version in the usual way.

1.5 Migrating PLC programs to a n F-CPU S7-1500

To migrate an F-CPU S7-300/400 onto an F-CPU S7-1500, proceed as with the migration of a standard CPU S7-300/400 onto a CPU S7-1500.

Points to note after migration:

- Non-automatable actions
  - Creating an F-runtime group and assigning it to the main safety block.
  - The hardware configuration including the I/O of the initial F-CPU is not automatically transferred to an S7-1500 F-CPU. Implement the hardware configuration of the new CPU manually after migration.

    Please also read the sections
    "Specify F-destination address for F-I/O of PROFIsafe address type 1" and "Specify F-destination address for F-I/O of PROFIsafe address type 2" in chapter "Configuring an F-CPU (Page 39)". Otherwise, this can lead to a reassignment of the F-destination addresses in the configuration.
  - When using F-I/O with PROFIsafe Protocol Version = Expanded Protocol (XP) (for example S7-1500/ET 200MP F-modules), keep in mind that you need one byte more in the address area of S7-1200/1500 F-CPUs than in S7-300/400 F-CPUs.
  - Replacement of the OV instruction by the connection of the ENO output for mathematical functions (Page 542).
  - Replacement of the RD_FDB instruction by the instructions RD_ARRAY_I (Page 559) and RD_ARRAY_DI (Page 561).
  - Replacement of the F-runtime group communication through Communication via Flexible F-Link (Page 141).
- Instructions not supported:
  - MUTING
  - TWO_HAND
  - WR_FDB
  - OPN
  - SENDS7
  - RCVS7
- Data types not supported
  - DWORD

- Changes to safety program programming
  - F_GLOBDB.VKE0/1 replaced by FALSE/TRUE (Page 116).
  - Readable values from the F_GLOBDB replaced by the F-runtime group information DB. Additional information is available under F-shared DB (S7-300, S7-400) (Page 148) and F-runtime group information DB (S7-1200, S7-1500) (Page 149).
  - Replacement of the QBAD_I_xx or QBAD_O_xx tag by the value status. Additional information is available under Value status (S7-1200, S7-1500) (Page 153) and F-I/O DB (Page 157).
- New naming convention when naming the F-I/O DBs
- Modified behavior of QBAD and PASS_OUT (Page 162) tags for F-I/O with "RIOforFA safety" profile.

Compile the safety program and eliminate any compilation errors displayed.

NOTE
A new acceptance must be carried out following F-CPU migration.

See also

Programming (Page 108)

1.6 Upgrading projects to the latest version of STEP 7 Safety

Re-create the safety summary after an upgrade to a newer version of *STEP 7 Safety*. The versions listed in the new safety summary of *STEP 7 Safety* will then match the new version of *STEP 7 Safety*.

1.6.1 Upgrading projects from STEP 7 Safety as of V14 SP1 to the latest version

If you want to continue working with a project from *STEP 7 Safety* as of *V14 SP1*, you must upgrade the project to the latest version of *STEP 7 Safety*.

NOTE
The project must be consistent before upgrading.

Perform the upgrade following the usual procedure for *STEP 7*. After upgrading to the latest version, you must compile your safety program and download it in STOP.

If you want to compile a migrated safety program with STEP 7 Safety for the first time, we recommend that you first update to the latest available version of the instruction. You will then avoid number conflicts.

If you have upgraded a project <= V17 to the latest version and compiled it, the Collective F-signature remains the same, but the version comparison between the online and offline programs shows a change. The differences shown are due to the improved calculation of the signatures as of V18. Because the Collective F-Signature has remained the same, re-acceptance is not necessary. We recommend creating a new safety summary so that the new signatures are documented.

Keep in mind that existing change histories are not upgraded. All previous entries are deleted after the upgrade. If required, print out the change log before you upgrade.

If you have created your project with *STEP 7 Safety V18* and have stored the Safety program in a Safety unit in this project, you must upgrade the project and then re-create the safety summary, which replaces the Safety summary created with *STEP 7 Safety V18*. This is required for the SENDDP and RCVDP instructions in the "System library elements used in Safety program" section to be displayed correctly.

1.7 First steps

Getting Started in SIMATIC Safety

Three Getting Started documents are available to help you begin using SIMATIC Safety.

The Getting Started documentation is an instruction manual that provides a step-by-step description of how to create a project with SIMATIC Safety. It gives you the opportunity to quickly become familiar with the scope of features of SIMATIC Safety.

Contents

The Getting Started documentation describes the creation of a single, continuous project that is extended with each section. Based on the configuration, you program a fail-safe shutdown, make changes to the programming, and accept the system.

In addition to the step-by-step instructions, the Getting Started documentation also gives you background information for every new topic, which explains the functions used in more detail and how they interrelate.

Target audience

The Getting Started documentation is intended for beginners but is also suitable for users who are switching from *S7 Distributed Safety*.

Download

Three Getting Started documents are available as PDF files for free download in the Industry Online Support:

- STEP 7 Safety Advanced V11 with S7-300/400 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/49972838)
- STEP 7 Safety Basic V13 SP1 with S7-1200 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/104547552) (part of the manual "S7-1200 Functional Safety manual")
- STEP 7 Safety Advanced V13 with S7-1500 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/101177693)

Configuring

2

2.1 Overview of Configuration

Introduction

You basically configure a SIMATIC Safety F-system in the same way as a standard S7-300, S7-400, S7-1200, S7-1500 or ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200S, ET 200iSP, ET 200eco, ET 200eco PN or ET 200pro automation system in *STEP 7*.

This section presents only the essential differences compared to standard configuration you encounter when configuring a SIMATIC Safety F-system.

This documentation distinguishes between three groups of F-I/O:

F-I/Os of PROFIsafe address type 1

F-I/Os which ensure the uniqueness of the PROFIsafe address solely with the F-destination address, for example, ET 200S F-modules. The PROFIsafe address is usually assigned by DIP switches.

F-I/Os of PROFIsafe address type 2

F-I/O for which the uniqueness of the PROFIsafe address can be ensured through the combination of F-source address and F-destination address, for example, S7-1500/ET 200MP F-modules. You normally assign the PROFIsafe address with *STEP 7 Safety*.

F-I/O of PROFIsafe address type 3

F-I/O for which the uniqueness of the PROFIsafe address can be ensured through an F-BaseID in addition to the combination of F-source address and F-destination address, for example, certain S7-1500/ET 200SP F-modules. The F-BaseID saves you the work of ensuring the uniqueness of the PROFIsafe address network-wide/worldwide yourself (for more information, see "PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68)"). You normally assign the PROFIsafe address (including the F-BaseID) with *STEP 7 Safety*.

NOTE

The terminology "PROFIsafe address type 3" used in this documentation is equivalent to the designation "PROFIsafe address type 2 with BaseID". This applies in TIA Portal as well as to F-I/Os.

Which F-components can you configure with *STEP 7 Basic/STEP 7 Professional* and *STEP 7 Safety Advanced*?

The table below shows you which F-CPUs you can configure with *STEP 7 Safety Advanced*:

F-CPUs	*STEP 7 Safety Advanced*
S7-300	x
S7-400	x
S7-1200	x *
S7-1500(H)	x
SIMATIC Drive Controller	x
S7-1500 F Software Controller	x
S7-1500 F Virtual Controller	x

* You can configure S7-1200 F-CPUs without a license for *STEP 7 Safety*.

The table below shows you which F-I/Os you can configure with *STEP 7 Safety Advanced* as well as which PROFIsafe address type they support:

F-I/O	*STEP 7 Safety Advanced*	PROFIsafe address type
S7-300 F-SMs	x**	1
ET 200S F-modules	x	1
ET 200pro F-modules	x	1
ET 200iSP F-modules	x	1
ET 200eco DP F-I/O modules	With S7-300/400 F-CPUs (only PROFIsafe V1 mode)	1
ET 200eco PN F-I/O modules	x	2
S7-1200 F-modules (centrally on S7-1200 F-CPUs)	x***	2
ET 200SP F-modules	x	2 or 3
ET 200SP HA F-modules	x	2
S7-1500/ET 200MP F-modules	x	2
ET 200AL F-modules	x	2
fail-safe GSD based DP slaves	x	*
fail-safe GSD based I/O devices	x	*

* Consult the respective documentation to determine the PROFIsafe address type of a GSD based DP slave/GSD based I/O device. If in doubt, assume that the PROFIsafe address is type 1.

*** F-SMs that only support PROFIsafe V1 mode can only be used on F-CPUs S7-300/400.

*** You can configure S7-1200 F-modules without a license for *STEP 7 Safety*.

Special F-parameters

For the F-functionality there are special F-parameters that you can review and set in the "Properties" of the fail-safe components (F-CPU and F-I/O). F-parameters are marked in yellow.

F-parameters are explained in "Configuring an F-CPU (Page 39)" and "Configuring F-I/O (Page 51)".

Changing safety-related parameters

NOTE

If you change a safety-related parameter (marked in yellow) for an F-I/O or an F-CPU, you must then compile and download the modified hardware configuration and the Compiling the safety program (Page 344) (context menu "Compile > Hardware and software (only changes)"). This also applies to changes to F-I/O that are not used in the safety program. F-I/O in standard operation is not affected by this.

Compiling the hardware configuration

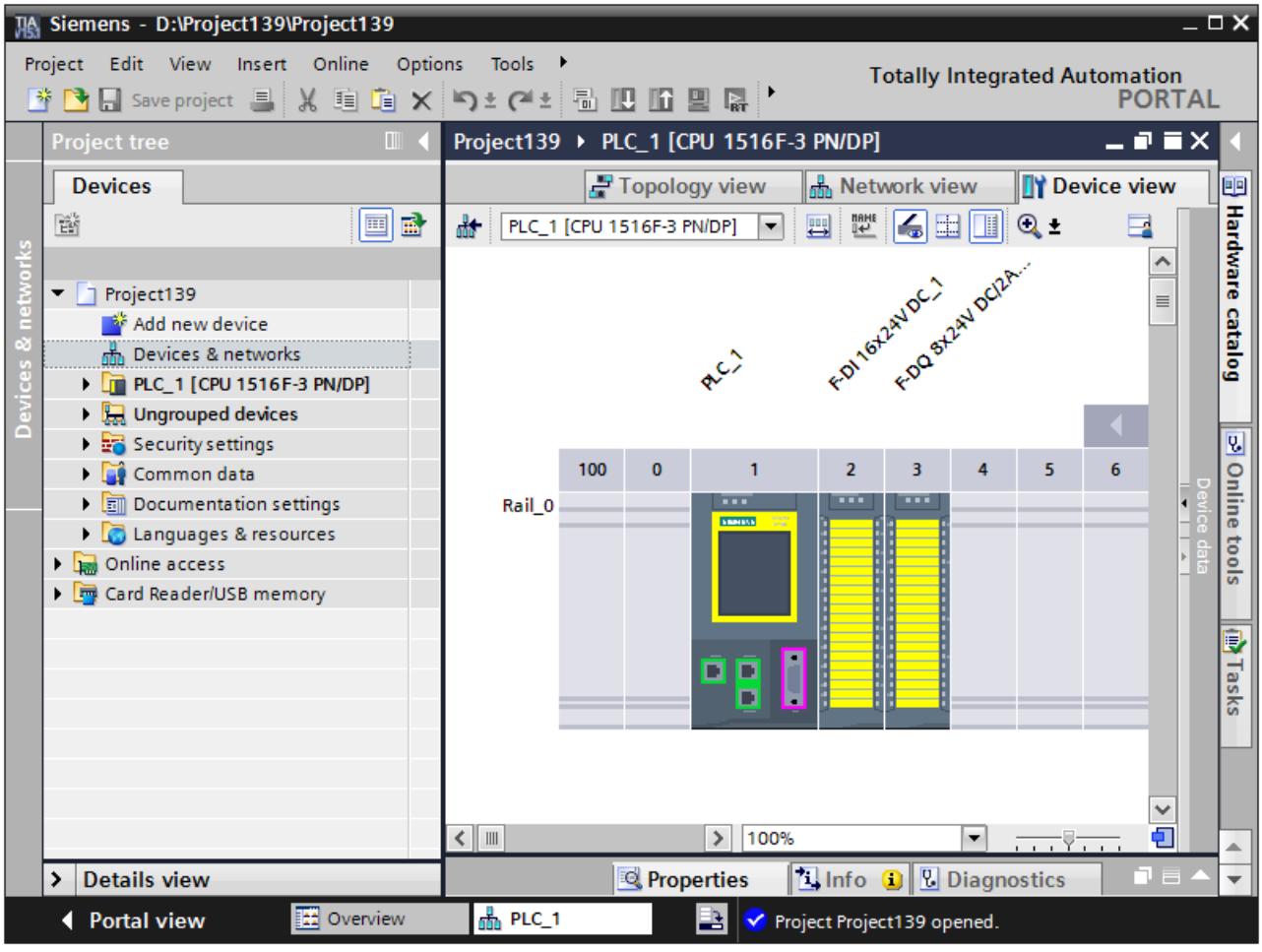
You must compile the hardware configuration of the SIMATIC Safety F-system (context menu "Compile > Hardware configuration"). A configured F-CPU with enabled F-capability is the only prerequisite for programming the safety program.

NOTE

Inconsistencies are possible when configuring the hardware and can also be saved. A full consistency check of the hardware configuration and possible connection data is performed only during compilation. Therefore, perform "Edit > Compile" regularly.

Example: Configured F-system in *STEP 7 Professional*

The following figure presents a configured F-system. You choose the fail-safe components in the "Hardware catalog" task card as you would do with standard components and place them in the work area of the network or device view. F-components are shown in yellow.



More information

For detailed information on F-I/O, refer to the *manuals for the relevant F-I/O*.

Which safety-related communication options can you configure?

You need to use the *hardware and network editor* to configure the following safety-related communication options (see Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 196) or Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 241)):

- Communication with OPC UA Safety (Page 279)
- Communication with Flexible F-Link (Page 338)
- Safety-related master-master communication

- Safety-related master-master communication for *S7 Distributed Safety*
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related I-slave-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for *S7 Distributed Safety*
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication
- Safety-related communication via S7 connections
- Safety-related communication via S7 connections for *S7 Distributed Safety* or *S7 F Systems*

2.2 Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices

Requirement

In order to use fail-safe GSD based DP slaves for SIMATIC Safety, these GSD based slaves must be operated on PROFIBUS DP and support the PROFIsafe bus profile. When used in an S7-1200/1500 F-CPU, they must support the PROFIsafe bus profile in V2 mode.

Fail-safe GSD based DP slaves used in hybrid configurations on PROFIBUS DP and PROFINET IO downstream from a IE/PB link must support the PROFIsafe bus profile in V2 mode.

In order to use fail-safe GSD based I/O devices for SIMATIC Safety, the GSD based devices must be operated on PROFINET IO and support the PROFIsafe bus profile in V2 mode.

Configuration with GSD files

As is the case in a standard system, the basis for configuring fail-safe GSD based DP slaves/IO devices is the device specification in the GSD file (device master file).

A GSD file contains all of the properties of a GSD based DP slave or GSD based I/O device. For fail-safe GSD based DP slaves/GSD based I/O devices, certain parts are protected by a CRC.

The GSD files are supplied by the device manufacturers.

Protection of the data structure of the device in GSD files

The only GSD files supported are those that satisfy the requirements for protection defined as of *PROFIsafe Specification* V2.0 using a CRC stored in this file ("setpoint" for F_IO_StructureDescCRC).

The data structure described in the GSD file is checked when the F-I/O is added to the hardware configuration and when the hardware configuration is compiled. When an error is detected, you should clarify whether the GSD file provided by the device manufacturer contains the setpoint for F_IO_StructureDescCRC.

Assignment and setting of the PROFIsafe address

⚠ WARNING

Check the documentation for your fail-safe GSD based DP slaves / fail-safe GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. For configuring, proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 65), PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 66) or PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68).
Set the F-source address for fail-safe GSD based DP slaves / fail-safe GSD based I/O devices according to the manufacturer's specifications. If the F-source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, check the safety summary to verify that the value for the "Central F-source address" parameter corresponds to the value of the F-source address of the fail-safe GSD based DP slave/fail-safe GSD based I/O device.
(S053)

Configuration procedure with GSD files

You import the GSD files to your project (see *Help on STEP 7 "GSD files"*).

1. Select the fail-safe GSD based DP slave / GSD based I/O device in the "Hardware catalog" task card and connect it to the relevant subnet in the network view.
2. Select the fail-safe GSD based DP slave/GSD based I/O device and insert the necessary F-modules, if this does not occur automatically.
3. Select the relevant F-module and open the "Properties" tab in the inspector window.

For fail-safe GSD based DP slaves/GSD based I/O devices (contrary to other F-I/O), the "Manual assignment of F-monitoring time" parameter is enabled. The result is that the value specified in the GSD file for the F-monitoring time is used as default value when the slaves/devices are plugged. You can change both values (time and type of assignment) later manually.

F-parameter "F_CRC_Seed" and "F_Passivation" for fail-safe GSD based I/O devices

The F-parameters "F_CRC_Seed" and "F_Passivation" influence the behavior of a fail-safe GSD based I/O device. The combination of the F-parameters cannot be set but is specified by selecting a corresponding F-module. Up to three F-module variants can be used, depending on the S7-300/400 or S7-1200/1500 F-CPU used.

F-module variant	F_CRC_Seed	F_Passivation	Behavior of the fail-safe GSD based I/O device	Can be used with F-CPU
1	Parameter does not exist	Parameter does not exist	The GSD based I/O device works with the Basic Protocol (BP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-300/400/1200/1-500*
2	CRC-Seed24/32	Device/module	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-1200/1500
3	CRC-Seed24/32	Channel	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is supported.	S7-1200/1500

* Only use the F-module variant 1 with S7-1200/1500 F-CPUs if neither F-module variant 2 nor 3 exists.

More information

You can find the description of the parameters in the Help on fail-safe GSD based DP slaves and GSD based I/O devices.

2.3 Configuring an F-CPU

Introduction

You configure the F-CPU basically in the same way as a standard automation system.

F-CPUs are always configurable in *STEP 7*, regardless of whether or not the *STEP 7 Safety* license is installed.

If you want to use the F-I/O in safety mode or in safety-related communication, the F-capability of the F-CPU must be enabled.

F-capability is activated by default when *STEP 7 Safety* license is installed.

Enabling F-capability

If you want to enable the F-capability, proceed as follows:

1. Select the F-CPU in the device or network view, and select the "Properties" tab in the Inspector window.
2. Select "Fail-safe" in the area navigation.
3. Enable the F-capability with the "Enable F-activation" button.

Disabling F-capability

If you want to disable the F-capability for an F-CPU because you intend to use the F-CPU as a standard CPU, note the following:

- You need F-access permission for the safety program, if assigned.
- The Safety Administration Editor (Page 78) is deleted from the project tree.
- The F-OBs are deleted. (S7-1200, S7-1500)
- All F-blocks are deleted.
- From now on you cannot use F-I/O in safety mode with this F-CPU.

If you want to disable the F-capability, proceed as follows:

1. Select the F-CPU in the device or network view, and select the "Properties" tab in the Inspector window.
2. Select "Fail-safe" in the area navigation.
3. Disable the F-capability with the "Disable F-activation" button.
4. Confirm the "Disable F-activation" dialog with "Yes".

Although you can enable the F-capability of the F-CPU without F-access permission, this permission is required to disable it.
If you do not have F-access permission and have enabled the F-capability accidentally, you can only disable it using "Undo".

Configuring the F-parameters of the F-CPU

In the "Properties" tab of the F-CPU, you can change or apply the default settings for the following parameters:

- F-destination address range
  - Low limit for F-destination addresses for F-I/Os of PROFIsafe address type 1
  - High limit for F-destination addresses for F-I/Os of PROFIsafe address type 1
- The F-source address for F-I/Os of PROFIsafe address types 2 and 3.
- The F-BaseID for F-I/O of PROFIsafe address type 3 at the F-CPU
  - Enable manual assignment and set F-BaseID
  - Button for automatic generation according to PROFIsafe specification
  - Activate delayed transfer (internal value 0x7C6)
- Default F-monitoring time for central or distributed F-I/O at the F-CPU
  (For HF-CPUs, only the default F-monitoring time for distributed F-I/O.)

NOTE
A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

Specify F-destination address for F-I/O of PROFIsafe address type 1

With the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" you specify a range for this F-CPU in which the F-destination address of newly inserted F-I/Os of PROFIsafe address type 1 (Page 65) is assigned automatically. The F-destination address of an F-I/O is automatically moved to the destination address range of an F-CPU as soon as it is newly assigned to it.

The F-destination address is assigned in ascending order starting at the "Low limit for F-destination addresses". When no free F-destination address is available in the F-destination address range, the next available free F-destination address outside the F-destination address range is assigned and a warning is output during compilation.

The maximum possible F-destination address for ET 200S, ET 200eco, ET 200pro, ET 200iSP F-modules and S7-300 F-SMs is 1022.

The F-destination addresses for F-I/O of PROFIsafe address type 1 must be unique network-wide and CPU-wide.

By selecting different F-destination address ranges for different F-CPUs, you can define different ranges for the automatic assignment of the F-destination address. This is useful when you are operating multiple F-CPUs in one network. Subsequent manual address changes are possible. (see also Recommendation for PROFIsafe address assignment (Page 61))

Example:

You have configured the F-destination address range as follows:

- Low limit for F-destination addresses = 100
- High limit for F-destination addresses = 199

When inserting the first F-I/O of PROFIsafe address type 1, the F-destination address 100 is assigned. When inserting an additional F-I/O of PROFIsafe address type 1, the F-destination address 101 is assigned.

NOTE

The parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" have no effect on the following F-I/Os:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 bit (article number 6ES7336-1HE00-0AB0)

Specifying the F-destination address range for F-I/O of PROFIsafe address types 2 and 3

The F-destination address of F-I/O of PROFIsafe address type 2 (Page 66) and F-I/O of PROFIsafe address type 3 (Page 68) is assigned automatically for each F-CPU in descending order starting from 65534. The low limit is the value configured with the parameter "High limit for F-destination addresses" (for F-I/O of PROFIsafe address type 1) + 1.
If the value configured with the parameter "High limit for F-destination addresses" is reached, a warning is output during compilation. (See also Recommendation for PROFIsafe address assignment (Page 61))

Specifying F-source address for F-I/O of PROFIsafe address types 2 and 3

You specify the F-source address for F-I/O of PROFIsafe address type 2 (Page 66) and for F-I/O of PROFIsafe address type 3 (Page 68) assigned to this F-CPU with the parameter "Central F-source address". The F-source address must be unique network-wide for F-I/O of PROFIsafe address type 2. The F-source address or F-BaseID must be unique network-wide for F-I/O of PROFIsafe address type 3 (see also Recommendation for PROFIsafe address assignment (Page 61))

NOTE

A change to the "Central F-source address" parameter has the consequence that the safety program is different after recompilation. A new acceptance may therefore be required because the F-source addresses of all F-I/Os of address types 2 and 3 are changed centrally as a result.

Specifying F-BaseID for F-I/O of PROFIsafe address type 3

You specify the F-BaseID for the F-CPU and for F-I/O of PROFIsafe address type 3 (Page 68) assigned to this F-CPU with the parameter "F-BaseID". This is a uniformly distributed 64-bit random number that is generated by an algorithm in accordance with the PROFIsafe specification.
A manual assignment of values generated otherwise in accordance with the PROFIsafe specification is possible provided that the requirement for uniqueness is complied with:

⚠ WARNING

Only use generation tools with which you can track adherence to the PROFIsafe generation rules, e.g. based on the documentation. The TIA Portal tools comply with these rules. *(S116)*

⚠ WARNING

The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.
With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

To enable assignment of the F-BaseID during startup of the F-CPU, "Delayed transfer" can be activated (see also Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 629)).

NOTE

A change to the "F-BaseID " parameter has the consequence that the hardware configuration must be compiled and downloaded again because the F-BaseID values of all F-I/Os of address type 3 are changed centrally as a result. If you change the F-BaseID from "Delayed transfer" to another setting, you must also compile and download the safety program again.

Normally, a new acceptance of the safety-related project data (Page 427) is not required after a change of the F-BaseID because this does not change the behavior of the safety program and/or the F-I/Os. For this reason, it is also not included in the Collective F-Signature. However, an acceptance of the overall function on the destination hardware may still be necessary.

"Default F-monitoring time" parameter

Configure the "Default F-monitoring time" for monitoring the communication between the F-CPU and F-I/O.

You can adjust the F-monitoring time via the following parameters:

- "Default F-monitoring time for central F-I/O"
- "Default F-monitoring time for F-I/O of this interface"

The **default F-monitoring time for the central F-I/O** acts on the F-I/O that is arranged centrally, i.e. near the F-CPU. You set this parameter in the properties of the F-CPU (select F-CPU, then select "Properties > Fail-safe > F-parameters").

The **default F-monitoring time for the F-I/O of this interface** acts on the F-I/O that is assigned to this interface of the F-CPU (PROFIBUS or PROFINET). You change this parameter in the properties of the relevant interface (selection of the interface in the "Device view" tab, then "F-parameters").

The various settings available allow you to flexibly adapt the F-monitoring time to the conditions of your F-system, for example to take account of different bus cycles.

You can also change the F-monitoring time individually for each F-I/O in the F-I/O properties (see Configuring F-I/O (Page 51) or Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 37)).

NOTE

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

NOTE
The default value for the "Default F-monitoring time for the F-I/O" for an HF-system is 2300 ms and is designed for an MRP ring. For line topology, you can set the "Default F-monitoring time for the F-I/O" smaller by a factor of approx. 2. You can determine the exact value as described in section "Monitoring and response times (Page 615)". You can set this value in the properties of the F-CPU (selection of the F-CPU, then "Properties > Fail-safe > F-parameters > PROFINET interface [X1]").

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find more information in Monitoring and response times (Page 615).

Automatic generation of the safety program

The safety program of an F-CPU consists of one or two F-runtime groups that contain the F-blocks (see also Defining F-Runtime Groups (Page 129)). When the F-CPU (with activated F-capability) is inserted into the work area of the device view or network view, a safety program with an F-runtime group is generated automatically.

You can define in *STEP 7 Safety* that no F-runtime group is generated while inserting the F-CPU (with activated F-capability).

Proceed as follows:

1. Select the "Options > Settings" menu command.
2. Select the "STEP 7 Safety" area.
3. If it is not already disabled, disable automatic generation of an F-runtime group by deselecting the "Generate default fail-safe program" option.

This change has no influence on any existing safety programs; it only defines whether an F-runtime group is automatically generated for each one of the subsequently inserted F-CPUs.

Configuring the protection level of the F-CPU

⚠ WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.
With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

⚠ WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.
If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.
If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.
If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".
Assign different passwords for the individual access levels. *(S041)*

You configure the protection level following the same procedure as for standard CPUs.
For information on the password for the F-CPU, refer to Access protection (Page 96). Pay special attention to the warnings in Access protection for the F-CPU (Page 100).

2.3.1 Special features of the S7-1500 F Virtual Controller

When you configure an S7-1500 F Virtual Controller, you must provide an additional timer for forming the safe time within the S7-1500 F Virtual Controller. This timer must always involve a network card or a selected Ethernet interface of the Edge device.

In this context, observe the following warning:

⚠ WARNING

You must configure an Ethernet interface or network adapter for your S7-1500 F Virtual Controller or central Virtual Timeservice in the Edge Resource Manager of the respective Edge Device.

You need to add the respective network card via the installation interface in the configuration menu of the Industrial Edge applications S7-1500VF or the virtual time service.

- Ensure, for example using data sheets or manufacturer confirmation, that the network card you selected is a separate, non-integrated IEEE1588-capable network card within your device or an externally plugged IEEE1588-capable network card.
- Ensure that the network card has a built-in quartz for the functionality according to IEEE 1588, e.g. through data sheets or manufacturer confirmation.

You must not use network cards or Ethernet interfaces configured for the safe time of an S7-1500 F Virtual Controller for time synchronization via PTP. Neither read nor write access is permitted to the physical hardware clock (PHC) of the network card.

You must differentiate between two types of operation in the Edge environment of an S7-1500 F Virtual Controller.

- You can operate the S7-1500 F Virtual Controller on an IED. In this case, you must always configure the network card or Ethernet interface directly for the S7-1500 F Virtual Controller.
- In the second case, you can operate the S7-1500 F Virtual Controller on an IEVD within a host. Depending on the application, you can directly assign a network card or Ethernet interface to the S7-1500 F Virtual Controller in an IEVD, as in the IED case.
  If you operate multiple S7-1500 F Virtual Controllers, you can use the Virtual Timeservice offered as an Industrial Edge application. The Virtual Timeservice distributes the safe time centrally for all S7-1500 F Virtual Controllers within your host. For this, you must configure the network card or Ethernet interface for the Virtual Timeservice and set up a suitable network for distributing the time stamp. An S7-1500 F Virtual Controller supports up to two Virtual Timeservices in a network. You must label the network for the Virtual Timeservice for each S7-1500 F Virtual Controller as "virtual-timeservice".
  If you operate the S7-1500 F Virtual Controller on a virtual Edge device within a host, you must provide the network cards or Ethernet interfaces for forming the safe time of an S7-1500 F Virtual Controller in the hypervisor of your host directly, exclusively and not virtualized via PCI passthrough for the respective Virtual Timeservice application or your S7-1500 F Virtual Controller application.

Check that the network card driver for the hardware time stamping function based on PTP is compatible with the version of your hypervisor and the kernel version of your IE(V)D.

Note that a reconfiguration of the settings of an IE(V)D with an S7-1500 F Virtual Controller during operation can result in STOP. *(S101)*

2.3.1.1 Operating the S7-1500 F Virtual Controller without central Virtual Timeservice

Installing the S7-1500 F Virtual Controller application

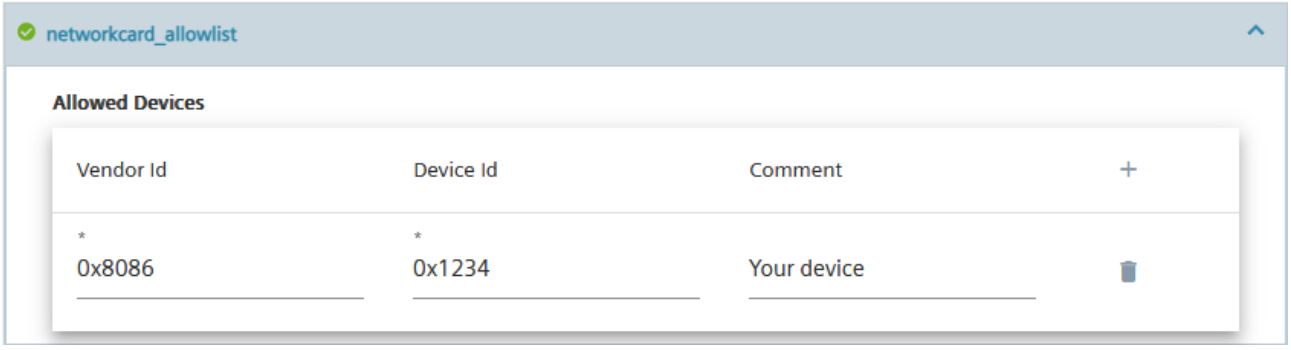
If you have not set up a central Virtual Timeservice and you want to configure a shared IEEE1588-capable interface (according to warning S101) for PROFINET communication and provision of the 2nd time base for the S7-1500 F Virtual Controller, add the network card or Ethernet interface to the "allow list" of the network cards.

NOTE

In the Installation menu, if you click "Back" and deselect the configuration with the plus sign, the previously configured networkcard_allowlist is installed/updated nonetheless. If you wish to correct your configuration, close the window by clicking the "X" and start the installation/update again.

Proceed as follows:

1. Select the "CPU 1517VF" app in the "Edge Management" under "Catalog".
2. Click "Install".
3. Add an IEEE1588-capable network card to the "vplc_x1" interface from the Resource Manager in accordance with warning S101. The "Application Manager" must be installed for this purpose.
   - To do this, check the box next to "networkcard_allowlist" and click on the plus sign in the "Allowed Devices" list.
   - Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".



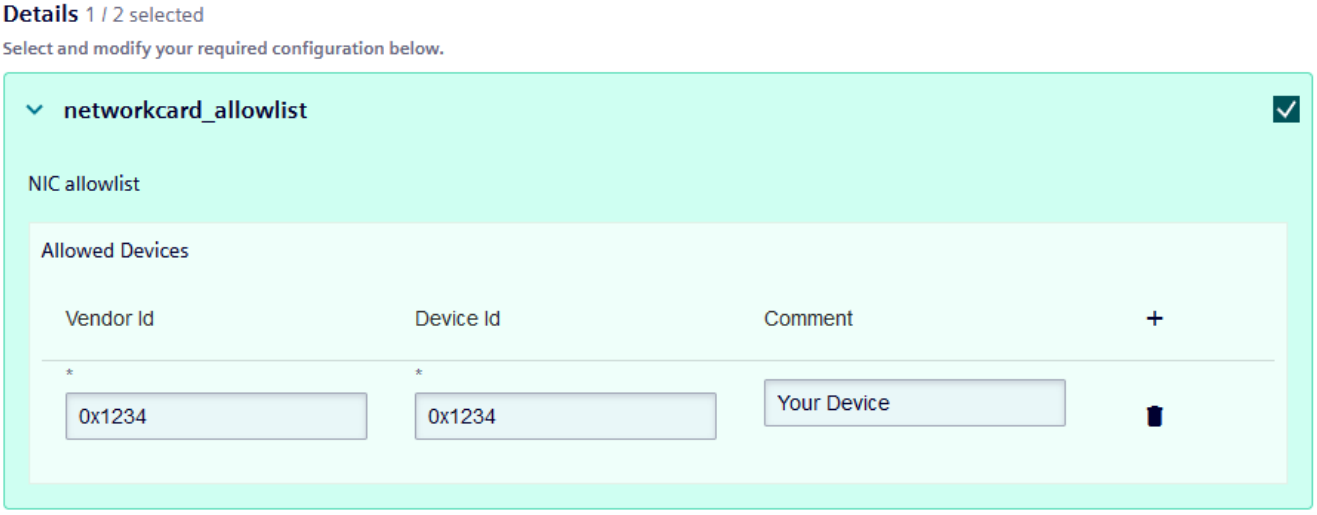
4. Click "Next".
5. Select the Edge device on which you want to install the app.
6. Click "Install Now".

Please note: The allow list can also be replaced later by updating the app.

If you are using the new UX of Edge via "new experience", follow these steps:

1. In "Edge Management", under Devices, select the Edge device on which you wish to install the "CPU 1517VF" app.
2. Click "Install application".
3. By means of the checkbox, select the "CPU 1517VF" app, whereupon the configuration menu for the app appears on the right.

4. Add an IEEE1588-capable network card to the "vplc_x1" interface from the Resource Manager in accordance with S101.
   - Open the "networkcard_allowlist" tab and click the plus sign in the "Allowed Devices" list.
   - Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".
   - To install the configuration, put a check mark in the checkbox at the top right of the field so that the field becomes green.
5. Click "Install(1)".



Updating the S7-1500 F Virtual Controller application or replacing the allow list by updating the configuration

If you want to update the S7-1500 F Virtual Controller app without a set-up central Virtual Timeservice and **not** replace the allow list in the process, follow these steps:

1. Select the new version of the "CPU1517VF" app under "Catalog" in "Edge Management".
2. Click "Update". (For all Edge devices on which no version of the "CPU1517VF" app is installed, "Install" is displayed)
3. Use "Next" to jump to the "Configuration" menu. The green check mark next to "networkcard_allowlist" must be cleared.

If you want to update the S7-1500 F Virtual Controller app or update the configuration and replace the allow list in the process, follow these steps:

1. In "My Installed Apps", click on the respective app and select "Update Configuration" in the menu.

   For an update of the app, select the new version of the "CPU1517VF" app under "Catalog" in "Edge Management".
2. Click "Update".
3. Click on the plus sign.
4. Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".
5. Set the green check mark to the left of "networkcard-allowlist".

6. Click "Next".
7. Select "Update Now".

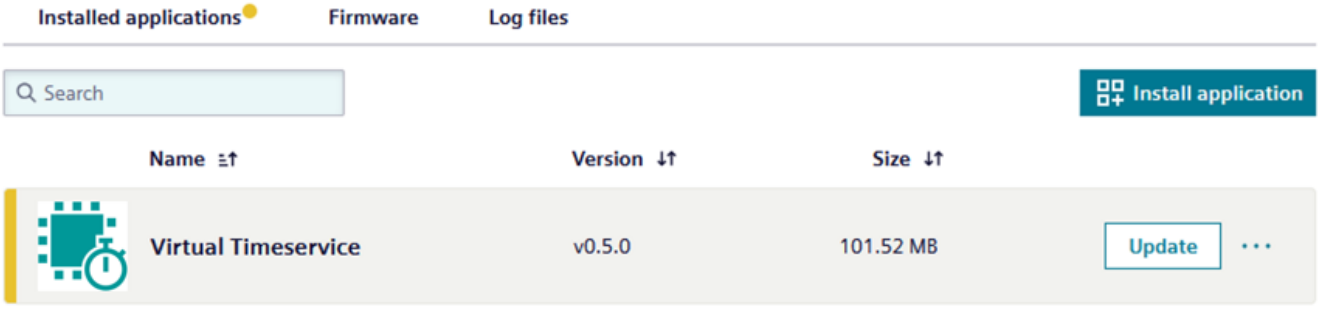
Note that when the configuration is updated, the allow list is only replaced after a STOP/START of the "CPU1517VF" app and not after a STOP/RUN of the S7-1500VF Virtual Controller.

If you are using the new UX of Edge via "new experience", follow these steps for an "Update Configuration":

1. Select the Edge device with your app in "Edge Management", under Devices.
2. Right-click on the three dots and select "Update Configuration".
3. Thereafter, follow the same procedure as for installing an app.
4. Click "Update(1)".

If you are using the new UX of Edge via "new experience", follow these steps for an "Update":

1. Select the Edge device with your app in "Edge Management", under Devices.
2. If there is an update available, you will see the "Update" button. Click "Update".
3. Thereafter, follow the same procedure as for installing an app.
4. Click "Update(1)".



NOTE

When you perform an Update Configuration, you need to stop and then restart the app for the configuration change to take effect.

2.3.1.2 Operating the S7-1500 F Virtual Controller with central Virtual Timeservice

Installation and setup of the Industrial Edge Virtual Timeservice application for forming a second time base for the S7-1500 F Virtual Controller

If you want to set up the Virtual Timeservice centrally for multiple S7-1500 F Virtual Controllers on a host with multiple S7-1500 F Virtual Controllers, observe the following:

- Install the Virtual Timeservice on a separate virtual Edge Device. You must not operate a Virtual Timeservice and an S7-1500 F Virtual Controller on the same virtual Edge Device.
- Connect all participating virtual Edge devices with an S7-1500 F Virtual Controller to the virtual Edge Device on which the central Virtual Timeservice has been installed and set up via a dedicated real-time capable network.
- This network should be used exclusively by the Virtual Timeservice for distributing the second time base.

- You can set up up to two central Virtual Timeservices for a dedicated network. To increase the availability of the system, you should set up two Virtual Timeservices.
- You must configure a separate IEEE1588-capable Ethernet interface or network card for each virtual time service in accordance with warning S101.
- Active PTP synchronization between the Virtual Timeservice and the S7-1500VF using, for example, boundary clock switches in the network can result in a connection abort and, thus, a STOP of the S7-1500VF. The active Virtual Timeservice ID indicated in the S7-1500VF can be changed by an active PTP-synchronizing component and consequently differ from the original Virtual Timeservice ID.

More information on setting up the Virtual Timeservice is provided in the "Virtual Timeservice App" Operating Manual.

Configuring a second network interface for the S7-1500 F Virtual Controller with a central Virtual Timeservice

For the S7-1500 F Virtual Controller to use the Virtual Timeservice as 2nd time base, follow these steps to configure network resources for the IEVD with the S7-1500 F Virtual Controller.

1. Open the "Settings" menu item in the IEVD web interface.
2. Go to the "Ressource Manager" tab.
3. To add a network, click on the plus sign to the right of "Isolatable Networks" under "Configuration".

   The new input fields appear at the end of the page (you may have to scroll down).
4. Under "Name", enter the name of the corresponding network interface.

   In "Annotations", right-click on the plus sign again to be able to assign a label for the interface.
5. For the S7-1500 F Virtual Controller with a Virtual Timeservice, create an additional entry for the provision of the 2nd time base next to the interface with label "vplc_x1".

   Assign the "virtual-timeservice" label to the interface to the real-time-capable network via which the time stamp is distributed and received by the S7-1500 F Virtual Controller
6. Click on "Submit" at the bottom to accept the entries.

Installing the S7-1500 F Virtual Controller application with central Virtual Timeservice

If you have set up a central Virtual Timeservice, install the app as described in the "Virtual Timeservice App" Operating Manual. Do not specify any additional network card under "Configurations" in the installation menu.

2.4 Configuring F-I/O

Introduction

You configure the S7-1500/ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200S, ET 200eco (S7-300, S7-400), ET 200eco PN, ET 200pro, ET 200iSP F-modules, the S7-300 F-SMs and the S7-1200 F-modules as usual in *STEP 7*.

After you have inserted the F-I/O in the work area of the *device or network view*, you access the configuration dialogs by selecting the relevant F-I/O and the "Properties" tab.

NOTE

Changes to the parameter assignment result in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

The ET 200SP F-modules can be used in distributed system with:

- IM 155-6 PN ST as of firmware V1.1
- IM 155-6 PN HF
- IM 155-6 PN/2 HF as of firmware V4.2
- IM 155-6 PN/3 HF as of firmware V4.2
- IM 155-6 MF HF
- IM 155-6 PN HS
- IM 155-6 DP HF
- IM 155-6 PN R1

  You can find information on whether operation with R1 is supported for an ET 200SP F-module on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

The distributed use of S7-1500/ET 200MP F-modules is possible with:

- IM 155-5 PN BA as of firmware V4.3
- IM 155-5 PN ST as of firmware V3.0
- IM 155-5 PN HF as of firmware V2.0
- IM 155-5 DP ST as of firmware V3.0

The central use of S7-1500/ET 200MP F-modules is possible with S7-1500 F-CPUs as of firmware V1.7, distributed use as of firmware V1.5.

(S7-1200 G1) We recommend you limit the total number of F-I/Os used centrally or distributed in an S7-1200 G1 F-CPU to 12. Depending on the volume of project data, the maximum number of F-I/Os can be smaller.

WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test (Page 390).
Examples for such changes are:

- Adding F-I/O
- Changing the start address of F-I/O
- Changing the slot position of F-I/O
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Channel-granular passivation after channel faults

You can configure how the F-I/O will respond to channel faults, such as a short-circuit, overload, discrepancy error, or wire break, provided the F-I/O supports this parameter (e.g. for ET 200S or ET 200pro F-modules). You configure this response in the properties for the relevant F-I/O ("Behavior after channel fault" parameter). This parameter is used to specify whether the entire F-I/O or just the faulty channel(s) are passivated in the event of channel faults.

NOTE

(S7-300, S7-400) Note that channel-granular passivation increases the runtime of the F-runtime group(s) compared to passivation of the entire F-I/O (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

"Channel failure acknowledge" parameter (S7-1200, S7-1500)

In the case of F-I/Os that support the "Channel failure acknowledge" channel parameter (for example S7-1500/ET 200MP F-modules, S7-1200 F-modules or ET 200AL F-modules), this function replaces the ACK_NEC tag of the F-I/O DB.

If an F-I/O fault is detected by the F-I/O, passivation of all channels of the relevant F-I/O occurs. If channel faults are detected, the relevant channels are passivated if "Passivate channel" is configured. If "Passivate the entire module" is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated, reintegration of the relevant F-I/O/the relevant channel occurs in line with the "Channel failure acknowledge" parameter.

- Automatically
- Manually

The parameter "Channel failure acknowledge" can be set individually for each channel with channel-granular passivation if "Adjustable" has been parameterized at the "Reintegration after channel fault" parameter.

⚠ WARNING

The parameter assignment "Channel failure acknowledge = Automatic" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint.*(S045)*

NOTE

The default assignment for the "Channel failure acknowledge" parameter when the F-module is created is "Manually".

Organization block/Process image (S7-1200, S7-1500)

If you use F-I/O in standard mode, you can select the organization block/process image as you do for standard I/O.

If you use F-I/O in safety mode, no selection is possible. The process image is always updated automatically at the beginning or end of the F-runtime group (see section Program structure of the safety program (S7-1200, S7-1500) (Page 110)).

Contrary to F-I/O operated in non-isochronous mode, you need to selected a process image partition, such as PIP 1 for F-I/O that is operated in isochronous mode (see "Configuring isochronous mode (S7-1200 G2, S7-1500) (Page 60)").

Changing the name and number of the F-I/O DB

For more information, refer to the section "Fail-safe I/O data block (Page 157)".

Customizing the F-monitoring time for F-I/O

You can customize the F-monitoring time in the properties of the F-I/O under "F-parameters". This may be necessary to prevent a timeout being triggered when no error occurs and the F-I/O requires a longer F-monitoring time or assignment with a default F-monitoring time is not possible. For this purpose, activate the corresponding check box and assign an F-monitoring time.

NOTE

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find more information in Monitoring and response times (Page 615).

Group diagnostics for fail-safe S7-300 signal modules

By disabling a channel of the fail-safe signal module in the module properties, you also disable the group diagnostics for this channel.

Exception for S7-300/400 F-CPUs:

For the following S7-300 fail-safe signal modules, the monitoring of channel-specific diagnostic messages (for example, wire break, short-circuit) from the F-SM to the F-CPU is enabled and disabled with the "Group diagnostics" parameter.

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13Bit (article number 6ES7336-1HE00-0AB0)

You should disable group diagnostics for **unused** input or output channels.

⚠ WARNING

(S7-300, S7-400) For the following S7-300 fail-safe signal modules (F-SMs) with activated safety mode, "Group diagnostics" must be enabled on all used channels:

- SM 326; DI 8 x NAMUR (article numbers 6ES7326-1RF00-0AB0 and 6ES7326-1RF01-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

(S003)

Diagnostic interrupts can be enabled optionally.

More information

For detailed description of the **parameters**, refer to the help on the properties of the respective F-I/O and in the respective *manual for the F-I/O*.

2.5 Configuration control (option handling) for F-I/Os

For configuration control (option handling) with F-I/Os proceed as with the standard I/O devices. Detailed information can be obtained by searching for "Configuration control (option handling)" in the help of *STEP 7*.

The following section describes what you have to observe additionally for F-I/Os.

Requirements

- The requirements that are specified under "Configuration control (option handling)" in the help of *STEP 7* are fulfilled.
- The requirements that are specified under "Configuration control (option handling)" in the help of *STEP 7* are fulfilled. Handle the F-I/O as standard I/O.
- V2.1 or higher is set as the safety system version.
- The F-I/Os for which you use the configuration control (option handling) are located
  - Distributed at an F-CPU S7-300/400/1200/1500
  - Centrally at an F-CPU S7-1500

  The PROFIsafe address of the F-I/Os are set or assigned.

NOTE

Only if the maximum configuration actually exists is assigning the PROFIsafe addresses (Page 70) possible.

Procedure

(S7-1200, S7-1500) Disable the F-I/Os not existing in the respective variant (option) by setting the DISABLE (Page 162) variable in the associated F-I/O DB (Page 157) to "1". This prevents the flashing of the error LED of the F-CPU and diagnostic entries of the safety program that reference these F-I/Os. With the DISABLED (Page 162) variable of the associated F-IO data block, you can evaluate whether an F-module is deactivated.

(S7-300, S7-400) To prevent the flashing of the error LEDs of the F-CPUs you do not have to observe anything further. You cannot suppress diagnostics entries.

⚠ WARNING

If configuration control is used, your actual configuration deviates from the configured maximum configuration. You identify F-I/Os that do not exist in the current option (station option) via control record as "not available".
If an F-I/O marked as "not available" is possibly nevertheless in the real system, it has to be ensured that substitute values (0) are provided for these F-I/Os in the safety program or output at the outputs. This is achieved by setting the DISABLE tag (S7-1200, S7-1500) or respectively PASS_ON tag (S7-300, S7-400) in the associated F-I/O DB to "1". *(S077)*

2.5.1 Example

Introduction

The following example shows how you to

- Select/detect a station option
- Deactivate F-I/Os that are not present in a station option (S7-1200, S7-1500)
- Provide your safety program for various station options

Safe selection/detection of the station option

You carry out a safe selection/detection of a station option with inputs of an F-I/O wired fixed to M/L+.

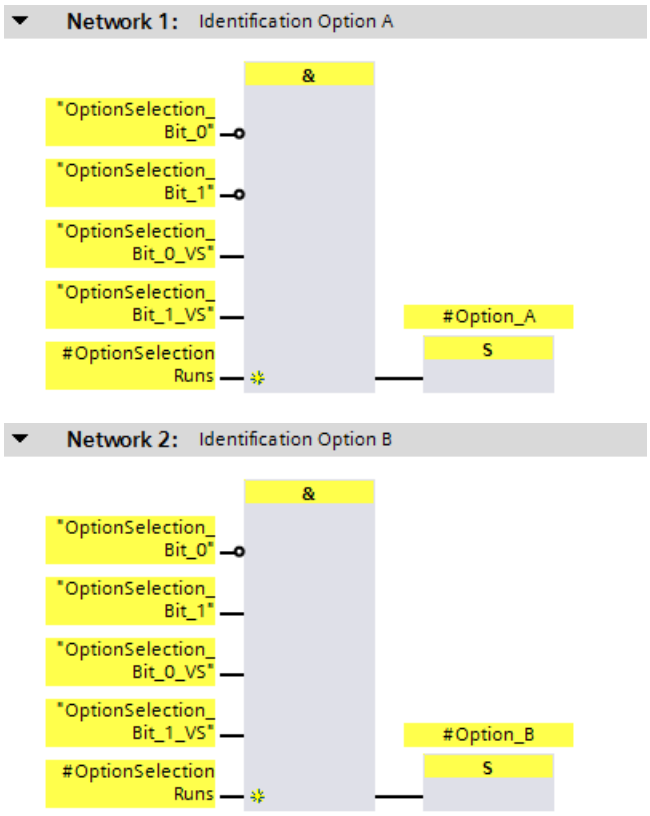
For example, you can select up to 4 station options with 2 inputs of an F-I/O.

Option	OptionSelection_Bit_0	OptionSelection_Bit_1
Q	0	0
B	0	1
C	1	0
D	1	1

Note when detecting the station option that substitute values (0) are used for the inputs of the F-I/O in certain situations, e.g. during startup of the F-system or when F-I/O channel errors occur.

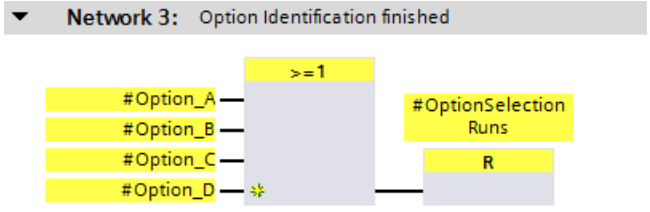
In these situations, the present station option cannot be detected. You should therefore also evaluate the value status of inputs and only apply the station option one-time after startup of the F-system.

For one-time recognition of the station option, define a static local datum, for example, OptionSelectionRuns with default value "TRUE".



Correspondingly for options C and D.

As soon as a station option is detected, reset the static local datum for one-time detection of the station option:



NOTE

When you make the selection/detection of a station option only in the standard user program, only the "Station option" is available to you as a standard datum that is not secured. Make sure that no dangerous states arise from this.

Read the section "Data exchange between standard user program and safety program (Page 192)".

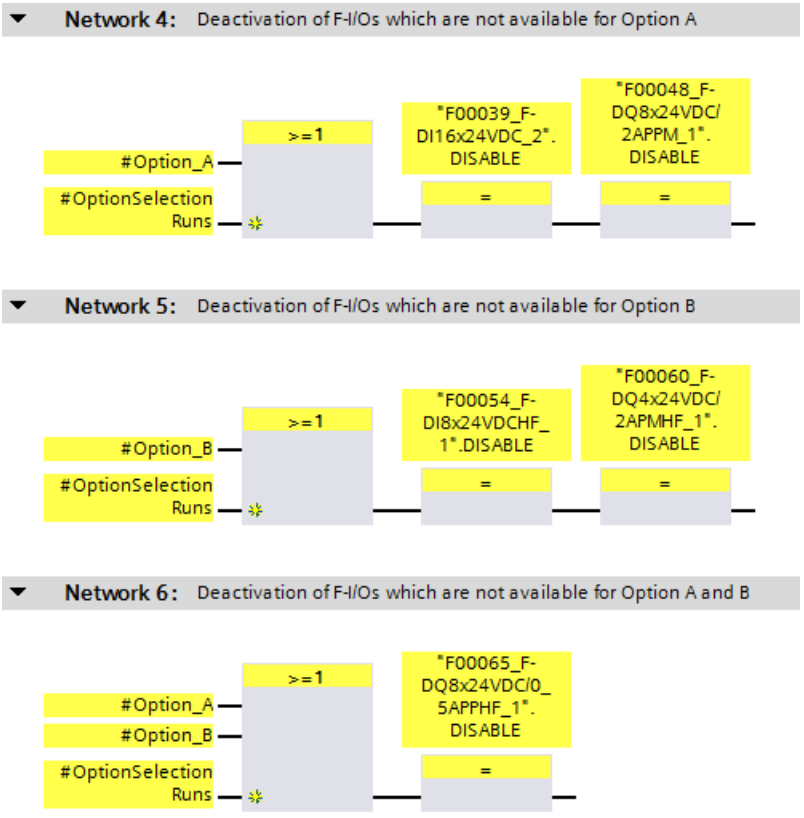
Disabling F-I/Os that are not present in a station option

If one or more F-I/Os are not present in a station option, you can prevent the blinking of the error LED of the F-CPU by disabling these F-I/Os.

In addition, diagnostic messages of the safety program that refer to these F-I/Os are suppressed.

NOTE

As long as the detection of the station option (during startup of the F-system) is not yet complete (OptionSelectionRuns = TRUE), you should disable all "optional" F-I/O devices.



Providing the safety program for various station options

In the following example, the EMERGENCY STOP signals of different plant units or machines are combined into a collective EMERGENCY STOP signal.

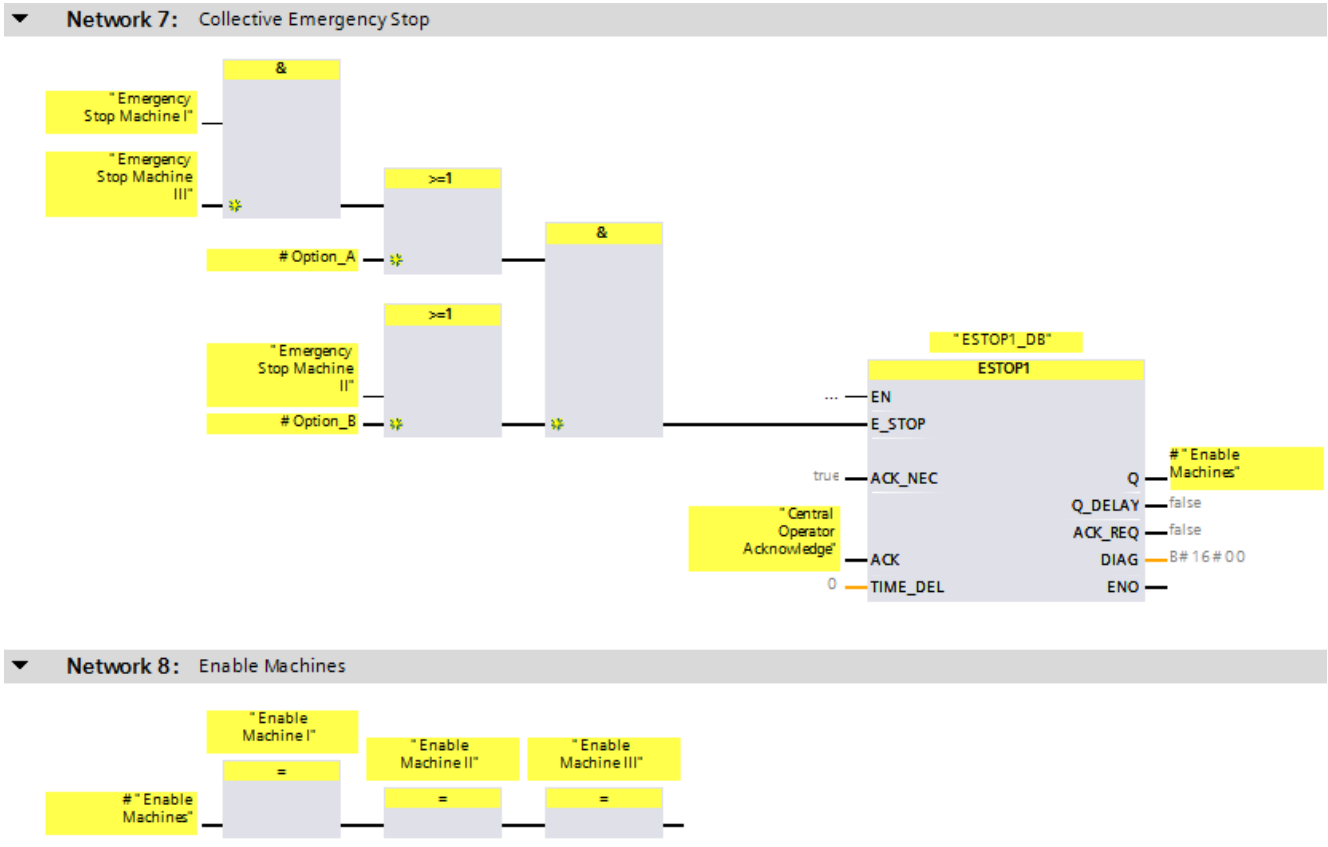
Machines I and III and the corresponding F-I/O with the EMERGENCY STOP signal for machines I and III are not present with station option A.

Machine II and the corresponding F-I/O with the EMERGENCY STOP signal for machine II is not present with station option B.

The substitute values (0) are therefore used in the safety program for the EMERGENCY STOP signals from the respective unavailable machines.

In order to prevent the collective EMERGENCY STOP from being triggered because machines / EMERGENCY STOP signals are not present with certain station options, you can suppress the

evaluation of the EMERGENCY STOP signal for unavailable machines by taking into account the present station option.



2.6 Configuring shared device

To configure shared devices follow the procedure as in the standard. The configuration is described in the *STEP 7* help under "Configuring shared devices" and in the function manual "PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856)" in the chapter "Shared Device".

F-destination addresses

Please also read the chapter "Recommendation for PROFIsafe address assignment (Page 61)" for assigning the F-destination address.

See also

Assigning PROFIsafe address to an F-module in a shared device in multiple projects (Page 75)
Assigning PROFIsafe address to an F-module in a shared device in a common project (Page 76)

2.7 Configuring isochronous mode (S7-1200 G2, S7-1500)

To configure isochronous mode for F-I/Os that support this mode, e.g. "Profisafe Telgr 902" submodule of the SINAMICS S120 CU310-2 PN V5.1 drive, proceed as in the standard. The configuration is described in the *STEP 7* help under "Configuring isochronous mode".

Note the following:

- Contrary to F-I/O operated in non-isochronous mode, you need to selected a process image partition, such as PIP 1 for F-I/O that is operated in isochronous mode.
  This process image partition must contain only F-I/O operated in isochronous mode and no standard I/O.
- The assigned isochronous mode interrupt OB must first be generated as F-OB by specifying a F-runtime group (see Procedure for defining an F-runtime group (S7-1200, S7-1500) (Page 134)). It is not possible to add an F-OB with event class "Synchronous Cycle" directly during the configuration of the isochronous mode.

Requirement

F-CPUs that support IRT.

Connection of F-I/O operated in isochronous mode to the isochronous mode interrupt OB

You access F-I/O operated in isochronous mode in the same way as you do standard I/O operated in isochronous mode, via the select process image partition.

Contrary to standard I/O that is operated in isochronous mode, the process image partition is updated by the F-system at the beginning or end of the F-OB (see Program structure of the safety program (S7-1200, S7-1500) (Page 110)).

No calling of the instructions SYNC_PI and SYNC_PO is required in the F-OB.

NOTE

With isochronously operated F-I/O, it is not ensured (fail-safe) that all input data of the F-I/Os assigned to the process image partition are consistently available at the beginning of the main safety block or all output data is transferred consistently to the F-I/Os, in other words, logically and temporally together. The consistency is only ensured within an F-I/O.
The consistency of all isochronous F-I/Os of the process image partition usually depends on the number of isochronous F-I/Os and the scope of the safety program in the isochronous mode interrupt OB.
If corresponding consistency requirements exist, you need to check the consistency of the input and output data yourself, e.g. by also transferring and evaluating time stamps in the input and output data of the isochronously operated F-I/O.

2.8 Recommendation for PROFIsafe address assignment

Before inserting the F-I/O, specify an address range for each F-CPU for the F-destination addresses of the F-I/O of PROFIsafe address type 1 (Page 65) that does not overlap with the address range of any other F-CPU network-wide or CPU-wide (system-wide). You define the range with the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" (see also section Configuring an F-CPU (Page 39)).

In a redundant S7-1500HF system, consider both F-CPUs of the redundant S7-1500HF system as one F-CPU with regard to the PROFIsafe addresses. The "Low/high limit for F-destination addresses" or the "Central F-source address" and, if present, the F-BaseID is therefore set identically by the system for both F-CPUs.

The F-destination addresses of F-I/O of PROFIsafe address type 2 (Page 66) must not overlap with any address range of the F-I/O of PROFIsafe address type 1. The ranges of the F-destination addresses of the F-I/O of PROFIsafe address type 2 may overlap if the F-source addresses are different. This is the case for supported configurations (Page 62) if the "Central F-source address" parameter has been set differently for each F-CPU.

If the F-BaseID was generated individually for each F-CPU by the TIA Portal for an F-I/O of PROFIsafe address type 3, its F-source addresses and/or F-destination addresses can overlap with those of the F-I/Os of F-address type 1 or 2 of any other F-CPUs as needed.

Assign relatively low F-destination addresses for F-I/O of PROFIsafe address type 1 and relatively high F-destination addresses for F-I/O of PROFIsafe address type 2 and 3.

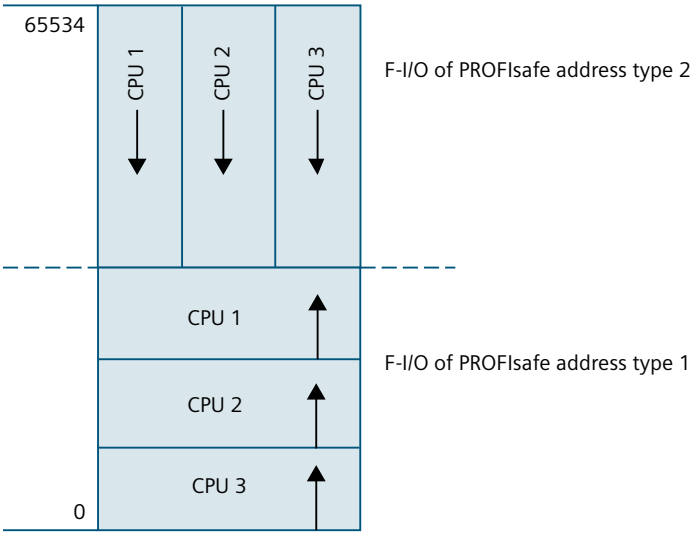


Figure 2-1 Address assignment for F-I/O of PROFIsafe address types 1 and 2

The safety summary (Page 409) lists the following information for each F-CPU:

- "Central F-source address" parameter (F-source address for F-I/O of PROFIsafe address type 2 and 3)
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 1
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 2
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 3

Any F-I/O configured using I-slave-slave communication is taken into account in the safety summary as part of the F-destination address range of the I-slave.

Any F-I/O configured in a shared device is indicated in the safety summary as part of the F-destination address range of the F-CPU to which this F-I/O is assigned.

2.9 Configurations supported by the SIMATIC Safety F-system

Supported configurations

F-I/Os (see Overview of Configuration (Page 33)) are supported in the following configurations:

Central configuration (also I-slave):

- The F-I/O is in the same rack as the associated F-CPU.
- The F-I/O is located in a subrack of the rack of the associated F-CPU.

Distributed configuration (at integrated DP-/PN interface of the CPU or at CP/CM):

- PROFIBUS DP (also after IE/PB link)
  - The F-I/O is located on a DP Slave.
  - The F-I/O is located on a DP Slave and is addressed via I-slave-slave communication. The assigned DP master (of the assigned IO controller of the IE/PB link) can be a standard CPU or an F-CPU.
- PROFINET IO
  - The F-I/O is located on an IO Device.
  - The F-I/O is located in a shared I-device.
  - The F-I/O is located in a shared device.

For a redundant S7-1500HF system the only supported configuration is:

Distributed configuration (at integrated PN interface of the HF-CPU)

- PROFIBUS DP after IE/PB link
  - The F-I/O is located on a DP slave
- PROFINET IO
  - The F-I/O is located in an IO device that is assigned to the IO systems of both F-CPUs.

    More information on IO devices for R1, S1 and S2 redundancy is available in the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856) in section "PROFINET with the redundant S7-1500R/H system".

For F-I/O not listed in "Overview of Configuration (Page 33)", check the relevant documentation to see whether it is supported by the SIMATIC Safety F-system. If in doubt, treat these F-I/Os as part of a configuration that is not supported.

Checks performed by the SIMATIC Safety F-system

For supported configuration, the F-system checks:

- Whether the PROFIsafe operating mode parameter (F_Par_Version) is set to V2 mode in the PROFINET IO environment**.
- Whether the F-destination addresses have been assigned uniquely CPU-wide.
  You yourself must ensure the network-wide uniqueness of the PROFIsafe address when using F-modules with F-PROFIsafe address type 1 and/or PROFIsafe address type 2 (see also "Recommendation for PROFIsafe address assignment (Page 61)")
- Whether the F-source address for F-I/O of PROFIsafe address types 2 and 3 corresponds to the "Central F-source address" parameter of the F-CPU.
- Whether the F-BaseID for F-I/O of PROFIsafe address type 3 corresponds to the "F-BaseID" parameter of the F-CPU.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

Not supported configurations

For configurations that are not supported, the TIA Portal cannot automatically check the parameter assignment of the F-I/Os. In addition, it is not assured that these have been captured in the safety summary. You must therefore observe the following warning:

⚠ WARNING

If you create a configuration that is not one of the supported configurations, you must observe the following in addition to the warnings S051, S052, S053 and S115:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/O in the PROFINET IO environment[1], you must check the safety summary for correctness of the PROFIsafe operating mode parameter (F_Par_Version). V2 mode must be set in the PROFINET IO environment. F-I/O that support only V1 mode must not be used in the PROFINET IO environment.
- Based on the safety summary, you must check whether the components of the PROFIsafe address centrally assigned for the F-CPU were transferred correctly into the respective F-I/Os:
  - PROFIsafe address type 3: F-BaseID from the "F-BaseID" parameter of the F-CPU.
  - PROFIsafe address type 2 and 3: F-source addresses from the "Central F-source address" parameter of the F-CPU.
- You must ensure the CPU-wide[2,3] and/or network-wide[4] unique assignment of the F-destination address for F-I/Os:
  - For F-I/O of PROFIsafe address type 1 or 2 (if you cannot set the F-source address to match the "Central F-source address" parameter of the F-CPU), you must ensure the network-wide[4] uniqueness of the PROFIsafe address through the unique assignment of the F-destination address alone.
  - In an unsupported configuration, you must check the uniqueness of the F-destination address individually for each F-I/O using the safety summary, regardless of the PROFIsafe address type.
    PROFIsafe address type 1: Network-wide[4] and CPU-wide[2,3]
    PROFIsafe address type 2 and 3: Only CPU-wide[2,3].

(S050)

1) The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

2) "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

3) In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

4) A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In

PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

2.10 PROFIsafe addresses for F-I/O of PROFIsafe address type 1

F-destination address

The uniqueness of the PROFIsafe address is ensured solely with the F-destination address. The F-source address is not displayed and has no effect on whether or not the PROFIsafe address is unique.

Therefore, the F-destination address must be unique network-wide and CPU-wide (see the following rules for address assignment).

To prevent incorrect parameter assignment, an F-destination address which is unique CPU-wide is automatically assigned during placement of the F-I/O in the work area of the device or network view as long as you only configure supported configurations (Page 62).

To ensure a network-wide unique F-destination address assignment when multiple DP master systems and PROFINET IO systems are operated on one network, you must set the "Low limit for F-destination addresses" and "High limit for F-destination addresses" in the properties of the F-CPU in SIMATIC Safety F-systems appropriately, before placing the F-I/O (see section "Recommendations for address assignment") so that the F-destination address ranges do not overlap.

When you change the F-destination address of an F-I/O, the CPU-wide uniqueness of the F-destination address is checked automatically for supported configurations. You yourself must ensure the network-wide uniqueness of the F-destination address.

For ET 200S, ET 200eco (PROFIBUS), ET 200pro, ET 200iSP F-modules and S7-300 F-SMs: You must set the F-destination address at the F-I/O with the DIP switch before you install the F-I/O. You can assign up to 1022 different F-destination addresses.

NOTE

(S7-300, S7-400) For the following fail-safe S7-300 signal modules, the F-destination address is the start address of the F-SM divided by 8:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You must check the F-destination addresses in the safety summary during system acceptance.

Rules for address assignment

⚠ WARNING

F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).
The F-destination address (and therefore also the switch position on the address switch) of the F-I/O of PROFIsafe address type 1 must be unique network-wide* and CPU-wide**/*** (system-wide) **for the entire** F-I/O. For this, the F-I/O of PROFIsafe address type 2 and PROFIsafe address type 3 when F-BaseID is inactive (value = 0) must also be taken into account. *(S051)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

Also note Recommendation for PROFIsafe address assignment (Page 61).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

See also

Completeness of the safety summary (Page 409)

2.11 PROFIsafe addresses for F-I/O of PROFIsafe address type 2

F-source address and F-destination address

The uniqueness of the PROFIsafe address is ensured by the combination of F-source address and F-destination address.

The PROFIsafe address must be unique network-wide and CPU-wide. This is the case if the following two conditions are met:

- The F-source address ("Central F-source address" parameter) of the F-CPU is unique network-wide. Keep this in mind for changes.
- The F-destination address of the F-module is unique CPU-wide.

You define the F-source address using the "Central F-source address" parameter in the F-CPU. Provided you only configure supported configurations (Page 62), this parameter is

automatically applied as the F-source address and a CPU-wide unique F-destination address is assigned (usually in descending order starting with 65534).

For supported configurations, if you change the F-destination address, then the CPU-wide uniqueness of the F-destination address is checked automatically.

You must assign the F-source address and F-destination address to the F-I/O before you commission the F-I/O. You can find more information in Assigning a PROFIsafe address of the F-I/Os with SIMATIC Safety (Page 70).

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You must check the F-source and F-destination addresses in the safety summary during system acceptance.

Rules for address assignment

⚠ WARNING

F-I/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.

The combination of F-source address and F-destination address for each F-I/O of PROFIsafe address type 2 must be unique network-wide* and CPU-wide**/*** (system-wide). In addition, the F-destination address must not be occupied by F-I/O of PROFIsafe address type 1.

If you use a supported configuration (Page 62), you only have to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

Also note Recommendation for PROFIsafe address assignment (Page 61).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

See also

Completeness of the safety summary (Page 409)

2.12 PROFIsafe addresses for F-I/O of PROFIsafe address type 3

Introduction

As well as the F-source address and F-destination address, F-I/Os of the PROFIsafe address type 3 have an additional address named the F-BaseID.

NOTE

The terminology "PROFIsafe address type 3" used in this documentation is equivalent to the designation "PROFIsafe address type 2 with BaseID". This applies in TIA Portal as well as to F-I/Os.

This F-BaseID is a 64-bit number, which is valid centrally for all F-I/Os of PROFIsafe address type 3 of an F-CPU and must be randomly generated and evenly distributed by a generator. The TIA Portal has these generators so that you can easily generate an F-BaseID.

The advantage of the F-BaseID is that, for F-I/Os with PROFIsafe address type 3, you do not need to worry about uniqueness within the network and CPU. Network boundaries are irrelevant, so you do not need network isolators (e.g. SCALANCE SC622-2C) in systems in which only F-I/Os with F-address type 3 are used. Due to its 64-bit size and its generation as an evenly distributed random number, the F-BaseID is sufficiently likely to be unique worldwide.

You no longer need to manage or coordinate the PROFIsafe addresses of your plant for F-I/Os with PROFIsafe address type 3 to guarantee that they are unique network-wide. The TIA Portal ensures that the F-destination addresses are unique CPU-wide (for supported configurations (Page 62)). Therefore, you only need to generate a new F-BaseID.

Delayed transfer

Another advantage of the F-BaseID is the "delayed transfer" property. With this, you can have the F-BaseID generated in the user program on an F-CPU on the first startup. In this way, you can create series machine programs that you distribute to multiple F-CPUs by simply copying SD cards. *STEP 7 Safety* offers specific instructions, which are described in the appendix "Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 629)", to generate the F-BaseID in the user program.

Requirements for using the F-BaseID

The F-BaseID is supported for S7-1200 G2 F-CPUs and S7-1500 F-CPUs as of firmware V4.1 or F-Software Controllers as of V40.1. Safety system version V2.8 or higher must also be set in the *Safety Administration Editor*.

To find out which F-modules support the F-BaseID, refer to the respective equipment manual.

Generation of the F-BaseID

To have an F-BaseID generated, press the "Generate F-BaseID" button in the "F-BaseID for PROFIsafe address type 3" section in the "Fail-safe" area of the properties of an F-CPU.

⚠ WARNING

The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.
With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

You can also generate the F-BaseID using tools outside of the TIA Portal and then assign it manually. However, observe the following warning in this case:

⚠ WARNING

Only use generation tools with which you can track adherence to the PROFIsafe generation rules, e.g. based on the documentation. The TIA Portal tools comply with these rules. *(S116)*

If you select the "Activate delayed transfer of F-BaseID" option, a specific value (0x7C6) is set for the F-BaseID which informs the F-CPU and all F-I/Os (of PROFIsafe address type 3) assigned to it that the F-BaseID will be determined and possibly re-generated on startup of the F-CPU. It is not possible to operate the F-I/Os with this F-BaseID (0x7C6). You can find more information on this in the appendix "Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 629)".

Rules for address assignment

In a homogeneous network in which all F-I/O have PROFIsafe address type 3 and a generated F-BaseID, the following conditions must be met:

- The F-destination address of the F-module is unique CPU-wide.
- The F-BaseID has been generated individually for the F-CPU according to the requirements of the PROFIsafe specification.

The F-destination address is automatically assigned uniquely CPU-wide for supported configurations by the TIA Portal (normally in descending order from 65534) and there is an automatic check that the F-destination address is unique CPU-wide in the event of changes. If you have the F-BaseID generated in the TIA Portal, the requirements of the PROFIsafe specification are adhered to.

⚠ WARNING

If you are uncertain whether the F-BaseID is unique, generate a new F-BaseID. *(S117)*

Note that F-I/Os of PROFIsafe address type 3 with inactive F-BaseID (value = 0) should be viewed the same as F-I/Os of PROFIsafe address type 2.

In a heterogeneous network with F-I/O of PROFIsafe address types 2 and 3, the F-source address ("Central F-source address" parameter) of the F-CPUs ensures that the PROFIsafe addresses are unique network-wide. Therefore, for the F-I/Os of PROFIsafe address type 3, you can use the F-BaseID with the value "0", but you must consider the network boundaries and the conditions for the F-destination address (see warning S052) for PROFIsafe address type 2. To be future-proof, generate an F-BaseID for the F-I/Os of PROFIsafe address type 3.

We recommend that you generate the F-BaseID directly before downloading the fail-safe project data to a productive system for the first time. In general, you are prompted at this time for the serial number of the productive F-CPU, and the PROFIsafe addresses of the F-I/Os of PROFIsafe address type 2 and 3 are not yet assigned. If you assign them after downloading, the newly generated F-BaseID is automatically also assigned.

Even with a generated F-BaseID, uniqueness is not automatically guaranteed. For example, when copying a TIA project or an SD card with loaded fail-safe project data, the F-BaseIDs contained therein are also copied. It is your responsibility to generate new F-BaseIDs in each copy after the copying in order to restore their uniqueness.

⚠ WARNING

For copy operations that also copy the value of the F-BaseID, e.g. copying the project or copying the SD card, we strongly recommend generating a new F-BaseID. Otherwise, you must ensure the uniqueness of the PROFIsafe addresses for F-I/Os in another way. *(S114)*

Projects in which you have activated the delayed transfer for the F-BaseID are an exception. In these projects, a valid F-BaseID is generated using the instructions made available by the TIA Portal on the first startup of the F-CPU. You can copy the SD card as much as you like before this first startup. Copying the TIA Portal project data is also possible later. Therefore, the delayed transfer is especially suitable for creating series machines.

2.13 Setting the F-destination address for F-I/O with DIP switches

Information on how to set the F-destination address for F-I/O with DIP switches is available in the documentation of the respective F-I/O.

2.14 Assigning a PROFIsafe address of the F-I/Os with SIMATIC Safety

Introduction

You assign the PROFIsafe address of PROFIsafe address type 2 (Page 66) or PROFIsafe address type 3 (Page 68), consisting of F-source address and F-destination address and, optionally for PROFIsafe address type 3, the F-BaseID for the following F-I/Os directly from *STEP 7 Safety*:

- ET 200SP fail-safe modules
- ET 200SP HA fail-safe modules
- S7-1500/ET 200MP fail-safe modules
- ET 200AL fail-safe I/O modules
- ET 200eco PN fail-safe I/O modules

Refer to the equipment manual of the respective F-I/O for the exact PROFIsafe address type.

The PROFIsafe addresses for S7-1200 F-modules are automatically assigned during download of the hardware configuration.

None of these F-I/O modules have a DIP switch for setting the unique F-destination address for each module.

A new assignment is required for the F-modules mentioned above in the following situations:

- Later placement of a fail-safe module during initial commissioning (not for ET 200eco PN)
- Intentional modification of the F-destination address
- Modification of the "Central F-source address" parameter for the associated F-CPU (changes the F-source address).
- Modification of the "F-BaseID" parameter of the associated F-CPU
- Replacement of the electronic coding element
- Commissioning of a mass-produced machine

In the following cases, a reassignment is not required for fail-safe ET 200SP modules, fail-safe ET 200SP HA modules and fail-safe S7-1500/ET 200MP modules:

- POWER OFF/POWER ON
- Replacement of an F-module (repair) without PG/PC
- Replacement of the BaseUnit (transfer of electronic coding element with assigned F-source address and F-destination address and, if present, F-BaseID to the new BaseUnit)
- Replacement of a BaseUnit without electronic coding element
- Changes in the design in case a new BaseUnit is inserted in front of a fail-safe module
- Repair/replacement of the interface module

Reassignment is not required for fail-safe ET 200eco PN and ET 200AL I/O modules in the following cases:

- POWER OFF/POWER ON
- Replacement of the compact device (transfer of electronic coding element with assigned F-source address and F-destination address and, if present, F-BaseID to the new compact device)

Basic procedure

NOTE

Assigning the PROFIsafe address for S7-1200 fail-safe modules

The procedure described below for identifying and assigning the PROFIsafe addresses is not required for S7-1200 fail-safe modules.

Note that an S7-1200 must not include an additional unconfigured F-module.

1. Set the F-destination address (Page 66) and F-source address (Page 66) and, optionally for F-I/Os of PROFIsafe address type 3, the F-BaseID (Page 68) in the hardware configuration in *STEP 7 Safety*.
2. Identify the F-modules ET 200SP, ET 200SP HA, S7-1500/ET 200MP, F-I/O modules ET 200AL or F-I/O modules ET 200eco PN to which you want to assign the PROFIsafe address.
3. Assign the PROFIsafe address to the F-I/Os.

Assigning the PROFIsafe address for F-I/Os via a redundant S7-1500HF system

In the "Assign PROFIsafe address" dialog under "Select PLC of HF-System", select the HF-CPU of the redundant S7-1500HF system via which you want to assign the PROFIsafe address.

The following table uses the system status to show you via which HF-CPU of the redundant S7-1500HF system you can assign the PROFIsafe address.

System status/F-CPU role	Primary	Backup
RUN-Redundant	x	x
RUN-Solo	x	-
STOP	x	-

x: Assignment possible, -: Assignment not possible

NOTE

Use of R1 devices

Assigning the PROFIsafe address for F-I/Os in an R1 device is only possible via the left interface module of the R1 device. Therefore, the left interface module is always displayed in the "Assign PROFIsafe address" dialog. The left interface module must be supplied with voltage for the assignment of the PROFIsafe address.

If the two HF-CPUs of the redundant S7-1500HF system are located in two separate subnets, the PG and the HF-CPU via which the assignment of the PROFIsafe address is to be performed must be located in the same subnet.

2.14.1 Identifying F-modules

Requirement

The following requirements must be met:

- The F-CPU and fail-safe modules are configured.
- When using an ET 200SP Open Controller, the hardware configuration of the ET 200SP Open Controller **and** of the fail-safe Software Controller must be downloaded.
- The F-CPU and fail-safe modules can be reached online.

⚠ WARNING

Make sure that the latest hardware configuration has been downloaded to the F-CPU before identification. By clicking the "Identification" button and then clicking on "Assign PROFIsafe address", you confirm the correctness of the PROFIsafe addresses for the F-I/Os.
Therefore, proceed carefully when confirming the F-I/Os by LED flashing or the serial number of the F-CPU with central F-I/Os or the serial number of the interface module with F-I/Os.
To do this, you must read and write down the serial number directly at the F-CPU* or the interface module**. Reading out the serial number via the online and diagnostics view of the TIA Portal is not permitted.
With F-I/O of PROFIsafe address type 3, you need to confirm the assignment by flashing or serial number even if you have only changed the F-BaseID.
A special rule applies for F-I/Os of the ET 200AL distributed I/O system. For these F-I/Os, only identification by LED flashing is permissible and only exactly one F-I/Os at a time may be selected for assignment of the PROFIsafe address.
* When an ET 200SP Open Controller is used, you must read and write down the serial number from the display of the S7-1500 Fail-safe Software Controller in menu "Overview > CPU".
** When an R1 device is used, you must read and write down the serial number of the left interface module. *(S046)*

Procedure

Proceed as follows to identify the F-modules:

1. Establish an online connection to the F-CPU to which the F-modules are assigned.
2. In the network view, select
   - the F-CPU with F-modules,
   - the interface module with F-modules,

   to which you want to assign PROFIsafe addresses.
   Alternatively, you can select only a single F-module.

3. Select "Assign PROFIsafe address" from the shortcut menu.

   NOTE
   If you integrate a fail-safe ET 200AL module into a configuration of the ET 200SP distributed I/O system (mixed configuration ET 200AL/ET 200SP with ET connection), you must open the dialog "Assign PROFIsafe address" in the device view of the ET 200SP separately for each fail-safe ET 200AL module.

4. Under "Assign PROFIsafe address by", select the method to be used for identifying the F-modules.
   – "Identification by LED flashing"
     This is the default setting. The DIAG and STATUS LEDs of the F-modules to be identified flash upon identification.
   – "Identification by serial number"
     If you cannot see the fail-safe modules directly, you can identify the fail-safe modules by the noted serial number of the F-CPU or interface module.

     NOTE
     The displayed serial number may be amended with a year number compared to the serial number printed on the F-CPU or the interface module. The serial numbers are nevertheless identical.

5. With identification in the "Assign" column, select all F-modules to which you want to assign the PROFIsafe address.
   If you select the F-CPU or the interface module in the "Assign" column, all F-modules of the station are selected.

   NOTE
   For F-I/Os of PROFIsafe address type 3 for which the F-BaseID is set to "Delayed transfer", there can be no identification or assignment (see section PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68)). For identification and assignment of the F-source address and F-destination address only, the value "0" must be configured and downloaded for the F-Base ID of these F-I/Os.

6. Click the "Identification" button. Check whether the DIAG and STATUS LEDs for the F-modules whose PROFIsafe address you want to assign are flashing green. If you identify using the serial number, compare the displayed serial number to the noted serial number of the F-CPU with central fail-safe modules or the interface module with fail-safe modules.
   Observe the following behavior for certain F-modules and configuration variants:
   – If you have configured more F-modules than actually exist, a dialog is displayed. In this dialog, enter the number of F-modules actually existing and confirm the dialog.
   – If you have configured fewer F-modules than are actually available, an online-offline difference is shown and the assignment of the PROFIsafe address is not possible.

2.14.2 Assign PROFIsafe address

Requirement

The F-modules have been successfully identified.

Procedure

To assign a PROFIsafe address, proceed as follows:

1. In the "Confirm" column, select all the F-modules to which you want to assign the PROFIsafe address.
2. Use the "Assign PROFIsafe address" button to assign the PROFIsafe address to the fail-safe modules. You may have to enter the password of the F-CPU or need the user right "Full access including fail-safe".

   To assign the PROFIsafe address, you must confirm the "Confirm PROFIsafe address assignment" dialog within 60 seconds.

2.14.3 Assigning PROFIsafe address to an F-module in a shared device in multiple projects

Introduction

The assignment of the PROFIsafe address for a F-module in a shared device in different projects can only take place after the selection of the IO Controller (F-CPU) to which the F-module is assigned

Therefore, only the F-modules that are assigned to an IO controller (F-CPU) of this project can be selected for assigning the PROFIsafe address in the "Assign PROFIsafe address" dialog.

Requirement

The following requirements must be met:

- All requirements from the sections "Identifying F-modules (Page 73)" and "Assign PROFIsafe address (Page 75)".
- The hardware configuration of all IO controllers (F-CPUs) to which an F-module from the shared device has been assigned is loaded.
- All IO controllers (F-CPUs) to which an F-module from the shared device has been assigned and the shared device must be located in the same subnet.

Procedure

To identify the F-modules and assign the PROFIsafe address, proceed as described in sections "Identifying F-modules (Page 73)" and "Assign PROFIsafe address (Page 75)".

If the F-modules in a shared device are assigned to several IO controllers (F-CPUs) in different projects, make the assignment from the different projects one after the other.

See also

Configuring shared device (Page 59)

2.14.4 Assigning PROFIsafe address to an F-module in a shared device in a common project

Introduction

The assignment of the PROFIsafe address for a F-module in a shared device in a common project can only take place after the selection of the IO Controller (F-CPU) to which the F-module is assigned.
Therefore, only the F-modules that are assigned to the selected IO controller (F-CPU) can be selected for assigning the PROFIsafe address in the "Assign PROFIsafe address" dialog.

Requirement

The following requirements must be met:

- All requirements from the sections "Identifying F-modules (Page 73)" and "Assign PROFIsafe address (Page 75)".
- The hardware configuration of all IO controllers (F-CPUs) to which an F-module from the shared device has been assigned is loaded.
- All IO controllers (F-CPUs) to which an F-module from the shared device has been assigned and the shared device must be located in the same subnet.

Procedure

To identify the F-modules and assign the PROFIsafe address, proceed as described in sections "Identifying F-modules (Page 73)" and "Assign PROFIsafe address (Page 75)".

If the F-modules in a shared device in a common project are assigned to several IO controllers (F-CPUs), select an IO controller in the "Assign PROFIsafe address" dialog and first carry out the assignment for the F-modules that are assigned to the selected IO controller.
Subsequently you select further IO controllers and proceed accordingly.

See also

Configuring shared device (Page 59)

2.14.5 Changing the PROFIsafe address

Changing the PROFIsafe address

NOTE

Keep in mind that after changing the PROFIsafe address of an F-I/O you must also carry out an acceptance (Page 412) including a check of your change (Page 427) in the safety summary (Page 382).

1. Change the PROFIsafe address (F-destination address, F-source address and, if present, F-BaseID) in the hardware configuration.
2. Compile the hardware configuration.
3. Download the hardware configuration to the F-CPU.
4. Select "Assign PROFIsafe address" from the shortcut menu.
5. Proceed as described under Identifying F-modules (Page 73) and Assign PROFIsafe address (Page 75).

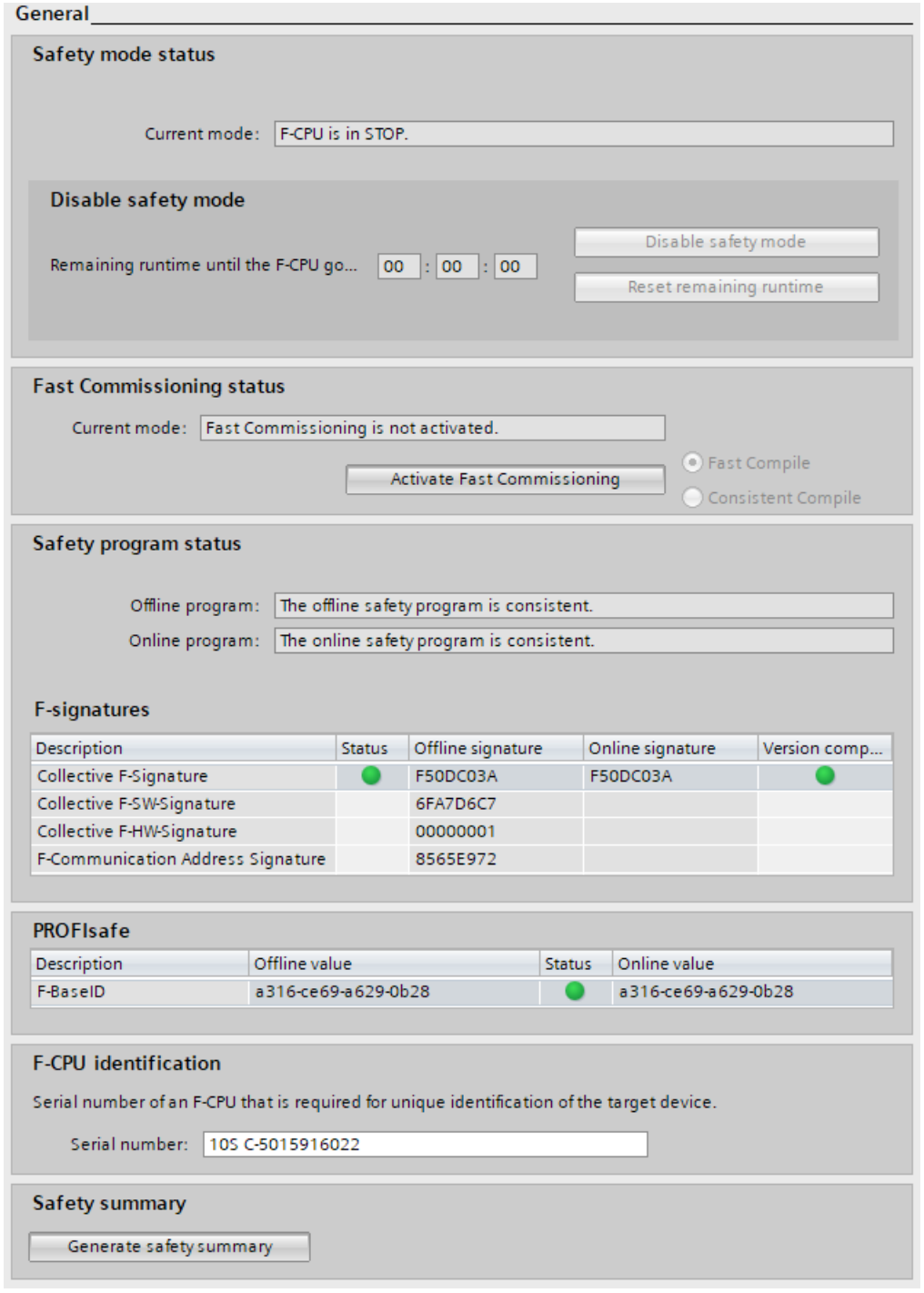
Safety Administration Editor

3

Overview

The *Safety Administration Editor* supports you as follows:

- Displaying of status of safety mode
- Disabling safety mode
- (S7-1200, S7-1500) Displaying and changing the Fast Commissioning Status
- Displaying of status of the safety program
- Displaying of Collective F-Signature
- (S7-1200, S7-1500) Show Collective F-SW-Signature
- (S7-1200, S7-1500) Show Collective F-HW-Signature
- (S7-1200, S7-1500) F-communication address signature
- (S7-1200 G2 as of firmware V4.1, S7-1500 as of firmware V4.1, S7-1500 F Software Controller as of V40.1) Display F-BaseID
- (S7-1200, S7-1500) Specify/change serial number for F-CPU identification
- Creating a safety summary
- Creating and organizing of F-runtime groups
- Displaying information on the F-blocks
- Displaying information about F-compliant PLC data types (UDT)
- Specifying/changing access protection
- (S7-1200 G1, S7-1500) Information for users with F-Admin permission
- Set/modify settings for the safety program, e.g. Enable F-change history
- (S7-1200, S7-1500) Create/display/delete F-communications via Flexible F-Link


General
Safety mode status
Current mode:
F-CPU is in STOP.
Disable safety mode
Remaining runtime until the F-CPU go...
00 : 00 : 00
Disable safety mode
Reset remaining runtime
Fast Commissioning status
Current mode:
Fast Commissioning is not activated.
Activate Fast Commissioning
Fast Compile
Consistent Compile
Safety program status
Offline program:
The offline safety program is consistent.
Online program:
The online safety program is consistent.
F-signatures
Description
Status
Offline signature
Online signature
Version comp...
Collective F-Signature
F50DC03A
F50DC03A
Collective F-SW-Signature
6FA7D6C7
Collective F-HW-Signature
00000001
F-Communication Address Signature
8565E972
PROFIsafe
Description
Offline value
Status
Online value
F-BaseID
a316-ce69-a629-0b28
a316-ce69-a629-0b28
F-CPU identification
Serial number of an F-CPU that is required for unique identification of the target device.
Serial number:
10S C-5015916022
Safety summary
Generate safety summary

The *Safety Administration Editor* is divided into the following areas:

- General

  Under "General" the following is displayed:

  – Safety mode status
  – Fast Commissioning Status
  – Safety program status
  – F-signatures
  – PROFIsafe
  – F-CPU identification
  – Safety summary

  More information on the "General" area can be obtained in ""General" area of the Safety Administration Editor (Page 81)".
- F-runtime group

  You define the blocks and properties of an F-runtime under "F-runtime group".

  You can find information on F-runtime groups at ""F-runtime group" area (Page 85)".
- F-blocks

  Under "F-blocks", you can find information on the F-blocks used in your safety program and their properties . More information on the "F-blocks" area can be obtained in ""F-blocks" area of the Safety Administration Editor (Page 86)".
- F-compliant PLC data types

  Under "F-compliant PLC data types", you obtain information on the created F-compliant PLC data types (UDT). There you also obtain information whether or not an F-compliant PLC data type (UDT) is used in the safety program. More information on "F-compliant PLC data types" can be found in ""F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 88)".
- Access protection

  Under "Access protection", you can set up, change, or revoke the password for the safety program. Alternatively, you can set up access protection for safety-related project data via project protection. Access protection is mandatory for productive operation. More information on access protection can be found in "CPU-wide access protection for the safety-related project data (Page 97)".
- Web server F-Admins

  Under "Web server F-admins", you obtain information on users with the F-Admin attribute for the Web server of the F-CPU. More information on the "Web server F-Admins" area can be obtained in ""Web server F-admins" area of the Safety Administration Editor (S7-1200 G1, S7-1500) (Page 88)".
- Settings

  Under "Settings", you set the parameters for the safety program. Information on the settings for your safety program can be found in ""Settings" area of the Safety Administration Editor (Page 89)".
- Flexible F-Link

  In the "Flexible F-Link" area, you will find information about the configured F-communications via Flexible F-Link in tabular form and create F-communications. You can obtain information at ""Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 94)".

See also

Program structure of the safety program (S7-1200, S7-1500) (Page 110)
Program structure of the safety program (S7-300, S7-400) (Page 108)
Defining F-Runtime Groups (Page 129)

3.1 Opening the Safety Administration Editor

Requirement

The *Safety Administration Editor* is visible as an element in the project tree, if you have configured a CPU as an F-CPU in the project, which means the "F-capability activated" option must be selected (in the properties of the F-CPU).

Procedure

To open the *Safety Administration Editor*, follow these steps:

1. Open the folder for your F-CPU in the project tree.
2. Double-click on "Safety administration" or right-click and select the corresponding shortcut menu for the *Safety Administration Editor*.

Result

The *Safety Administration Editor* for your F-CPU opens in the work area.

3.2 "General" area of the Safety Administration Editor

"Safety mode status"

The "Safety mode status" shows the current status of safety mode. The prerequisite is an existing online connection to the selected F-CPU.

The following statuses are possible:

- "Safety mode is activated"
- "The safety mode is not activated"
- "F-CPU is in STOP"
- "No active F-CPU available"
- "F-runtime group was not called"
- "The safety program is not called"
- "(No online connection)"

"Disable safety mode"

For existing online connection and active safety mode operation, you have the option of using the "Disable safety mode" button to disable safety mode for the selected F-CPU. Safety mode can be deactivated only for the entire safety program and not for individual F-runtime groups.

As of Safety system version V2.4, disabled Safety mode for S7-1200/1500 F-CPUs is time-limited.

To use Fast Commissioning mode, make sure that the option "Safety mode can be disabled" is selected in the "Settings" area (Page 89).

For more information, refer to the section "Disabling safety mode (Page 386)".

"Fast Commissioning Status"

To use the Fast Commissioning mode, make sure that the option "Safety mode can be disabled" is selected in the "Settings" area (Page 89) and that the safety program was compiled consistently. The Fast Commissioning mode can be executed with "Fast Compile" (default setting) or with "Consistent Compile". For more information, refer to the section "Safety program in RUN mode (S7-1200, S7-1500) (Page 399)".

"Safety program status"

"Safety program status" displays the current status of your online and offline program.

The following statuses are possible:

- Consistent

  With information if no password has been assigned. This information does not apply when project protection is used.
- Inconsistent
- Modified
- Fast Commissioning mode is active

  If Fast Commissioning mode was activated with "Fast Compile" and a change was made in the program.
- (No online connection)

  If no connection to the online program could be established.

"F-signatures"

When no online connection exists

Under "F-signatures" multiple signatures are displayed. Each signature is formed from different parts of the fail-safe project data.

- Collective F-Signature: This signature changes with each change of the fail-safe project data. It can contain the signatures described below.
- Collective F-SW-Signature (S7-1200, S7-1500): This signature changes with each change of the safety program.

- Collective F-HW-Signature (S7-1200, S7-1500): This signature changes with each change of the fail-safe HW configuration.
- F-Communication address signature (S7-1200, S7-1500): This signature changes with each change of the name or the F-communication UUID of communication connections with Flexible F-Link.

Note that the F-BaseID does not enter into the Collective F-HW-Signature or the Collective F-Signature.

The time of the last compilation process is displayed for the Collective F-Signature in the "Time stamp" column.

When an online connection exists

For an existing online connection, the following is displayed under the "Program signature":

- The status of safety program

Status	Meaning
	The online and offline Collective F-Signatures match.
	The online and offline Collective F-Signatures *do not* match.
—	The safety program status could not be determined.

- The online and offline Collective F-Signatures
- When the Collective F-Signatures match: Information on whether the F-block versions are consistent online and offline.

Status	Version comparison	Statement
	Not relevant	The online and offline Collective F-Signatures *do not* match.
		The online and offline Collective F-Signatures match, but the online versions of F-blocks differ from the offline versions.
		The online and offline Collective F-Signatures match, identical versions of F-blocks are being used online and offline.
Not relevant	—	The safety system versions could not be determined.

You can find more information on the consistency of the online safety program at under Identity of online and offline program (Page 424).

"PROFIsafe" (S7-1200 G2, S7-1500)

When no online connection exists

The F-BaseID is displayed under "PROFIsafe". It applies to all F-I/Os of PROFIsafe address type 3 (Page 33) assigned to the F-CPU. The F-BaseID allows a clear differentiation to be made between F-I/Os of PROFIsafe address type 3 having the same F-source address and F-destination address.

More information on the F-BaseID can be found in section "Configuring an F-CPU (Page 39)".

For S7-1200/1500 F-CPUs that do not support the F-BaseID, this area is grayed out.

When an online connection exists
When an online connection exists, the following is also displayed under "PROFIsafe":

Table 2-1 Status of the F-BaseID

Status	Meaning
	The online and offline F-BaseIDs match.
	The online and offline F-BaseIDs do *not* match.
	The F-BaseID could not be determined online or is not supported.

The online-offline comparison of the F-BaseID does not enter into the status of the "General" area.

"F-CPU identification" (S7-1200, S7-1500)

The serial number of the F-CPU to which the safety program is to be downloaded is entered under "F-CPU identification". This serial number is used to ensure connection to the correct F-CPU in the network. If the serial number is not entered at the time of download to the F-CPU, you must confirm it in the "Load preview" dialog to be able to continue the download. The confirmed serial number is then automatically entered in this field.

"Safety summary"

Under "Safety summary", you have the option to create the safety summary (Page 382) for the F-CPU.

See also

Program identification (Page 378)

3.3 "F-runtime group" area of the Safety Administration Editor

3.3.1 "F-runtime group" area

A safety program consists of one or two F-runtime groups.

General information on F-runtime groups can be found in "Program structure of the safety program (S7-300, S7-400) (Page 108)" and "Program structure of the safety program (S7-1200, S7-1500) (Page 110)".

You can find information on creating F-runtime groups at Defining F-Runtime Groups (Page 129)

(S7-1200, S7-1500) "Creating a global F-I/O status block"

You can create a standard block (FB) with the name "RTGx_GLOB_FIO_STATUS", which evaluates whether substitute values are output instead of process values for at least one F-I/O or at least one channel of an F-I/O of an F-runtime group x. The result of the evaluation is available at the "QSTATUS" output.

The following are not included:

- F-I/O that you disabled with the DISABLE tag in the F-I/O DB.
- Channel error of channels that you disabled when configuring an F-I/O.

The "RIOforFA_VALUE_STATUS" output is set to "1" if no substitute value is output for **any** F-I/O **with "RIOforFA-Safety"** profile of the F-runtime group x.

To generate this standard FB, you use the "Create global F-I/O status block" button. You can only create the standard FB when your safety program has been compiled. You can call the standard FB anywhere in your standard user program.

NOTE

When adding or deleting an F-I/O, you have to generate "RTGx_GLOB_FIO_STATUS" again.

See also

Process Data or Fail-Safe Values (Page 155)

3.3.2 Pre-/postprocessing (S7-1200, S7-1500)

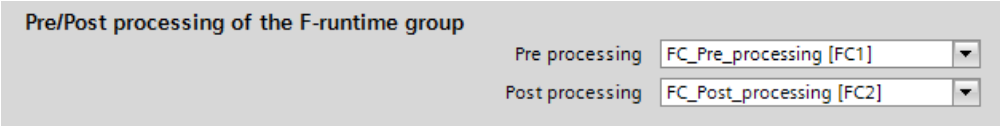
With pre-processing and post-processing you have the option of calling standard blocks (FCs) directly before or after an F-runtime group, for example for data transfer with fail-safe communication via Flexible F-Link (Page 338) or OPC UA Safety (Page 279). The calls are made in the same F-OB or synchronized with the F-runtime group.

Requirement

- Only standard-FCs usable.
- Only temporary local data and constants are permitted in the block interface of a standard-FC.

Procedure

1. Create the standard-FCs for the pre-processing and the post-processing.
2. Assign the standard-FCs in the Safety Administration Editor under "Pre-/post-processing of the F-runtime group".



NOTE
When you delete an assigned FC or overwrite it by copying, its selection as a pre-processing / post-processing block is automatically reset.

Effect on the safety program

- The runtime of the F-runtime group is extended by the runtime of the standard FCs for pre-/post-processing (influence on TRTG_CURR and TRTG_LONG in the F-runtime group information DB).
- Because the pre-processing / post-processing does not change the functionality of the safety program, the collective F-signature remains unchanged after compilation.

Load behavior

The calls of the selected standard FCs are placed during compiling or after the call of the main safety block in the F-OB.
This means that the STOP operating state is required during a subsequent download.

Changes in the contents at the selected standard FCs can take place in RUN.

Exceptions are changes of the block name and block numbers which also include the compilation of the safety program.

When a pre-processing/post-processing block is uploaded individually by the F-CPU, it does not automatically connect to the F-runtime group in the *Safety Administration Editor*.

If consistent loading of the F-CPU into the PG/PC is performed instead, the settings for pre-processing and post-processing are updated according to the online CPU.

3.4 "F-blocks" area of the Safety Administration Editor

Overview

The "F-Blocks" area helps you in the following tasks:

- Displaying the F-blocks used in your safety programs.
- Displaying the F-blocks used in the F-runtime groups.
- Displaying additional information about the F-blocks.

The F-blocks are hierarchically displayed as in the "Program blocks" folder.

A description of the F-blocks is available in "Creating F-blocks (Page 145)".

Displayed information

The following information is displayed in offline mode:

- Have displayed F-blocks been compiled and used?
- Function of F-blocks in safety program
- Block signature
- Group signature
- Change time stamp of the F-blocks

The following information is displayed in online mode:

- Status (whether block has the same time stamp online and offline)
- Function of F-block in the safety program
- Block signature offline
- Group signature offline
- Block signature online
- Group signature online

NOTE

During the offline-online comparison, the comparison statuses may occasionally differ between the *comparison editor* and status display in the *Safety Administration Editor*. The decisive status is the result of the comparison in the *comparison editor*, since this is the only comparison that takes into account the contents of the F-blocks.

NOTE

Group signatures are formed from the signatures of the F-blocks contained in the group and in subgroups. Only F-blocks that are used in the safety program are taken into account. Only the group signatures up to the 6th hierarchy level are displayed.

Filter function



Using the filter function, you can select whether you want to view all F-blocks of a certain F-runtime group or the entire safety program.

- Select "All F-blocks " from the drop-down list to view all F-blocks.
- Select an F-runtime group from the drop-down list to see all F-blocks of this F-runtime group.

3.5 "F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500)

Overview

Under "F-compliant PLC Data Types" you obtain information on the F-compliant PLC data types (UDT) you have defined.

You can delete F-compliant PLC data types (UDT) from the shortcut menu.

More information on the F-compliant PLC data types (UDT) can be found in "F-compliant PLC data types (UDT) (S7-1200, S7-1500) (Page 122)".

Displayed information

The following information is displayed for F-compliant PLC data types (UDT) in offline mode:

- Is the F-compliant PLC data type used in the Safety program?
- Time stamp of the last change.

The following information is displayed for F-compliant PLC data types (UDT) in online mode:

- Status (whether the F-compliant PLC data types (UDT) have the same time stamp online and offline)

The F-compliant PLC data types (UDT) are displayed hierarchically as in the folder "PLC Data Types".

Double-click the F-compliant PLC data type (UDT) to open it for editing.

More information can be found on the symbols in the "Status" column at "Comparing Safety Programs (Page 380)".

NOTE

During offline-online comparison, the comparison statuses between the *comparison editor* and status display in the *Safety Administration Editor* can be different under certain circumstances. The comparison result in the *comparison editor* is decisive, since this is the only comparison that takes into account the contents of the F-compliant PLC data types (UDT).

3.6 "Web server F-admins" area of the Safety Administration Editor (S7-1200 G1, S7-1500)

The "Web server F-Admins" area is displayed for S7-1500 F-CPUs only for firmware < V3.1 and for S7-1200 G1 F-CPUs only for firmware <V4.7.

You need "F-admin" rights in order to restore a backup (Page 368) via the Web server or Web API interface of your F-CPU. You assign the "F-admin" right in the hardware configuration of the F-CPU under the user management of the Web server.

In this section, you obtain information on which users have the "F-admin" right online or offline for F-CPUs that support this right. You can see from this whether a change to the "F-admin" right is active on the F-CPU. In order to make a change to the "F-admin" right effective, you have to load the configuration to the F-CPU.

If you are using user management, this area is omitted.

See also

Completeness and correctness of the hardware configuration (Page 412)

3.7 "Settings" area of the Safety Administration Editor

"Number ranges of the generated F-system blocks"

The number ranges assigned here are used by the F-System for new, automatically generated F-blocks.

At this point, you can select whether the number ranges are managed by the F-system or if a fixed range specified by you is used.

- "F-system managed"

  The number ranges are managed automatically by the F-system, depending on the F-CPU used. The F-system selects an available number range. The start and end ranges of the number ranges are displayed.
- "Fixed range"

  You can select the start and end ranges of the number ranges from the available range. The available range depends on the F-CPU used.

  An invalid number range selection is indicated by an error message.

  The only check performed during configuration is whether the configured low limit is less than or equal to the high limit and within the available range of the F-CPU. The check as to whether the configured range is sufficiently large is first made during compiling. You need to ensure a sufficiently large range. Where the available range is insufficient, a compiling error occurs. Not all blocks are generated and the safety program is not executable.

Changes will become valid only during the next compilation. The automatically created F-blocks may be moved into the new area during compilation. The F-I/O DBs are an exception. They always retain their original number that you may change in the properties of the F-I/O.

"Safety system version"

This parameter is used to specify the safety system version (including version of the F-system blocks and automatically generated F-blocks, see Overview of Programming (Page 108)).

A number of versions are available:

Version	S7-300/4-00	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.6	—	x	—	x	These versions have identical functions. Depending on the set version, the result may be different runtimes of the F-runtime group(s) (see Excel file for response time calculation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
2.0	x	x[1]	—	x[2]	

1 Supported as of firmware V4.2

2 Supported as of firmware V2.0

3 Fast Commissioning mode with "Fast Compile" is supported as of firmware V4.5.

4 Fast Commissioning mode with "Consistent Compile" is supported as of firmware V3.0. With the S7-1500 F-Software Controller, it is available only for approved IPCs as of firmware V30.0.

5 The F-BaseID is supported for S7-1200 G2 and S7-1500 as of firmware V4.1 or F-Software Controller as of V40.1.

6 If the F-OB of the associated F-runtime group has the event class "Cyclic interrupt".

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
2.1	—	x[1]	—	x[2]	Additionally supports the variables "DISABLE" and "DISABLED" in the F-I/O DB
2.2	—	x[1]	—	x[2]	Supports the safety-related CPU-CPU communication and F-runtime group communication with Flexible F-Link.
2.3	—	x[1]	—	x[2]	This version has identical functions to version 2.2.
2.4	—	x[1, 3]	—	x[2]	Additionally supports: • F-CPUs • Fast Commissioning mode with "Fast Compile" • Runtime for the deactivated safety mode
2.5	—	x	—	x[4]	Additionally supports: • Fast Commissioning mode with "Consistent Compile" (S7-1500) • F-I/Os with more than 13 bytes net data (e.g. F-AI 8xI 0(4)..20mA)
2.6	—	x	—	x	The functions of this version are identical to those of version 2.5.
2.7	—	x	x	x	Additionally supports: • S7-1500 F Virtual Controller • OPC UA Safety
2.8	—	x	x[5]	x[5]	Additionally supports: • F-BaseID[5] • Improved response time of F-I/O for inputs[6]

1 Supported as of firmware V4.2

2 Supported as of firmware V2.0

3 Fast Commissioning mode with "Fast Compile" is supported as of firmware V4.5.

4 Fast Commissioning mode with "Consistent Compile" is supported as of firmware V3.0. With the S7-1500 F-Software Controller, it is available only for approved IPCs as of firmware V30.0.

5 The F-BaseID is supported for S7-1200 G2 and S7-1500 as of firmware V4.1 or F-Software Controller as of V40.1.

6 If the F-OB of the associated F-runtime group has the event class "Cyclic interrupt".

Usually, you do not need to make any settings for this parameters.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

"Local data used in safety program" (S7-300, S7-400)

You use this parameter to specify the amount of temporary local data (in bytes) that is available for the call hierarchy below the main safety block.

The setting applies to each F-runtime group of a safety program. More information on F-runtime groups can be found in "Program structure of the safety program (S7-1200, S7-1500) (Page 110)" and "Program structure of the safety program (S7-300, S7-400) (Page 108)".

The **minimum possible amount** is determined by the local data requirement of the F-blocks generated automatically when the safety program is compiled.

For this reason, you must provide at least 440 bytes. However, the local data requirement for the automatically added F-blocks may be higher depending on the local data requirement of the F-blocks you created with FBD or LAD.

Therefore, provide as much local data as possible. If there is not enough local data available for the automatically added F-blocks (440 bytes or more), the safety program will be compiled nevertheless.

Data in automatically added F-DBs are then used instead of local data. However, this increases the runtime of the F-runtime group(s). You will receive a notice when the automatically added F-blocks require more local data than configured.

⚠ WARNING

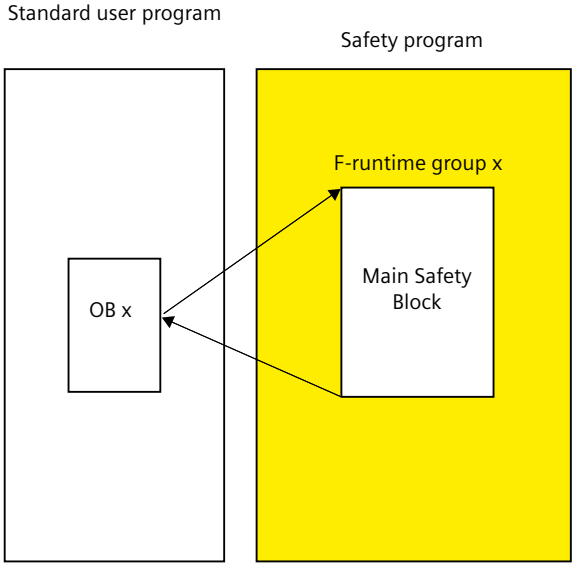
The calculated maximum runtime of the F-runtime group using the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) is no longer correct in this case because the calculation assumes sufficient availability of F-local data.
In this case, use the value you configured for the maximum cycle time of the F-runtime group (F-monitoring time) as the maximum runtime of the F-runtime group when calculating the maximum response times in the event of an error and for any runtimes of the standard system using the above-mentioned Excel file. *(S004)*

The maximum possible amount depends on:

- Local data requirement of the main safety block and the higher-level standard user program. For this reason, you should call the main safety blocks directly in OBs (cyclic interrupt OBs, whenever possible), and additional local data should not be declared in these cyclic interrupt OBs.
- Maximum volume of local data of the utilized F-CPU (see Technical Specifications in the product information for the utilized F-CPU). For S7-400 F-CPUs, you can configure the local data for each priority class. Therefore, assign the largest possible local data volume for the priority classes in which the safety program (the main safety blocks) is called (e.g., OB 35).

Maximum possible amount of local data as a function of local data requirement of main safety block and higher-level standard user program (S7-300, S7-400):

Case 1: Main safety block called directly from OBs

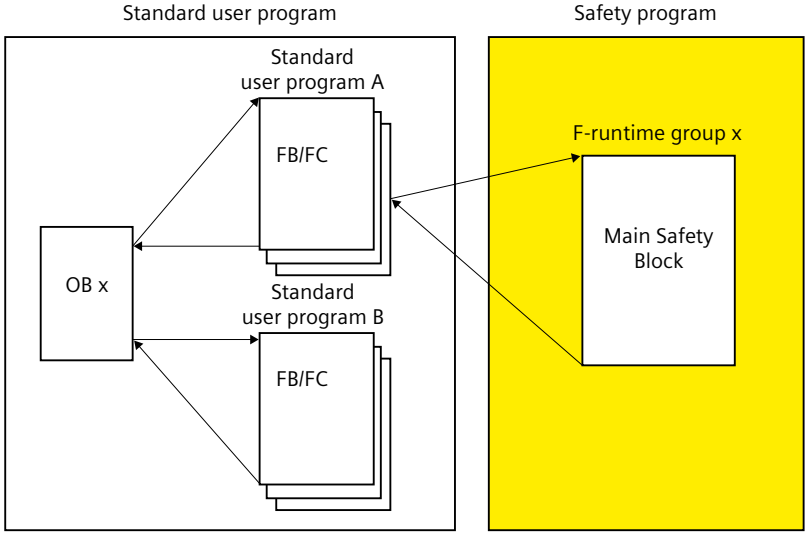


Set the "Local data used in safety program" parameter to the maximum amount of local data of the utilized F-CPU minus the local data requirement of the main safety block (if the main safety block has 2 F-runtime groups, use the largest local data requirement) and minus the local data requirement of the calling OBx (if there are 2 F-runtime groups, use the OB with the largest local data requirement).

Note: If you have not declared any temporary local data in the main safety blocks and calling OBx, the local data requirement of the main safety blocks is 6 bytes and the local data requirement of the calling OBx is 26 bytes. You can derive the local data requirement of the main safety blocks and calling OBx from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

Case 2: Main safety block not called directly from OBs



Set the "Local data settings" parameter to the value calculated for Case 1, minus the local data requirement of standard user program A (if standard user program A has 2 F-runtime groups, use the largest local data requirement).

Note: You can derive the local data requirement of the standard user program A from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

"Advanced settings"

"Safety mode can be disabled"

With this option you can prevent the safety mode for a safety program from being disabled.

Under "Runtime for the deactivated safety mode", you set the time after which the F-CPU goes to STOP after safety mode is deactivated.

When you change the setting for this option, you need to recompile the safety program and download it to the F-CPU for the change to become effective. This changes the Collective F-Signature and the Collective F-SW-Signatures of your safety program.

To exclude an unintentional disabling of the safety mode, make sure that the option is disabled in productive operation.

"Enable F-change history"
Enable the logging of changes to the safety program by using the "Enable F-change history" option. For more information, refer to the section "F-change history (Page 405)".

"Enable consistent upload from the F-CPU" (S7-1500)
This option allows you to load the loaded project data (including safety-related project data) consistently from the F-CPU to the PG/PC.

The option can only be activated if the F-CPU and the firmware of the F-CPU supports the loading of the project data (including safety-related project data).

F-CPUs S7-1500 as of firmware V2.1 are supported. S7-1500 F Software Controllers are not supported.

At every change to this option you have to load the project data to the F-CPU.

Note that the activation of this option extends the loading of the safety-related project data into the F-CPU.

"Activate variable F-communication- IDs" (S7-1200, S7-1500)
If you activate this option, you can supply the DP_DP_ID input of the SENDDP or RCVDP instructions with the variable values from a global F-DB.

⚠ WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

"System-generated objects" (S7-1200, S7-1500)

"Creates F-I/O DBs without prefix"

When you select this option, the names of the F-I/O DBs (Page 157) are created without prefix.

"Clean up"

The "Clean up" button is provided for service and support purposes and cleans up the result of the fail-safe compilation.

3.8 "Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500)

In the "Flexible F-Link" area, you create new F-communications, obtain information on existing F-communications and delete F-communications.

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- Safety system version as of V2.2

Information on created F-communications

In the "Flexible F-Link" area, you receive information on configured F-communications in tabular form:

- CPU-wide unique name of F-communication
- F-compliant PLC data type (UDT) for send/receive data
- Direction of F-communication: Transmitting/receiving
- F-monitoring time of F-communication
- F-Communication UUID
- Tag for send data
- Tag for receive data

Creating F-communication

1. In an empty row of the table click "<Add new>"
2. Assign a name to the communication connection.
3. Select an F-compliant PLC data type (UUID) for the communication connection.
   If you have not yet created an F-compliant PLC data type (UDT) for the communication connection or wish to create a new one, create a new F-compliant PLC data type (UDT) (Page 122) with any structure. Note that the size can be up to 1500 bytes.
4. Select the direction of the communication connection ("Send" or "Receive").
5. Select the F-monitoring time of the communication connection (Page 616).

The UUID of the F-communication is displayed via Flexible F-Link in the "F communication UUID" column. The F-communication UUID ensures sufficient uniqueness of the safety-related communication ID even across network limits.

The "Tag for send data" column shows you the newly created tag for send data of the F-communication DB (Page 341).

The "Tag for receive data" column shows you the newly created tag for receive data of the F-communication DB (Page 341).

You can find the newly created F-communication DB for this F-communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".

Deleting F-communication

1. Select the entire row and confirm "Delete" in the shortcut menu. You can also delete multiple F-communications at the same time.

Copying F-communication

1. Select the entire row and confirm "Copy" in the shortcut menu. You can also copy multiple F-communications at the same time.
2. With the "Paste" menu command, you can paste the copied F-communications into the table as often as needed. The UUID for the respective F-communication is retained during copying. If necessary, re-generate the UUID.

Generating a new F-communication-UUID

1. Select the entire row and confirm "Generate UUID" in the shortcut menu. You can also generate multiple UUIDs at the same time.

See also

Flexible F-Link (Page 338)
F-runtime group communication (S7-1200, S7-1500) (Page 141)

4 Access protection

Access protection is necessary for productive operation

Access protection to the SIMATIC Safety F-system is mandatory for productive operation.

⚠ WARNING

Access to the SIMATIC Safety F-system without access protection is intended for test purposes, commissioning, etc., when the system is not in productive operation. Without access protection, you need to ensure the safety of the plant through other organizational measures.
Before you transition into productive operation, you must have set up and activated access protection. *(S005)*

NOTE
We recommend making the settings for access protection in the "PLC security settings" dialog when creating the project.

4.1 Overview of access protection

Introduction

You can control access to the SIMATIC Safety F-system with the access protection for the safety-related project data and the access protection for the F-CPU.

Access protection for the safety-related project data

Access protection for the safety-related project data (Page 97) is available in two forms:

- Assignment of a password for the safety-related project data (F-CPU-granular), assigned in the *Safety Administration Editor*
- Setup of project protection for all safety-related project data in the TIA project

Access protection for the F-CPU

The access protection (Page 100) is set at the F-CPU level. To do this, you assign a password for the F-CPU in the F-CPU configuration or assign F rights as part of user management, if supported by the respective F-CPU (only 1200/1500 F-CPUs as of certain firmware versions (Page 103)). For S7-300/400 F-CPUs, the password is also used to identify the F-CPU and must therefore be unique network-wide. For S7-1200/1500 F-CPUs, the password no longer needs to be unique because the serial number is used for identification.

4.2 Access protection for the safety-related project data

The access protection for the safety-related project data is in effect for all operations in which the safety-related project data can be inconsistent offline, for example:

- When changing the Safety program
- When changing and deleting F-runtime groups
- When changing safety-related parameters of F-I/O

NOTE

Note that, for usability reasons, the F-BaseID falls under the offline access protection for the safety-related project data, but it is not covered by the online access protection of the F-CPU for safety-related project data. Here, the F-BaseID is treated like a standard parameter.
There is an exception for switching between an F-BaseID with the value "Delayed transfer" and an F-BaseID with a specific value (either 0 or an active F-BaseID).

- When compiling

NOTE

Note that the access protection for the safety-related project data is only effective if you are making the changes in the TIA Portal. Although the TIA Portal detects changes to the project data made directly in the related files in the file system, these changes cannot be prevented or undone.

Safety program recompilation is required after changes to standard DBs to which the safety program has read or write access.

4.2.1 CPU-wide access protection for the safety-related project data

Requirement

The project does not use user management to protect the project data

Setting up CPU-wide access protection for safety-related project data

To set up CPU-wide access protection for safety-related project data, assign a password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.
   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Under "Offline safety program protection", click "Setup" and enter the password (max. 30 characters) for the safety program in the following dialog in the "New password" and "Confirm password" fields.
4. Confirm the assigned password with "OK".

You have set up CPU-wide access protection for safety-related project data and have gained access permission for the safety-related project data.

NOTE
Use different passwords for the F-CPU and the safety program to optimize access protection.

Changing the password for safety-related project data

You can change the password for the safety-related project data as long as you have the necessary access permissions. It also takes place in the "Access protection" area (via "Change" button) and is carried out as usual under Windows through entry of the old and double entry of the new password.

Deleting CPU-wide access protection for safety-related project data

To delete CPU-wide access protection for safety-related project data, delete the password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.
   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Click the "Change" button.
4. Under "Old password", enter the password for the safety program.
5. Click "Revoke" and then on "OK".

Gaining access permission through login to the safety program

Log in to the safety program as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.
   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Enter the password for the safety program in the "Password" input field.
4. Select the "Login" button.

Validity of access permission for safety-related project data

If access permission for safety-related project data was obtained by entering the password, this remains until the project is closed. When the TIA Portal is closed, any project that is still open is automatically closed and any access permission granted is canceled.

Cancelling access permission through logoff

The access permission for safety-related project data can be cancelled as follows:

- By clicking the "Log off" button in the "Access protection" area in the "*Safety Administration Editor*".
- In the shortcut menu for the *Safety Administration Editor* (access by right-clicking).
- By using the lock symbol in the line of the *Safety Administration Editor*.

The user will then be prompted to enter the password for the safety program again the next time an action requiring a password is performed.

Displaying the availability of access authorization

The status of the access authorization is displayed in the project tree as follows:

- The access authorization is available when the lock symbol in the line of the *Safety Administration Editor* is shown unlocked.
- The access permission is not available, if the lock symbol shows a closed lock.
- If no lock symbol is shown, no password was assigned.

4.2.2 Project-wide access protection for the safety-related project data

As an alternative to CPU-wide access protection for the safety-related project data with a password in the *Safety Administration Editor*, you can use the project protection for the TIA project.

To do this, assign the "Edit safety-related project data" function right to users who are allowed to edit safety-related project data. To do this, proceed as usual for function rights. You can find more information in the help for *STEP 7* under "Managing users and roles".

NOTE

When project-wide project access protection is activated, any existing passwords for safety-related project data for all F-CPUs of the project are deleted.

Users who need the "Edit safety-related project data" function right may require additional function rights, for example:

- "Modify PLC program" to change the safety program
- "Downloading to PLC" to load the safety-related project data into the F-CPU
- "Modify hardware configuration" to make changes to the safety-related hardware configuration

4.3 Access protection for the F-CPU

The access protection for the F-CPU is effective for all operations in which the safety-related project data can be changed online, for example:

- When downloading the safety program to the F-CPU
- When downloading the hardware configuration to the F-CPU, also when changes are made to F-I/O not used in the Safety program

NOTE

Note that, for usability reasons, the F-BaseID falls under the access protection for the safety-related project data, but it is not covered by the access protection of the F-CPU for safety-related project data. Here, the F-BaseID is treated like a standard parameter.
There is an exception for switching between an F-BaseID with the value "Delayed transfer" and an F-BaseID with a specific value (either 0 or an active F-BaseID).

- (S7-1200, S7-1500) When downloading a hardware configuration to the F-CPU containing safety-related changes
- When assigning the PROFIsafe address
- When loading or deleting F-blocks used in the safety program
- When disabling safety mode or when resetting the remaining runtime (the password must always be entered, even if access permission for the F-CPU is still valid.)
- When restoring a backup of the F-CPU
  Exception with S7-1200/1500 F-CPUs: If neither the Safety program nor the password for the F-CPU or users with the rights "Change F-System parameters (F-Admin)" or "Full access including fail-safe" are changed as a result, the access protection for the F-CPU is not queried.

4.3.1 Access protection through the use of protection levels

This section describes the access protection for F-CPUs through the use of protection levels.

You can use access levels for the following F-CPUs:

- S7-300/400
- S7-1200 G1 up to firmware 4.6 (as of firmware V4.7 only if the option "Use access control via access levels" is activated)
- S7-1200 G2 if the parameter "Use access control via access levels" is selected.
- S7-1500 up to firmware V3.0 (as of firmware V3.1 only if the parameter "Use access control via access levels" is activated)
- S7-1500 F Software Controller up to firmware V3x.0 (as of firmware V3x.1 only if the parameter "Use access control via access levels" is activated)

Setting up access protection for the F-CPU

To set up access protection for the F-CPU, assign a password in the F-CPU configuration. Proceed as described in the *STEP 7* help under "Configuring access levels".

Clicking on the link "Go to the "Protection" area of the F-CPU" in the "Access protection" area of the *Safety Administration Editor* takes you directly to the password for the F-CPU.

⚠ WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the Safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.
With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the Safety program. *(S001)*

⚠ WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.
If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.
If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the Safety program.
If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".
Assign different passwords for the individual access levels. *(S041)*

You enable access protection by downloading (Page 345) the hardware configuration to the F-CPU.

⚠ WARNING

(S7-300, S7-400) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by **the same programming device or PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU:
Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.
Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety-related project data to an F-CPU, existing access permission for any other F-CPU must first be cancelled.
- The last download of the safety-related project data prior to switching to productive operation must be made with enabled access protection. *(S021)*

⚠ WARNING

When using tools for the automation or operation (of TIA Portal or web server) with which the access protection for the F-CPU can be removed, the safety-related project data may not be protected against unintentional changes anymore. When using corresponding tools, the requirements regarding access protection of the F-CPU must still be met. *(S078)*

Changing the password for the F-CPU

For the new password to become valid after a change to an access level password for the F-CPU, you must download the changed configuration into the F-CPU. If necessary, you must enter the "old" password for the F-CPU for this load operation. The F-CPU must be in STOP mode.

Deleting access protection for the F-CPU

To delete configured access protection for the F-CPU, change the access level and delete the passwords for the F-CPU that are no longer required. To do this, proceed as in the standard.

Obtaining access permission for the F-CPU

You obtain access permission for the F-CPU by entering the password for the F-CPU, according to the configured protection level, prior to performing an action requiring a password.

Validity of access permission for the F-CPU

Access permission for the F-CPU remains valid until the TIA Portal is closed or access permission is revoked.

Canceling access permission for the F-CPU

You cancel the access permission with the menu command "Online > Delete access rights" auf.

⚠ WARNING

The safety-related project data must be protected against unintentional changes.
For this you must cancel the access permission and the online connection for the F-CPU whenever you leave the PG/PC.
Alternatively, you can also take other organizational measures. *(S006)*

4.3.2 Access protection through user management

This section describes the access protection for F-CPUs through the use of user management and the runtime right for the F-CPU.

You can use local user management for the following F-CPUs if the "Use access control via access levels" parameter is not activated:

- S7-1200 G1 as of firmware V4.7
- S7-1200 G2 as of firmware V1.0
- S7-1500 as of firmware V3.1
- S7-1500 F Software Controller as of firmware V3x.1

You can use central user management for the following F-CPUs:

- S7-1200 G2 as of firmware V4.1
- S7-1500 as of firmware V4.0
- S7-1500 F Software Controller as of firmware V4x.0

Setting up access protection for the F-CPU

To set up access protection for the F-CPU, use the user management with the function right for the F-CPU. Proceed as described in the *STEP 7* help under "Local user management" or "Central user management" and "Settings for users and roles".

If the "Use access control via access levels" option is selected in addition to "Enable access control", you must assign at least a password for "Full access including fail-safe" for the F-CPU in the F-CPU configuration. Proceed as described in the *STEP 7* help under "Configuring access levels".

You can go directly to the settings for access protection of the F-CPU if you click the link "Go to the "Protection" area of the F-CPU" in the "Access protection" area in the *Safety Administration Editor*.

⚠ WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.
If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.
If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.
If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".
Assign different passwords for the individual access levels. *(S041)*

You enable access protection by downloading (Page 345) the hardware configuration to the F-CPU.

⚠ WARNING

When using tools for the automation or operation (of TIA Portal or web server) with which the access protection for the F-CPU can be removed, the safety-related project data may not be protected against unintentional changes anymore. When using corresponding tools, the requirements regarding access protection of the F-CPU must still be met. *(S078)*

Changing access protection for the F-CPU

For the changed users or the changed password to take effect after a change to the users with F-right or a password change for the F-CPU, you must download the changed configuration to the F-CPU and select the "Download all user management data (reset to project settings)" option in the "Load preview" dialog when downloading. For this download, you must legitimate yourself as a user with F-right or enter the existing password for the F-CPU, if necessary. For changes in the "Access protection via protection levels" area, the F-CPU must be in STOP.

Changes that you make as part of the central user management on the associated UMC server of the F-CPU (e.g. a new user password) take effect immediately without a download.

Deleting access protection for the F-CPU

To delete the access protection for the F-CPU, grant the user Anonymous the F-right ("Full access including fail-safe").

Obtaining access permission for the F-CPU

You obtain access permission for the F-CPU by legitimating yourself as a user with F-right or when "Use access control via access levels" mode is enabled by entering the password for the F-CPU prior to performing an action requiring a password.

Validity of access permission for the F-CPU

Access permission for the F-CPU remains valid until the TIA Portal is closed, access permission is revoked or the maximum legitimation time is exceeded. A maximum legitimation time of up to 600 minutes can be set for each user.

Canceling access permission for the F-CPU

You revoke the access permission with the menu command "Online > Delete access rights".

⚠ WARNING

The safety-related project data must be protected against unintentional changes.
For this you must cancel the access permission and the online connection for the F-CPU whenever you leave the PG/PC.
Alternatively, you can also take other organizational measures. *(S006)*

4.4 Access protection through organizational measures

To prevent a safety program from being swapped without authorization by exchanging removable media (e.g. flash card, SIMATIC Micro Memory Card or hard disk with S7-1500 F Software Controller), you must observe the following warning:

⚠ WARNING

You must limit access to the F-CPU through organizational measures to persons who are authorized to plug in removable devices. *(S079)*

To prevent unintentional access to an S7-1500 F Virtual Controller and the virtual time service, you need to observe the following warning:

⚠ WARNING

You must take organizational measures to limit access to an IE(V)D with an S7-1500 F Virtual Controller or a virtual time service to persons who are authorized and appropriately trained to commission and operate an IE(V)D.
The following change must not be made by a system administrator under any circumstances, either at the level of a host hypervisor, in Industrial Edge Management or within the IE(V)D operating system:

- Change of data storage of the portion of the Linux file system of the IE(V)D managed by Docker.

If you operate the S7-1500 F Virtual Controller, note the following:

- You may not use images to duplicate the S7-1500 F Virtual Controller because the uniqueness of the S7-1500 F Virtual Controller when loading cannot be guaranteed based on the unique serial number.
- When creating images (e.g. snapshots) of virtual machines or Edge Devices with an S7-1500 F Virtual Controller, you must label them clearly. When importing an image, use program identification to ensure that the correct Safety program is executed.
- If you use automated mechanisms for mirroring images of virtual machines (e.g. cyclical mechanisms provided by the hypervisor for data backup), you need to perform the following steps each time you import new safety-related project data. This ensures that the correct Safety program is executed when the mirrored images of your virtual machines are started:
  1. Load the safety-related project data into the active target CPU
  2. Ensure that hypervisor mechanisms are used to delete all virtual machine images of the active target CPU.
  3. Make a program identification in the active target CPU.
- If you use a mechanism to provide distributed shared data storage (e.g. vSAN) without multiple protection of the data (FTT Failures To Tolerate = 0) in the virtualized environment, you have to ensure for each change of the configuration of this data storage to other retentive memory areas that the previously used memory area does not contain any safety-related project data by deleting this. If you use multiple protection of the data (FTT > 0) in this distributed data storage, you have to perform program identification before each restart of the active target CPU.

(S100)

To ensure that an S7-1500 F Software Controller is not uninstalled or installed unintentionally, you must observe the following warning:

⚠ WARNING

You must limit access to an S7-1500 F Software Controller by organizational measures to persons who are authorized to uninstall and install or repair an S7-1500 F Software Controller (e.g. via the Windows administrator privileges (ADMIN)). *(S075)*

With an S7-1500 F-Software Controller with a PC station version up to incl. V2.1, the function "Delete Configuration" on the PC Station Panel is only offered when no access protection (no protection) is set up on the F-CPU.

With a PC station as of V2.2, it is checked whether the current Windows user is a member of the "Failsafe Operators" Windows user group. When the logged-on Windows user is a member of the group, he/she can execute the "Delete Configuration" function even when the F-password is set. If the logged-on Windows user is not a member of the group, the PC station behaves as up to V2.1.

We therefore recommend that you do not set up F-access protection until after commissioning.

To prevent unintentional restoration of the safety-related project data, formatting of the F-CPU and deletion of program folders via the display of an S7-1500 F-CPU, you must observe the following warning:

⚠ WARNING

The password for the display of the F-CPU may only be disclosed to persons who are authorized to restore safety-related project data, to format the F-CPU and to delete program folders. If a password is not set up for the display, you must protect the display through organizational measures against unauthorized operation. *(S063)*

To prevent unintentional restoration of the safety-related project data of the safety program with the web server in an S7-1200/1500 F-CPU, you must observe the following warning:

⚠ WARNING

The "Change parameter of the F-System (F-Admin)" authorization for the web server (including web server API) without password protection (user "Everybody", or user "Anonymous" when using the user management) is intended only for testing, commissioning, etc. This means only when the system is not in productive operation. In this case, you must ensure the safety of the system through other organizational measures.
Before the transition to productive operation, you must remove the rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" from the "Everybody" or "Anonymous" user.
The password of the web server user with "Change parameter of the F-System (F-Admin)" right may only be disclosed to authorized persons. After downloading the hardware configuration, check whether only permitted users of the web server have the "Change parameter of the F-System (F-Admin)" right on the F-CPU. To do so, use the online mode of the *Safety Administration Editor* for an F-CPU without user management or the "Security settings\Users and roles" tab for an F-CPU with user management.
Saving the login file and the password of the web server in the browser is only permitted when usage by unauthorized persons is prevented through other organizational measures.
If you use the ticket mechanism, handling of the tickets must be just as restrictive as handling of the user password of the web server with the "Change parameter of the F-System (F-Admin)" right. *(S064)*

Programming

5

5.1 Overview of Programming

Introduction

A safety program consists of F-blocks that you create using the FBD or LAD programming language and F-blocks that are automatically added. Fault detection measures and fault reaction measures are automatically added to the safety program you create, and additional safety-related tests are performed. Moreover, you have the option to incorporate special ready-made safety functions in the form of instructions into your safety program.

An overview of the following is given below:

- The structure of the safety program
- The fail-safe blocks
- Differences in the programming of the safety program with FBD/LAD compared to programming of standard user programs

5.1.1 Program structure of the safety program (S7-300, S7-400)

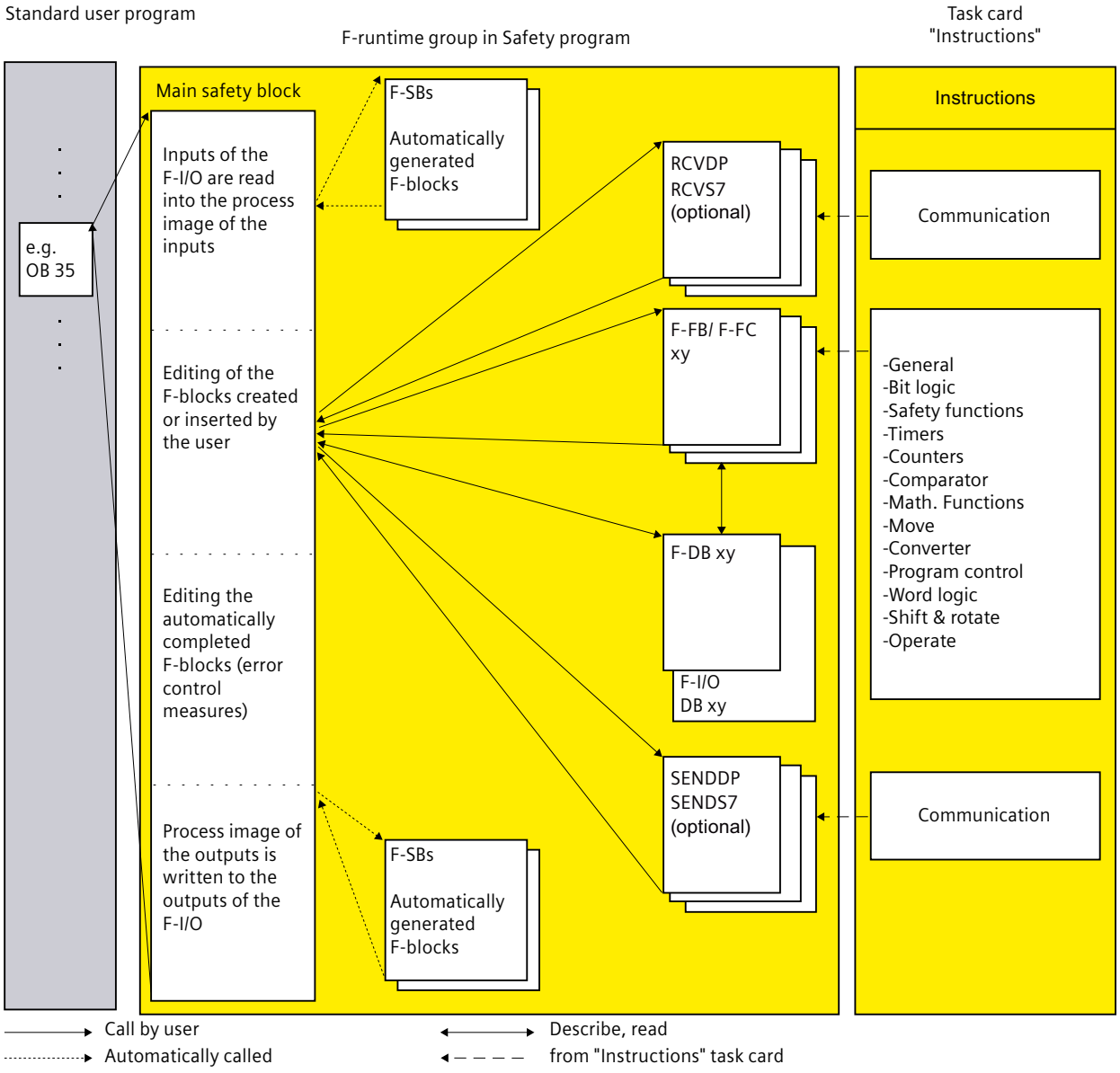
Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks, automatically generated F-blocks, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-300/400 F-CPU.

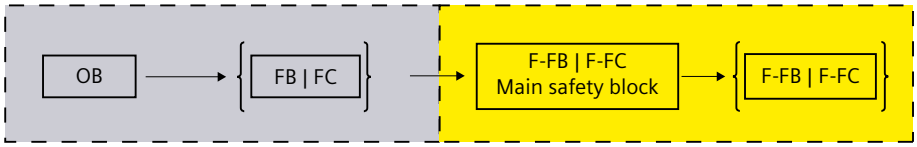


Main safety block

The main safety block is the first F-block of the safety program that you program yourself. During compiling, it is supplemented by additional invisible calls of F-system blocks.

You must assign the main safety block to an F-runtime group (Page 129).

The main safety block in an S7-300/400 F-CPU is called from any block in the standard user program. We recommend a call from an OB 3x.



F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- A main safety block (an F-FB/F-FC that you assign to the calling OB (FB/FC) as needed)
- Any additional F-FBs/F-FCs that you call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

You can only transfer data between the F-runtime groups using F-runtime group communication (Page 138).

5.1.2 Program structure of the safety program (S7-1200, S7-1500)

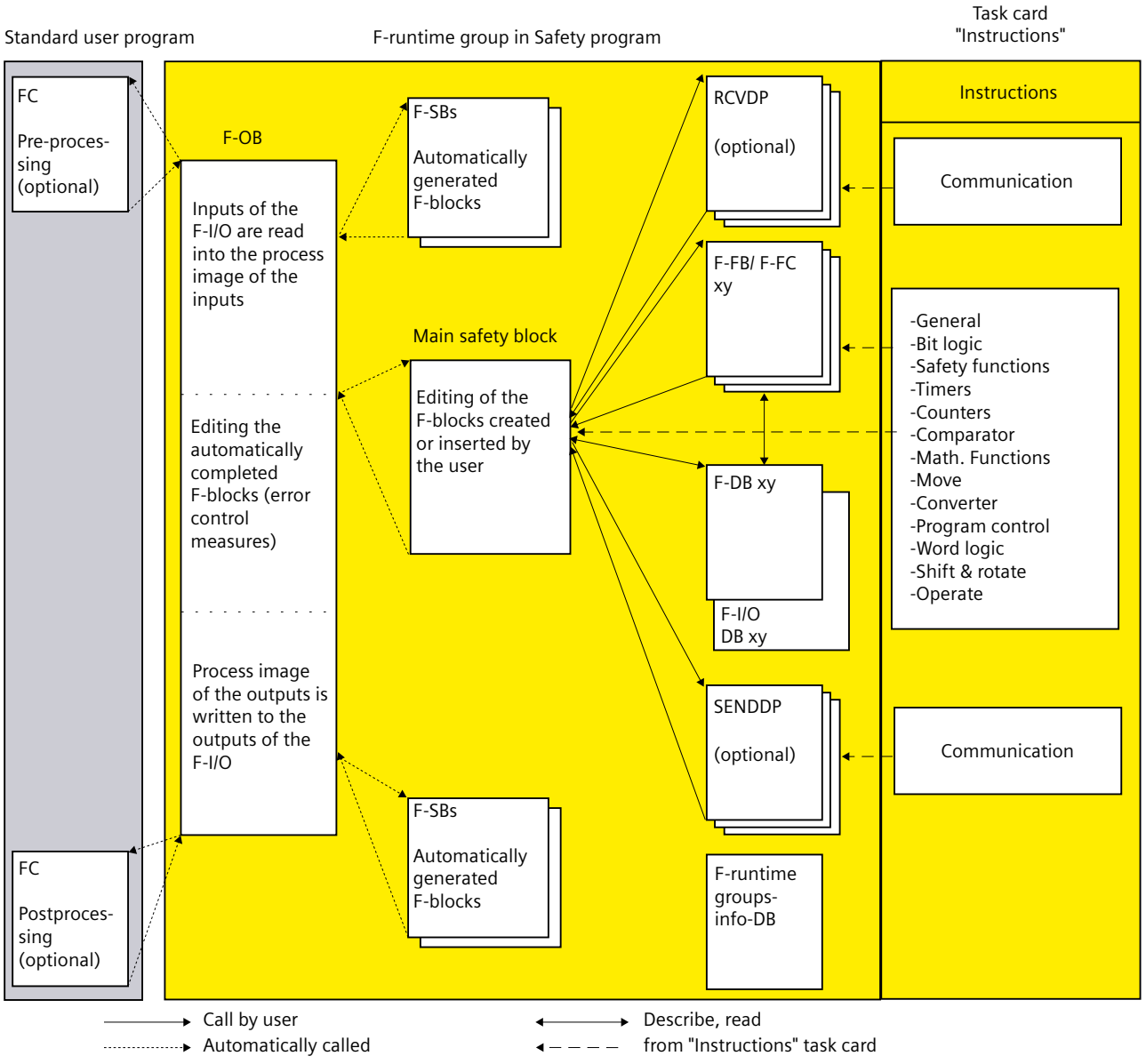
Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks F-SBs, automatically generated F-blocks, F-runtime DB, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-1200/1500 F-CPU.

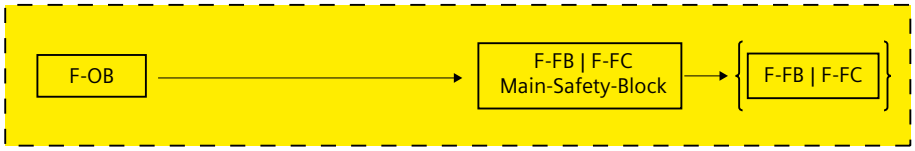


Main safety block

The main safety block is the first F-block of the safety program that you program yourself.

You must assign the main safety block to an F-runtime group (Page 129).

The main safety block in an S7-1200/1500 F-CPU is called by the F-OB assigned to the F-runtime group.



F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- An F-OB which calls the main safety block
- A main safety block (an F-FB/F-FC that you assign to the F-OB)
- Any additional F-FBs or F-FCs that you call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-runtime group information DB
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks
- A preprocessing and/or postprocessing block, as needed (see Pre-/postprocessing (S7-1200, S7-1500) (Page 85))

Pre-/postprocessing of an F-runtime group

You have the option of calling blocks of the standard user program (FCs) directly before or after an F-runtime group, for example, for data transfer during fail-safe communication via Flexible F-Link. (see Pre-/postprocessing (S7-1200, S7-1500) (Page 85))

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

You can only transfer data between the F-runtime groups using F-runtime group communication (Page 141).

See also

F-runtime group information DB (S7-1200, S7-1500) (Page 149)

5.1.3 Safety program in Software Unit (Safety Unit) (S7-1500)

Introduction

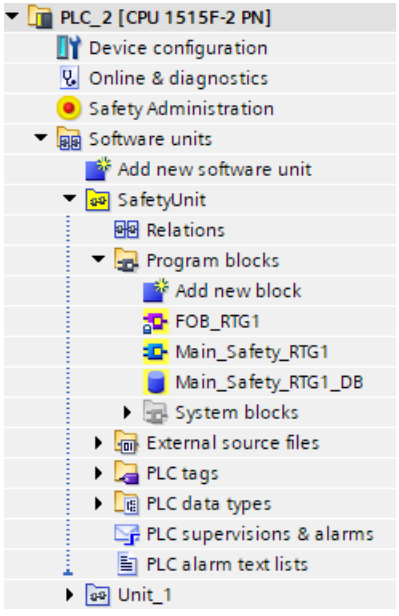
You can use Safety Units if you want to use the advantages of the Software Units for the safety program as well, e.g. independent compiling and loading.
The blocks of the safety program are then located exclusively in the Safety Unit and can no longer be created in the "Program blocks" folder directly below the F-CPU.
You must make the decision for the Safety Unit before creating the F-CPU. After creating the F-CPU, the decision for this F-CPU can no longer be changed.

Requirement

- F-CPU S7-1500 as of FW V2.6
- The check box "Manages safety program in 'Safety Units' environment" is selected under "Options/Settings/STEP 7 Safety".
- The F-CPU is newly created.

Safety program in the Safety Unit

After a new F-CPU has been created, the safety program is located in the Safety Unit.



Store the transfer DBs for the data transfer from/to the standard user program (Page 192) in the Safety unit.

Information on Software Units is available in the help for *STEP 7* under "Using Software Units".

Particularities

- You cannot store the Safety Unit in a library.
- System blocks in the Safety Unit cannot be published.

5.1.4 Fail-Safe Blocks

F-blocks of an F-runtime group

The following table shows the F-blocks that you use in an F-runtime group:

F-block	Function	S7-300/400 F-CPUs	S7-1200/1-500 F-CPUs
Main safety block	The first step in programming of the Safety program is the main safety block. The main safety block in S7-300/400 F-CPUs is an F-FC or F-FB (with instance DB), which is called by a standard block (recommendation: OB 35) from the standard user program. The main safety block in S7-1200/1500 F-CPUs is an F-FC or F-FB (with instance DB), which is called by the F-OB.	X	X
F-FB/F-FC	Both in the main safety block as well as additional F-FBs and F-FCs, you can perform the following: • Program the Safety program with the instructions available for F-blocks • Call other created F-FBs/F-FCs for structuring the Safety program • Insert F-blocks from the project library or global libraries	X	X
F-DB	Optional fail-safe data blocks that can be read- and write-accessed within the entire Safety program.	X	X
F-I/O DB	An F-I/O DB is automatically generated for each F-I/O when it is configured. You access the tags of the F-I/O DB in connection with F-I/O access.	X	X
F-shared DB	The F-shared DB is a fail-safe data block that contains all of the shared data of the Safety program and additional information needed by the F-system.	X	—
F-runtime group information DB	An F-runtime group information DB is created when you create an F-runtime group. The F-runtime group information DB provides information on the F-runtime group and on the Safety program as a whole.	—	X
DB for F-runtime group communication	Created for safety-related communication between F-runtime groups in the *Safety Administration Editor*. With this, you can read fail-safe tags that were made available in an F-DB from an F-runtime group in a different F-runtime group.	X	—
F_SystemInfo_DB	More information (e.g. signatures) on the Safety program can be found in the F_SystemInfo_DB. You cannot access this information in the Safety program.	—	X
F-communication DB	For each communication connection with Flexible F-Link, an F-communication DB is generated automatically when the communication connection is created. You access the tags of the F-communication DB in connection with Flexible F-Link communication connections.	—	X
F-OPC UA Consumer DB	For communication connections via OPC UA Safety, an F-OPC UA Consumer DB is automatically generated for each SafetyConsumer when the OPC UA SafetyProvider information model is imported. You access the variables of the F-OPC UA Consumer DB in connection with OPC UA Safety communication connections.	—	X

NOTE

You are not permitted to insert F-system blocks from the "System blocks" folder in a main safety block/F-FB/F-FC.

Instructions for the Safety program

In the "Instructions" task card, you can find instructions for the F-CPU used and which you can to use program the Safety program.

You can find instructions that you know from the standard user program, such as bit logic operations, mathematical functions, functions for program control, and word logic operations.

Moreover, there are instructions with safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, feedback monitoring and instructions for safety-related communication between F-CPUs.

More information

For a detailed description of the instructions for the Safety program, refer to Overview of instructions (Page 443).

Using instruction versions

As with the instructions for the standard user program, there may also be different versions of the instructions for the Safety program.

More information on instruction versions can be found in the help on STEP 7 in "Basics for instruction versions".

More information on the differences of the individual versions of the instructions for the Safety program can be found in the relevant chapter of the instructions.

NOTE

Note the following:

- If you change the version of an instruction used in the Safety program in the task card "Instructions" to a version which does not have identical functions, the functioning of your Safety program may change after recompiling the Safety program. In addition to the signature of the F-block that uses the instruction, the Collective F-Signature and the Collective F-SW-Signature of your Safety program also change. You may have to perform an acceptance test (Page 427).
- (S7-300, S7-400) If you use a know-how protected F-block in your Safety program which uses an instruction which is not the same version as that set in the task card "Instructions", when the program is compiled without entering the password for the know-how protected F-block, it is adjusted to the version set in the task card "Instructions". If the instruction versions do not have identical functions, the functioning of the know-how protected F-block may change and always its signature.

5.1.5 Restrictions in the programming languages FBD/LAD

LAD and FBD programming languages

The user program in the F-CPU typically consists of a standard user program and a safety program.

The standard user program is created using standard programming languages such as SCL, STL, LAD, or FBD.

For the safety program, LAD or FBD may be used with certain restrictions in the instructions and the applicable data types and operand areas. Also note the restrictions for the individual instructions.

Supported instructions

The instructions available depend on the F-CPU used. You can find the supported instructions in the description of the instructions (starting from STEP 7 Safety V21 instructions (Page 443)).

NOTE

Enable input EN cannot be connected.
(S7 -300, S7-400) Output ENO cannot be connected.
(S7-1200, S7-1500) Output ENO can only be connected with the following instructions:

- ADD: Add (Page 542)
- SUB: Subtract (Page 545)
- MUL: Multiply (Page 548)
- DIV: Divide (Page 551)
- NEG: Create twos complement (Page 554)
- ABS: Form absolute value (Page 556)
- CONVERT: Convert value (Page 566)

Supported data types and parameter types

Only the following data types are supported:

- BOOL
- INT
- WORD
- DINT
- DWORD (S7-300, S7-400)
- TIME

- ARRAY, ARRAY[*] when using the instructions RD_ARRAY_I: Read value from INT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500) (Page 559) and RD_ARRAY_DI: Read value from DINT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500) (Page 561).

  Restrictions:
  - ARRAY only in F-DBs
  - ARRAY limits: 0 up to max. 10000
  - ARRAY[*] only as InOut parameter (InOut) in F-FCs and F-FBs
  - Only ARRAY of INT or ARRAY of DINT permissible
- F-compliant PLC data type (UDT) (S7-1200, S7-1500) (Page 122)
- Named value data types (S7-1500) (Page 127)

NOTE

If the result of an instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostic buffer of the F-CPU.
You must therefore ensure that the permitted range for the data type is observed when creating the program, select a matching data type or use the ENO output for S7-1200/1500 F-CPUs or the OV instruction (Page 596) for S7-300/400 F-CPUs.
Note the description of the individual instructions.

Non-permitted data and parameter types

The following types are **not** permitted:

- All types not listed in the section "Supported data types and parameters types" (e.g. BYTE, REAL)
- Compound data types (e.g. STRING, ARRAY (S7-300, S7-400, S7-1200 G1), STRUCT, PLC data type (UDT) (S7-300, S7-400), Named value data types (S7-300, S7-400, S7-1200))
- Parameter types (e.g. BLOCK_FB, BLOCK_DB, ANY)

Supported operand areas

The system memory of an F-CPU is divided into the same operand areas as the system memory of a standard CPU. You can access the operand areas listed in the table below from within the safety program.

Table 2-2 Supported operand areas

Operand area	Description
Process image of the inputs	
• Of F-I/O	Only read-only access to input channels of F-I/O is possible. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. The process image of the inputs of F-I/O is updated prior to the start of the main safety block.

Operand area	Description
• Of standard I/O	Input channels of standard I/O can only be accessed read-only. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In addition, a process-specific validity check is required. See the *STEP 7 help* for the update times of the process image of the inputs of standard I/O.
Process image of the outputs	
• Of F-I/O	Only write-only access to output channels of F-I/O is possible. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the F-I/O are calculated and stored in the process image of the outputs. The process image of the outputs for F-I/O is updated after the end of the main safety block.
• Of standard I/O	Output channels of standard I/O are write-only channels. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the standard I/O are also calculated and stored in the process image of the outputs, if needed. See the *STEP 7 help* for the update times of the process image of the outputs of standard I/O.
Bit memory	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. A particular element of the bit memory can be either read- or write-accessed in the safety program. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. Note that it is only permitted to use bit memory for connecting the standard user program and the safety program; it must not be used as a buffer for F-data.
Data blocks	
• F-DB	Data blocks store information for the program. They can either be defined as global data blocks such that all F-FBs, F-FCs, or main safety blocks can access them or assigned to a particular F-FB or main safety block (instance DB). A tag of a shared DB can only be accessed from one F-runtime group, and an instance DB only from the F-runtime group in which the corresponding F-FB/instruction is called.
• DB	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. For a tag of a DB, either read access or write access is possible in the safety program. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. Note that the tags of a DB can only be used for transferring data between the standard user program and the safety program; DBs must not be used as a buffer for F-data.
Temporary local data	This memory area holds the temporary tags of a block (or F-block) while the (F-) block is being executed. The local data stack also provides memory for transferring block parameters and for saving intermediate results.

Data type conversion

As with the standard user program, there are two possibilities for data type conversion in the safety program:

- Implicit conversion
  The implicit conversion is executed as in the standard user program with the following restrictions: The bit length of the source data type has to match the bit length of the destination data type.
- Explicit conversion
  You use an explicit conversion instruction (Page 566) before the actual instruction is executed.

Slice access

Slice access is not possible in the safety program.

Non-permitted operand areas

Access via units other than those listed in the table above is **not** permitted. The same applies to access to operand areas not listed, in particular:

- Data blocks that were automatically added
  Exception: Certain tags in the F-I/O DB (Page 157) and in the F-shared DB (S7-300, S7-400) (Page 148) or F-runtime group information DB (S7-1200, S7-1500) (Page 149)
- I/O area: Inputs
- I/O area: Outputs

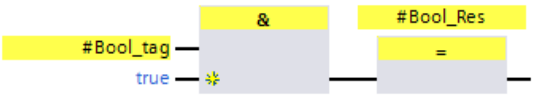
Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-300, S7-400)

The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-300/400 F-CPUs as "Tags" "RLO0" and "RLO1" in the F-shared DB. You access them through a fully qualified DB access ("F_GLOBDB".RLO0 or "F_GLOBDB".RLO1).

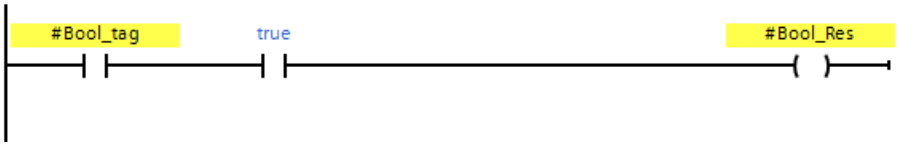
Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-1200, S7-1500)

The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-1200/1500 F-CPUs to assign parameters during block calls. You can enter this directly in FBD or LAD at the respective block inputs.

Example FBD:



Example LAD:



As an alternative, as before you have the option to also set "1" or "TRUE" in a tag using the "Assignment (Page 455)" instruction.

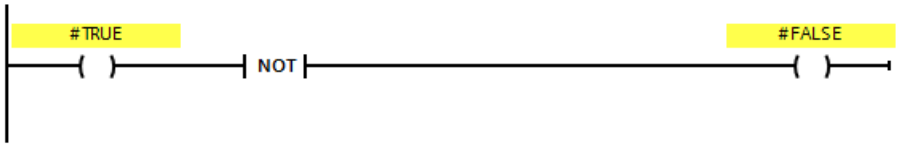
To do so, do not interconnect the box input of the "Assignment" instruction in FBD. In LAD, you interconnect the input directly with the supply rail.

You obtain a tag with "0" or "FALSE" by subsequent inversion with the instruction "Invert RLO (Page 452)".

Example FBD:



Example LAD:



Operand area of temporary local data: Particularities

NOTE

Note when using the operand area of temporary local data that the first access of a local data element in a main safety block/F-FB/F-FC must always be a write access. This initializes the local data element.

Make sure that a temporary local data element is initialized prior to the first JMP, JMPN, or RET instruction.

The "local data bit" should be initialized with the Assign ("=") (FBD) or ("--( )") (LAD) instruction. Assign the local data bit a signal state of "0" or "1" as a Boolean constant.

Local data bits cannot be initialized with the Flip Flop (SR, RS), Set Output (S) or Reset Output (R) instructions.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

"Fully qualified DB access"

Access to tags of a data block in an F-FB/F-FC is "fully qualified DB access". This also applies to initial access to tags of a data block after a jump label.

For S7-300/400 F-CPUs, only initial access needs to be "fully qualified DB access". Alternatively, you can use the instruction "OPN".

Example of "fully qualified DB access":

Assign a name for the F-DB, e.g. "F_Data_1". Use the names assigned in the declaration of the F-DB instead of the absolute addresses.

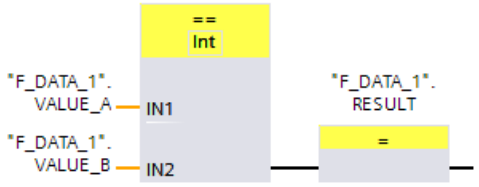


Figure 2-2 Example with fully-qualified access

Example of "non-fully qualified DB access" (S7-300, S7-400):

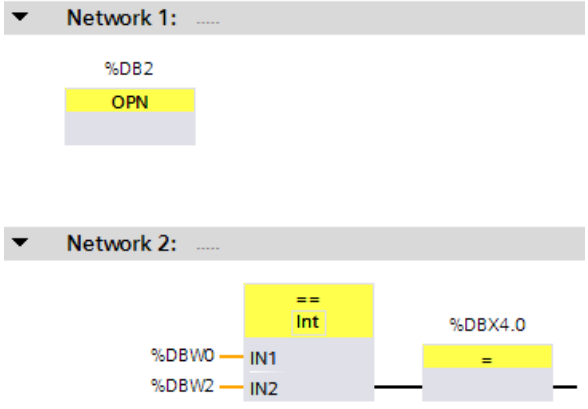


Figure 2-3 Example without fully-qualified access

Access to instance DBs

You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

(S7-300, S7-400) Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

Note the following warning for S7-1200/1500 F-CPUs:

WARNING

When you program global access to instance DBs of F-FBs, you must ensure that the associated F-FB is called in the safety program. *(S096)*

5.1.6 F-compliant PLC data types (UDT) (S7-1200, S7-1500)

Introduction

You declare and use F-compliant PLC data types (UDT) as you would standard PLC data types (UDT). You can use F-compliant PLC data types (UDT) in the safety program as well as in the standard user program.

Differences to standard PLC data types (UDT) are described in this chapter.

Information on the use and declaration of standard PLC data types (UDT) is available in the *STEP 7 help* under "Declaring PLC data types".

Declaring F-compliant PLC data types (UDT)

You declare F-compliant PLC data types (UDT) as you would PLC data types (UDT).

In F-compliant PLC data types (UDT), you can use all data types (Page 116) that you can also use in safety programs. Exception: ARRAY.

Proceed as follows for declaration:

1. Click on "Add new PLC data type" in the "PLC Data Types" folder in the project tree.
2. To create an F-compliant PLC data type (UDT), enable the option "Create F-compliant PLC data type" in the "Add new PLC data type" dialog.
3. Proceed as described in the *STEP 7 help* under "Programming structure of PLC data types".

You specify default values for F-compliant PLC data types (UDT) during the declaration.

Using F-compliant PLC data types (UDT)

You use F-compliant PLC data types as you would standard PLC data types (UDT).

Nesting depth for F-compliant PLC data types

For F-compliant PLC data types, the maximum nesting depth is limited compared to the standard PLC data types (maximum nesting depth = 8). There is a dependency on the call sequence of the block in which a tag of the nested F-compliant PLC data type is declared. Each call level of F-FCs or multi-instance F-FBs reduces the maximum nesting depth of the F-compliant PLC data type used. For multi-instance F-FBs, the caller counts as an additional level.

When a tag of a nested F-compliant PLC data type is declared in a global F-DB, its maximum nesting depth is 7.

Example 1
The main safety block (level 1) calls an F-FB as multi-instance (level 2) which, in turn, calls an F-FC (level 3) in which a tag of the type of a nested F-compliant PLC data type is declared. This means a maximum nesting depth of 5 is available for the fail-safe compliant PLC data type used by the tag.

Example 2
The main safety block calls an F-FB as a single instance (level 1) which, in turn, calls an F-FC (level 2) in which a tag of the type of a nested F-compliant PLC data type is declared. This

means a maximum nesting depth of 6 is available for the fail-safe compliant PLC data type used by the tag.

Changes to F-compliant PLC data types (UDT)

You need the password for the safety program to change F-compliant PLC data types (UDT). Regardless if you are using the F-compliant PLC data type (UDT) in an F-block, in a standard block or not at all.

See also

"F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 88)

5.1.6.1 Grouping PLC tags for inputs and outputs of F-I/O in structures (S7-1200, S7-1500)

You group PLC tags for inputs and outputs of F-I/O in structures (structured PLC tag) as you would for inputs and outputs of standard I/O.

Use F-compliant PLC data types (UDT).

Rules

When creating structured PLC tags for inputs and outputs of F-I/O, you must also observe the following rules in addition to the rules in the standard:

- You must not group inputs/outputs of standard I/O and F-I/O at the same time in a structured PLC tag.
- You may only group inputs/outputs of actually existing channels (channel value and value status) in a structured PLC tag.

  See also Addressing F-I/O (Page 151)
- You may only group inputs/outputs of channels (channel value and value status) that are enabled in the hardware configuration in a structured PLC tag.

  See also Addressing F-I/O (Page 151)
- You may only group inputs of channels (channel value and value status) that provide the result of the "1oo2 sensor evaluation" with set "1oo2 sensor evaluation".

  See also Addressing F-I/O (Page 151)
- You should combine all inputs and outputs of an F-I/O in a structured PLC tag. When divided into several structured PLC tags, these can only begin with multiples of 16 bits. This also applies to nested F-compliant PLC data types (UDT). See rules in the standard.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- A structured PLC tag that groups outputs of an F-I/O must not overlap with other PLC tags.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- In a structured PLC tag for inputs and outputs of F-I/O, the data types WORD, DWORD and TIME are not permitted in the associated PLC data type (UDT).

NOTE
To observe these rules, you must declare the F-compliant PLC data type that is used for the structured PLC tag accordingly.

You can find the addresses allocated to a structured PLC tag in the "IO tags" tab of an F-I/O configuration.

5.1.6.2 Example of structured PLC tags for inputs and outputs of F-I/O (S7-1200, S7-1500)

Introduction

This example uses the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation to demonstrate how you use structured PLC tags for access to F-I/O.

Channel structure of the 4 F-DI/3 F-DO DC24V/2A F-module

The table below sets out the channel structure and address assignment of the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation. You may only access existing and enabled channels (addresses I15.0 to I15.3 and I16.0 to I16.3). These channels provide the result of 1oo2 evaluation generated internally in the F-module.

Table 2-3 Channel structure and addresses of the channel values of inputs with 1oo2 evaluation

Channel	Address
DI channel 0 channel value	I15.0
DI channel 1 channel value	I15.1
DI channel 2 channel value	I15.2
DI channel 3 channel value	I15.3
—	I15.4
—	I15.5
—	I15.6
—	I15.7

Table 2-4 Channel structure and addresses of the value status of the inputs with 1oo2 evaluation

Channel	Address
DI channel 0 value status	I16.0
DI channel 1 value status	I16.1
DI channel 2 value status	I16.2
DI channel 3 value status	I16.3
—	I16.4
—	I16.5
—	I16.6
—	I16.7

Table 2-5 Channel structure and addresses of the value status of outputs

Channel	Address
DO channel 0 value status	I17.0
DO channel 1 value status	I17.1
DO channel 2 value status	I17.2
DO channel 3 value status	I17.3

Table 2-6 Channel structure and addresses of the channel values of outputs

Channel	Address
DO channel 0 channel value	Q15.0
DO channel 1 channel value	Q15.1
DO channel 2 channel value	Q15.2
DO channel 3 channel value	Q15.3

Creating F-compliant PLC data types (UDT)

Create two F-compliant PLC data types (UDT), for example, for access to all channels.

The figure below shows an F-compliant PLC data type (UDT) for access to the channel values and value status of the inputs with 1oo2 evaluation:

4 F-DI/3 F-DO DC24V/2A_DI

	Name	Data type	Comment
1	CH_DI_0	Bool	Channel 0 (DI)
2	CH_DI_1	Bool	Channel 1 (DI)
3	CH_DI_2	Bool	Channel 2 (DI)
4	CH_DI_3	Bool	Channel 3 (DI)

The figure below shows the F-compliant PLC data type (UDT) for access to the channel values and value status of the outputs:

4 F-DI/3 F-DO DC24V/2A_DO

	Name	Data type	Comment
1	CH_DO_0	Bool	Channel 0 (DO)
2	CH_DO_1	Bool	Channel 1 (DO)
3	CH_DO_2	Bool	Channel 2 (DO)

Using F-compliant PLC data types (UDT)

As demonstrated in the figure below, you can use the two F-compliant PLC data types (UDT) that you have created in an F-FC (e.g. "Motor"):

Motor

	Name	Data type	Comment
1	Input		
2	Motor SS DI	"4 F-DI/3 F-DO DC24V/2A_DI"	Motor interface channel values DI
3	CH_DI_0	Bool	Kanal 0 (DI)
4	CH_DI_1	Bool	Kanal 1 (DI)
5	CH_DI_2	Bool	Kanal 2 (DI)
6	CH_DI_3	Bool	Kanal 3 (DI)
7	Motor SS DI VS	"4 F-DI/3 F-DO DC24V/2A_DI"	Motor interface value status DI
8	CH_DI_0	Bool	Kanal 0 (DI)
9	CH_DI_1	Bool	Kanal 1 (DI)
10	CH_DI_2	Bool	Kanal 2 (DI)
11	CH_DI_3	Bool	Kanal 3 (DI)
12	Motor SS DO VS	"4 F-DI/3 F-DO DC24V/2A_DO"	Motor interface value status DI
13	CH_DO_0	Bool	Kanal 0 (DO)
14	CH_DO_1	Bool	Kanal 1 (DO)
15	CH_DO_2	Bool	Kanal 2 (DO)
16	Output		
17	Motor SS DO	"4 F-DI/3 F-DO DC24V/2A_DO"	Motor interface channel values DO
18	CH_DO_0	Bool	Kanal 0 (DO)
19	CH_DO_1	Bool	Kanal 1 (DO)
20	CH_DO_2	Bool	Kanal 2 (DO)

Creating structured PLC tag for the F-module 4 F-DI/3 F-DO DC24V/2A

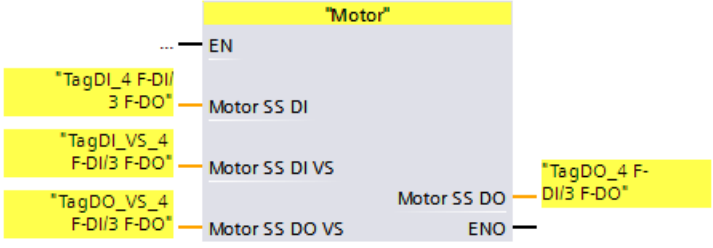
Create structured PLC tags for the F-module 4 F-DI/3 F-DO DC24V/2A:

Tag table_1

	Name	Data type	Address	Comment
1	TagDI_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DI"	%I15.0	Motor 1 DI
2	TagDI_VS_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DI"	%I16.0	Motor 1 DI VS
3	TagDO_VS_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DO"	%I17.0	Motor 1 DO VS
4	TagDO_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DO"	%Q15.0	Motor 1 DO

Accessing the F-FC

Transfer the structured PLC tags you have created when you call the F-FC (e.g. "Motor"):



See also

Addressing F-I/O (Page 151)
Value status (S7-1200, S7-1500) (Page 153)

5.1.7 Named value data types (S7-1500)

You use named value data types as in the standard.

For named value data types in a safety program, you can only use the data types supported by the safety program (Page 116) (except TIME) as base data types.

NOTE

If you change Named value data types, this also changes the collective F signature.

You can find more information on named value data types in the *STEP 7 online help* under "Named value data types" and "Declaring named value data types".

5.1.8 Editing PLC tags with external editors

To edit PLC tags with external editors follow the procedure as in the standard. Additional information can be found in the *STEP 7* help in "Editing PLC tags with external editors".

Note the following:

NOTE

After importing a tag table which contains tags used in the safety program, the collective F-signature of the safety program is reset.

To form the collective F-signature again you have to recompile the project data. For this, with access protection set up for the safety program, you need a valid access authorization for the safety program.

If you would like to edit PLC tags with external editors, we therefore recommend that you store PLC tags to be used in the safety program in a separate tag table.

5.1.9 Using Multiuser engineering

If you want to use Multiuser engineering, proceed as described in the *STEP 7* help under "Using Multiuser engineering".

5.1.10 Deleting the safety program

Deleting individual F-blocks

To delete an F-block, follow the same procedure as in *STEP 7*.

Deleting an F-runtime group

See Deleting an F-runtime group (Page 144)

(S7-300, S7-400) Remove all calls that you have used to call the safety program (Main_Safety).

Deleting the entire safety program for S7-300/400 F-CPUs *with* inserted memory card (SIMATIC Micro Memory Card or flash card)

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
4. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.
5. To delete a safety program on the Memory Card (SIMATIC Micro Memory Card or Flash Card), insert the Memory Card (SIMATIC Micro Memory Card or Flash Card) in the programming device or PC or in a SIMATIC USB prommer.
6. Select the menu command "Project > Card Reader/USB memory > Show Card Reader/USB memory" in the menu bar.
7. Open the "SIMATIC Card Reader" folder and delete the Memory Card.
8. Insert the Memory Card into the F-CPU.
9. Perform a memory reset of the F-CPU (flashing of the STOP LED requests a memory reset).

You can then download the offline standard user program to the F-CPU.

Deleting the entire safety program for S7-400 F-CPUs *without* inserted flash card

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.

4. Compile the project data of the F-CPU
   The offline project no longer contains a safety program.
5. Perform a memory reset on the F-CPU (in the "Online tools" task card of the F-CPU).

You can then download the offline standard user program to the F-CPU.

Delete the entire safety program for SIMATIC S7-1200/1500 F-CPUs

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
3. Compile the project data of the F-CPU
   The offline project no longer contains a safety program.

You can then download the offline standard user program to the F-CPU.

5.2 Defining F-Runtime Groups

5.2.1 Rules for F-Runtime Groups of the Safety Program

Rules

Note the following:

- The channels (channel values and value status) of an F-I/O can only be accessed from a single F-runtime group.
- Tags of the F-I/O DB of an F-I/O can only be accessed from one F-runtime group and only from that F-runtime group from which the channels or value status of this F-I/O are also accessed (if access is made).
- F-FBs can be used in more than one F-runtime group but they must be called with different instance DBs.
- Instance DBs of F-FB can only be accessed from the F-runtime group in which the associated F-FB is called.
- A tag of a global F-DB (except the F-global DB) can only be accessed from one F-runtime group (however, a global F-DB can be used in more than one F-runtime group).
- (S7-300, S7-400) A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", but only read-accessed by the "receiver" F-runtime group.
- (S7-300, S7-400) An F-communication DB can only be accessed from one F-runtime group.
- (S7-1200, S7-1500) You must not call the main safety block yourself. It is automatically called by the assigned F-OB.

NOTE

F-OBs are protected by F-system know-how. The OB start information of F-OBs therefore cannot be evaluated.

- (S7-1200, S7-1500). The F-OB should be created with the highest priority of all OBs.

  NOTE
  The cycle time/runtime of an F-OB can be prolonged by, among other things, communication load, the processing of higher-priority interrupts, as well as by test and commissioning functions. In a redundant S7-1500HF system, it is also dependent on the current system state.

- (S7-300, S7-400) The main safety block may only be called once from a standard block. Multiple calls can cause the F-CPU to go to STOP mode.
- (S7-300, S7-400) For optimal use of temporary local data, you must call the F-runtime group (the main safety block) directly in an OB (cyclic interrupt OB, if possible); you should not declare any additional temporary local data in this cyclic interrupt OB.
- (S7-300, S7-400) Within a cyclic interrupt OB, the F-runtime group should be executed **before** the standard user program; i.e. it should be called at the very beginning of the OB, so that the F-runtime group is always called at fixed time intervals, regardless of how long it takes to process the standard user program.

  For this reason, the cyclic interrupt OB should also not be interrupted by higher priority interrupts.
- The process image of the inputs and outputs of standard I/O, bit memory, and tags of DBs in the standard user program may be accessed either as read-only or read/write from more than one F-runtime group. (see also Data exchange between standard user program and safety program (Page 192))
- F-FCs can generally be called in more than one F-runtime group.

NOTE

You can improve performance by writing sections of the program that are not required for the safety function in the standard user program.
When determining which elements to include in the standard user program and which to include in the Safety program, you should keep in mind that the standard user program can be modified and downloaded to the F-CPU more easily. In general, changes in the standard user program do not require an acceptance.

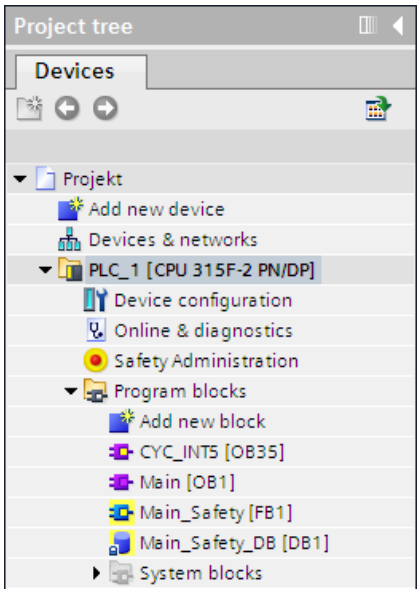
5.2.2 Procedure for defining an F-runtime group (S7-300, S7-400)

Requirements

- You have inserted an S7-300/400 F-CPU in your project.
- In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default after an F-CPU has been added. When you open the "Program blocks" folder, you see the (F-)blocks of the F-runtime group (CYC_INT5 [OB 35], Main_Safety [FB 1], and Main_Safety_DB [DB1]) in the project tree.



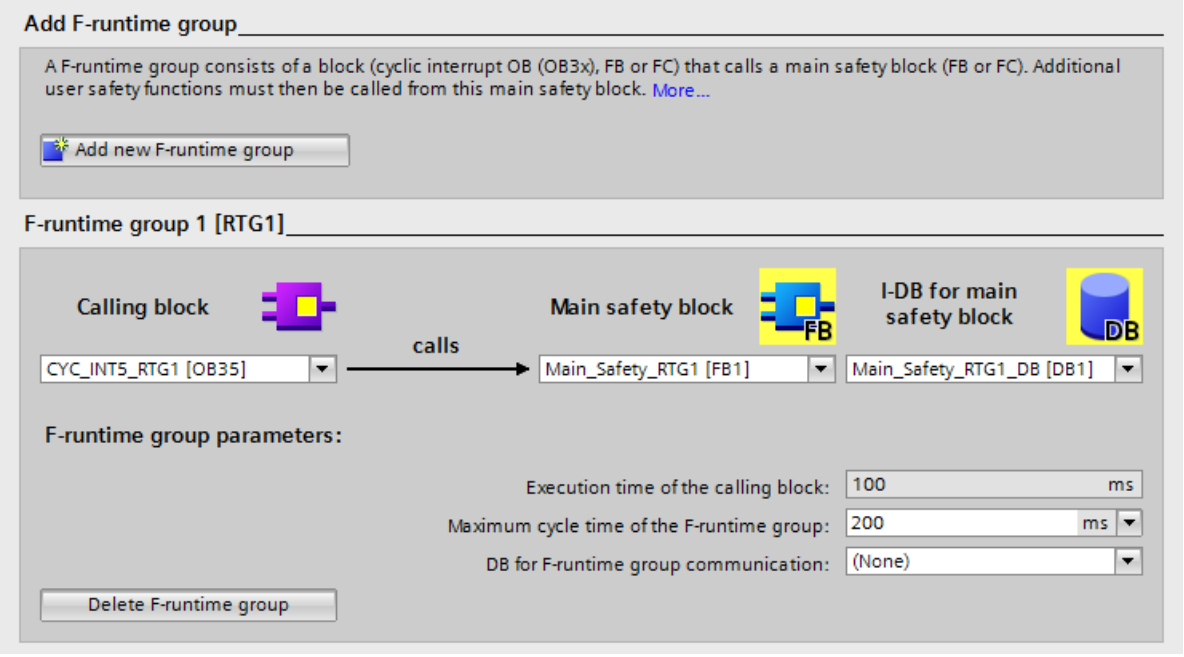
The following section describes how you modify the settings / parameters of the F-runtime group created by default or add and additional F-runtime group.

Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.



3. Specify the block in which the main safety block is to be called.

   Cyclic interrupt OB 35 is suggested here by default. The advantage of cyclic interrupt OBs is that they interrupt the cyclic program processing in OB 1 of the standard user program at fixed intervals. This means that the safety program is called and run at fixed time intervals in a cyclic interrupt OB.

   In this input field, you can select only those blocks that were created in the LAD, FBD, or STL programming language. If you select a block here, the call is inserted automatically into the selected block and, if necessary, removed from a previously selected block.

   If you want to call the main safety block in a block that was created in another programming language, you must program this call itself. The input field is then not editable (grayed out), and you can change the call only in the calling block and not the *Safety Administration Editor*.
4. Assign the desired main safety block to the F-runtime group. If the main safety block is an FB, you must also assign an instance DB.

   Main_Safety [FB1] and Main_Safety_DB [DB1] are suggested by default.

5. The F-CPU monitors the F-cycle time of the F-runtime group. For "Maximum cycle time of F-runtime group", enter the maximum permitted time between two calls of the F-runtime group.

⚠ WARNING

The call interval of the F-runtime group is monitored for a maximum value. This means that monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often or, for example, isochronously. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 522) from the "Instructions" task card and not using counters (OB calls). *(S007)*

⚠ WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.
Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.
Examples:

– Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
– The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the Collective F-Signature.
If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 616)).
The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the Collective F-SW-Signature.
When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

6. If one F-runtime group is to provide tags for evaluation to another F-runtime group of the safety program, assign a DB for F-runtime group communication. Select an F-DB for "DB for F-runtime group communication". (See also F-runtime group communication (S7-300, S7-400) (Page 138))
7. If you want to create a **second F-runtime group**, click the "Add new F-runtime group" button.
8. Assign an F-FB or F-FC as the main safety block to a calling block. This F-FB or F-FC is automatically generated in the project tree, if not already present.

9. If the main safety block is an F-FB, assign an instance DB to the main safety block. The instance DB is generated automatically in the project tree.
10. Follow steps 3 to 5 above to complete generation of the second F-runtime group.

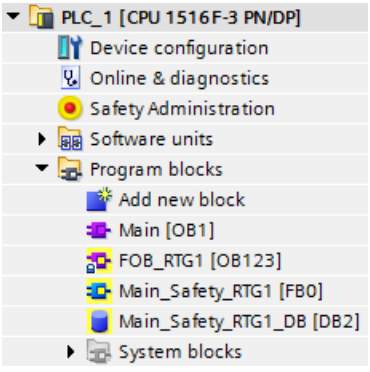
5.2.3 Procedure for defining an F-runtime group (S7-1200, S7-1500)

Requirements

- You have inserted an S7-1200/1500 F-CPU in your project.
- In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default after an F-CPU has been added. When you open the "Program blocks", you see the (F-)blocks of the F-runtime group (FOB_RTG1 [OB123], Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1]) in the project tree.



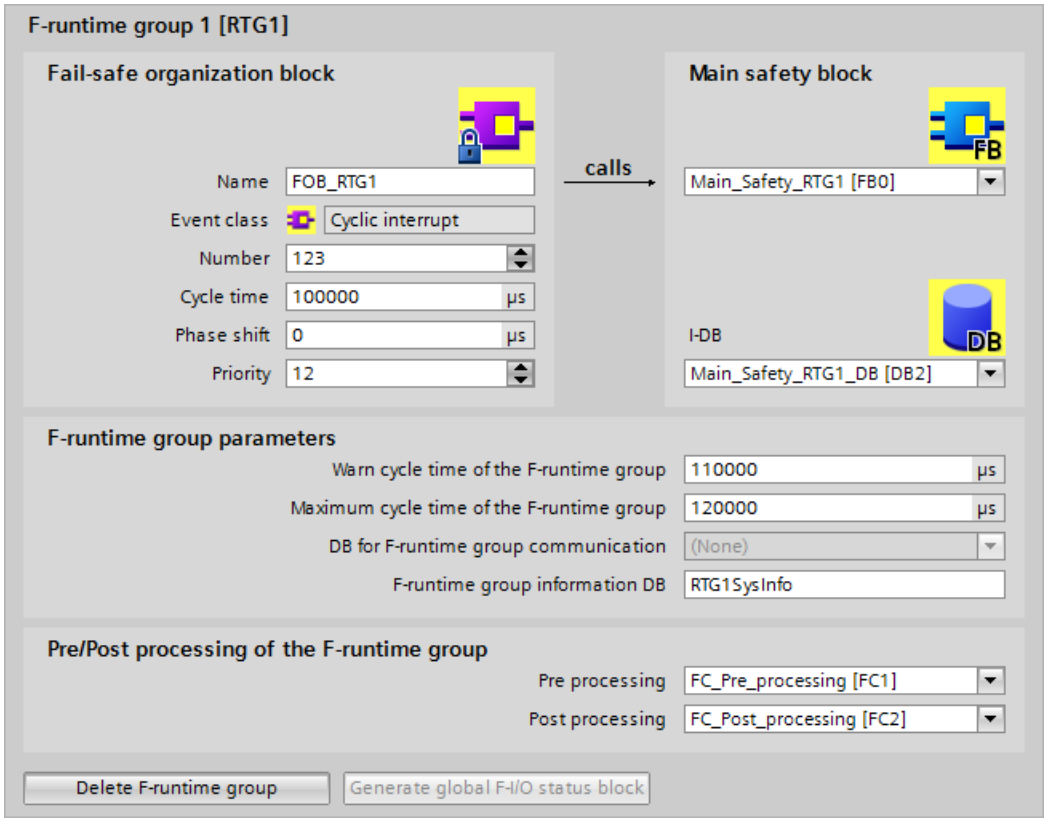
The following section describes how you modify the settings / parameters of the F-runtime group created by default or add and additional F-runtime group.

Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.



3. Assign a name for the F-OB under "F-OB".
4. Specify the event class of the F-OB when you create a new F-runtime group.

   For an F-OB you can select between the event classes "Program cycle", "Cyclic interrupt" or "Synchronous cycle".

   In the case of the F-runtime group created by default, the F-OB has the event class "Cyclic interrupt". To change the event class of the F-OB of an already created F-runtime group, you need to delete and F-runtime group and create a new one.

NOTE

We recommend creating the F-OB with the event class "Cyclic interrupt". The safety program will then be called and executed at fixed time intervals.
F-OBs with the event class "Synchronous cycle" are only recommended in conjunction with F-IOs that support isochronous mode, for example submodule "Profisafe Telgr 902" of drive SINAMICS S120 CU310-2 PN V5.1.
F-OBs with the event class "Program cycle" are not recommended, as these have the lowest priority "1" (see below).

NOTE
Note the maximum permissible number of OBs (incl. F-OBs) with event class "Synchronous cycle" (see technical specifications in the product manuals of the S7-1500 CPUs).

5. If required, you can manually change the number of the F-OB proposed by the system. To do so, note the number ranges valid for the relevant event class.
6. Assign cycle time, phase shift and priority parameters for F-OBs with event class "Cyclic interrupt".
   Assign the priority parameter for F-OBs with event class "Synchronous cycle".
   – Select a cycle time which is less than the "Maximum cycle time of the F-runtime group" and less than the "Cycle time warning limit of F-runtime group".
   – Select a phase shift which is less than the cycle time.
   – If possible, select a priority that is higher than the priority of all other OBs.

NOTE
Through a high priority of the F-OB you ensure that the run time of the safety program and the reaction time of your safety functions (Page 616) are influenced as little as possibly by the standard user program.

NOTE
For F-OBs with event class "Synchronous cycle" you need to also assign parameters for application cycle (ms) and possibly delay time (ms) after defining the F-runtime group and the connection of the isochronous F-I/O to the isochronous mode interrupt OB. You can find these parameters in the "Properties" dialog box of the isochronous mode interrupt OB in the "Isochronous mode" group. Proceed as described in the STEP 7 help under "Configuring isochronous mode interrupt OBs".

7. Assign the calling main safety block to the F-OB. If the main safety block is an FB, you must also assign an instance DB.
   Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1] are suggested by default.
8. The F-CPU monitors the F-cycle time of the F-runtime group. Two parameters are available:
   – If the "Warn cycle time of the F-runtime group" is exceeded, a maintenance demanded is written to the diagnostics buffer of the F-CPU and the MAINT LED of the F-CPU is activated. This parameter can, for example, be used to determine whether the cycle time exceeds a required value without the F-CPU switching to STOP mode.

     NOTE
     The maintenance demanded is marked as an outgoing event by a STOP/RUN transition of the F-CPU. In an HF-system you must set both HF-CPUs or the redundant S7-1500HF system to STOP before you restart the HF-CPUs.
     As an alternative, you can mark the maintenance demanded as outgoing with the standard instruction "ACK_FCT_WARN". To do so, call the instruction "ACK_FCT_WARN" with a rising edge at the input parameter "ACK_WARN" in your standard user program.
     A renewed violation of the warning limit is not signaled until after a STOP/RUN transition of the F-CPU.

– If the "Maximum cycle time of F-runtime group" is exceeded, the F-CPU will go to STOP. For "Maximum cycle time of F-runtime group", select the maximum time that can elapse between two calls of this F-runtime group (max. 20000000 µs).

WARNING

The call interval of the F-runtime group is monitored for a maximum value. This means that monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often or, for example, isochronously. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 522) from the "Instructions" task card and not using counters (OB calls). *(S007)*

WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.
Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.
Examples:

– Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
– The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the Collective F-Signature.
If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 616)).
The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the Collective F-SW-Signature.
When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

The "Cycle time warning limit of F-runtime group" must be configured as less than or equal to the "Maximum cycle time of F-runtime group".

9. If necessary, you can change the name suggested by the system for the F-runtime group information DB (Page 149) under "F-runtime group information DB".

10. If required, you can select blocks of the standard program (FCs) with regard to preprocessing or postprocessing of an F-runtime group (see Pre-/postprocessing (S7-1200, S7-1500) (Page 85))
11. If you want to create a **second F-runtime group**, click the "Add new F-runtime group" button. Follow steps 3 to 10 above.

5.2.4 F-runtime group communication (S7-300, S7-400)

Safety-related communication between F-runtime groups

Safety-related communication can take place between the two F-runtime groups of a safety program. This means fail-safe tags can be provided by one F-runtime group in an F-DB and read in another F-runtime group.

NOTE

A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", while it can only be read-accessed by the "receiver" F-runtime group.

Tip: You can improve performance by structuring your safety program in such a way that as few tags as possible are exchanged between the F-runtime groups.

Procedure for defining a DB for F-runtime group communication

You define the DB for F-runtime group communication in the work area "F-runtime groups". Proceed as follows:

1. Click "F-runtime groups" in "*Safety Administration Editor*".
2. Select an existing F-DB in the "DB for F-runtime group communication" field or assign a new one.
3. Assign a name to the F-DB.

Up-to-dateness of tags read from another F-runtime group

NOTE

Tags read are up-to-date as at the time of the last completed processing cycle of the F-runtime group providing the tags prior to start-up of the F-runtime group reading the tags.

If the tags supplied undergo multiple changes during runtime of the F-runtime group supplying the tags, the F-runtime group reading the tags only receives the last change (see figure below).

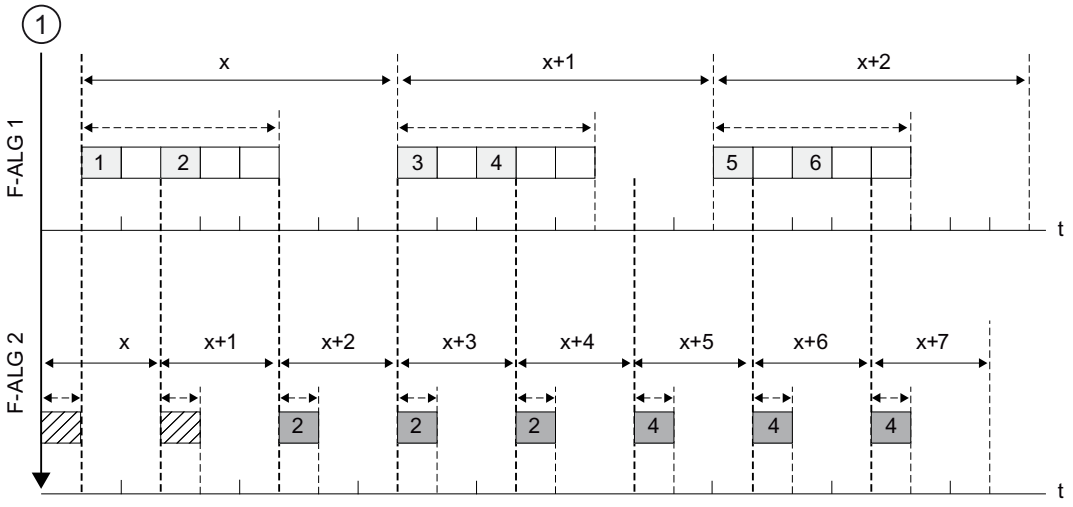
Assignment of fail-safe values

After F-system start-up, fail-safe values are supplied to the F-runtime group which has read access to tags in the DB for F-runtime group communication of another F-runtime group (for example, F-runtime group 2). These are the values you specified as initial values in the DB for F-runtime group communication of F-runtime group 1.

F-runtime group 2 reads the fail-safe values the first time it is called. The second time the F-runtime group 2 is called, it reads the latest tags if F-runtime group 1 has been processed completely between the two calls of F-runtime group 2. If F-runtime group 1 has not been processed completely, F-runtime group 2 continues to read the fail-safe values until F-runtime group 1 is completely processed.

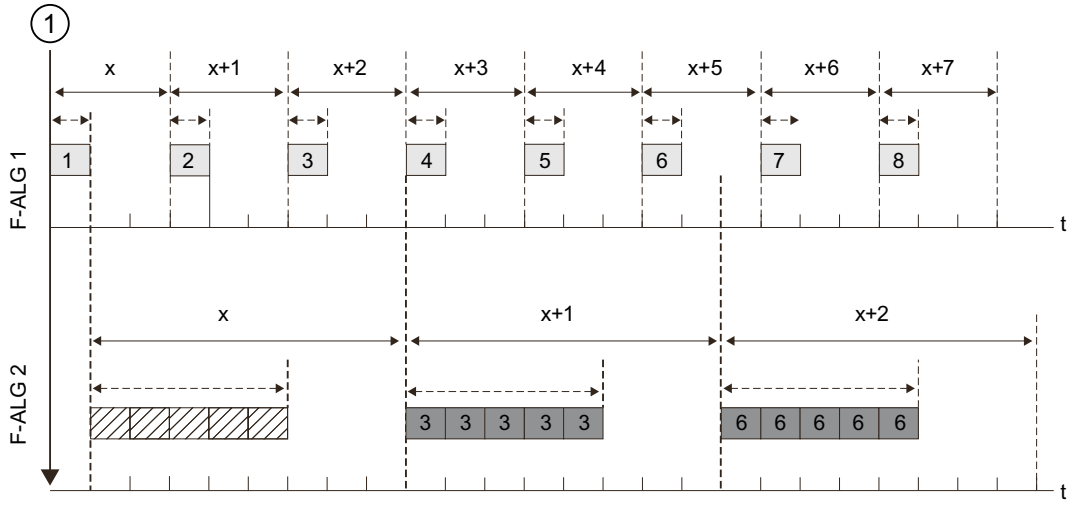
The behavior is illustrated in the two figures below.

Reading tags from F-runtime group 1, which has a longer OB cycle and lower priority than F-runtime group 2



①	Startup of F-system
←→	Cycle time of the (F-)OB in which the F-runtime group is called.
←- - -→	Runtime of the F-runtime group
1	... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1
2	...Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1
▨	Initial value in the DB for F-runtime group communication

Reading tags from F-runtime group 1, which has a shorter OB cycle and higher priority than F-runtime group 2



①	Startup of F-system
←→	Cycle time of the (F-)OB in which the F-runtime group is called.
←- - -→	Runtime of the F-runtime group
1	... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1
2	... Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1
▨	Initial value in the DB for F-runtime group communication

F-runtime group supplying tags is not processed

NOTE

If the F-runtime group whose DB for F-runtime group communication is to supply the tags is not processed (the main safety block of the F-runtime group is not called), the F-CPU goes to STOP mode. One of the following diagnostics events is then entered in the diagnostics buffer of the F-CPU:

- Error in safety program: cycle time exceeded
- Number of the relevant main safety block (of F-runtime group that is not processed)
- Current cycle time in ms: "0"

5.2.5 F-runtime group communication (S7-1200, S7-1500)

Introduction

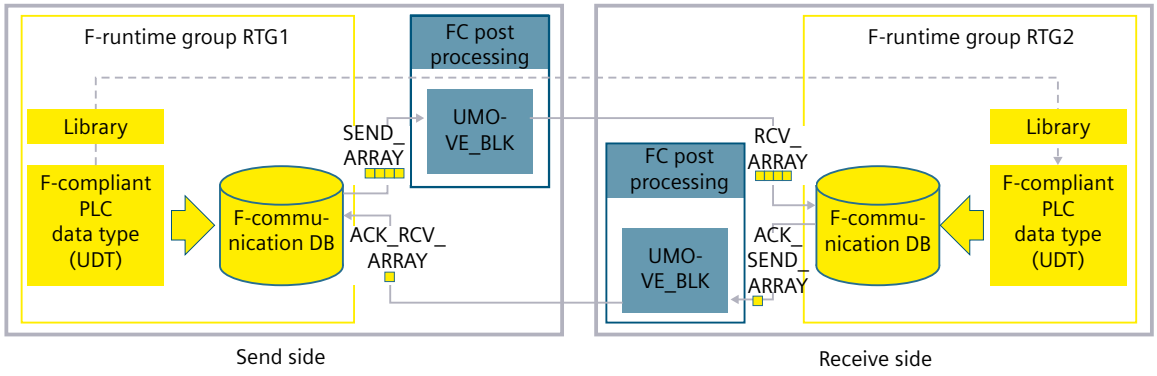
With the help of Flexible F-Link you realize a F-runtime group communication.

With Flexible F-Link, a coded F-array is made available for the send data of the F-runtime group. The coded F-array is transferred to the other F-runtime group with standard instructions such as UNMOVE_BLK.

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- Safety system version as of V2.2

F-runtime group communication



If you want to send a data fail-safe from one F-runtime group to another F-runtime group, follow these steps:

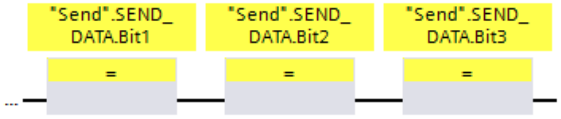
1. Create a non-nested F-compliant PLC data type (UDT) for the F-runtime group communication. The size can be up to 1500 bytes, including a maximum of 800 elements of data type BOOL.
2. Create two safety-related communications for F-runtime group communication in the Safety Administration Editor in the "Flexible F-Link" area. One safety-related communication each for the send and receive sides.

3. Configure the same F-monitoring time and F-communication UUID for each F-runtime group communication relationship.
   Information on calculating the F-monitoring times can be found in Monitoring and response times (Page 615).
   For example:

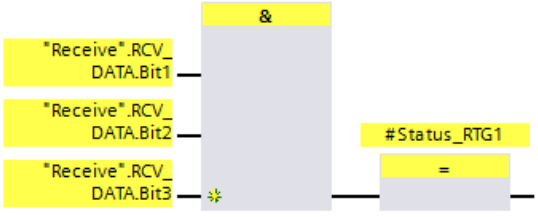
Flexible F-Link settings

	Name	PLC Data Type	Direction	F-monitoring time: (ms)	F-communication UUID
1	Send	Data	Send	500	5d61f443-ede6-4e4e-9db6-e79af634f9ad
2	Receive	Data	Receive	500	5d61f443-ede6-4e4e-9db6-e79af634f9ad

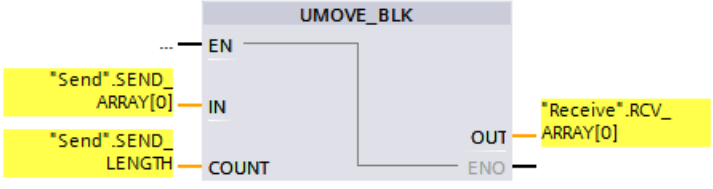
4. On the send side (e.g. RTG1) supply the data of the F-communication DB (Page 341) for the send direction with the data to be sent.
   For example:



5. On the receive side (e.g. RTG2), read the received data from the F-communication DB (Page 341) for the receive direction.
   For example:



6. Call the instruction "UMOVE_BLK" in the F-runtime group for the send data (e.g. RTG1) in the FC for post processing (Page 85).
7. Interconnect the "UMOVE_BLK" instruction for the data to be sent as follows:



   "Send" is the F-communication DB (Page 341) of the F-runtime group that sends the data.
   "Receive" is the F-communication DB (Page 341) of the F-runtime group that receives the data.
8. Call the instruction "UMOVE_BLK" in the F-runtime group for acknowledgment (e.g. RTG2) in the FC for post processing (Page 94).

9. Interconnect the "UMOVE_BLK" instruction for the acknowledgment connection as follows:



"Receive" is the F-communication DB (Page 341) of the F-runtime group that sends the acknowledgment telegram.

"Send" is the F-communication DB (Page 341) of the F-runtime group that receives the acknowledgment telegram.

10. Compile the user program.

11. Download the user program to the F-CPU.

WARNING

For each communication connection via Flexible F-Link, you must check that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides when you accept the safety program. You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Up-to-dateness of tags read from another F-runtime group

The same statements as those in the section "F-runtime group communication (S7-300, S7-400) (Page 138)" apply (except for the storage locations written or read or initial values).

5.2.6 Deleting an F-runtime group

Deleting an F-runtime group

To delete an F-runtime group, proceed as follows:

1. In the area navigation of the *Safety Administration Editor*, click on the F-runtime group to be deleted.
2. Select the "Delete F-runtime group" button in the work area.
3. Confirm the dialog with "Yes".
4. Perform a Compilation of the safety program (Page 344) (menu command "Edit > Compile") for your changes to take effect.

The assignment of the F-blocks to an F-runtime group (to the calling block of the main safety block) is deleted. However, the F-blocks continue to exist.

5.2.7 Changing the F-runtime group (S7-300, S7-400)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Specify another block as the calling block of the main safety block.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time of the F-runtime group
- Specify another DB as a data block for F-runtime group communication.

5.2.8 Changing the F-runtime group (S7-1200, S7-1500)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Change the name, number, cycle time, phase shift and priority of the F-OB.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time and the cycle time warning limit of the F-runtime group.
- Assign another name for the F-runtime group information DB.
- Specify an FC for the preprocessing and postprocessing.

5.3 Creating F-blocks

5.3.1 Creating F-blocks

Introduction

In order to create F-FBs, F-FCs, and F-DBs for the safety program, you should follow the same basic procedure as in the standard. In the following, only the deviations from the procedure for standard blocks are presented.

Creating F-FBs, F-FCs, and F-DBs

You create F-blocks in the same way as for standard blocks. Proceed as follows:

1. In the project tree of the F-CPU or the Safety Unit, double-click on "Add new block" under "Program blocks".
2. In the dialog that appears, specify the type, name, and language and select the "Create F-block" check box. (If you do not select the check box, a standard block is created.)
3. After the dialog is confirmed, the F-block is opened in the *Program editor*.

Note the following

Note the following important instructions:

NOTE

- You may not declare block parameters in the block interface of the main safety block because they cannot be supplied.
- (S7-1200, S7-1500) You can edit start values in instance DBs.
- The function "Apply actual values" is not supported.
- You may not access static local data in single instances or multi-instances of other F-FBs.
- You must always initialize outputs of F-FCs.
  The F-CPU can go to STOP mode if the information above is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- (S7-300, S7-400) If you wish to assign an address from the data area (data block) to a formal parameter of an F-FC as an actual parameter, you have to use fully qualified DB access.
- Its inputs may only be accessed by a block in reading mode and its outputs only in writing mode.
  Use an in/out if you wish to have both read and write access.
- For greater clarity, assign meaningful names to the F-blocks you have created.

Copying/pasting F-blocks

You can copy F-FBs, F-FCs, and F-DBs in exactly the same was as blocks of the standard user program.

Exceptions:

- (S7-1200, S7-1500) You may not copy an F-OB.
- You cannot copy blocks from the folder "Program blocks > System blocks".
- (S7-1500) F-blocks cannot be copied from the Safety Unit to a standard unit or between the Safety Unit and the "Program blocks" folder of the F-CPU.

See also

Changing the F-runtime group (S7-1200, S7-1500) (Page 144)

5.3.2 Know-how protection

For know-how protection of F-blocks, proceed as described in the *STEP 7* help under "Protecting blocks".

Requirements

Note the following with regard to know-how protection of F-blocks for S7-1200/1500 F-CPUs:

- An F-block to which you wish to assign know-how protection must be called in the Safety program.
- Before you can set up the know-how protection for an F-block, the Safety program must be consistent. For this purpose, compile (Page 344) the Safety program.

NOTE

No source code is output in the safety summary for know-how-protected F-blocks. Therefore, create the safety summary (for example, for carrying out a code review or for F-block acceptance) before you set up the know-how protection.

NOTE

If you want to edit the program code and/or the block interface of a know-how protected F-block, we recommend that you do not open the F-block by entering a password, but rather remove the know-how protection completely and set it up again after compiling.

NOTE

(S7-1200, S7-1500) When a know-how protected F-block or F-blocks called by it are renamed, the signature of the know-how protected F-block is not changed until the password is entered when opening or removing the know-how protection.

NOTE

When know-how protected F-blocks are used, warnings and error messages whose cause can lie in the know-how protected F-blocks can be displayed during compilation of the Safety program. The warnings and error messages contain corresponding information. Example: In a know-how protected F-block, you perform read access to a tag of the standard user program to which write access is taking place in a different (know-how protected) F-block.

For S7-1200/1500 F-CPUs, you can obtain additional information in the section "Know-how protected F-blocks in the Safety program" of the safety summary.

See also

Reuse of F-blocks (Page 147)

5.3.3 Reuse of F-blocks

Introduction

You can reuse F-blocks that you have already tested and, if applicable, approved, in other Safety programs – without having to test and approve them again.

You can protect the content of the F-block by setting up the know-how protection. You may only set this protection after acceptance of the F-block to ensure that the safety summary contains this F-block in its entirety.

Like standard blocks, you can store F-blocks as master copies or types in global libraries or in the project library.

More information can be found in the *STEP 7 help* under "Using libraries".

Creating safety summary for the F-block to be reused

Create a safety summary with the following information for F-blocks that you want to reuse.

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-FBs and F-FCs
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version when setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-FBs and F-FCs
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

The safety summary should also contain a description of the functionality of the F-block, in particular if it is know-how protected.

The required information is obtained by creating the safety summary of the Safety program in which you originally created, tested and approved the F-block to be reused.

This safety summary can also serve directly as the safety summary for the F-block to be reused.

Checks when using the F-block to be reused

When reusing the F-block, ensure the following:

- The signature and initial value signature (S7-300, S7-400) of the F-block are unchanged.
- (SIMATIC S7-1200, S7-1500) The documented safety system version is set.
- The documented (or functionally identical) versions of the versioned LAD/FBD instructions are set. You can find information about the instruction versions in the description of the instructions.
- (S7-1200, S7-1500) The called and accessed F-blocks with the documented signatures are used.
- (S7-300, S7-400) The called F-blocks with the documented signatures and initial value signatures are used.

If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

See also

Compliance of the know-how protected F-blocks used in the Safety program with their safety summary. (Page 411)

5.4 Information interface to the safety program

5.4.1 F-shared DB (S7-300, S7-400)

Function

The F-shared DB is a fail-safe data block that contains all of the shared data of the safety program and additional information needed by the F-system. The F-shared DB is automatically inserted when the hardware configuration is compiled.

Using its name F_GLOBDB, you can evaluate certain data elements of the safety program in the standard user program.

Reading an F-shared DB in the standard user program

You can read out the following information in the F-shared DB in the standard user program or on an operator control and monitoring system:

- Operating mode: safety mode or disabled safety mode ("MODE" tag)
- Error information "Error occurred when executing safety program" ("ERROR" tag)
- Collective F-Signature ("F_PROG_SIG" tag)
- Compilation date of the safety program ("F_PROG_DAT" tag, DATE_AND_TIME data type)

You use fully qualified access to access these tags (e.g. ""F_GLOBDB".MODE").

5.4.2 F-runtime group information DB (S7-1200, S7-1500)

Introduction

The F-runtime group information DB provides key information on the corresponding F-runtime group and on the safety program as a whole.

The F-runtime group information DB is generated automatically when an F-runtime group is created. A symbol, for example, "RTG1SysInfo", is assigned for the F-runtime group information DB. You can change the name in the *Safety Administration Editor*.

You must not access the information in the "F_SYSINFO" parameter from the safety program.

Information in the F-runtime group information DB

The F-runtime group information DB provides the following information:

Name	Data type	For processing in the safety program	For processing in the standard user program	Description
MODE	BOOL	x	x	1 = Disabled safety mode
MODE_REMAINING_TIME	TIME	x	x	Remaining runtime in deactivated safety mode until the F-CPU switches to STOP [1]
MODE_VPLC_TIME_SERVICE	BOOL	—	x	1 = Redundant operation of the Virtual Time Service application [2]
F_SYSINFO				
MODE	BOOL	—	x	1 = Disabled safety mode
TCYC_CURR	DINT	—	x	Current cycle time of the F-runtime group, in ms
TCYC_LONG	DINT	—	x	Longest cycle time of the F-runtime group, in ms
TRTG_CURR	DINT	—	x	Current runtime of the F-runtime group, in ms
TRTG_LONG	DINT	—	x	Longest runtime of the F-runtime group, in ms
T1RTG_CURR	DINT	—	x	Not supported by *STEP 7 Safety V21*.
T1RTG_LONG	DINT	—	x	Not supported by *STEP 7 Safety V21*.
F_PROG_SIG	DWORD	—	x	Collective F-Signature of the safety program
F_PROG_DAT	DTL	—	x	Compilation date of the safety program
F_RTG_SIG	DWORD	—	x	F-runtime groups signature
F_RTG_DAT	DTL	—	x	Compilation date of the F-runtime group
VERS_S7SAF	DWORD	—	x	Version identifier for *STEP 7 Safety*

1 When the F-CPU switches to STOP after the runtime for the deactivated safety mode has expired, the remaining time still present in the last cycle is displayed.

2 Only relevant for S7-1500 F Virtual Controller.

You access the content of the F-runtime group information DB with fully qualified addressing. Either collectively with the F_SYSINFO PLC data type (UDT), for example, "RTG1SysInfo.F_SYSINFO", provided by the F-system or individual information, for example, "RTG1SysInfo.F_SYSINFO.MODE".

See also

Program identification (Page 378)

5.5 Programming startup protection

Introduction

WARNING

Unintentional restart
In contrast to the standard user program, when the safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.
If an unintentional startup of your process is not allowed, you must program restart/startup protection in the safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 184)"). This user acknowledgment must not take place until safe output of process values is possible.
You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:
  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

Example of restart/startup prevention

In order to implement a restart/startup prevention, it must be possible to detect a startup. To detect a startup, you declare a tag of data type BOOL with initial value "TRUE" in an F-DB.

Block the output of process data when this tag has the value "1," for example, by passivating F-I/O using the PASS_ON tag in the F-I/O DB.

If the output of the process values is safely possible and errors have been corrected, reset this tag by a user acknowledgment.

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 184)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 189)

F-I/O DB (Page 157)

F-I/O access

6

The following sections contain a general description of F-I/O access.

The following sections are only valid to a limited extent for technology modules (e.g. F-TM Count 1x1Vpp sin/cos HF). You can find more detailed information in the respective equipment manuals.

For F-I/O with integrated safety functions (such as ET 200ecoPN M12-L F), outputs can be written from both the safety program of the F-CPU and from the integrated safety functions. You can find information on which values ultimately take effect here in the respective manuals.

6.1 Addressing F-I/O

Overview

Below you will find a description of how to address the F-I/O in the safety program and which rules must be observed in the process.

Addressing via the process image

As with standard I/O, you access F-I/O (e.g., S7-1500/ET 200MP fail-safe modules) via the **process image** (PII and PIQ).

Direct reading (with I/O identification ":P") of inputs or writing of outputs is not possible in the safety program.

Updating the process image

The process image of the inputs of F-I/O is updated at the start of the F-runtime group. The process image of the outputs of F-I/O is updated at the end of the F-runtime group (see Program structure of the safety program (S7-300, S7-400) (Page 108) or Program structure of the safety program (S7-1200, S7-1500) (Page 110)). For more information on updating the process image, refer to the note in Data Transfer from the Safety Program to the Standard User Program (Page 192).

The communication required between the F-CPU (process image) and the F-I/O to update the process image uses a special safety protocol in accordance with PROFIsafe.

Rules

- You may only address a channel (channel value and value status) of an F-I/O in **one** F-runtime group. The first programmed addressing defines the assignment for the F-runtime group.
- You may only address a channel (channel value and value status) of an F-I/O with a unit that matches the data type of the channel.
  Example: To access input channels of data type BOOL, you must use the "input (bit)" (I x.y) unit. Access to the 16 consecutive input channels of the data type BOOL via the unit "input word" (IW x) is not possible.
- Analog channels always need to be entered in the tag table with data type INT or DINT. The data types WORD, DWORD and TIME are not permissible.
- Address only inputs and outputs that reference an actually existing channel (channel value and value status) (e.g. for an F-DO 10xDC24V with start address 10 only the outputs Q10.0 to Q11.1 for the channel values and the inputs I10.0 to I11.1 for the value status). Keep in mind that due to the special safety protocol, the F-I/O occupies a larger area of the process image than is required for the existing and enabled channels on the F-I/O (channel values and value status). To find the area of the process image where the channels (channel values and value status) are stored (channel structure), refer to the relevant manuals for the F-I/O.
- Channels can be disabled for certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules). Address only channels (channel value and value status) that are enabled in the hardware configuration. When you address channels that are disabled in the hardware configuration, a warning may be output when compiling the safety program.
- For certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules), a "1oo2 (2v2) sensor evaluation" can be specified. Two channels are grouped into one channel pair in this case, and the result of the "1oo2 sensor evaluation" is usually provided under the address of the channel with the lower channel number (see relevant manuals of the F-I/O). Address only this channel (channel value and value status) of the channel pair. When you address a different channel, a warning may be output when compiling the safety program.

⚠ WARNING

If you use an additional component between the F-CPU (S7-300, S7-400) and the F-I/O that copies the safety message frame in accordance with PROFIsafe between the F-CPU (S7-300, S7-400) and F-I/O per user program, you must test all safety functions affected by the copy function whenever you change the user-programmed copy function. *(S049)*

See also

Safety-related I-slave-slave communication - F-I/O access via process image (Page 183)
Value status (S7-1200, S7-1500) (Page 153)

6.2 Value status (S7-1200, S7-1500)

Properties

The value status is additional binary information for the channel value of an F-I/O. The value status is entered in the process image input (PII).

The value status is supported by fail-safe modules S7-1500/ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200eco PN, ET 200S, ET 200iSP, ET 200pro, S7-1200 or F-SMs S7-300, fail-safe GSD based IO devices as well as fail-safe GSD based DP slaves that support the "RIOforFA-Safety" profile. Information about the value status can be found in the documentation of the respective F-I/O.

We recommend you amend the name of the channel value with "_VS" for the value status, for example, "TagIn_1_VS".

The value status provides information on the validity of the corresponding channel value:

- 1: A valid process value is output for the channel.
- 0: A fail-safe value is output for the channel.

The channel value and value status of an F-I/O can only be accessed from the same F-runtime group.

Location of value status bits in the PII for F-I/O with digital inputs

The value status bits come straight after the channel values in the PII.

Table 2-7 Example: Address assignment in PII for F-I/O with 16 digital input channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
x + 1	DI_{15}	DI_{14}	DI_{13}	DI_{12}	DI_{11}	DI_{10}	DI_9	DI_8
x + 2	Value status DI_7	Value status DI_6	Value status DI_5	Value status DI_4	Value status DI_3	Value status DI_2	Value status DI_1	Value status DI_0
x + 3	Value status DI_{15}	Value status DI_{14}	Value status DI_{13}	Value status DI_{12}	Value status DI_{11}	Value status DI_{10}	Value status DI_9	Value status DI_8

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs

The value status bits in the PII are mapped with the same structure as the channel values in the PIQ.

Table 2-8 Example: Address assignment in PIQ for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

Table 2-9 Example: Address assignment in PII for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs and digital inputs

The value status bits come directly after the channel values in the PII in the following order:

- Value status bits for the digital inputs
- Value status bits for the digital outputs

Table 2-10 Example: Address assignment in PIQ for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bit in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

Table 2-11 Example: Address assignment in PII for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status DI_1	Value status DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

The location of the channel values in the PII and PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog inputs

The value status bits come straight after the channel values in the PII.

Table 2-12 Example: Address assignment in PII for F-I/O with 6 analog input channels (data type INT)

Byte in the F-CPU	Assigned bytes/bits in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AI_0							
...	...							
x + 10	Channel value AI_5							
x + 12	—	—	Value status AI_5	Value status AI_4	Value status AI_3	Value status AI_2	Value status AI_1	Value status AI_0

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog outputs

The value status bits are mapped in the PII.

Table 2-13 Example: Address assignment in PIQ for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bytes in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AO_0							
...	...							
x + 10	Channel value AO_5							

x = Module start address

Table 2-14 Example: Address assignment in PII for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	Value status AO_5	Value status AO_4	Value status AO_3	Value status AO_2	Value status AO_1	Value status AO_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

6.3 Process Data or Fail-Safe Values

When are fail-safe values used?

The safety function requires that fail-safe values (0) be used instead of process data for passivation of the entire F-I/O or individual channels of an F-I/O in the following cases. This applies both to digital channels (data type BOOL) as well as for analog channels (data type INT or DINT):

- When the F-system starts up
- When errors occur during safety-related communication (communication errors) between the F-CPU and F-I/O using the safety protocol in accordance with PROFIsafe
- When F-I/O faults and channel faults occur (such as wire break, short circuit, and discrepancy errors)
- As long as you enable passivation of the F-I/O with PASS_ON = 1 in the F-I/O DB (see below)
- As long as you disable the F-I/O with DISABLE = 1 in the F-I/O DB (see below)

Fail-safe value output for F-I/O/channels of an F-I/O

When **passivation** occurs for an **F-I/O with inputs**, the F-system provides the safety program with fail-safe values (0) in the PII instead of the process data pending at the fail-safe inputs of the F-I/O.

The overflow or underflow of a channel of the **SM 336; AI 6 x 13Bit** or **SM 336; F-AI 6 x 0/4 ... 20 mA HART** is recognized by the F-system as an F-I/O/channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If you want to process fail-safe values other than "0" in the safety program for an F-I/O with inputs **for analog channels of data type INT or DINT**, you can assign individual fail-safe

values for QBAD = 1 and value status = 0 or QBAD_I_xx/QBAD_O_xx = 1 (instructions JMP/JMPN, LABEL and MOVE). For details about the characteristics go to QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status (Page 162).

⚠ WARNING

For an F-I/O with digital input channels (data type BOOL), the value provided in the PII must always be processed in the safety program, regardless of the value status or QBAD/QBAD_I_xx. *(S009)*

When **passivation** occurs in an **F-I/O with outputs**, the F-system outputs fail-safe values (0) at the fail-safe outputs instead of the output values provided by the safety program in the PIQ.

State of associated PAA/PIQ by ...	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs	F-I/O without "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs	F-I/O with S7-300/400 F-CPUs
Startup of F-system[1]	The F-system overwrites the PII/PIQ with fail-safe values (0).		
Communication errors			
F-I/O faults	The F-system overwrites the PII with fail-safe values (0). In the PII the values formed in the safety program are retained.	The F-system overwrites the PII/PIQ with fail-safe values (0).	
Channel faults in configuration of passivation for complete F-I/O			
Channel faults during configuration of channel-granular passivation		For the affected channels: The F-system overwrites the PII/PIQ with fail-safe values (0).	
As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1	The F-system overwrites the PII/PIQ with fail-safe values (0).		
As long as the F-I/O is deactivated in the F-I/O DB with DISABLE = 1	The F-system overwrites the PII/PIQ with fail-safe values (0).		-

[1] During the delayed transfer of the F-Base ID, the F-system remains in startup.

Reintegration of F-I/O/channels of an F-I/O

The switchover from fail-safe values (0) to process data (**reintegration of an F-I/O**) takes place **automatically** or following **user acknowledgment** in the F-I/O DB. The reintegration method depends on the following:

- The reason for passivation of the F-I/O or channels of the F-I/O
- At F-I/Os without the "Channel failure acknowledge" channel parameter on the value of the ACK_NEC variable of the associated F-IO data blocks (Page 157).
- At F-I/Os with the "Channel failure acknowledge" channel parameter (for example F-modules S7-1500 / ET 200 MP / F-modules SIMATIC S7-1200) on the value of the channel parameter.

For fail-safe GSD based DP slaves / GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation.

NOTE
Note that for channel faults in the F-I/O, channel-granular passivation takes place if configured accordingly in the *hardware and network editor*. For the concerned channels, fail-safe values (0) are output.
Reintegration after channel faults reintegrates all channels whose faults were eliminated; faulty channels remain passivated.

See also

Configuring F-I/O (Page 51)

6.4 F-I/O DB

Introduction

An F-I/O DB is automatically generated for each F-I/O (in safety mode) when the F-I/O is configured in the *hardware and network editor*. The F-I/O DB contains tags that you can evaluate or can/must write to in the safety program. It is not permitted to change the initial values of the tags directly in the F-I/O DB. When an F-I/O is deleted, the associated F-I/O DB is also deleted.

Access to an F-I/O DB

You access tags of the F-I/O DB for the following reasons:

- For reintegration of F-I/O after communication errors, F-I/O faults, or channel faults
- If you want to passivate the F-I/O depending on particular states of your safety program (for example, group passivation)
- If you want to deactivate the F-I/O (for example, configuration control)
- For changing parameters for fail-safe GSD based DP slaves/GSD based I/O devices
- If you want to evaluate whether fail-safe values or process data are output

6.4.1 Name and number of the F-I/O DB

The name of the F-I/O DB is formed by:

- the fixed prefix "F"
- the start address of the F-I/O, and the names entered in the properties of the F-I/O in the *hardware and network editor* or in the device view (max. the first 24 characters)

Example: F00004_F-DI24xDC24V_1

The number is assigned within the number range defined in the "Settings" area (Page 89) of the *Safety Administration Editor*.

Option "Creates F-I/O DBs without prefix" (S7-1200, S7-1500)

When you select the option "Creates F-I/O DBs without prefix" in the "Settings" (Page 89) area in the *Safety Administration Editor*, the name is formed only from:

- the name entered in the properties of the F-I/O in the *hardware and network editor* or in the device view (max. 117 characters)

Example: F-DI24xDC24V_1

Changing the name and number of the F-I/O DB

You change the name by changing the name entered in the properties of the F-I/O in the *hardware and network editor* or in the device view.

You change the number in the "Properties"/"F-parameters" tab of the associated F-I/O.

6.4.2 Tags of the F-I/O DB

The following table presents the variables of an F-I/O DB:

	Tag	Data type	Description	Initial value
Tags that you can or must write	PASS_ON	BOOL	1=enable passivation	0
	ACK_NEC	BOOL	1=acknowledgment for reintegration required in the event of F-I/O or channel faults	1
	ACK_REI	BOOL	1=acknowledgment for reintegration	0
	IPAR_EN	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
	DISABLE[1]	BOOL	1=Deactivate F-I/O	0
Tags that you can evaluate	PASS_OUT	BOOL	Passivation output	1
	QBAD	BOOL	1=Fail-safe values are output	1
	ACK_REQ	BOOL	1=Acknowledgment request for reintegration	0
	IPAR_OK	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
	DIAG	BYTE	Non-fail-safe service information	0
	DISABLED[1]	BOOL	1=F-I/O is deactivated	0
	QBAD_I_xx	BOOL	1=Fail-safe values are output to input channel xx (S7-300, S7-400)	1
	QBAD_O_xx	BOOL	1=Fail-safe values are output to output channel xx (S7-300, S7-400)	1
	BASEID_ACTIVE[2]	LWORD	Active F-BaseID Non-fail-safe information	0

1 As of Safety system version V2.1 for S7-1200/1500

2 As of Safety system version V2.8 for S7-1200 G2/1500

Differences in evaluation in S7-1200/1500 F-CPUs and S7-300/400

The following table describes the differences in the evaluation of tags of the F-I/O DB and the value status depending on the F-I/O and F-CPU used.

Tag in the F-I/O DB or value status	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O with S7-300/400 F-CPU
ACK_NEC	—[2]	x	x
QBAD[3]	x	x	x
PASS_OUT[3]	x	x	x
QBAD_I_xx[1]	—	—	x
QBAD_O_xx[1]	—	—	x
Wertstatus[1]	x	x	—

1 QBAD_I_xx and QBAD_O_xx display the validity of the channel value channel-granular and thus correspond to the inverted value status with S7-1200/1500. Value status or QBAD_I_xx and QBAD_O_xx are not available with fail-safe DP GSD based slaves or fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

2 In the case of F-I/Os that support the "Channel failure acknowledge" channel parameter (for example S7-1500/ET 200MP F-modules or S7-1200 F-modules), this replaces the ACK_NEC variable of the F-IO data block.

3 For details about the characteristics, see "QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status"

6.4.2.1 PASS_ON

The PASS_ON tag allows you to enable passivation of an F-I/O, for example, depending on particular states in your safety program.

Using the PASS_ON tag in the F-I/O DB, you can passivate F-I/O; channel-granular passivation is not possible.

As long as PASS_ON = 1, **passivation** of the associated F-I/O occurs.

6.4.2.2 ACK_NEC

If an F-I/O fault is detected by the F-I/O, **passivation** of the relevant F-I/O occurs. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated, **reintegration** of the relevant F-I/O occurs, depending on ACK_NEC:

- With ACK_NEC = 0, you can assign an **automatic reintegration**.
- With ACK_NEC = 1, you can assign a **reintegration** by **user acknowledgment**.

⚠ WARNING

The parameter assignment of the ACK_NEC tag of the F-I/O DB with the value "0" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

NOTE
The initial value for ACK_NEC is 1 after creation of the F-I/O DB. If you do not require automatic reintegration, you do not have to write ACK_NEC.

See also

After F-I/O or channel faults (Page 171)

6.4.2.3 ACK_REI

When the F-system detects a communication error or an F-I/O fault for an F-I/O, the relevant F-I/O is passivated. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. **Reintegration** of the F-I/O/channels of the F-I/O after the fault has been eliminated requires a **user acknowledgment** with a positive edge at variable ACK_REI of the F-I/O DB:

- After every communication error
- After F-I/O or channel faults only with parameter assignment "Channel failure acknowledgement = manual" or ACK_NEC = 1

Reintegration after channel faults reintegrates all channels whose faults were eliminated.

Acknowledgment is not possible until tag ACK_REQ = 1.

In your safety program, you must provide a user acknowledgment by means of the ACK_REI tag for each F-I/O.

⚠ WARNING

A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

NOTE
Alternatively, you can use the "ACK_GL" instruction to carry out reintegration of the F-I/O following communication errors or F-I/O/channel faults (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21) (Page 520)).

6.4.2.4 IPAR_EN

The IPAR_EN tag corresponds to the iPar_EN_C tag in the PROFIsafe bus profile as of PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out when this tag must be set or reset when parameters of fail-safe GSD based DP slaves/GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Note that IPAR_EN = 1 does not trigger passivation of the relevant F-I/O.

If passivation is to occur when IPAR_EN = 1, you must also set tag PASS_ON = 1.

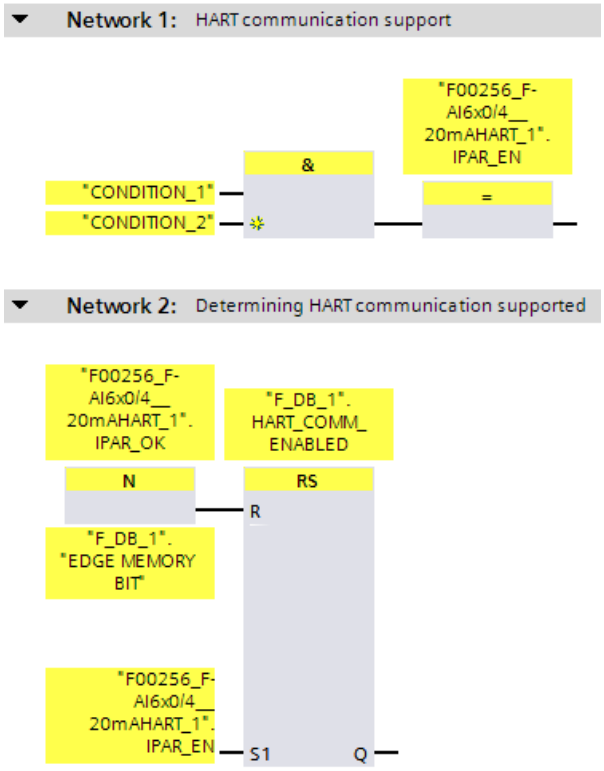
HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART

If you set the IPAR_EN tag to "1" while parameter "HART_Tor" = "switchable" is assigned, the HART communication for the SM 336; F-AI 6 x 0/4 ... 20 mA HART is enabled. Setting this tag to "0" disables the HART communication. The F-SM acknowledges the enabled or disabled HART communication with tag IPAR_OK = 1 or 0.

Enable HART communication only when your system is in a status, in which any reassignment of parameters for an associated HART device can be done without any risk.

If you want to evaluate the "HART communication enabled" status in your safety program, e.g., for the purpose of programming interlocks, you must build up the information as shown in the following example. This is necessary to ensure that the information is properly available even if communication errors occur while the HART communication is enabled with IPAR_EN = 1. Only change the status of the IPAR_EN tag during this evaluation if there is no passivation due to a communication error or F-I/O or channel fault.

Example of enabling HART communication



Additional information on HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART can be found in the Automation System S7-300, ET 200M Distributed I/O System manual, Fail-Safe Signal Modules (https://support.industry.siemens.com/cs/ww/en/view/19026151) manual and in the help on the F-module.

6.4.2.5 DISABLE

The DISABLE variable allows you to deactivate an F-I/O.

As long as DISABLE = 1, the associated F-I/Os are **passivated**.

Diagnostics entries of the safety program may no longer be entered in the diagnostics buffer of the F-CPU for this F-I/O (for example, due to communication error).

Existing diagnostics entries are marked as outgoing.

6.4.2.6 QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status

The following table set outs differences in the reaction of the channel values and QBAD, PASS_OUT, DISABLED, QBAD_I_xx/QBAD_O_xx variables and of the value status depending on the F-I/O and F-CPU used.

<table>
<tr><th>Fail-safe value output after...</th><th>F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU</th><th>F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPUs</th><th>F-I/O with S7-300/400 F-CPU</th></tr>
<tr><td>Startup of F-system[2]</td><td colspan="2" rowspan="3">QBAD and PASS_OUT = 1
DISABLED unchanged
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td rowspan="3">QBAD and PASS_OUT = 1
For all channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>Communication errors</td></tr>
<tr><td>F-I/O faults</td></tr>
<tr><td>Channel faults
in configuration of passivation for complete F-I/O</td><td colspan="2">QBAD and PASS_OUT = 1
DISABLED unchanged
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>QBAD and PASS_OUT = 1
For all channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>Channel faults during configuration of channel-granular passivation</td><td>QBAD, PASS_OUT and DISABLED unchanged
For the affected channels:
Channel value = fail-safe value (0)
Value status = 0</td><td>QBAD and PASS_OUT = 1
DISABLED unchanged
For the affected channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>QBAD and PASS_OUT = 1
For the affected channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1</td><td colspan="2">QBAD = 1, PASS_OUT and DISABLED unchanged
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>QBAD = 1,
PASS_OUT unchanged
For all channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>As long as the F-I/O is deactivated in the F-I/O DB with DISABLE = 1</td><td colspan="2">QBAD, PASS_OUT and DISABLED = 1
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>-</td></tr>
</table>

1 Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile

2 During delayed transfer of the F-Base ID, the F-system remains in startup.

6.4.2.7 ACK_REQ

When the F-system detects a communication error or an F-I/O fault or channel fault for an F-I/O, the relevant F-I/O or individual channels of the F-I/O are passivated. ACK_REQ = 1 signals that **user acknowledgment** is required for reintegration of the relevant F-I/O or channels of the F-I/O.

The F-system sets ACK_REQ = 1 as soon as the fault has been eliminated and user acknowledgment is possible. For channel-granular passivation, the F-system sets ACK_REQ = 1 as soon as the channel fault is corrected. User acknowledgment is possible for this fault. Once acknowledgment has occurred, the F-system resets ACK_REQ to 0.

NOTE

For F-I/O with outputs, acknowledgment after F-I/O or channel faults may only be possible some minutes after the fault has been eliminated, until the necessary test signal is applied (see *F-I/O manuals*).

6.4.2.8 IPAR_OK

The IPAR_OK tag corresponds to the iPar_OK_S tag in the PROFIsafe bus profile, PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out how to evaluate this tag when parameters of fail-safe GSD based DP slaves or GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

For HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART see Chapter IPAR_EN (Page 160).

6.4.2.9 DIAG

The DIAG tag provides non-fail-safe information (1 byte) about errors or faults that have occurred for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you perform an acknowledgment with the ACK_REI tag or until automatic reintegration takes place.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Timeout detected by F-I/O	The PROFIBUS/PROFINET connection between F-CPU and F-I/O is faulty. The value of the F-monitoring time for the F-I/O is set too low. The F-I/O are receiving invalid parameter assignment data or	• Check the PROFIBUS/PROFINET connection and ensure that there are no external sources of interference. • Check the parameter assignment of the F-I/O. If necessary, set a higher value for the monitoring time. Recompile the hardware configuration, and download it to the F-CPU. Recompile the safety program. • Check the diagnostics buffer of the F-I/O. • Turn the power of the F-I/O off and back on.
		Internal F-I/O fault or	Replace F-I/O
		Internal F-CPU fault	Replace F-CPU
Bit 1	F-I/O fault or channel fault detected by F-I/O[1]	See *F-I/O manuals*	See *F-I/O manuals*
Bit 2	CRC error or sequence number error detected by F-I/O	See description for bit 0	See description for bit 0
Bit 3	Reserved	—	—
Bit 4	Timeout detected by F-system	See description for bit 0	See description for bit 0
Bit 5	Sequence number error detected by F-system[2]	See description for bit 0	See description for bit 0
Bit 6	CRC-error detected by F-system	See description for bit 0	See description for bit 0
Bit 7	Addressing error[3]	—	Contact Service & Support

1 Not for F-I/O that support the "RIOforFA-Safety" profile.

2 For S7-300/400 F-CPUs only

3 For S7-1200/1500 F-CPUs only

6.4.2.10 BASEID_ACTIVE

The BASEID_ACTIVE tag contains the active F-BaseID as non-fail-safe information. The tag is available as of Safety System Version V2.8 and is only relevant if both the F-CPU and the F-I/O support PROFIsafe address type 3.

6.4.3 Accessing tags of the F-I/O DB

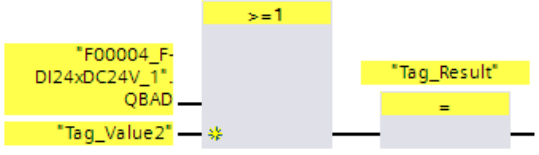
Rule for accessing tags of the F-I/O DB

Tags of the F-I/O DB of an F-I/O can only be accessed from the F-runtime group from which the channels of this F-I/O are accessed (if access is made).

"Fully qualified DB access"

You can access the tags of the F-I/O DB via a "fully qualified DB access" (that is, by specifying the name of the F-I/O DB and by specifying the name of the tag).

Example of evaluating the QBAD tag



See also

F-I/O DB (Page 157)

6.5 Passivation and reintegration of F-I/O

Overview

In the following you can find information on passivation and reintegration of F-I/O.

Signal sequence charts

The signal sequences presented below represent typical signal sequences for the indicated behavior.

Actual signal sequences and, in particular, the relative position of the status change of individual signals can deviate from the given signal sequences within the scope of known "fuzzy" cyclic program execution factors, depending on the following:

- The F-I/O used
- The F-CPU used
- The cycle time of the (F-)OB in which the associated F-runtime group is called
- The target rotation time of the PROFIBUS DP or the update time of the PROFINET IO

NOTE

The signal sequences shown refer to the status of signals in the user's safety program.

6.5.1 After startup of F-system

Behavior after a startup

Fail-safe value output after startup of the F-system	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
Passivation of the entire F-I/O occurs during startup.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the F-I/O, i.e. the provision of process values in the PII or the output of process values provided in the PIQ at the fail-safe outputs, takes place **automatically**, regardless of the setting at the ACK_NEC tag or the configuration "Channel failure acknowledge", no sooner than the second cycle of the F-runtime group after F-system startup.

You can find more information on pending F-communication, F-I/O or channel errors during startup of the F-system in the sections After communication errors (Page 169) and After F-I/O or channel faults (Page 171).

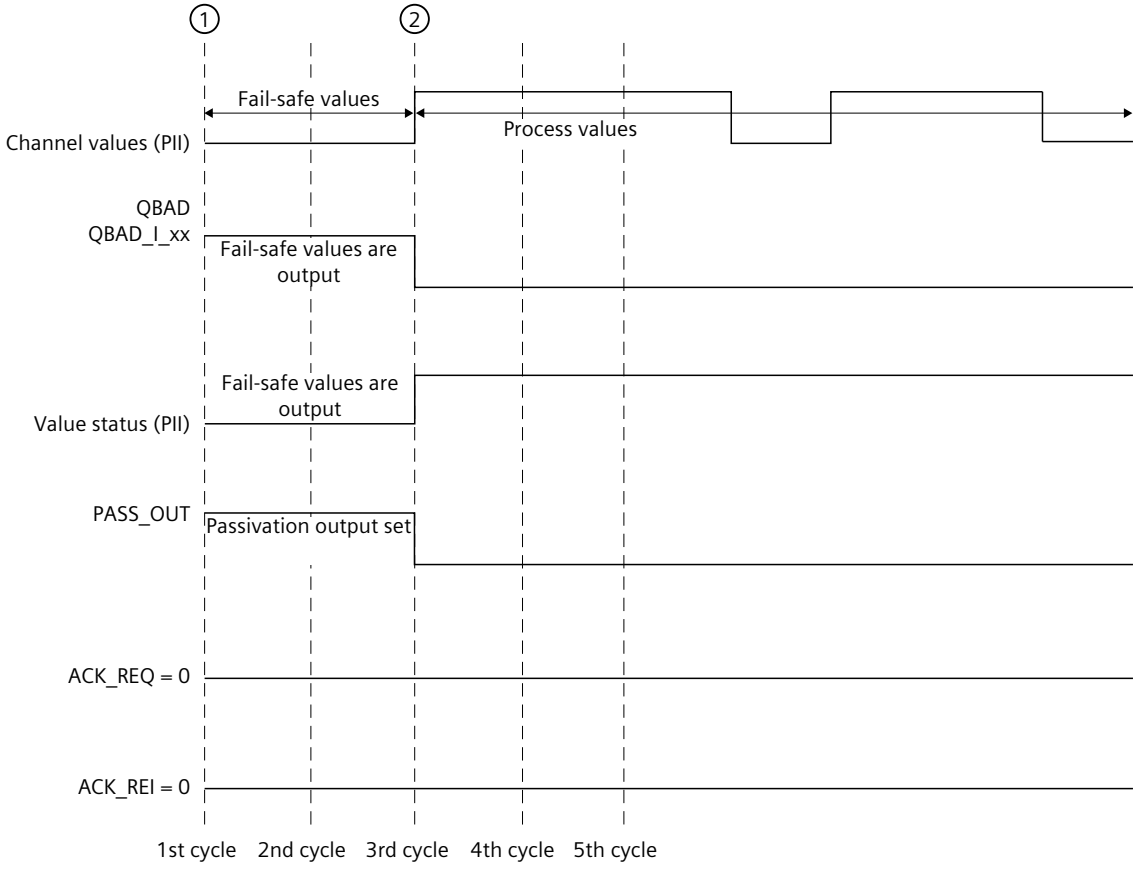
For fail-safe GSD based DP slaves/GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Depending on the F-I/O you are using and the cycle time of the F-runtime group and PROFIBUS DP/PROFINET IO, several cycles of the F-runtime group can elapse before reintegration occurs.

If communication between the F-CPU and F-I/O takes longer to establish than the F-monitoring time set in the properties for the F-I/O, automatic reintegration does not take place.

Signal sequence for passivation and reintegration of F-I/O after F-system startup

Example for an F-I/O with inputs:



① Startup of F-system/passivation
② Automatic reintegration (e.g. third cycle)

⚠ WARNING

Unintentional restart

In contrast to the standard user program, when the safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.

If an unintentional startup of your process is not allowed, you must program restart/startup protection in the safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 184)"). This user acknowledgment must not take place until safe output of process values is possible (see "Programming startup protection (Page 150)").

You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:
  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

6.5.2 After communication errors

Behavior after communication errors

Fail-safe value output after communication errors	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If a communication error between the F-CPU and the F-I/O is detected, all channels of the entire F-I/O are passivated.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

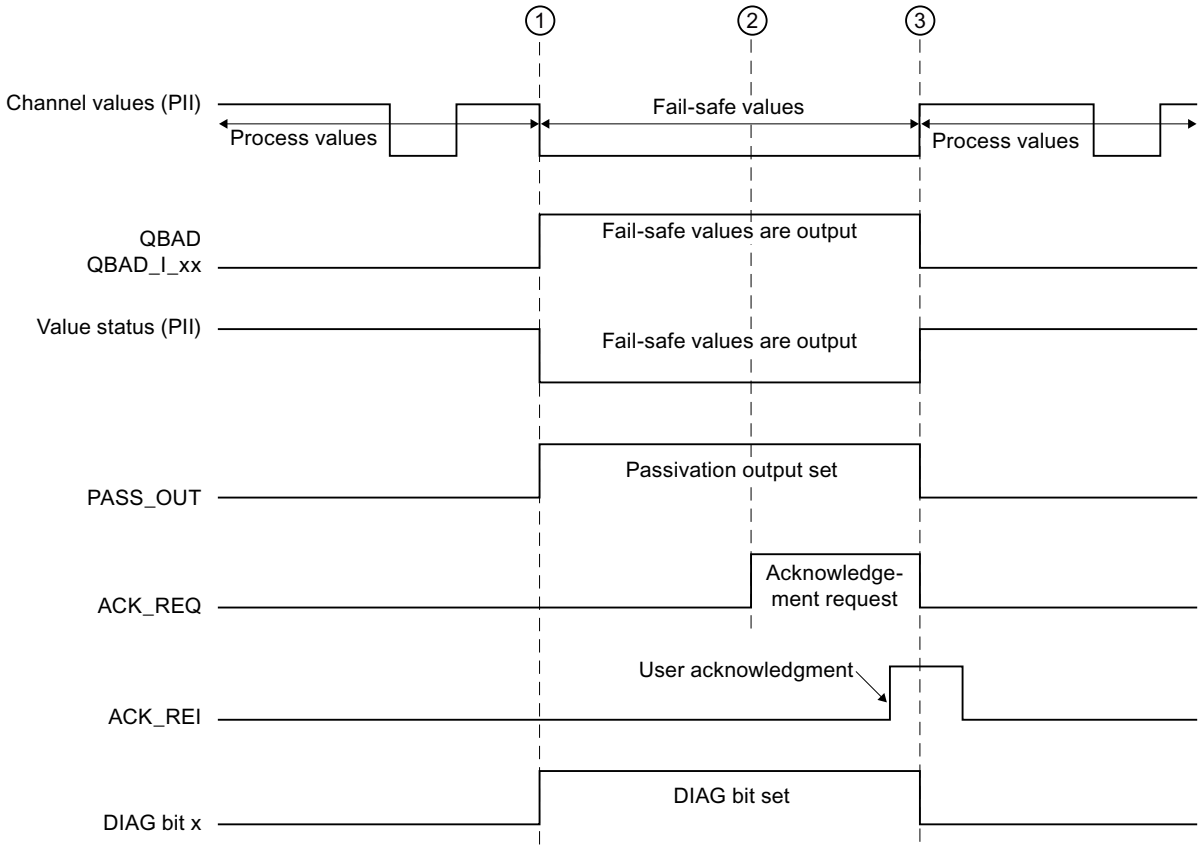
Reintegration of F-I/O

Reintegration of the relevant F-I/O, that is, provision of process values in the PII or output of process data provided in the PIQ at the fail-safe outputs, takes place only when the following occurs:

- All communication errors have been eliminated and the F-system has set tag ACK_REQ = 1
- A **user acknowledgment** with a positive edge has occurred:
  - At the ACK_REI tag of the F-I/O DB (Page 160) or
  - At the ACK_REI_GLOB input of the "ACK_GL" instruction (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21) (Page 520))

Signal sequence for passivation and reintegration of F-I/O after communication errors

Example for an F-I/O with inputs:



① Communication error/passivation
② All communication errors have been eliminated
③ Reintegration

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 184)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 189)

6.5.3 After F-I/O or channel faults

Behavior after F-I/O faults

Fail-safe value output after F-I/O faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If an F-I/O fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Behavior after channel fault

Fail-safe value output after channel faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
When passivation for **complete** F-I/O is configured: If a channel fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*
With configuration of **channel-granular** passivation: If a channel fault is detected by the F-system, passivation of all the affected channels of the entire F-I/O occurs.	QBAD and PASS_OUT **unchanged** For the **affected** channels: Channel value = fail-safe value (0) Value status = 0	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) Value status = 0*	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the relevant F-I/O or the relevant channels of the F-I/O, that is, provision of process data in the PII or output of process data provided in the PIQ at the failsafe outputs, takes place only when the following occurs:

- All F-I/O or channel faults have been eliminated.

If you have configured channel-granular passivation for the F-I/O, the relevant channels are reintegrated once the fault is corrected; any faulty channels remain passivated.

Reintegration is performed depending on your setting for the ACK_NEC tag or the "Channel failure acknowledge" parameter (configuration of the S7-1500/ET 200MP F-module and S7-1200 F-module)

- With ACK_NEC = 0 or the configuration "Channel failure acknowledge = automatic", **automatic reintegration** is performed as soon as the F-system detects that the fault has been corrected. For F-I/O with inputs, reintegration takes place right away. For F-I/O with outputs or F-I/O with inputs and outputs, depending on the F-I/O you are using, reintegration can take several minutes, first after the necessary test signals have been applied, which are used by the F-I/O to determine that the fault has been eliminated.
- With ACK_NEC = 1 or the configuration "Channel failure acknowledge = manual", reintegration is performed only as a result of user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB or at the ACK_REI_GLOB input of the "ACK_GL" instruction. Acknowledgment can be made as soon as the F-system detects that the fault has been eliminated and tag ACK_REQ = 1 has been set.

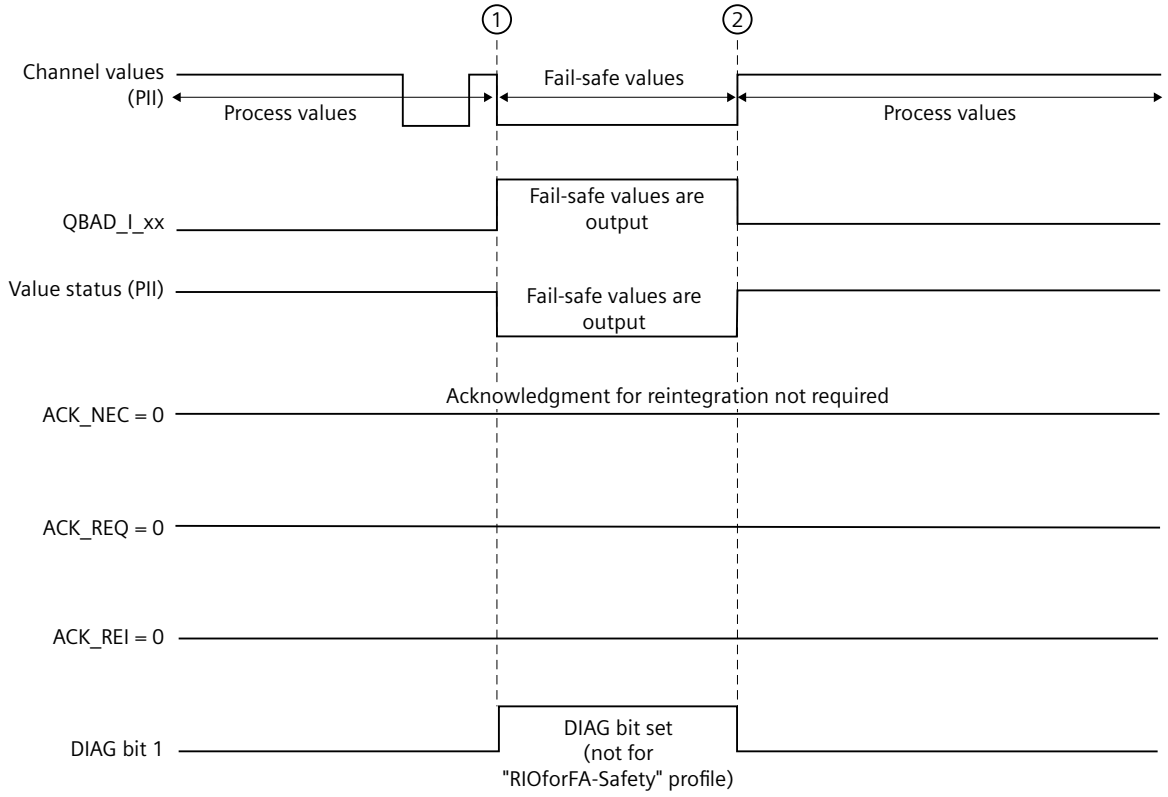
  For fail-safe GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based I/O device .

⚠ WARNING

Following a supply voltage failure of the F-I/O lasting less than the F-monitoring time assigned for the F-I/O, automatic reintegration can occur regardless of the setting for the ACK_NEC tag or the "Channel failure acknowledge" configuration.
If automatic reintegration is not permitted for the relevant process in this case, you must program startup protection by evaluating tags QBAD or QBAD_I_xx and QBAD_O_xx or value status or PASS_OUT.
In the event of a supply voltage failure of the F-I/O lasting longer than the specified F-monitoring time for the F-I/O, the F-system detects a communication error. *(S012)*

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 0 or configuration "Channel failure acknowledge = automatic" (for passivation of entire F-I/O after channel faults)

Example for an F-I/O with inputs:



① F-I/O or channel faults
Passivation

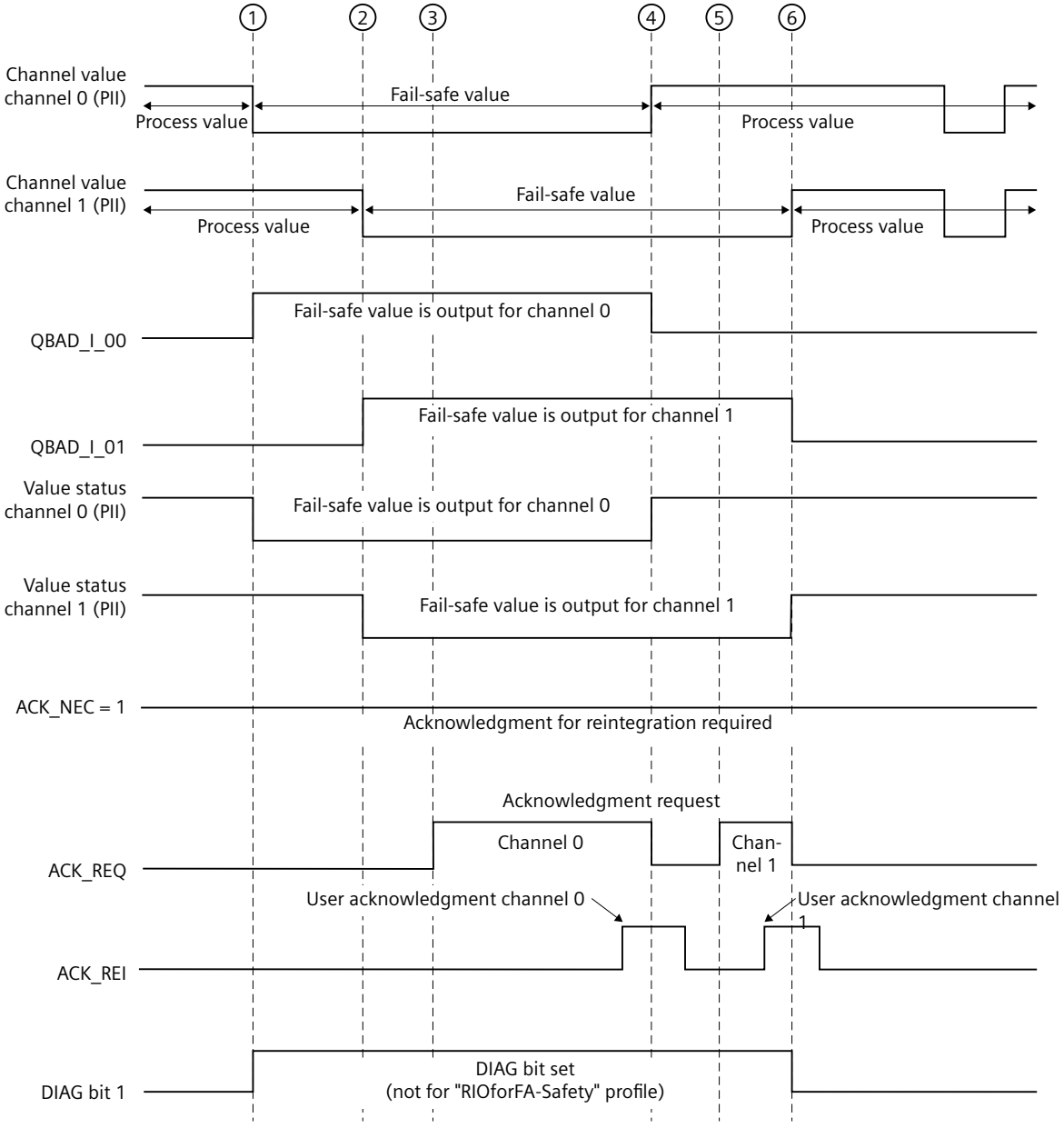
② F-I/O or channel faults corrected
Automatic reintegration

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for passivation of entire F-I/O after channel faults)

For the signal sequence for passivation and reintegration of F-I/O after F-I/O or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (initial value), see After communication errors (Page 169).

Signal sequence for passivation and reintegration of F-I/O after channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for channel-granular passivation)

Example for an F-I/O with inputs:



① Channel fault for channel 0/passivation of channel 0
② Channel fault for channel 1/passivation of channel 1
③ Channel fault eliminated for channel 0
④ Reintegration of channel 0
⑤ Channel fault eliminated for channel 1
⑥ Reintegration of channel 1

6.5.4 Group passivation

Programming a group passivation

If you want to enable passivation of additional F-I/O when an F-I/O or a channel of an F-I/O is passivated by the F-system, you can use the PASS_OUT/PASS_ON tags to perform **group passivation** of the associated F-I/O.

Group passivation by means of PASS_OUT/PASS_ON can, for example, be used to force simultaneous reintegration of all F-I/O after startup of the F-system.

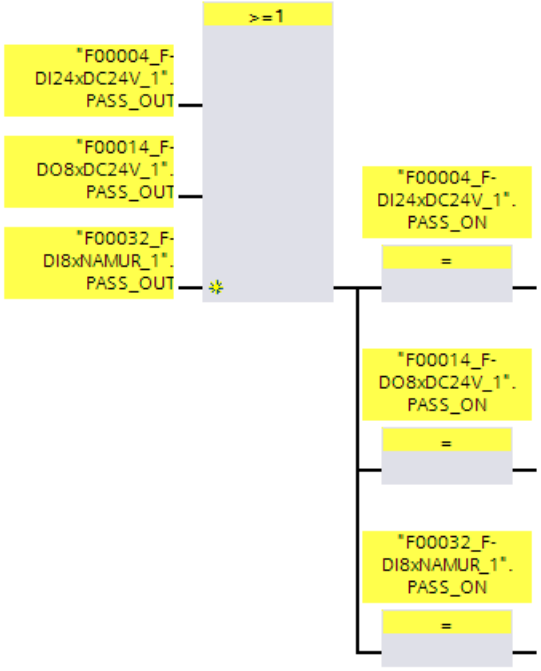
For group passivation, you must OR all PASS_OUT tags of the F-I/O in the group and assign the result to all PASS_ON tags of the F-I/O in the group.

During use of fail-safe values (0) due to group passivation by means of PASS_ON = 1, the QBAD tag of the F-I/O of this group = 1.

NOTE

Note the different behavior of PASS_OUT for F-I/O with/without "RIOforFA-Safety" profile (see table in section QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status (Page 162)).

Example of group passivation

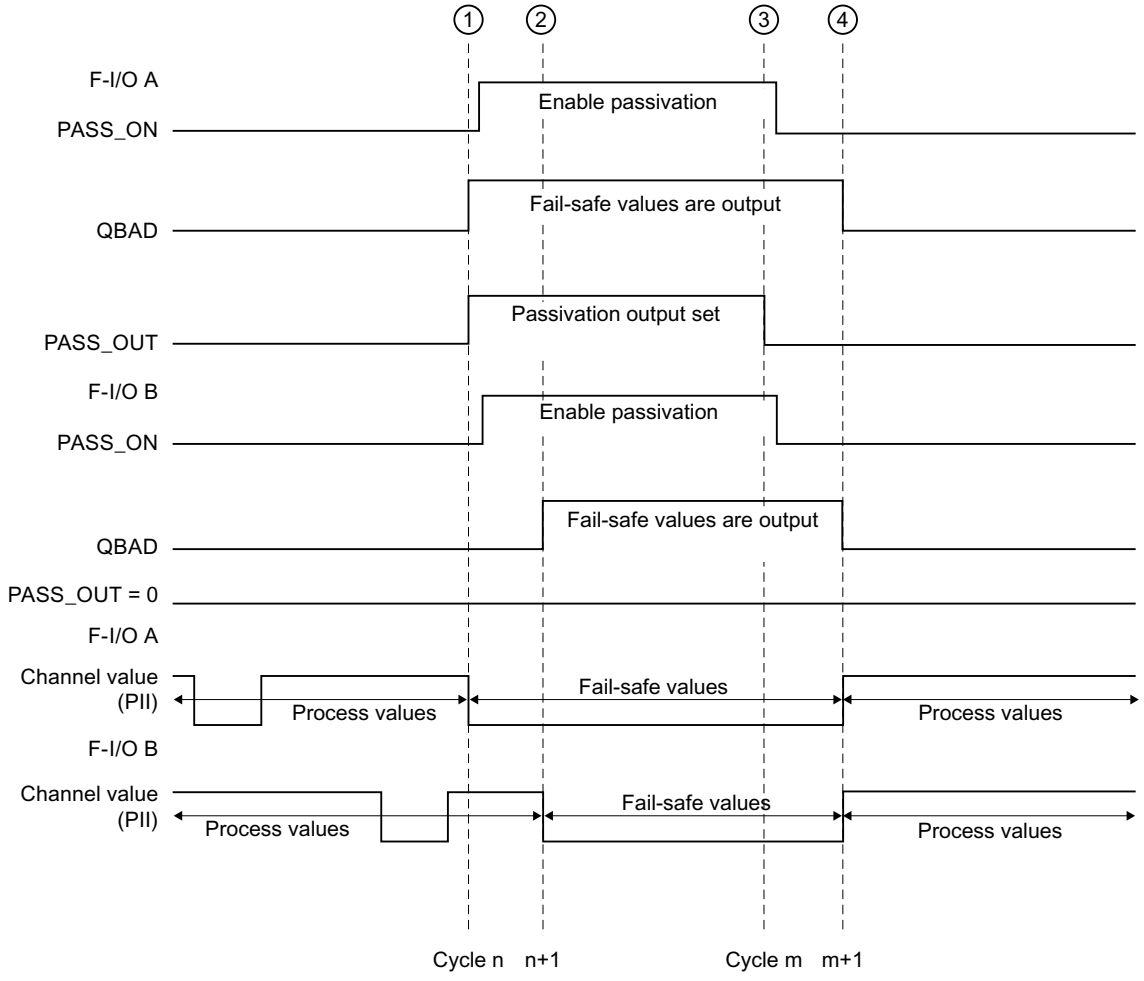


Reintegration of F-I/O

Reintegration of F-I/O passivated by group passivation occurs **automatically**, if a reintegration (**automatic** or **through user acknowledgment**) occurs for the F-I/O that triggered the group passivation (PASS_OUT = 0).

Signal sequence for group passivation following communication error

Example for two F-I/O with inputs:



① Communication error in F-I/O A
Passivation of F-I/O A

② Passivation of F-I/O B

③ Communication error in F-I/O A corrected and acknowledged

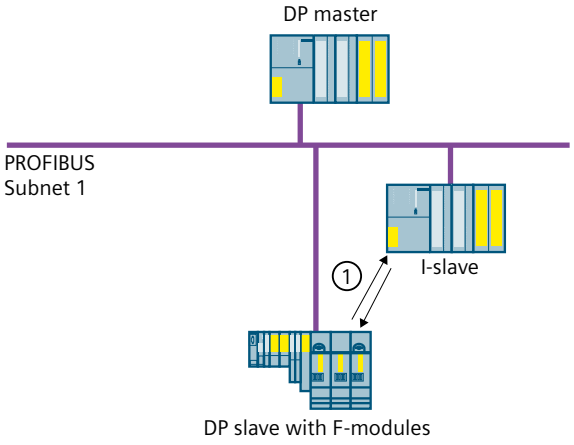
④ Reintegration F-I/O A and B

6.6 F-I/O access via I-slave-slave communication (S7-300, S7-400)

6.6.1 Overview

Principle of F-I/O access via I-slave-slave communication

The following figure shows the principle of F-I/O access via I-slave-slave communication.



① F-I/O access via I-slave-slave communication

F-I/O access via I-slave-slave communication

F-I/O access via I-slave-slave communication is possible with F-I/O in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O of a DP slave takes place using direct data exchange, as in the standard program. The process image is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave.

6.6.2 Configuring Safety-Related I-Slave-Slave Communication

Introduction

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O in a DP slave takes place using direct data exchange (**F**-DX-Mod), same as in standard programs.

You do not need any additional hardware for I-slave-slave communication.

I-slave-slave communication is also possible:

- when the assigned DP master is a standard CPU, if the standard CPU supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

An F-I/O DB is automatically generated for each F-I/O when it is configured in the *hardware and network editor*; this is required for the F-I/O access via safety-related I-slave-slave communication. The F-I/O DB is initially created in the safety program of the DP master, provided it is an F-CPU with F-activation. Only with the setup of the F-DX-Mod connection is the F-I/O DB created in the safety program of the I-slave and deleted in the safety program of the DP master.

The process image input is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave (see description in Safety-related I-slave-slave communication - F-I/O access via process image (Page 183)).

Restrictions

NOTE

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

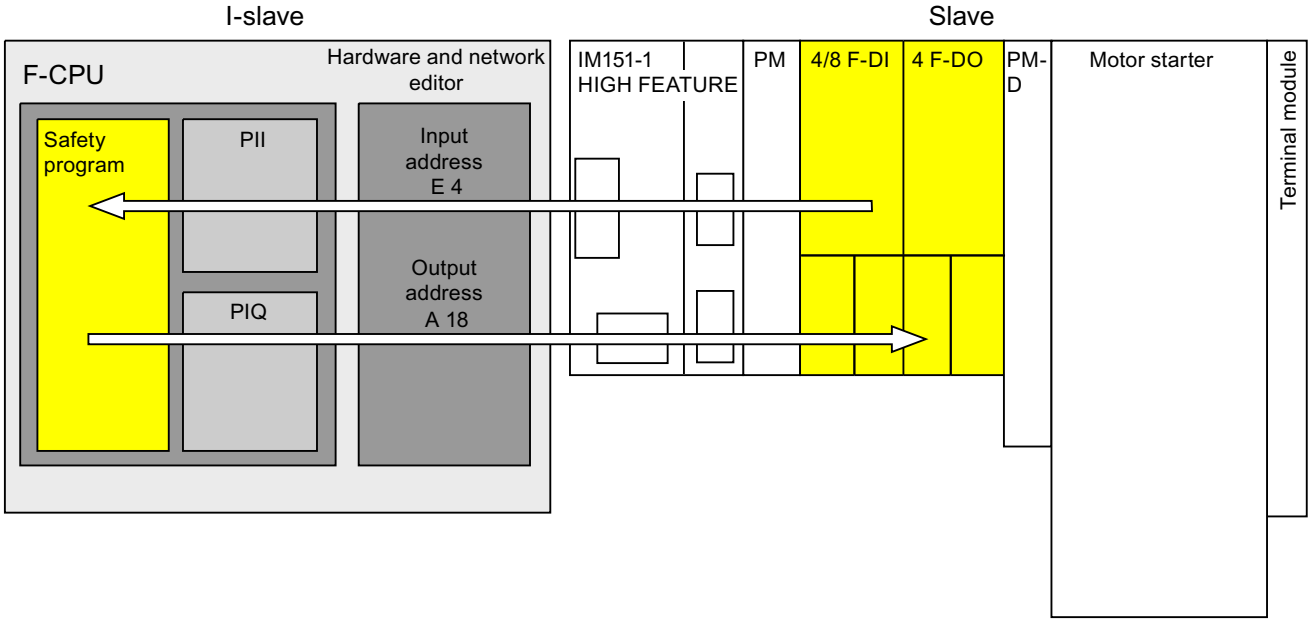
NOTE

With safety-related I-slave-slave communication, make sure that the CPU of the DP master is powered up before the F-CPU of the I-slave.
Otherwise, depending on the F-monitoring time specified for the F-I/O, the F-system can detect an error in safety-related communication (communication error) between the F-CPU and the F-I/O assigned to the I-slave. This means that the F-I/O are not reintegrated automatically after F-system startup. They are instead only reintegrated after a user acknowledgment with a positive edge in the ACK_REI tag of the F-I/O DB (see also After communication errors (Page 169) and After startup of F-system (Page 166)).

Configuring transfer areas

For every safety-related communication connection between an I-slave and slave, you must configure transfer areas in the *hardware and network editor*.

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX-Mod_PLC_2-PLC_1_1" for the first F-DX-Mod connection between F-CPU 1 and F-CPU 2.



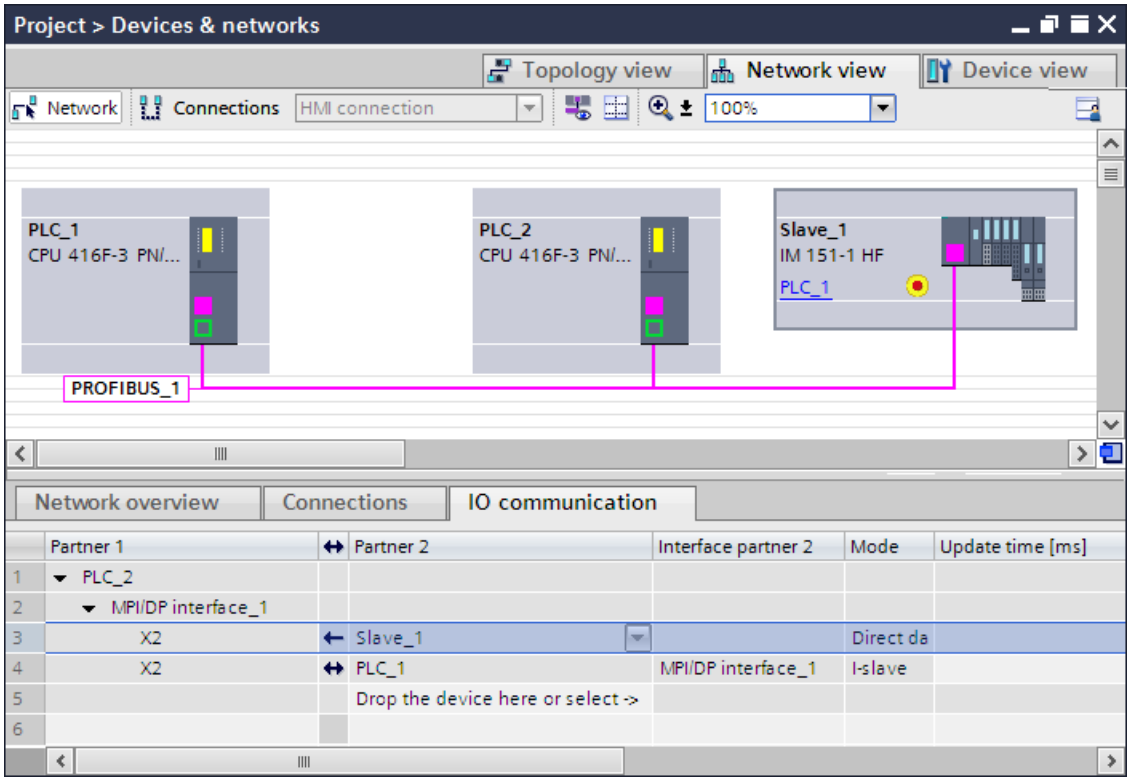
Configuration procedure using the example of an ET 200S with F-modules in the slave

The procedure for configuring safety-related I-slave-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Insert a suitable DP slave, e.g. IM 151-1 HF, article no. 6ES7151-1BA0... from the "Hardware catalog" task card into the network view of the *hardware and network editor*.
3. Insert a power module, a 4/8 F-DI module and a 4 F-DQ module in the device view of the ET 200S.
4. Activate "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this to F-CPU 1.
5. Assign the DP interface of the IM 151-1 HF to the DP master (F-CPU 1).
6. Select the DP interface of F-CPU 2 (I-slave) in the network view.
7. Select the "I/O communication" tab.

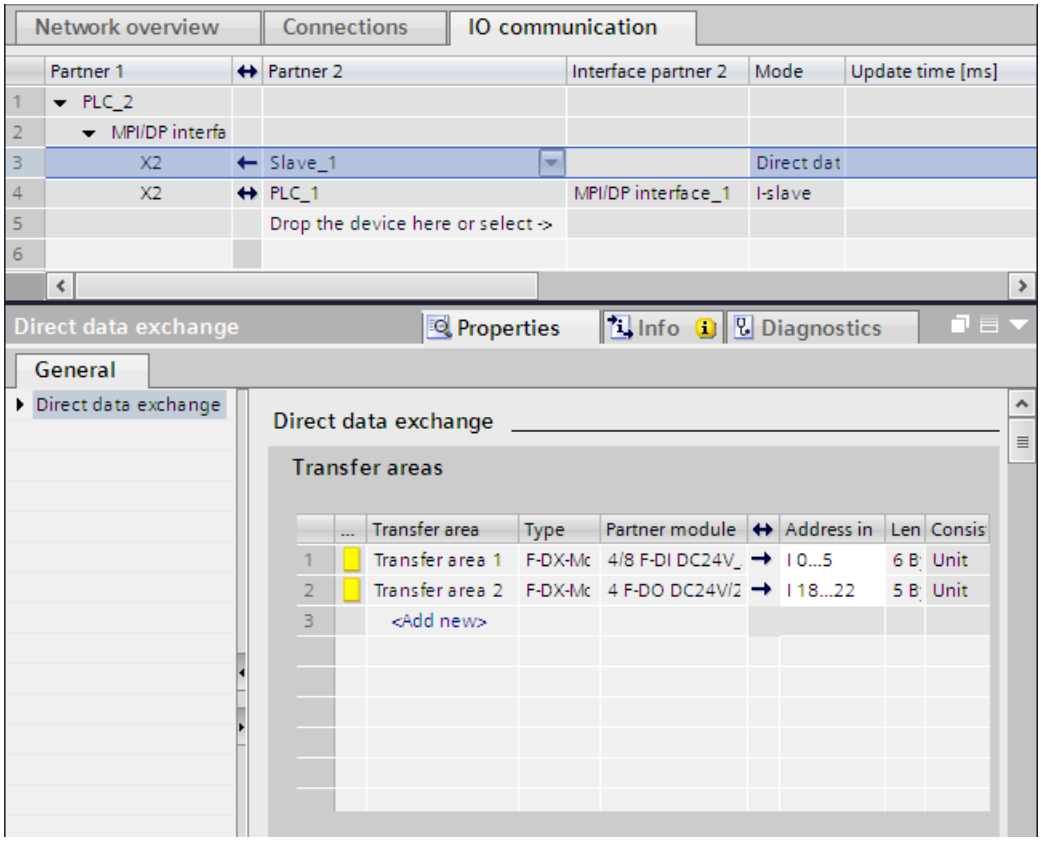
8. Use a drag-and-drop operation in the network view to move the ET 200S to the "Partner 2" column in the "I/O-communication" tab.



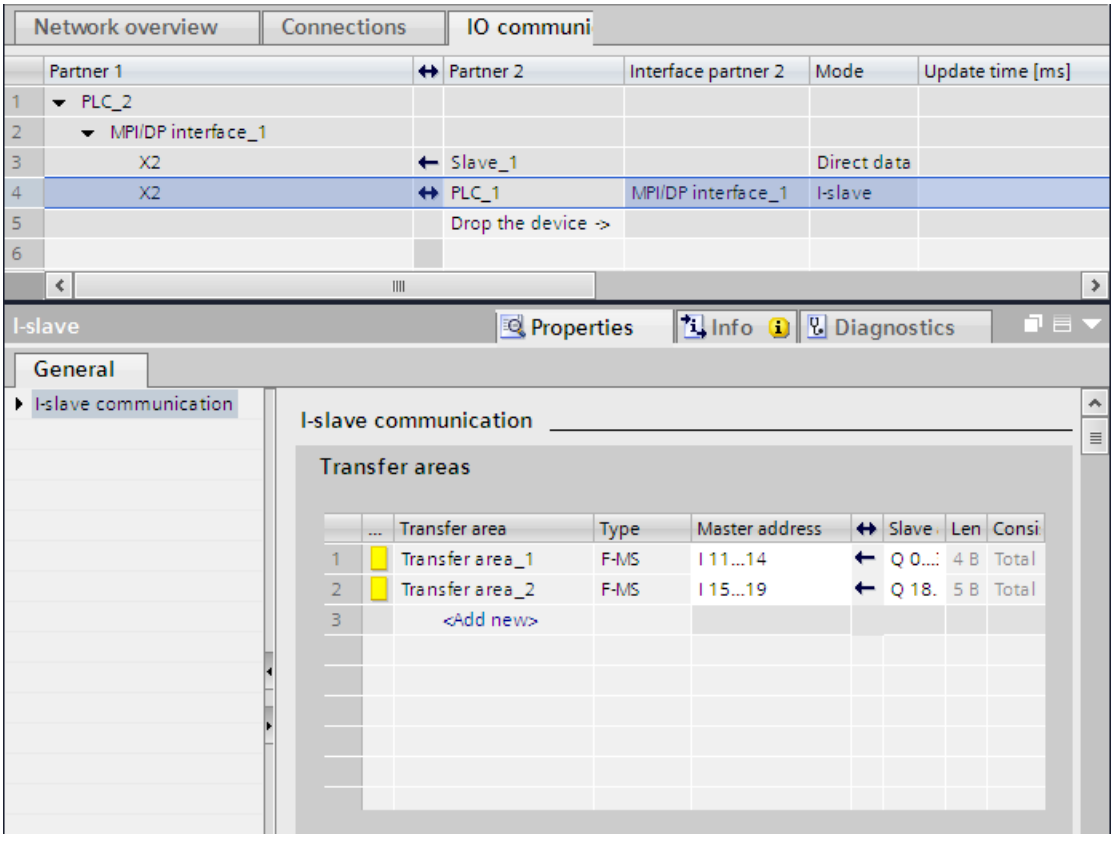
9. Click in the newly created line (←).
10. In "Transfer areas", create an F-DX-Mod connection (type "F-DX-Mod"). The F-DX-Mod connection is marked in yellow in the table. The addresses for the "partner module" 4/8 F-DI in the I-Slave (PLC_2) are displayed. You can change the addresses directly in the table, if required.

    This completes the configuration for the 4/8 F-DI module.
11. In "Transfer areas", create another F-DX-Mod connection.

12. Change the partner module to the 4 F-DO module, either directly in the "Transfer areas" table or in the details of transfer area 2, if the 4 F-DO module was not already selected.
    This completes the configuration for the 4 F-DO module.



In the "I-slave communication table" of the I-slave, a transfer area (type F-MS) for the master CPU is automatically created for each F-DX-Mod connection:



Change in configuration of I-slave-slave communication

WARNING

If you have added or deleted I-slave-slave communication for an F-I/O, you must compile and download the hardware configuration of the DP master as well as the hardware configuration of the I-slave.
The Collective F-Signature in the F-CPU of the I-slave and the Collective F-Signature in the F-CPU of the DP master (if a safety program exists there, too) are set to "0". You must then recompile the safety program(s). *(S019)*

6.6.3 Safety-related I-slave-slave communication - F-I/O access via process image

For F-I/O access via I-slave-slave communication, you use the process image (PII or PIQ) to access the F-I/O in the Safety program of the F-CPU of the I-slave. This is the same as F-I/O access to F-I/O that are directly assigned to an I-slave or DP master. In the I-slave you access the F-I/O with the addresses that were assigned for the F-DX-Mod connection in "Transfer areas" ("Direct data exchange" table).

In this case, ignore the displayed operand area. Access F-I/O with inputs using the PII and F-I/O with outputs using PIQ.

Information on I/O access can be found in F-I/O access (Page 151).

6.6.4 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

An example of the amount of output data and input data that are assigned for safety-related communication is shown in the table below for an ET 200S 4/8 F-DI and an ET 200S 4 F-DO:

Safety-related communication	Communication connection	Assigned input and output data*	
		Between I-slave and DP master	
		Output Data in the I-slave	Input data in the I-slave
I-slave-slave	I-slave-slave communication with 4/8 F-DI	4 bytes	6 bytes
	I-slave-slave communication with 4 F-DO	5 bytes	5 bytes

* Example for 4/8 F-DI and 4 F-DO of ET 200S

Consider all additional configured safety-related and standard communication connections (F-MS, F-DX, F-DX-Mod., MS and DX connections) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master. If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

Implementation of user acknowledgment 7

7.1 Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller

Options for user acknowledgment

Depending on the result of the risk analysis, you have the following options for implementing a user acknowledgment:

- With an acknowledgment key that you connect to an F-I/O with inputs.
- With an operator control and monitoring system.
- With an acknowledgment key that you connect to a standard I/O with inputs.
- By other mechanisms for reading in the user acknowledgment.

User acknowledgment by means of acknowledgment key

NOTE

When you implement user acknowledgment by means of acknowledgment key, and a communication error, an F-I/O fault, or a channel fault occurs in the F-I/O to which the acknowledgment key is connected, then it will not be possible to acknowledge the reintegration of this F-I/O.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU. In a redundant S7-1500HF system, you must set both HF CPUs or the redundant S7-1500HF system to STOP before you restart the HF CPUs.

Consequently, it is recommended that you also provide for an acknowledgment by means of an operator control and monitoring system, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected.

A user acknowledgment may be issued using an acknowledgment key connected to a standard I/O with inputs or other mechanisms for reading the user acknowledgment if the risk analysis allows this.

User acknowledgment by means of an operator control and monitoring system

For implementation of a user acknowledgment by means of an operator control and monitoring system, the ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 591) instruction is required.

Procedure for programming user acknowledgment by means of an operator control and monitoring system (S7-300, S7-400)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. On your operator control and monitoring system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and an "acknowledgment value" of "9" (2nd step in acknowledgment).

   or

   Assign function key 1 to transfer an "acknowledgment value" of "6" (1st step in acknowledgment) once, and function key 2 to transfer an "acknowledgment value" of "9" (2nd step in acknowledgment) once. You must assign the InOut IN (in the data area of the ACK_OP instruction) to the field or the function keys.
3. Optional: In your operator control and monitoring system, evaluate output Q in the instance DB of ACK_OP to show the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

If you want to perform a user acknowledgment exclusively from a programming device or PC using the watch table (monitor/modify tag) without having to disable safety mode, then you must transfer an operand (memory word or DBW of a DB of the standard user program) at InOut IN when calling ACK_OP. You can then transfer "acknowledgment values" "6" and "9" on the programming device or PC by modifying the memory word or DBW of a DB once. The memory word or DBW of a DB must not be written by the program.

NOTE

If you connect the InOut IN to a memory word or DBW of a DB, you must use a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction at the InOut IN.

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.
The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

⚠ WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored name. *(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE
The configuration of your operator control and monitoring system does not have any effect on the Collective F-Signature.

Procedure for programming user acknowledgment by means of an operator control and monitoring system (S7-1200, S7-1500)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. Assign the ACK_ID input an identifier between 9 and 30000 for the acknowledgment.
3. Assign the InOut IN a memory word or DBW of a DB of the standard user program.

   NOTE
   You must supply the InOut IN with a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction.

4. On your operator control and monitoring system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and the "Identifier" configured at the ACK_ID input (2nd step in acknowledgment).

   or

   Allocate a function key 1 for a one-time transfer of the "acknowledgment value" of "6" (1st step in acknowledgment) and a function key 2 for a one-time transfer of the "Identifier" set at the ACK_ID input (2nd step in acknowledgment).
   You must assign the memory word or the DBW of the DB of the standard user program assigned to the InOut IN to the field or the function keys.

5. Optional: In your operator control and monitoring system, evaluate output Q in the instance DB of ACK_OP to show the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

⚠ WARNING

The two acknowledgment steps must not be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.
The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

⚠ WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.
Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access to the ACK_ID tag in the associated instance DB is not permitted!

Alternative 2:

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

The supply of the IN iInOut of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the Collective F-Signature, the Collective F-SW-Signature or the signature of the block that calls the ACK_OP instruction. Changes to the supply of the IN InOut or to the configuration of your operator control and monitoring system therefore do not result in a changed Collective F-Signature/Collective F-SW-Signature/signature of the calling block.

Example of procedure for programming a user acknowledgment for reintegrating an F-I/O

1. Optional: set the ACK_NEC tag in the respective F-I/O DB (Page 159) to "0" if automatic reintegration (without user acknowledgment) is to take place after an F-I/O fault or a channel fault.

   ⚠ WARNING

   The parameter assignment of the ACK_NEC tag of the F-I/O DB with the value "0" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

2. Optional: Evaluate the QBAD or QBAD_I_xx/QBAD_O_xx (S7-300, S7-400) tags or value status (S7-1200, S7-1500) or DIAG in the respective F-I/O DB to trigger an indicator light in the event of an error, and/or generate error messages on the operator control and monitoring system in your standard user program by evaluating the above tags or the value status. These messages can be evaluated before performing the acknowledgment operation. Alternatively, you can evaluate the diagnostic buffer of the F-CPU.
3. Optional: Evaluate the ACK_REQ tag in the respective F-I/O DB, for example, in the standard user program or on the operator control and monitoring system, to query or to indicate whether user acknowledgment is required.
4. Assign the input of the acknowledgment key or the OUT output of the ACK_OP instruction to the ACK_REI tag in the respective F-I/O DB or the ACK_REI_GLOB input of the ACK_GL instruction (see above).

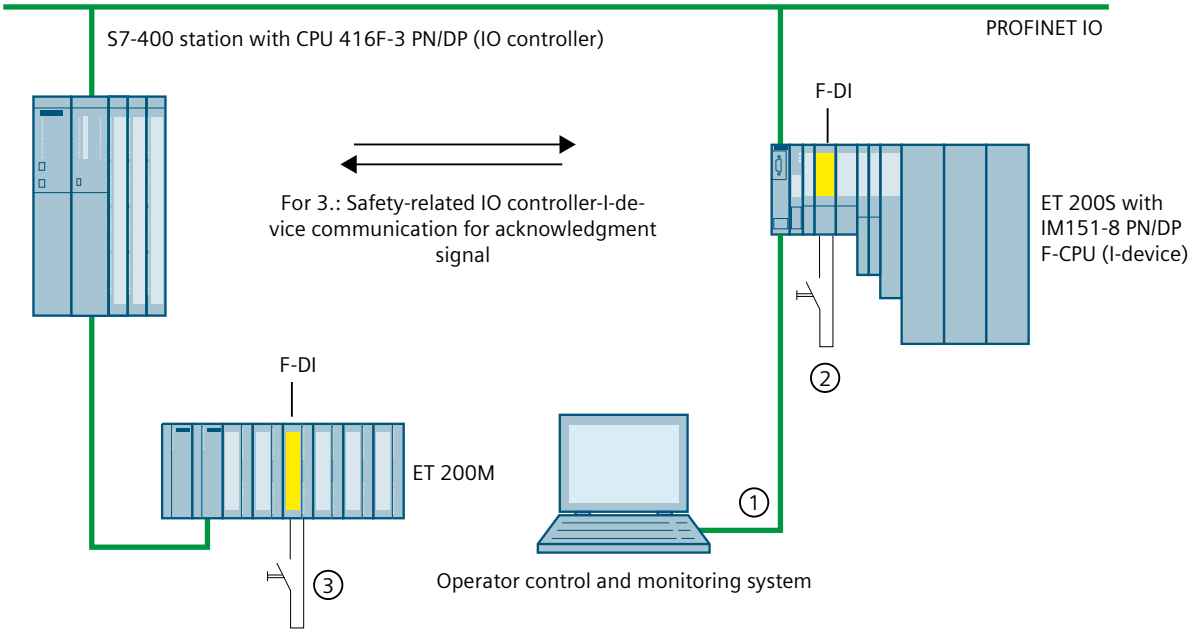
7.2 Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device

Options for user acknowledgment

You can implement a user acknowledgment by means of:

1. An HMI system that you can use to access the F-CPU of the I-slave/I-Device
2. An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the I-slave/I-Device
3. An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the DP master/IO controller

These three options are illustrated in the figure below.



1. User acknowledgment by means of an HMI system with which you can access the F-CPU of the I-slave/I-device

The ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 591) instruction is required to implement user acknowledgment with an HMI system that you can use to access the F-CPU of the I-slave/I-device.

Programming procedure

Follow the procedure described in "Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 184)" under "Programming procedure ...".

From your HMI system, you can then directly access the instance DB of ACK_OP in the I-slave/I-Device.

2. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the I-slave/I-device

NOTE

In the event of a communication error, F-I/O fault, or channel fault in the F-I/O to which the acknowledgment key is connected, an acknowledgment for reintegration of this F-I/O is no longer possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-device, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected (see 1).

3. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the DP master/IO controller

If you want to use the acknowledgment key that is assigned to the F-CPU at the DP master/IO controller to perform user acknowledgment in the safety program of the F-CPU of an I-slave/I-device as well, you must transmit the acknowledgment signal from the safety program in the F-CPU of the DP master/IO controller to the safety program in the F-CPU of the I-slave/I-device using safety-related master-I-slave/IO controller-I-device communication.

Programming procedure

1. Place the SENDDP (Page 599) instruction in the safety program in the F-CPU of the DP master/IO controller.
2. Place the RCVDP (Page 599) instruction in the safety program in the F-CPU of the I-slave/I-Device.
3. Supply an input SD_BO_xx of SENDDP with the input of the acknowledgment key.
4. The acknowledgment signal for evaluating user acknowledgments is now available at the corresponding RD_BO_xx output of RCVDP.

   The acknowledgment signal can now be read in the program sections in which further processing is to take place with fully qualified access directly in the associated instance DB (for example, "RCVDP_DB".RD_BO_02).

5. Supply the corresponding input SUBBO_xx of RCVDP with FALSE (fail-safe value 0) to ensure that user acknowledgment is not accidentally triggered before communication is established for the first time after startup of the sending and receiving F-systems, or in the event of a safety-related communication error.

NOTE

If a communication error, an F-I/O error, or a channel fault occurs at the F-I/O to which the acknowledgment key is connected, then an acknowledgment for reintegration of this F-I/O will no longer be possible.
This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the DP master/IO controller.
Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the DP master/IO controller, in order to acknowledge reintegration of the F-I/O to which an acknowledgment key is connected.
If a safety-related master-I-slave/IO controller-I-Device communication error occurs, the acknowledgment signal cannot be transmitted, and an acknowledgment for reintegration of safety-related communication is no longer possible.
This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.
Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-Device, in order to acknowledge reintegration of the safety-related communication for transmission of the acknowledgment signal (see 1).

Data exchange between standard user program and safety program

8

You have the option of transferring data between the safety program and the standard user program. Tags can be transferred using DBs, F-DBs and bit memory:

	From the standard user program		From the safety program	
	Read access	**Write access**	**Read access**	**Write access**
Tag from DB	Permitted	Permitted	A tag from the DB can be read-accessed *or* write-accessed	
Tag from F-DB	Permitted	**Not permitted**	Permitted	Permitted
Bit memory	Permitted	Permitted	Bit memory can be read-accessed *or* write-accessed	

You can also access the process image of the standard I/O and F-I/O:

		From the standard user program		From the safety program	
		Read access	**Write access**	**Read access**	**Write access**
Process image of standard I/O	PII	Permitted	Permitted	Permitted	**Not permitted**
	PIQ	Permitted	Permitted	**Not permitted**	Permitted
Process image of F-I/O	PII	Permitted	**Not permitted**	Permitted	**Not permitted**
	PIQ	Permitted	**Not permitted**	**Not permitted**	Permitted

Note possible restrictions/particularities when using Software Units or a Safety Unit (Page 113).

Decoupling of the safety program from the standard user program

For data exchange between standard user program and safety program, we recommend that you define special data blocks (transfer data blocks) in which the data to be exchanged is stored. This action allows you to decouple the blocks of the standard user program and the safety program. The changes in the standard user program do not affect the safety program (and vice versa) provided these data blocks are not modified.

8.1 Data Transfer from the Safety Program to the Standard User Program

Reading data of the safety program in the standard user program

The standard user program can read all data of the safety program, for example using symbolic (fully qualified) accesses to the following:

- The instance DBs of the F-FBs ("Name of instance DB".Signal_x)
- F-DBs (for example "Name of F_DB".Signal_1)

- The process image input and output of F-I/O (for example "Emergency_Stop_Button_1" (I 5.0))

NOTE

For S7-300/400 F-CPUs

The process image input of F-I/O is updated not only at the start of the F-runtime group, but also by the standard operating system.

To find the standard operating system update times, refer to the *Help on STEP 7* under "Process image input and output". For F-CPUs that support process image partitions, also bear in mind the update times when process image partitions are used. For this reason, when the process image input of F-I/O is accessed in the standard user program, it is possible to obtain different values than in the safety program. The differing values can occur due to:

– Different update times
– Use of fail-safe values in the safety program

To obtain the same values in the standard user program as in the safety program, you must not access the process image input in the standard program until after execution of an F-runtime group. In this case, you can also evaluate the QBAD or QBAD_I_xx tag in the associated F-I/O DB in the standard user program, in order to find out whether the process image input is receiving fail-safe values (0) or process data. When using process image partitions, also make sure that the process image is not updated by the standard operating system or by the UPDAT_PI instruction between execution of an F-runtime group and evaluation of the process image input in the standard user program.

NOTE

For S7-1200/1500 F-CPUs

The process image input of F-I/O is updated prior to processing the main safety block.

During the data transfer from the safety program to the standard user program, the integrity of the safety program and the safety-related data is not checked (see also section "Product Overview (Page 22)").

Writing data from the safety program to the standard user program

You can also write safety program data directly in the safety program to the standard user program (see also the table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 116)).

This is also true for non-fail-safe service information (e.g. outputs DIAG of the fail-safe instructions).

Note the table in section "Data exchange between standard user program and safety program (Page 192)".

When writing to a tag of the ARRAY data type, the index can either be a constant or a tag.

8.2 Data Transfer from Standard User Program to Safety Program

As a basic principle, only fail-safe data or fail-safe signals from F-I/O and other safety programs (in other F-CPUs) can be processed in the safety program, as standard tags are unsafe.

If you have to process tags from the standard user program in the safety program, however, you can evaluate either bit memory, tags from a standard DB, or the process image input (PII) of standard I/O in the safety program (see table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 116)).

Note the table in section "Data exchange between standard user program and safety program (Page 192)".

When reading a tag of the ARRAY data type, the index must be a constant. Tags are not permitted as index.

Note that structural changes to standard data blocks which are used in the safety program lead to inconsistencies of the safety program and can therefore only be executed if access permission for the safety-related project data is available. In this case the Collective F-Signature is the same as the original again after compilation. To prevent this effect, use "transfer data blocks" between the standard user program and the safety program.

⚠ WARNING

Because the values in these tags are not generated safely, you must program additional process-specific plausibility checks in the safety program to ensure that no dangerous states can arise. If bit memory, a tag of a standard DB, or an input of standard I/O is used in both F-runtime groups, you must perform the plausibility check separately in each F-runtime group. *(S015)*

To facilitate checks, all PLC tags from the standard user program that are evaluated in the safety program are printed out when creating the safety summary. (Page 382)

PLC tags from the standard user program that are evaluated in know-how-protected F-blocks are not included in the safety summary. The plausibility check must already be implemented by the creator of the know-how protected F-blocks.

Examples: Programming plausibility checks

- Use Comparison (Page 535) instructions to check whether tags from the standard user program exceed or fall below permitted high and low limits. You can then influence your safety function with the result of the comparison.
- Use the ---(S)---: Set output (STEP 7 Safety V21) (Page 457), ---(R)---: Reset output (STEP 7 Safety V21) (Page 455) or SR: Set/reset flip-flop (STEP 7 Safety V21) (Page 458) instructions, for example, with tags from the standard user program to allow a motor to be switched off, but not switched on.
- For switch-on sequences, use the AND logic operation instruction, for example, to logically combine tags from the standard user program with switch-on conditions that you derive from fail-safe tags.

If you want to process tags from the standard user program in the safety program, bear in mind that there is not a sufficiently simple method of checking plausibility for all tags.

Reading tags from the standard user program that can change during the runtime of an F-runtime group

If you want to read tags from the standard user program (bit memory, tags of a standard DB, or PII of standard I/O) in the safety program, and these tags can be changed - either by the standard user program or an operator control and monitoring system - during runtime of the F-runtime group in which they are read (for example because your standard user program is being processed by a higher-priority cyclic interrupt), you must use bit memory or tags of a standard DB for this purpose. We recommend using standard FCs for preprocessing (Page 85) for S7-1200/1500 F-CPUs.

(S7-300, S7-400) You must write the bit memory or tags of a standard DB with the tags from the standard user program immediately before calling the F-runtime group.

You are then permitted to access only this bit memory or these tags of a standard DB in the safety program.

Also note that **clock memory** that you defined when configuring your F-CPU in the "Properties" tab can change during runtime of the F-runtime group, since clock memory runs asynchronously to the F-CPU cycle.

NOTE

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Safety-related communication 9

9.1 Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions:

9.1.1 Overview

Introduction

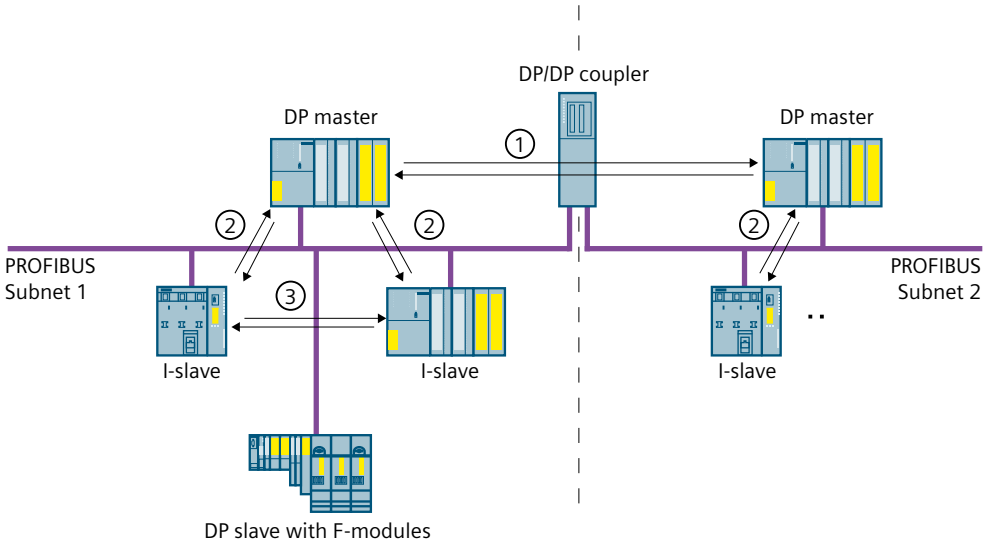
This section gives an overview of the options for safety-related communication options using the SENDDP/RCVDP or SENDS7/RCVS7 instructions in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

Safety-related CPU-CPU communication	On subnet	Additional hardware required	Required instructions
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
I-slave-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP
Safety-related communication via S7 connections	Industrial Ethernet	—	SENDS7/RCVS7
IO controller-IO controller communication for S7 Distributed Safety	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication for S7 Distributed Safety	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
Safety-related communication to S7 Distributed Safety or S7 F Systems via S7 connections	Industrial Ethernet	—	SENDS7/RCVS7

Overview of safety-related communication via PROFIBUS DP

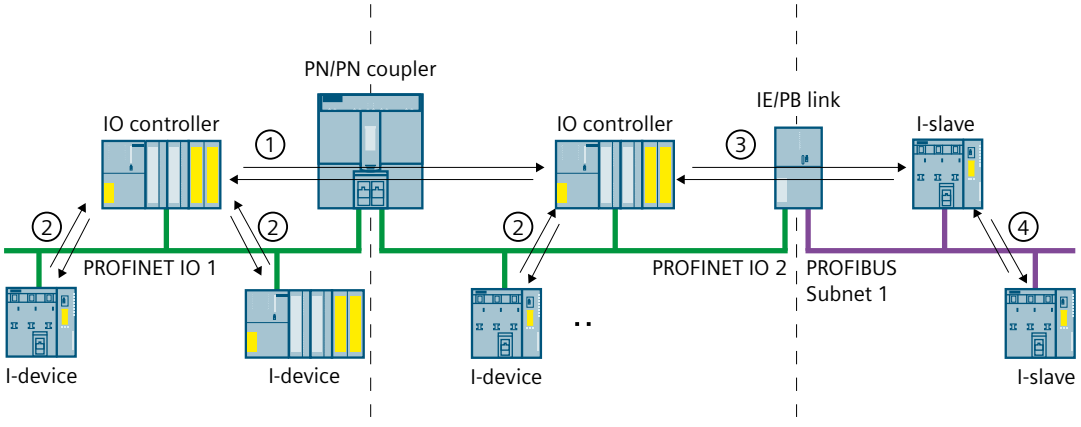
The figure below presents an overview of the three options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-300/400 F-CPUs.



① Safety-related master-master communication
② Safety-related master-I-slave communication
③ Safety-related I-slave-I-slave communication

Overview of safety-related communication via PROFINET IO

The figure below presents an overview of the four options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-300/400 F-CPUs. If an IE/PB-link is used, safety-related communication is possible between assigned I-slaves.



① Safety-related IO controller-IO controller communication
② Safety-related IO controller-I-device communication
③ Safety-related IO controller-I-slave communication
④ Safety-related I-slave-I-slave communication integrating an IO controller

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of fail-safe data of the data type INT or BOOL is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. Each transfer area consists of one input and one output address area.

Safety-related I-slave-slave communication via PROFIBUS DP

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O of a DP slave takes place using direct data exchange, as in the standard program. The process image is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave.

Safety-related CPU-CPU communication via Industrial Ethernet

Safety-related CPU-CPU communication via Industrial Ethernet is possible using S7 connections, both from and to the following:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

In safety-related communication via S7 connections, a specified amount of fail-safe data of data type BOOL, INT, WORD, DINT, DWORD, or TIME is transferred fail-safe between the safety programs of the F-CPUs linked by the S7 connection.

The data transfer makes use of the SENDS7 instruction for sending and the RCVS7 instruction for receiving. Data are exchanged using one F-DB ("F-communication DB") each at the sender and receiver ends.

Safety-related CPU-CPU communication with *S7 Distributed Safety* or *S7 F-systems*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety* or *S7 F-systems*.

9.1.2 Safety-related IO controller-IO controller communication

9.1.2.1 Configure safety-related IO controller-IO controller communication

Introduction

Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

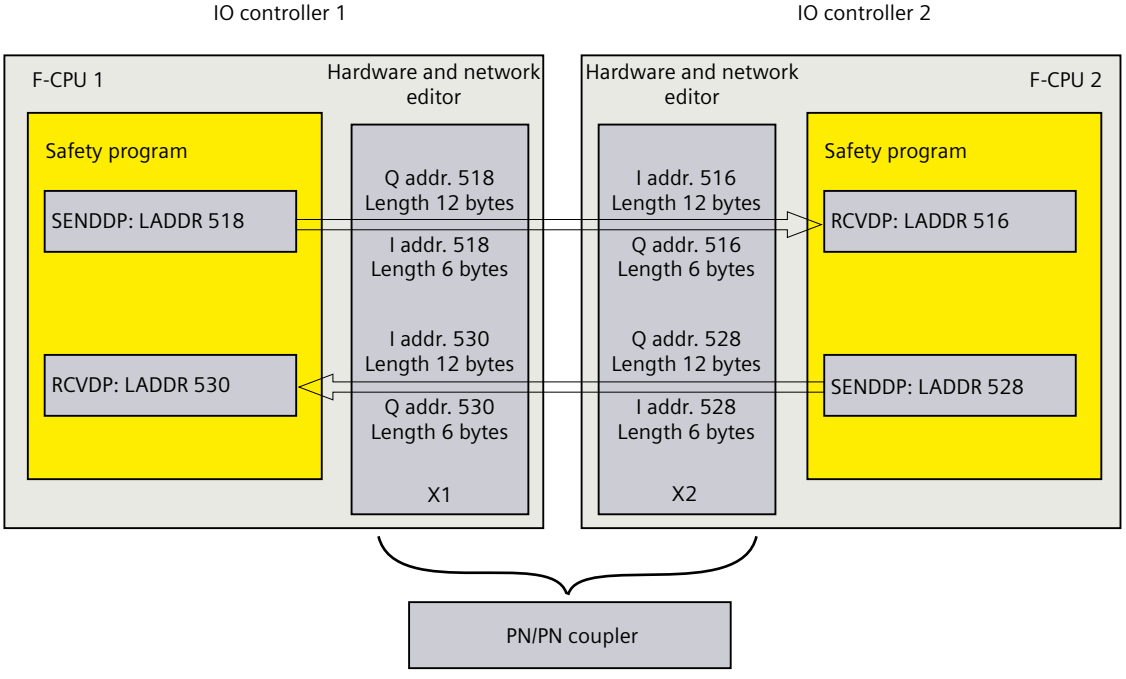
For 416F-2 DP CPUs without an integrated PROFINET interface, use a CP 443-1 or CP 443-1 Advanced-IT.

NOTE

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the PN/PN coupler for each of the two communication connections.



Rules for defining transfer areas

The transfer area for output data and the transfer area for input data for the **data to be sent** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

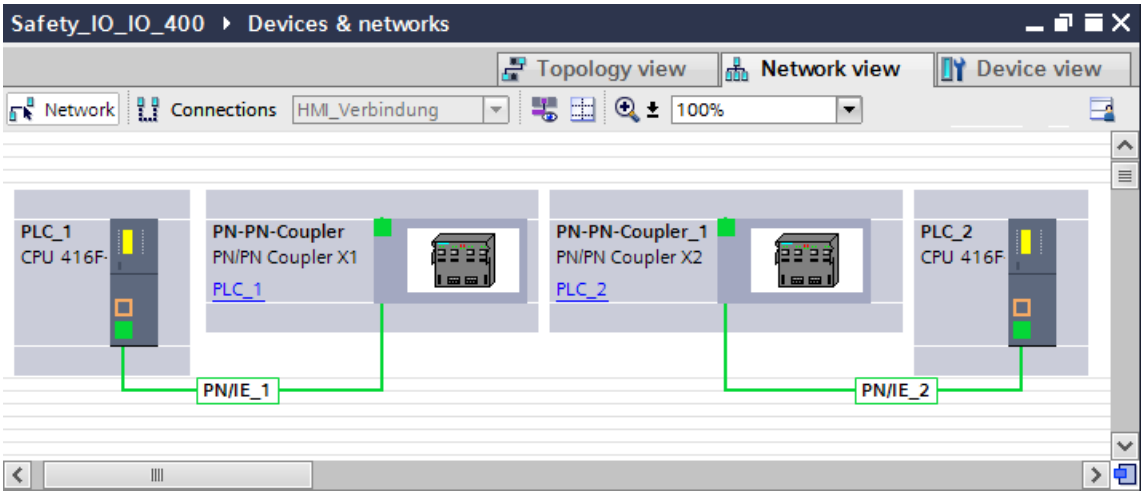
The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.



5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

6. In the properties of the modules, assign the addresses outside the process image as follows:

   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:

   – Input addresses: Start address 518
   – Output addresses: Start address 518

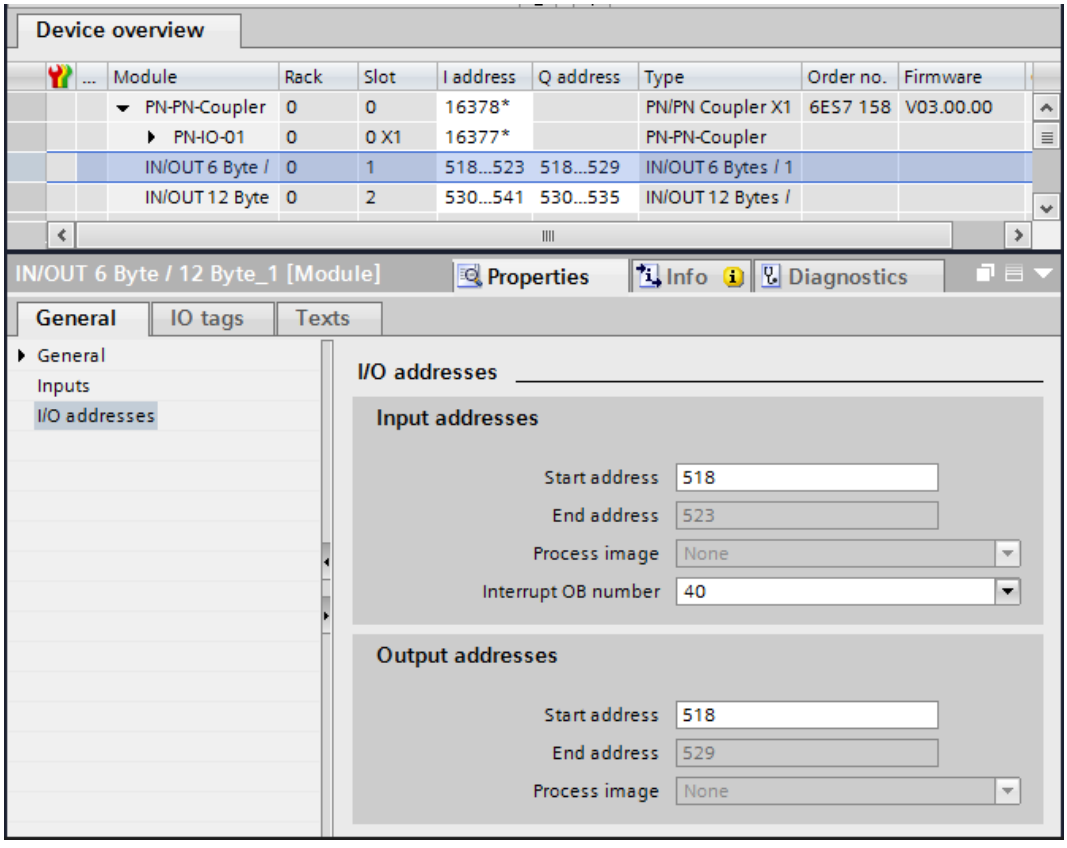
   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:

   – Input addresses: Start address 530
   – Output addresses: Start address 530

NOTE

Make sure that you assign identical start addresses for the address areas of the output and input data.

Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).



7. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:

   – One "IN/OUT 12 bytes / 6 bytes" module and
   – One "IN/OUT 6 bytes / 12 bytes" module

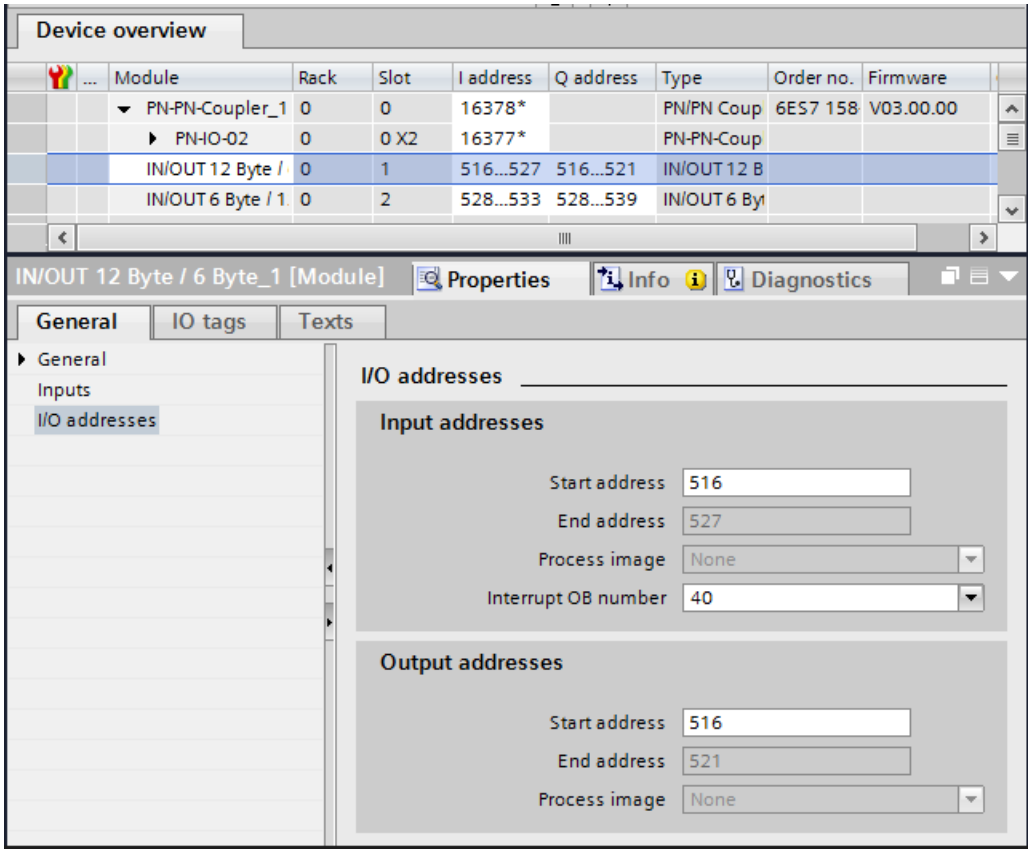
8. In the properties of the modules, assign the addresses outside the process image as follows:

   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:

   – Input addresses: Start address 516
   – Output addresses: Start address 516

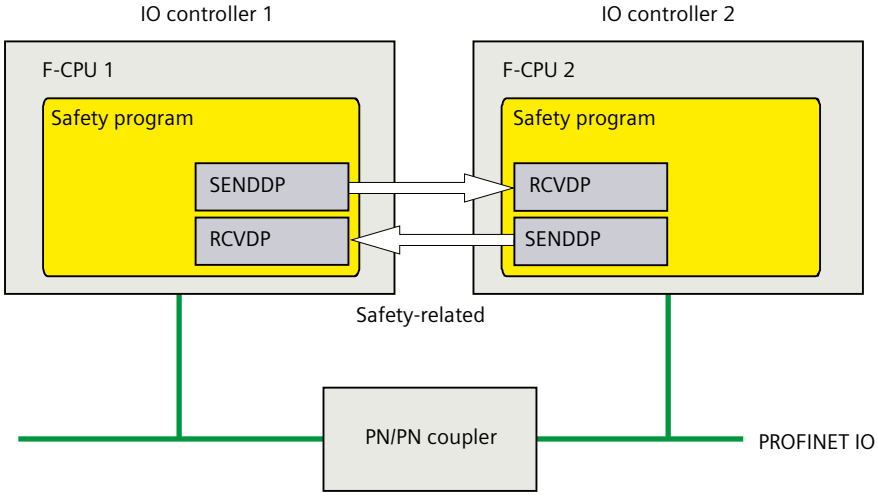
   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:

   – Input addresses: Start address 528
   – Output addresses: Start address 528



9.1.2.2 Program safety-related IO controller-IO controller communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

Programming procedure

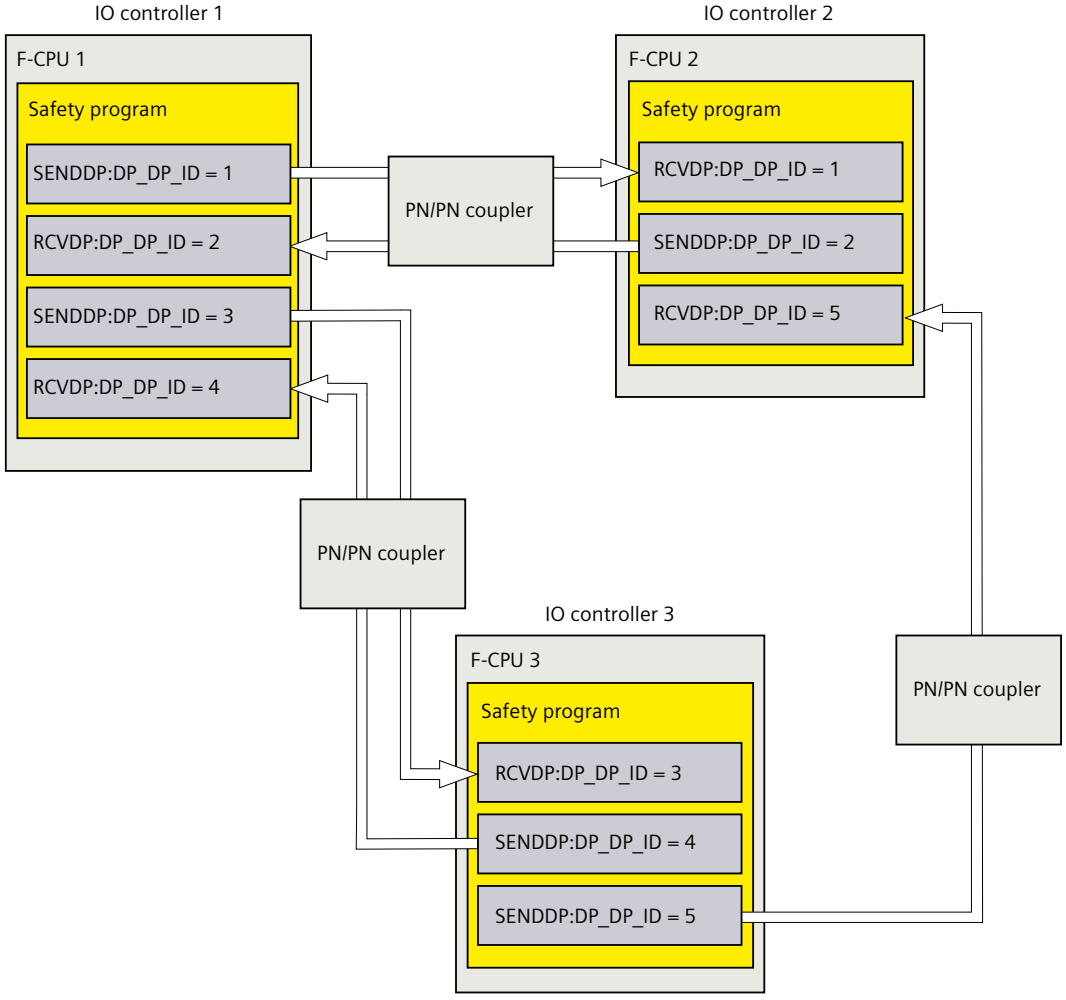
You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 599) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 599) for receiving at the start of the main safety block.
3. Assign the start addresses of the output and input data transfer areas of the PN/PN coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related IO controller-IO controller communication relationships.



⚠ WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via

PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, provide the tag "F_GOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     ⚠ WARNING

     Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*
8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).
9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.

11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 386).

9.1.2.3 Safety-related IO controller-IO controller communication - Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional communication connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.1.3 Safety-related master-master communication

9.1.3.1 Configure safety-related master-master communication

Introduction

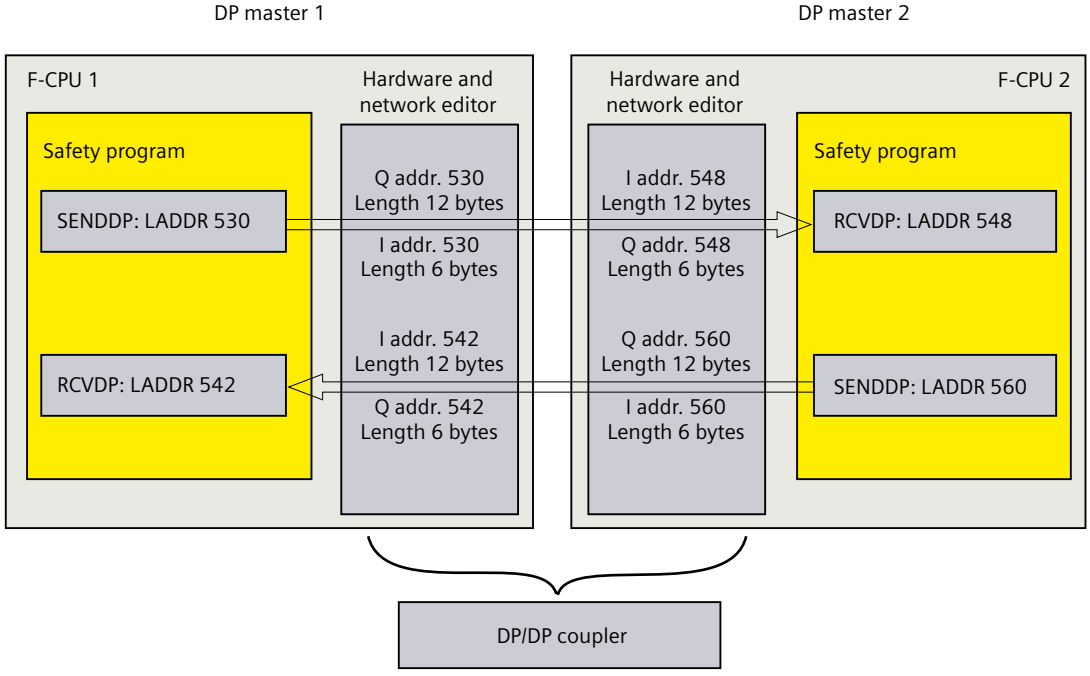
Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

NOTE

Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the DP/DP coupler for each of the two communication connections.



Rules for defining transfer areas

The transfer area for input data and the transfer area for output data for the **data to be sent** must begin with the same start address. A total of 6 bytes (consistent) is required for the transfer area for input data; 12 bytes (consistent) are required for the transfer area for output data.

The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

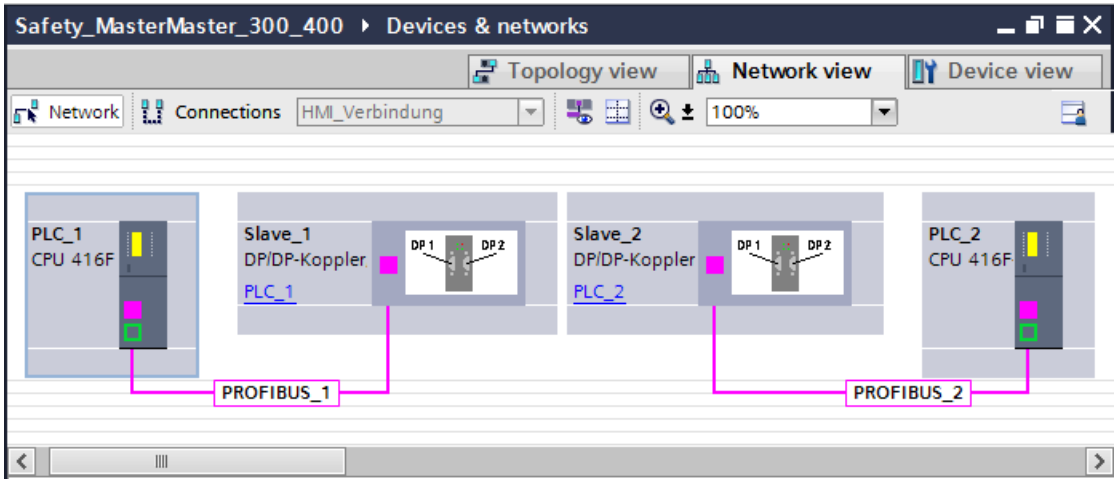
Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.

3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.
4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.



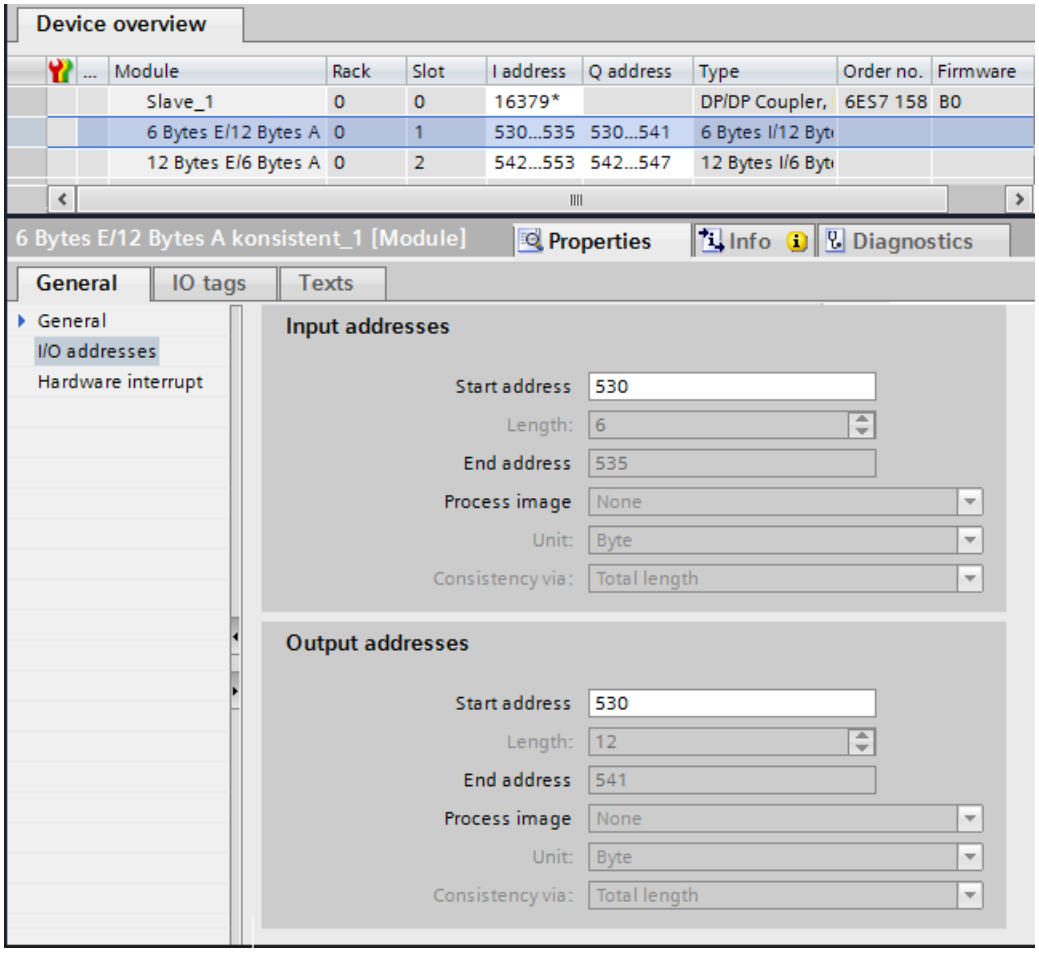
6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler of PLC 1, either by using the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (https://support.industry.siemens.com/cs/ww/en/view/1179382) manual).
7. Switch to the device view of the DP/DP coupler for PLC1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   – One "6 bytes I/12 bytes Q consistent" module, and
   – One "12 bytes I/6 bytes Q consistent" module
8. In the properties of the modules, assign the addresses outside the process image as follows:

   For "6 bytes I/12 bytes Q consistent" module for sending data for example:
   – Input addresses: Start address 530
   – Output addresses: Start address 530

   For "12 bytes I/6 bytes Q consistent" module for receiving data for example:
   – Input addresses: Start address 542
   – Output addresses: Start address 542

NOTE

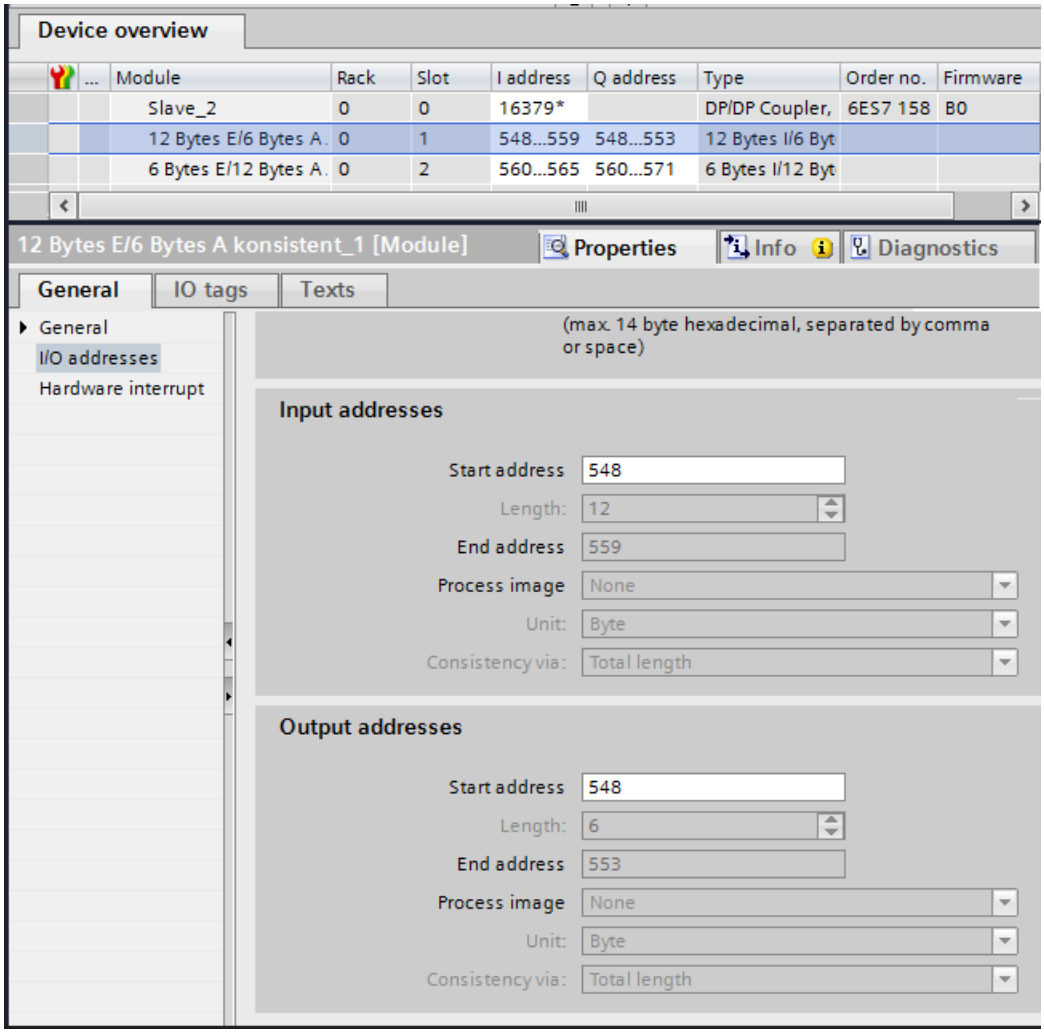
Make sure that you assign identical start addresses for the address areas of the output and input data.
Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).



9. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   - One "12 bytes I/6 bytes Q consistent" module, and
   - One "6 bytes I/12 bytes Q consistent" module
10. In the properties of the modules, assign the addresses outside the process image as follows:

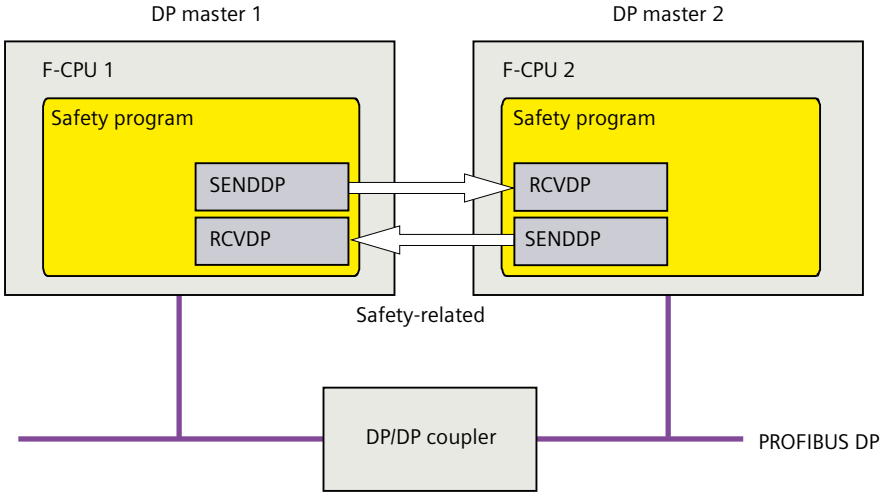
    For "12 bytes I/6 bytes Q consistent" module for receiving data for example:
    - Input addresses: Start address 548
    - Output addresses: Start address 548

    For "6 bytes I/12 bytes Q consistent" module for sending data for example:
    - Input addresses: Start address 560
    - Output addresses: Start address 560


Device overview
Module
Rack
Slot
I address
Q address
Type
Order no.
Firmware
Slave_2
0
0
16379*
DP/DP Coupler,
6ES7 158
B0
12 Bytes E/6 Bytes A...
0
1
548...559
548...553
12 Bytes I/6 Byt
6 Bytes E/12 Bytes A...
0
2
560...565
560...571
6 Bytes I/12 Byt
12 Bytes E/6 Bytes A konsistent_1 [Module]
Properties
Info
Diagnostics
General
IO tags
Texts
General
I/O addresses
Hardware interrupt
(max. 14 byte hexadecimal, separated by comma or space)
Input addresses
Start address
548
Length:
12
End address
559
Process image
None
Unit:
Byte
Consistency via:
Total length
Output addresses
Start address
548
Length:
6
End address
553
Process image
None
Unit:
Byte
Consistency via:
Total length

9.1.3.2 Program safety-related master-master communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The transfer areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

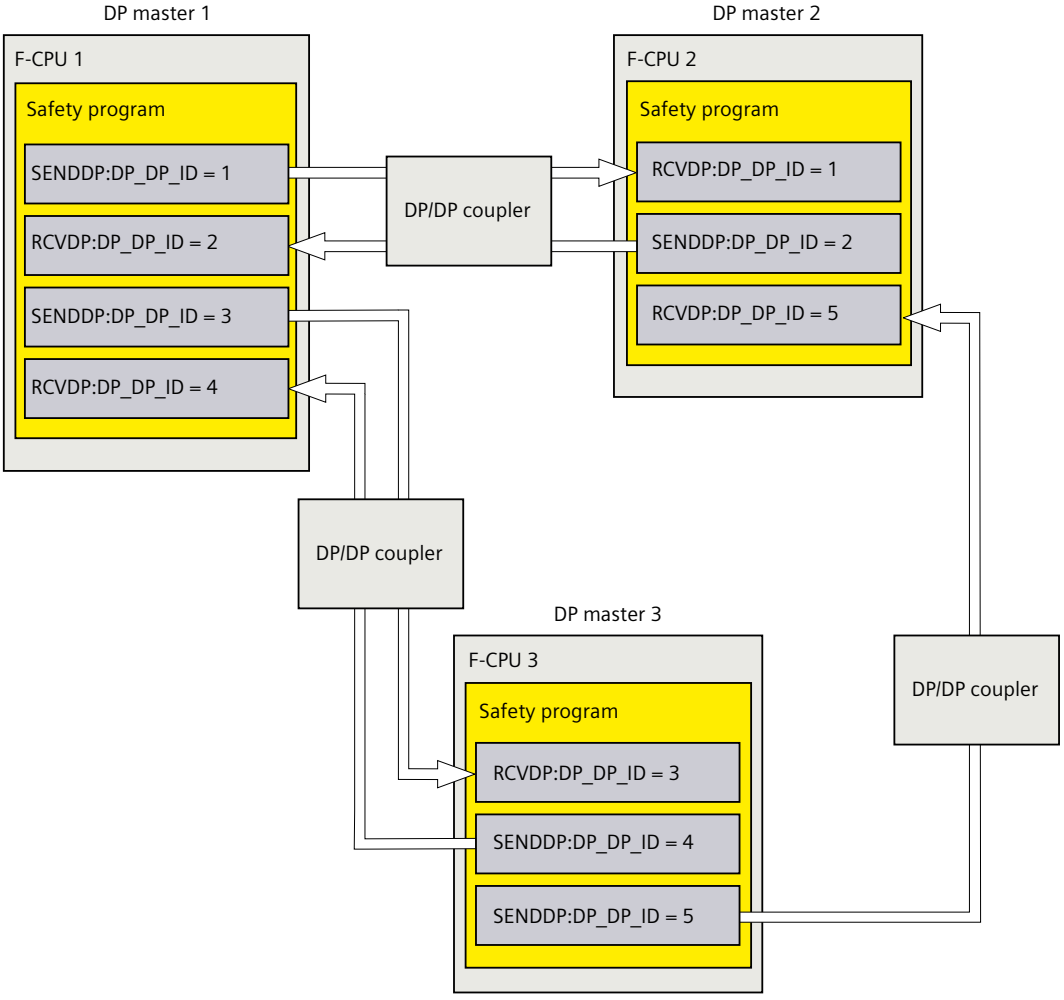
You program safety-related master-master communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 599) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 599) for receiving at the start of the main safety block.
3. Assign the start addresses of the transfer areas for output and input data of the DP/DP coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related master-master communications relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via

PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g. "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value for data of the data type BOOL, provide the tag "F_GLOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     ⚠ WARNING

     Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*
8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).
9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.

11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 386).

9.1.3.3 Safety-related master-master communication:Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.1.4 Safety-related IO controller-I-device communication

9.1.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

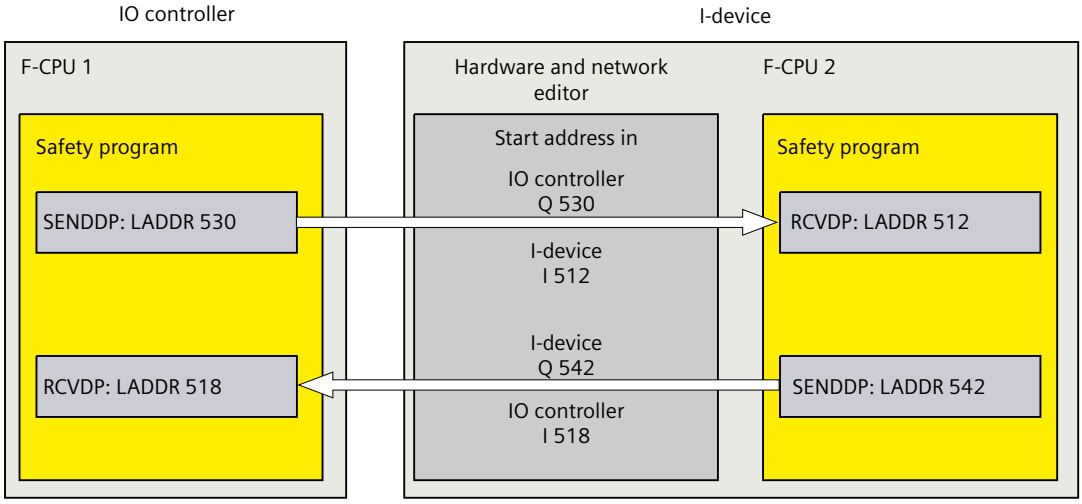
Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (**F**-CD) in PROFINET IO, as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

The F-CPU to be used as an I-device must support the "IO-device" operating mode.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

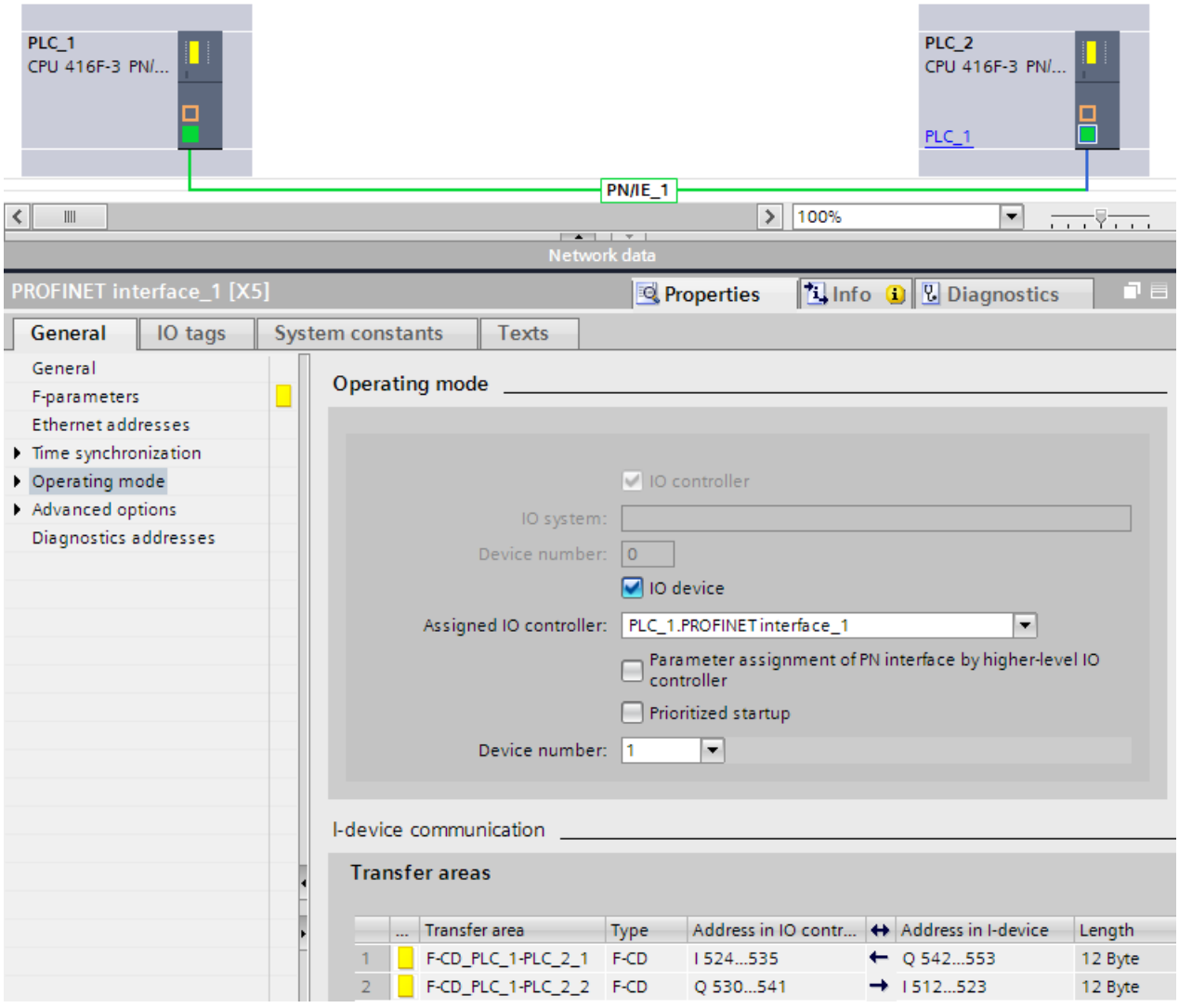
The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for sending to the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned outside of the process image are displayed.

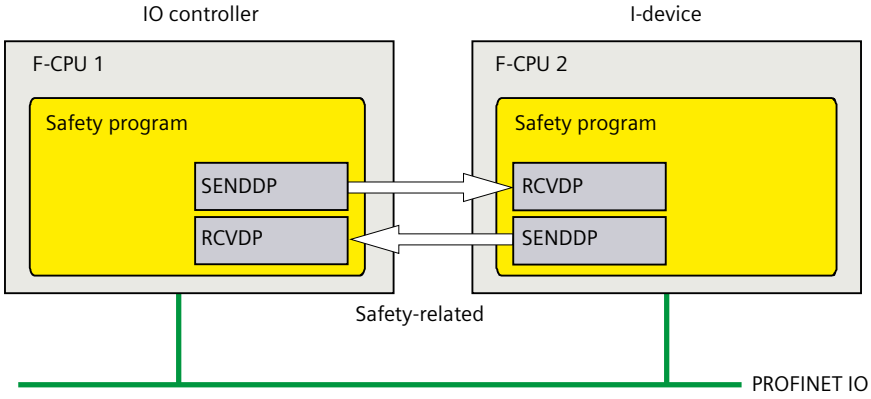
   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
4. Create an additional F-CD connection for receiving from the IO controller.

5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from IO controller (→).



9.1.4.2 Programming safety-related IO controller I-device communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The transfer areas must be configured.

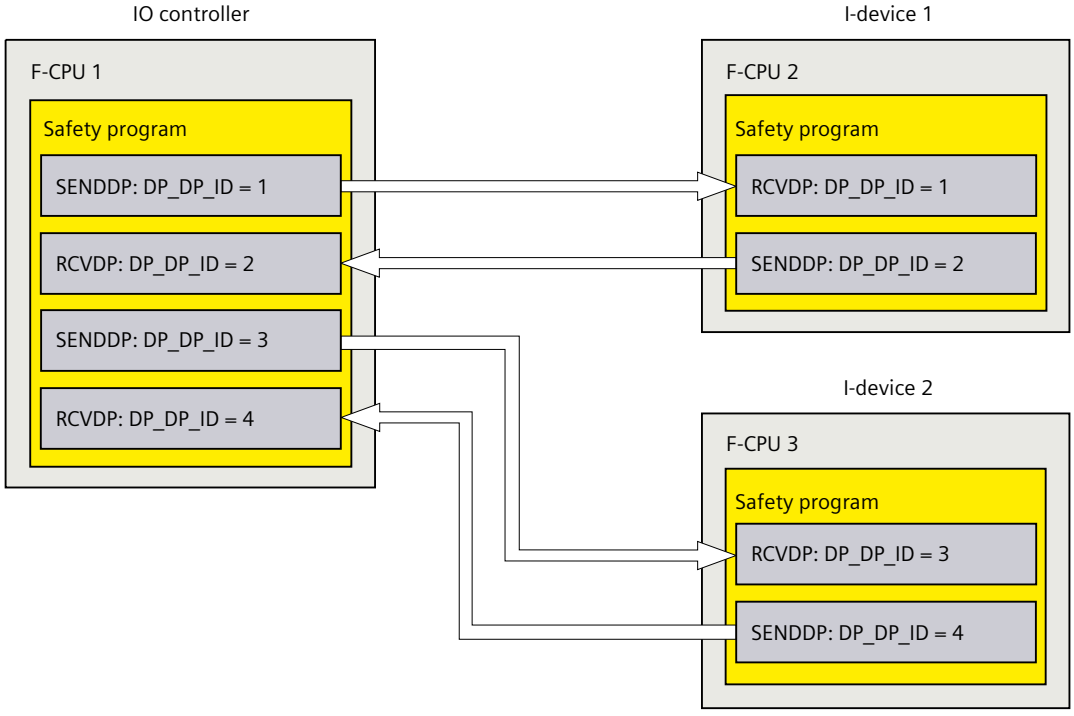
Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 203)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the IO controller	→	Address in the IO controller
RCVDP in the IO controller	←	Address in the IO controller
SENDDP in the I-device	←	Address in the IO device
RCVDP in the I-device	→	Address in the IO device

The figure below contains an example of how to specify the F-communication IDs for the inputs of the SENDDP and RCVDP instructions for 4 safety-related IO controller-I-device communication relationships.



⚠ WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time.*(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

9.1.4.3 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

9.1.5 Safety-related master-I-slave communication

9.1.5.1 Configuring safety-related master-I-slave communication

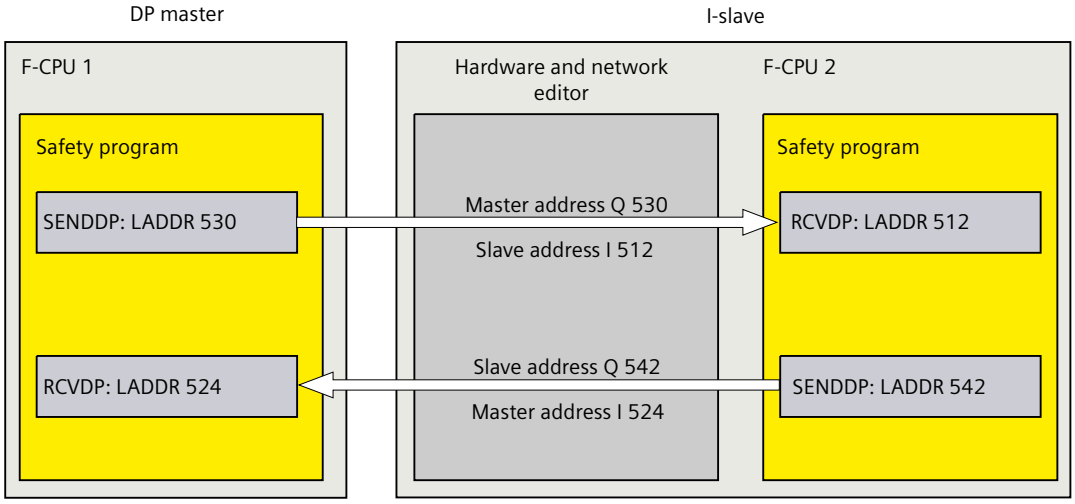
Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

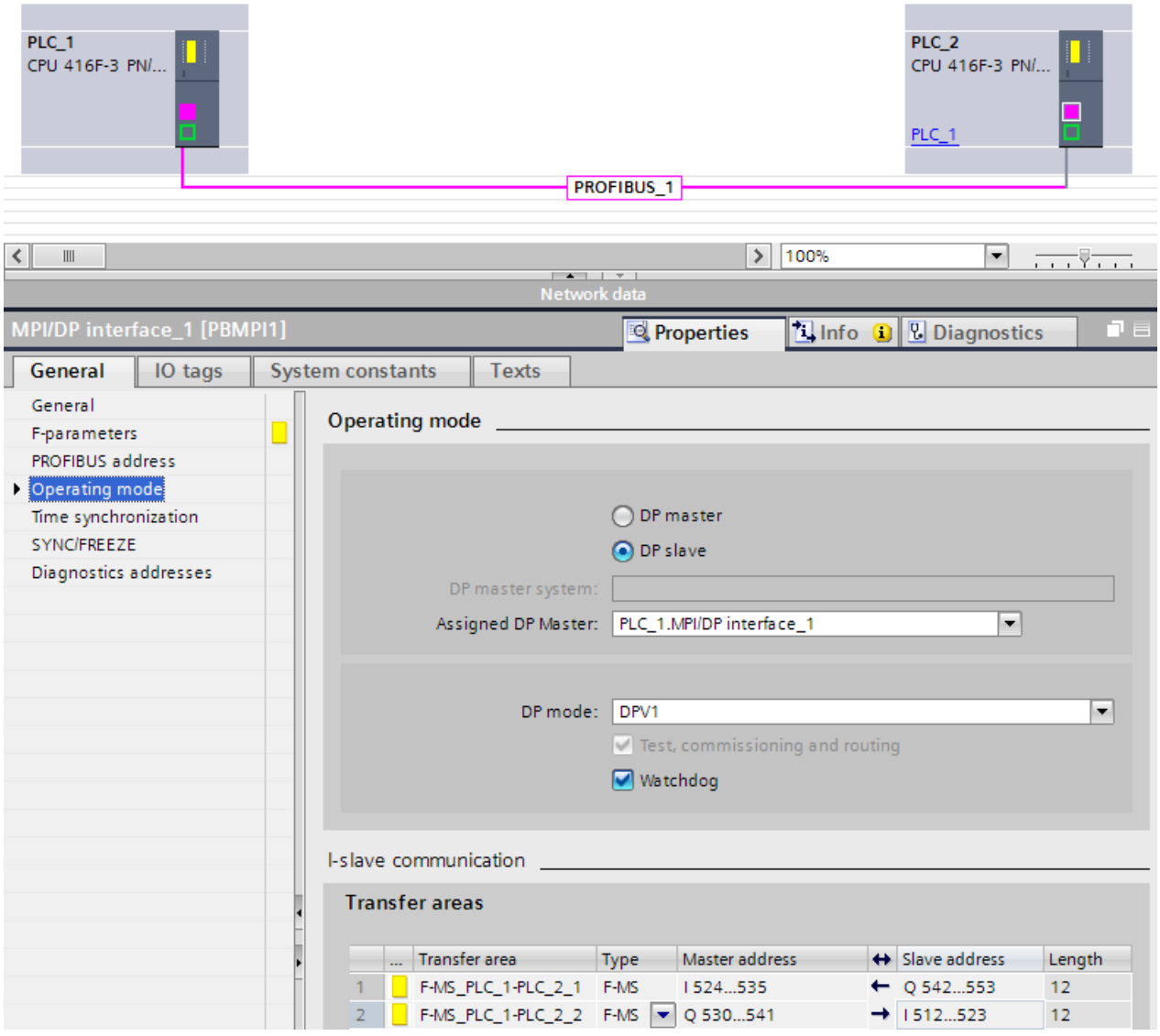
The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Activate the "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this DP interface to a DP interface of F-CPU 1.
3. Select the PROFIBUS interface of F-CPU 2. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the transfer areas in the I-slave and DP master assigned outside of the process image are displayed.

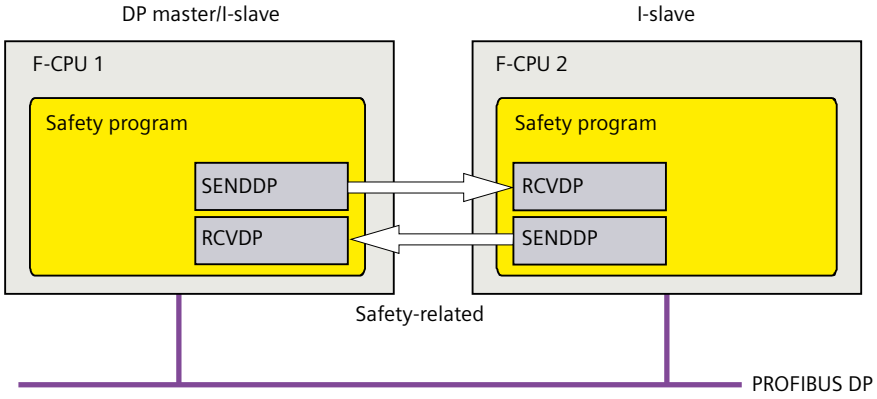
   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").
4. Create an additional F-MS connection for receiving from the DP master.

5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).



9.1.5.2 Program the safety-related master-I-slave or I-slave-I-slave communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master and an I-slave or between the F-CPUs of multiple I-slaves makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for configuration

The transfer areas must be configured.

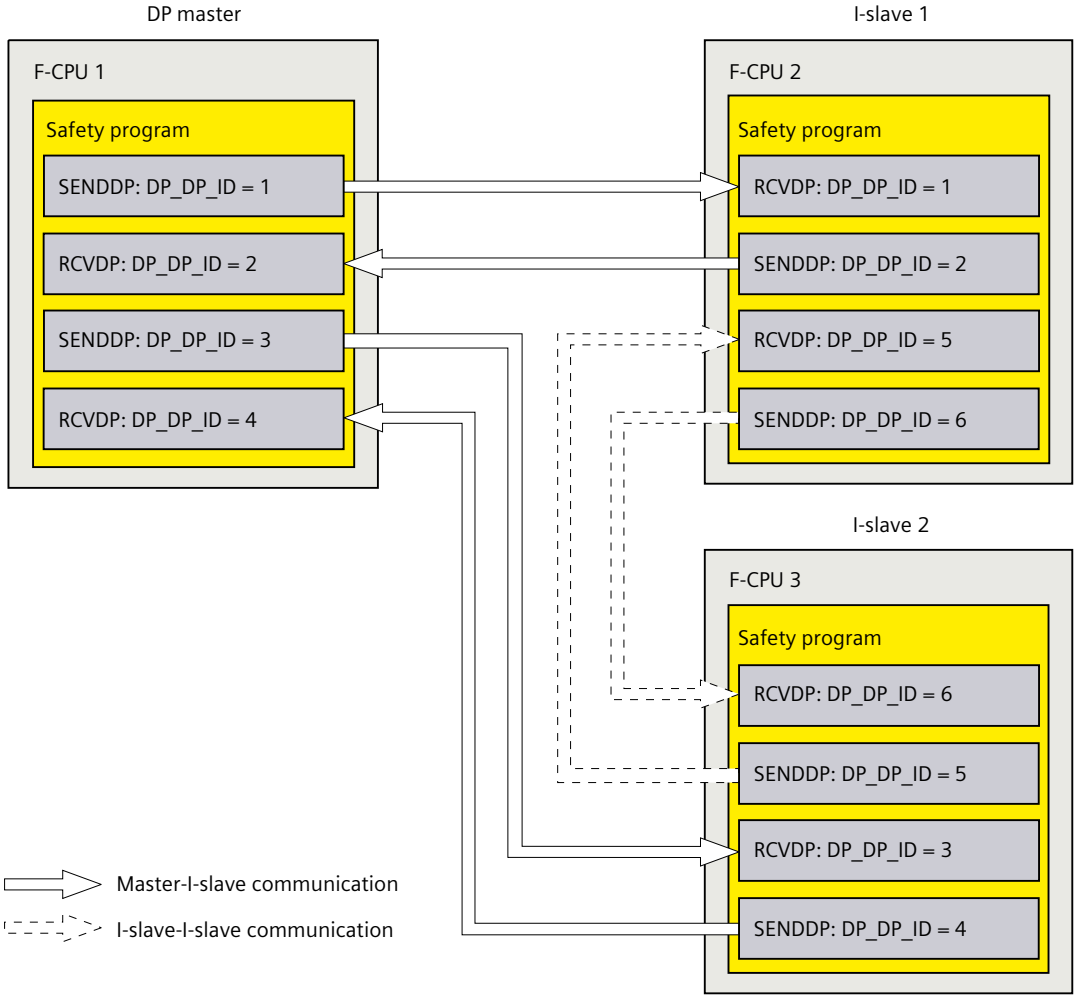
Programming procedure

The procedure for programming safety-related master-I-slave communication or I-slave-I-slave communication is the same as that for programming safety-related master-master communication (see Program safety-related master-master communication (Page 211)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the DP master	→	Master address
RCVDP in the DP master	←	Master address
SENDDP in the I-slave	←	Slave address
RCVDP in the I-slave	→	Slave address

The figure below contains an example of how to specify the F-communication IDs at the inputs of SENDDP and RCVDP instructions for four safety-related master-I-slave and two I-slave-I-slave communications relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

9.1.5.3 Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data					
		DP master		I-slave 1		I-slave 2	
		Output data	Input data	Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes	—	—
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes	—	—
I-slave-I-slave	**Sending:** I-slave 1 to I-slave 2	—	18 bytes	12 bytes	6 bytes	6 bytes	12 bytes
	Receiving: I-slave 1 from I-slave 2	—	18 bytes	6 bytes	12 bytes	12 bytes	6 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS, F-DX, F-DX-Mod., MS, DX). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.1.6 Safety-related I-slave-I-slave communication

9.1.6.1 Configure safety-related I-slave-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPUs of I-slaves takes place using direct data exchange (**F**-DX) – same as in standard programs.

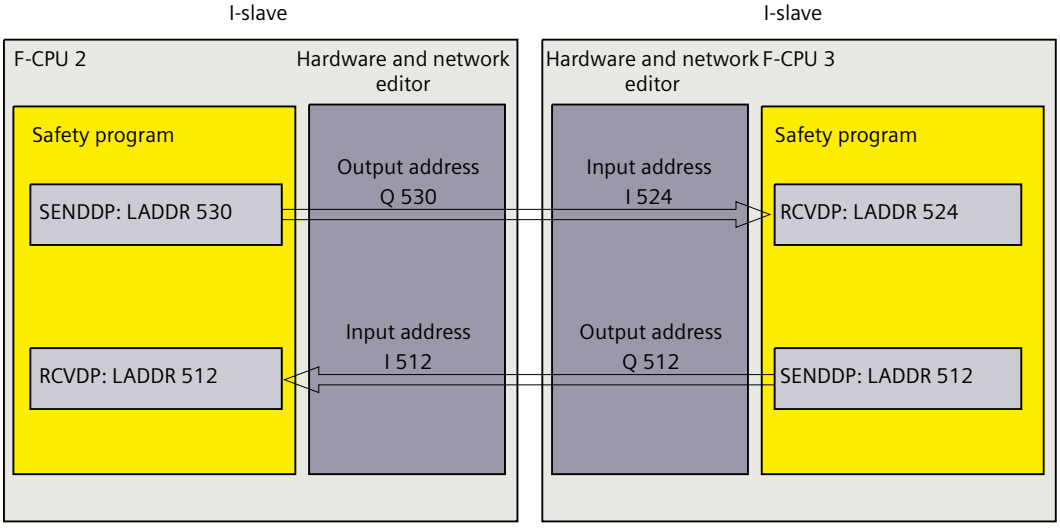
You do not need any additional hardware for I-slave-I-slave communication.

I-slave-I-slave communication is also possible:

- If the assigned DP master is a standard CPU that supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

Configuring transfer areas

For every safety-related communication connection between two I-slaves, you must configure transfer areas in the *hardware and network editor*. In the figure below, both of the I-slaves are to be able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX_PLC_2-PLC_1_1" for the first F-DX connection between F-CPU 1 and F-CPU 2.

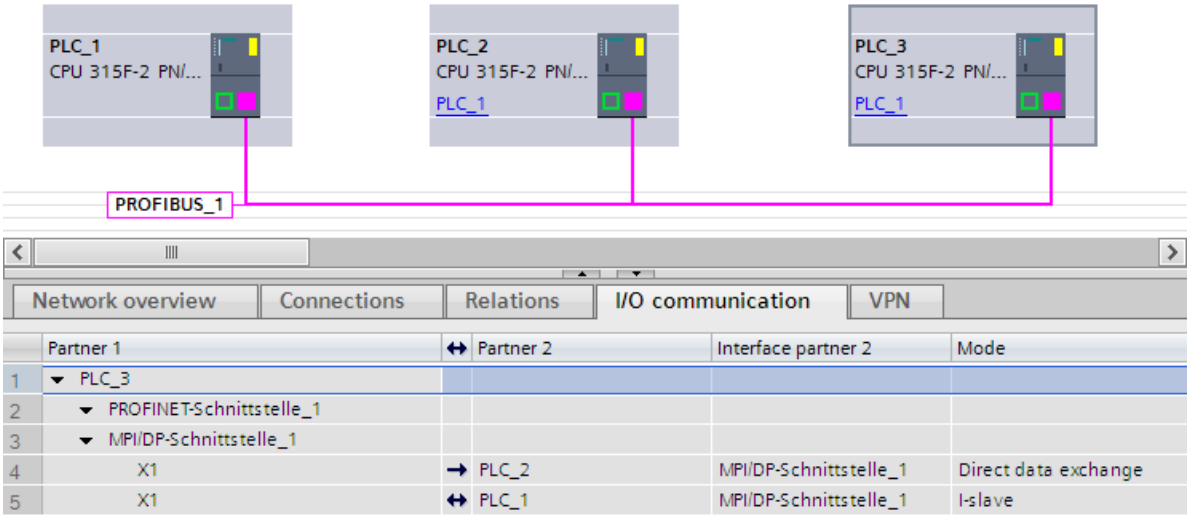
You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related I-slave-I-slave communication is identical to that in the standard system. Proceed as follows:

1. Insert three F-CPUS from the "Hardware catalog" task card in the project.
2. Activate "DP slaves" mode (I-slave) for F-CPU 2 and F-CPU 3 in the properties of their DP interfaces and assign these DP interfaces to a DP interface of F-CPU 1.
3. Select the DP interface of F-CPU 3 in the network view.
4. Select the "I/O communication" tab.
5. Use a drag-and-drop operation in the network view to move F-CPU 2 to the "Partner 2" column on the "I/O-communication" tab.

   This creates a line with "Direct data exchange" mode for sending to the I-slave (F-CPU 2) (→).

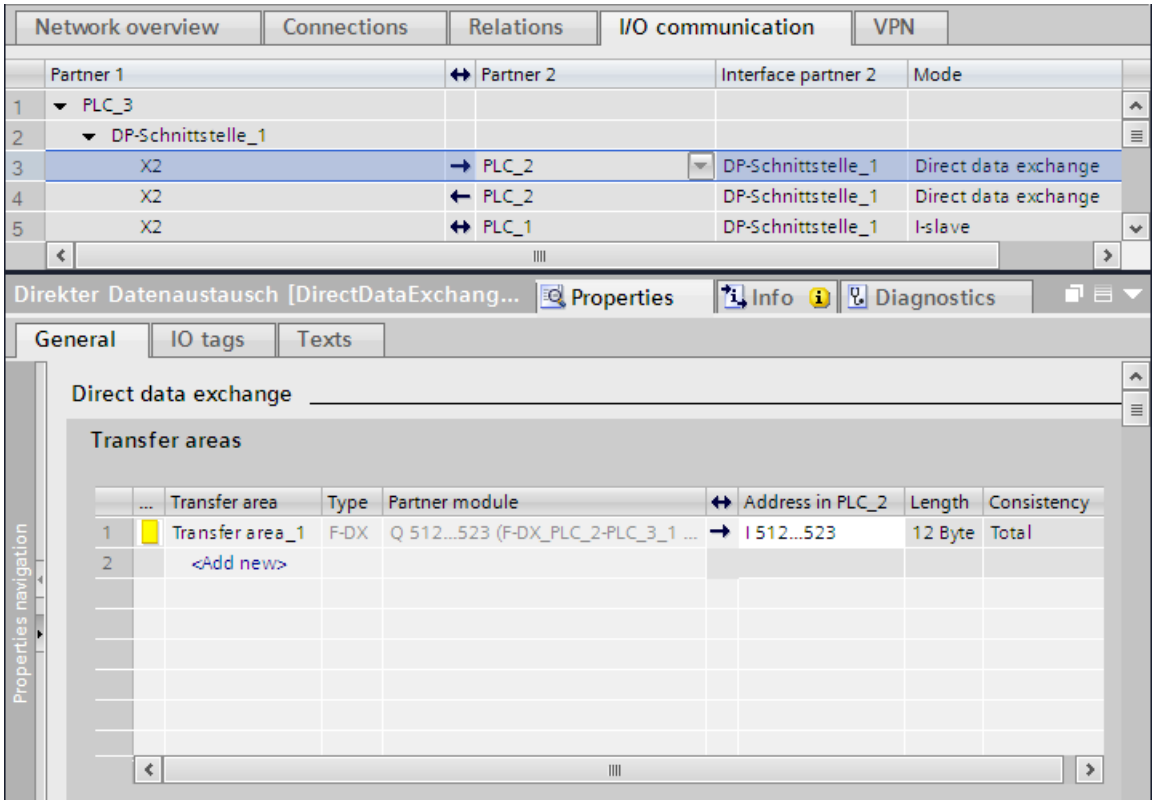


6. Click in the newly created line (→).
7. In "Transfer areas" ("Direct data exchange" table), create an F-DX connection (type "F-DX") for sending to the I-slave (F-CPU 2) (→). The F-DX connection is shown in yellow in the table and the transfer areas in the I-slaves assigned outside of the process image (PLC_2 and PLC_3) are displayed.

   In addition, a line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 2) (←) is created automatically in the "I/O communication" tab, and an acknowledgment connection (→, transfer area x_Ack) is created automatically in the associated "Direct data exchange" table.

   One transfer area (type F-MS) for the master CPU is created in the "I-slave communication table" of each I-slave.

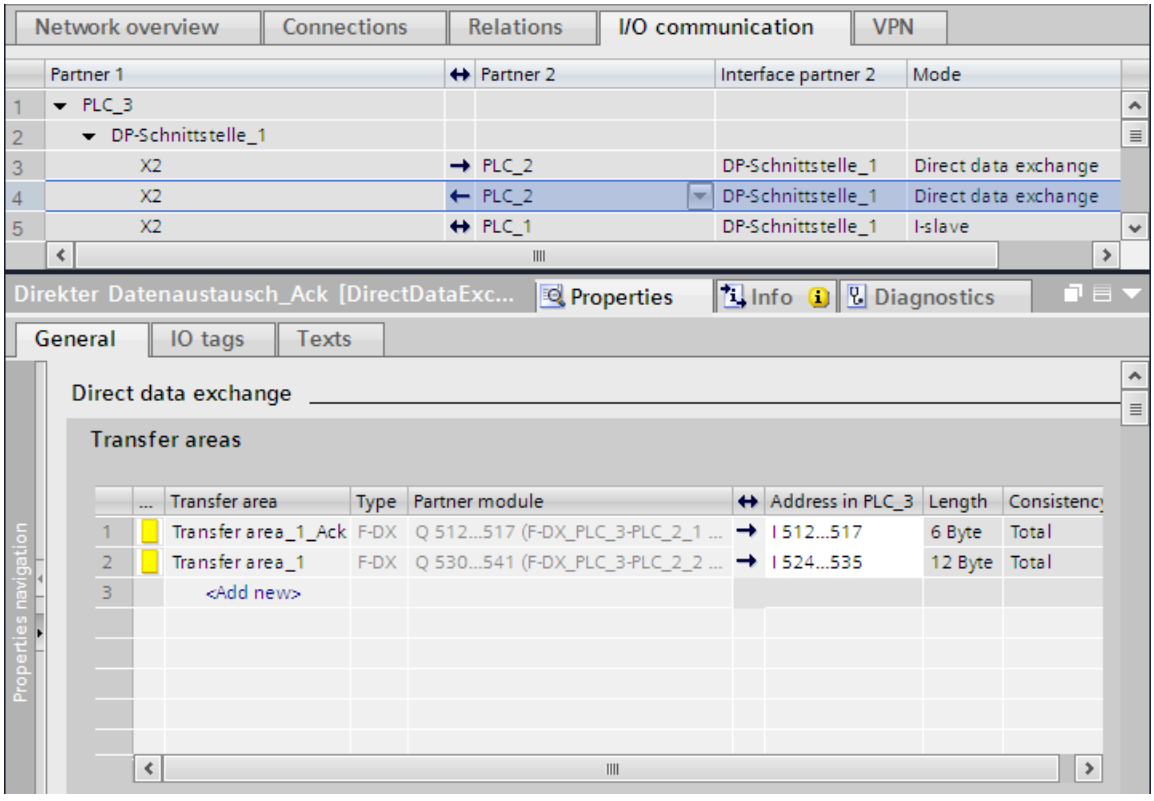
This completes the configuration for sending to F-CPU 2.



8. In the "I/O communication" tab, select the automatically created line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 2) (←).
9. In "Transfer areas" ("Direct data exchange" table), create another F-DX connection for receiving from the I-slave (F-CPU 3).

   In this case, as well, an acknowledgment connection (→, transfer area x_Ack) is created automatically in the "Direct data exchange table" and two transfer areas (type F-MS) for the master CPU are created in the "I-slave communication" table of both I-slaves.

This completes the configuration for receiving from F-CPU 2.



Changing disabled local address areas of the transfer areas

To change the disabled local address area of the "Transfer area x", you must change the start address of the address area of the corresponding acknowledgment connection "Transfer area x_Ack".

1. In "I/O communication", select the line with the arrow pointing in the same direction as the arrow of "Transfer area x" in the "Direct data exchange" table.
2. Then select the line with "Transfer area x_Ack" in the "Direct data exchange" table.
3. Change the start address of the address range there.

9.1.6.2 Programming safety-related I-slave-I-slave communication

Reference

The description of the programming of safety-related I-slave-I-slave communication can be found in Program the safety-related master-I-slave or I-slave-I-slave communication (Page 222).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the 1st I-slave	→	Address in the <1st I-slave> (in example column "Address in PLC_2")
RCVDP in the 1st I-slave	←	Address in the <1st I-slave> (in example column "Address in PLC_2")
SENDDP in the 2nd I-slave	←	Address in the <2nd I-slave> (in example column "Address in PLC_3")
RCVDP in the 2nd I-slave	→	Address in the <2nd I-slave> (in example column "Address in PLC_3")

9.1.6.3 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

The description of the limits for the data transfer of safety-related I-slave-I-slave communication can be found in Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication (Page 224).

9.1.7 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

NOTE

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 615)).
Note that the Excel file for calculating response times (https://support.industry.siemens.com/cs/ww/en/view/109783831) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 219) also applies.

9.1.8 Safety-related communication via S7 connections

9.1.8.1 Configuring safety-related communication via S7 connections

Introduction

Safety-related communication between the safety programs of F-CPUs via S7 connections takes place by means of established S7 connections that you create in the network view of the *hardware and network editor* - same as in standard programs.

Restrictions

NOTE

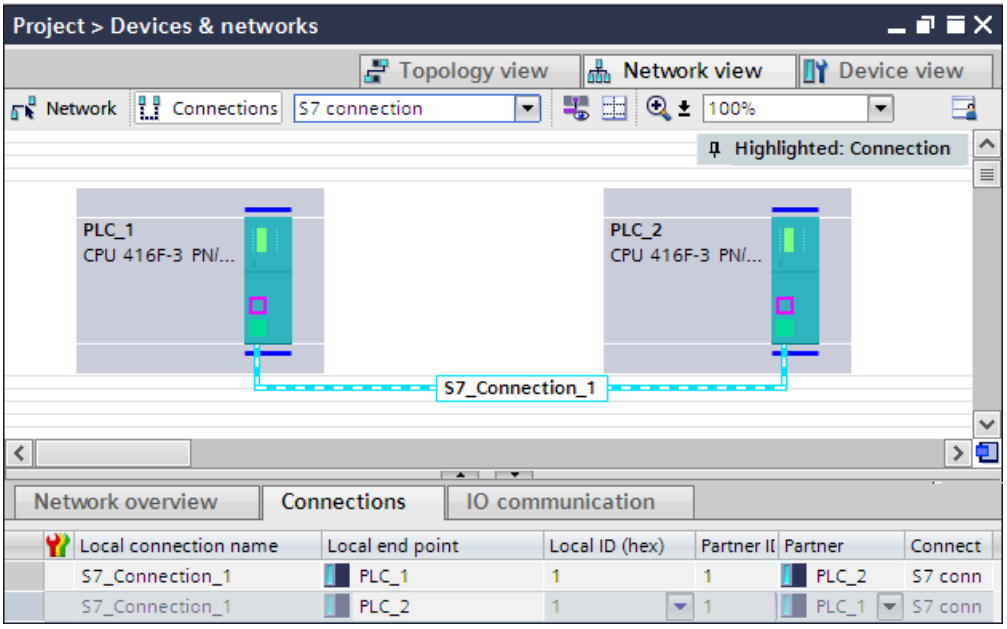
In SIMATIC Safety, S7 connections are generally permitted only via Industrial Ethernet.
Safety-related communication via S7 connections is possible from and to the following CPUs:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

Creating S7 connections

For each connection between two F-CPUs, you must create an S7 connection in the network view of the *hardware and network editor*.

For every end-point of a connection, a local and a partner ID is automatically assigned from the perspective of the end-point (the F-CPU). If necessary, you can change both IDs in the "Connections" tab. You assign the local ID to the "ID" input of the SENDS7 and RCVS7 instructions in the safety programs.

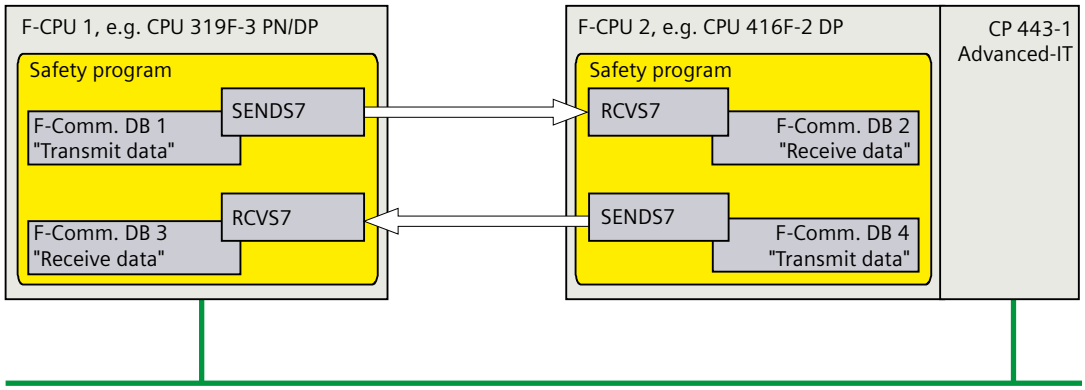


Procedure for configuring S7 connections

You configure the S7 connections for safety-related CPU-to-CPU communication in the same way as in *STEP 7 Professional* (see *Help on STEP 7 Professional* "S7 connections").

9.1.8.2 Programming safety-related communication via S7 connections

Communication via the SENDS7 and RCVS7 instructions



You use the **SENDS7 and RCVS7** instructions for fail-safe sending and receiving of data via S7 connections.

These instructions can be used to transmit a specified amount of fail-safe data of data types BOOL, INT, WORD, DINT, DWORD, and TIME in a fail-safe manner. The fail-safe data is stored in F-DBs (F-Communication DBs), which you create for each communication connection on the send and receive side.

You can find these instructions in the "Instructions" task card under "Communication". The RCVS7 instruction **must** be called at the start of the main safety block. The SENDS7 instruction **must** be called at the end of the main safety block.

Note that the send signals are sent only after calling the SENDS7 instruction at the end of the relevant F-runtime group execution.

A detailed description of the SENDS7 and RCVS7 instructions is found in SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 608).

Requirement for programming

The S7 connections between the relevant F-CPUs must be configured in the network view in the "Connections" tab of the *hardware and network editor*.

Creating and Editing an F-Communication DB

F-communication DBs are F-DBs that you create and edit in the same way as other F-DBs in the project tree. You can assign the F-communication DB numbers in the SENDS7 and RCVS7 instructions.

NOTE

The length and structure of the F-communication DB on the receiver side must match the length and structure of the associated F-communication DB on the sender side.
If the F-communication DBs do not match, the F-CPU can go to STOP mode. A diagnostics event is entered in the diagnostics buffer of the F-CPU.
For this reason, we recommend that you use the following procedure:

1. Create an F-communication DB in the project tree in or below the "Program blocks" folder of the F-CPU at the sender end.
2. Specify the appropriate structure of the F-communication DB, taking into account the data to be transferred.
3. Copy this F-communication DB to the project tree in or below the "Program blocks" folder of the F-CPU at the receiver end, and change the name, if necessary.

Other requirements for F-communication DBs

F-communication DBs must also conform to the following properties:

- They are not permitted to be instance DBs.
- Their length is not permitted to exceed 100 bytes.
- In F-communication DBs, only the following data types may be declared: BOOL, INT, WORD, DINT, DWORD, and TIME.
- The data types must be arranged block-wise and in the following order: BOOL, data types with bit length of 16 bits (INT, WORD), and data types with bit length of 32 bits (DINT, DWORD, and TIME). Within the data blocks with lengths of 16 bits and 32 bits, the data types can be arranged in any order.
- No more than 128 data elements of data type BOOL are permitted to be declared.
- The amount of data of data type BOOL must always be an integer multiple of 16 (word limit). Reserve data must be added, if necessary.

If these criteria are not fulfilled, *STEP 7 Safety Advanced* outputs an error message during compilation.

Assignment of fail-safe values

Fail-safe values are made available at the receiver end:

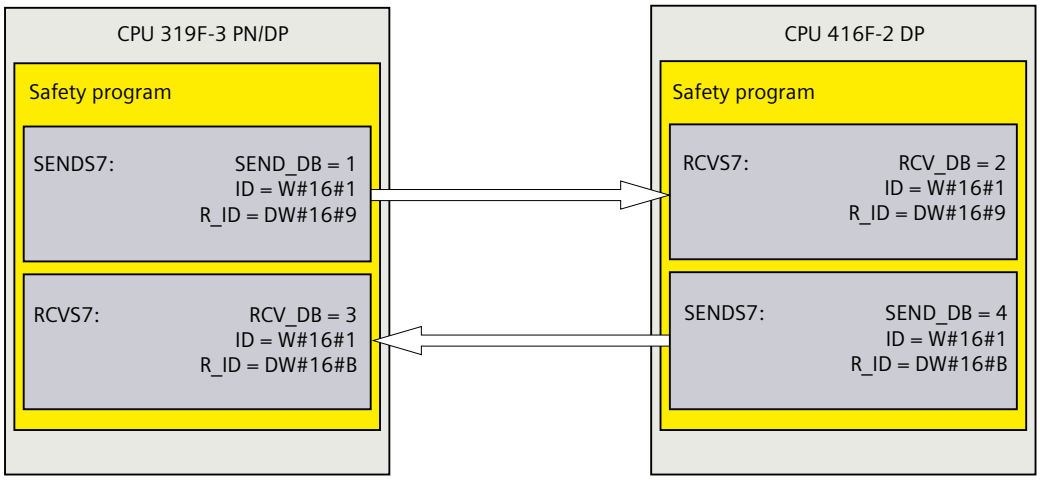
- While the connection between the communication partners is being established the first time after startup of the F-systems
- Whenever a communication error occurs

The values you specified as initial values in the F-communication DB at the receiver end are made available as initial values.

Programming procedure

You program safety-related communication via S7 connections as follows:

1. Supply the tags in the F-communication DB at the sender end with send signals using fully qualified access (e.g., "Name of F-communication DB".tag name).
2. Read the tags in the F-communication DB at the receiver end (receive signals) that you want to process further in other sections of the program using fully qualified access (e.g., "Name of F-communication DB".tag name).
3. In the safety program from which data is to be sent, call the SENDS7 instruction for sending at the end of the main safety block.
4. In the safety program in which data is to be received, call the instruction RCVS7 for receiving at the start of the main safety block.
5. Assign F-communication DB numbers to the SEND_DB input of SENDS7 and the RCV_DB input of RCVS7.
6. Assign the local ID of the S7 connection (data type: WORD) from the perspective of the F-CPU that was configured in the "Connections" tab of the network view to the ID input of SENDS7.
7. Assign the local ID of the S7 connection (data type: WORD) that was configured in the "Connections" tab of the network view to the ID input of RCVS7.
8. Assign an odd number (data type: DWORD) to the R_ID inputs of SENDS7 and RCVS7. This serves to specify that a SENDS7 instruction belongs to an RCVS7 instruction. The associated instructions receive the same value for R_ID.



WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.
You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via

PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

9. Assign the TIMEOUT inputs of the SENDS7 and RCVS7 instructions with the required monitoring time.

> **⚠ WARNING**
>
> It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

10. To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND (initial value = "TRUE") with 0. In this case, send data is no longer sent to the F-communication DB of the associated RCVS7 instruction and the receiver RCVS7 provides fail-safe values for this period (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.
11. Optional: Evaluate the ACK_REQ output of RCVS7, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
12. Supply the ACK_REI input of RCVS7 with the signal for the acknowledgment for reintegration.
13. Optional: evaluate the SUBS_ON output of RCVS7 or SENDS7 in order to query whether the RCVS7 instruction is outputting the fail-safe values you specified as initial values in the F-communication DB.
14. Optional: Evaluate the ERROR output of RCVS7 or SENDS7, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
15. Optional: evaluate the SENDMODE output of RCVS7 in order to query whether the F-CPU with the associated SENDS7 instruction is in disabled safety mode (Page 386).

Particularities for migrated projects

If you have migrated a project from *S7 Distributed Safety V5.4 SP5* to *STEP 7 Safety Advanced* in which safety-related communication via S7 connections is programmed, you must note the following:

- Do not delete migrated instance DBs for the SENDS7 and RCVS7 instructions in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks".

Otherwise, communication errors may occur in the relevant communication connections.

A migrated instance DB for the SENDS7 and RCVS7 instructions has been deleted if, after compiling the safety program, the "User-defined ID" in the newly generated instance DB is not identical to "FRCVS7CL" or "FSNDS7CL".

You can find the "User-defined ID" of a block in its properties in the "Information" area.

9.1.8.3 Safety-related communication via S7 connections - Limits of data transfer

NOTE
If the amount of data to be transmitted exceeds the permitted length for the F-communication DB (100 bytes), you can create a further F-communication DB that you transfer to additional SENDS7/RCVS7 instructions with a modified R_ID.

Note that USEND and URCV instructions are called internally at each SENDS7 or RCVS7 call and use connection resources in the F-CPU. This affects the maximum number of communication connections available (*see manuals for F-CPUs*).

More information can be found on the data transfer limits for S7 connections of individual F-CPUs is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/38549114).

9.1.9 Safety-related communication with other S7 F-systems

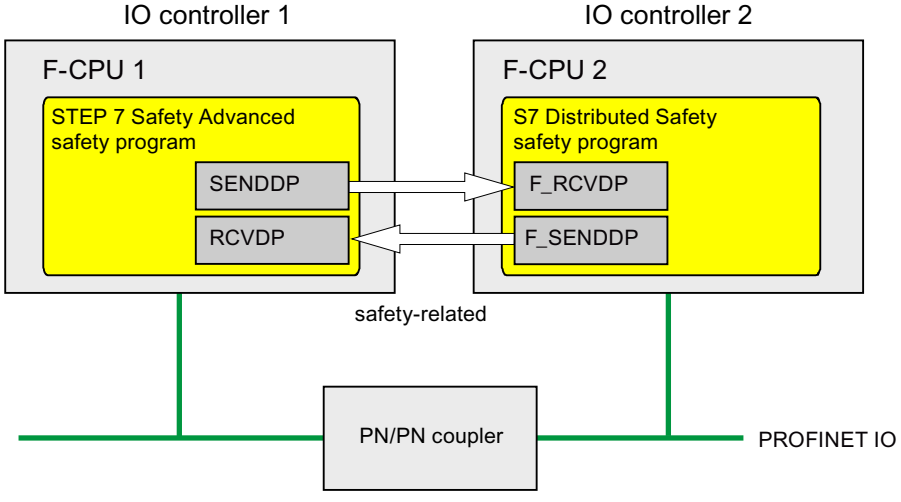
9.1.9.1 Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs as IO controller-IO controller communication, master-master communication or communication via established S7 connections.

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 F/FH Systems F-systems is possible via established S7 connections.

9.1.9.2 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

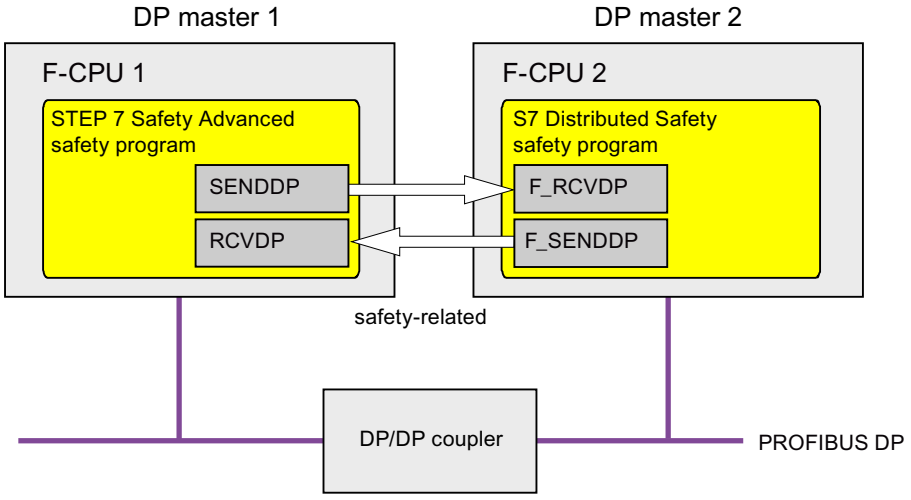
At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related IO controller-IO controller communication (Page 199).

9.1.9.3 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

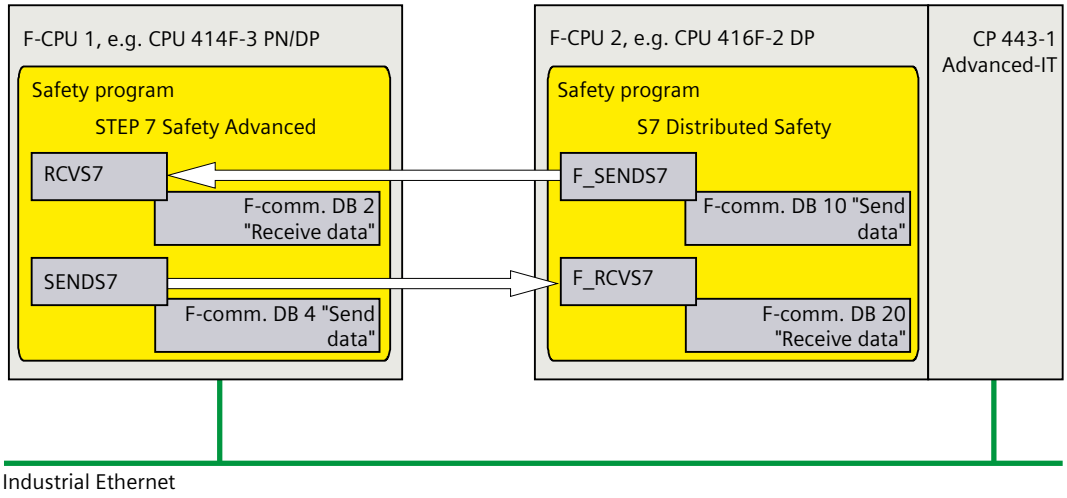
At the *S7 Distributed Safety* end, proceed as described in "Safety-related master-master communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related master-master communication (Page 206).

9.1.9.4 Communication with S7 Distributed Safety via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SENDS7/F_RCVS7 F-application blocks at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in section "Safety-related communication via S7 communications" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

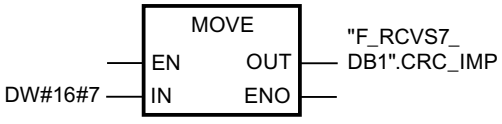
Because safety-related communication via S7 connections is not possible with unspecified partners in S7 Distributed Safety, you must first create a "virtual" SIMATIC station in *S7 Distributed Safety* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set these in the associated, unspecified S7 connection that you created in *STEP 7 Professional*.

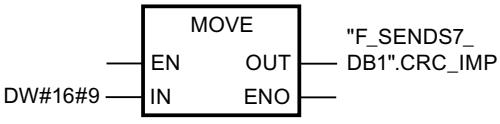
In addition, for all communication connections to this F-CPU, you must transfer the F-communication ID that you assigned in the R_ID input of the associated calls of the F_SENDS7 and F_RCVS7 F-application blocks additionally to the CRC_IMP tag in the instance DB of F_SENDS7 and F_RCVS7, respectively, in the standard user program immediately before calling the F-CALL.

Program example:

Network 1: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP



Network 2: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP



Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related communication via S7 connections (Page 230).

For the F-CPU in *S7 Distributed Safety*, you must create and specify an unspecified S7 connection. You can find information on this in the *STEP 7* help, under "Creating an unspecified connection" or "Specifying and unspecified connection".

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 Distributed Safety*.

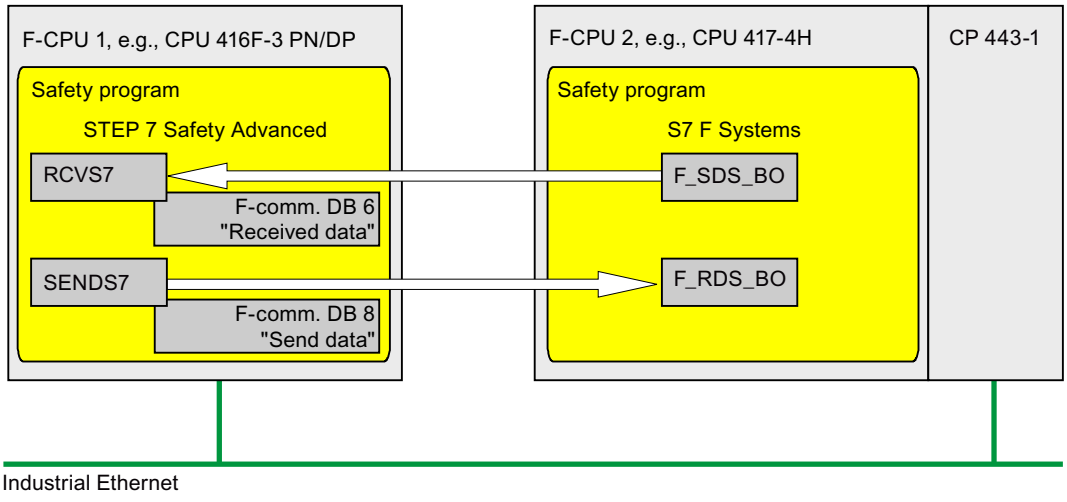
If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

If the instance DBs of the SENDS7 and RCVS7, instructions that you want to use for communication with *S7 Distributed Safety* were migrated from *S7 Distributed Safety*, you must delete them in the project tree in the "STEP 7 Safety" folder, under "Program blocks > System blocks" (contrary to the information in Programming safety-related communication via S7 connections (Page 232), section "Particularities for migrated projects").

9.1.9.5 Communication with S7 F/FH Systems via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SDS_BO/F_RDS_BO F-blocks at the *S7 F Systems* end.

A maximum of 32 data elements of data type BOOL can be exchanged.



Procedure at the *S7 F Systems* end

At the *S7 F systems* end, proceed as described in section "Safety-related communication between F-CPUs" in the S7 F/FH Systems - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/109802562) manual.

Because safety-related communication via S7 connections is not possible with unspecified partners in *S7 F/FH Systems*, you must first create a "virtual" SIMATIC station in *S7 F/FH Systems* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

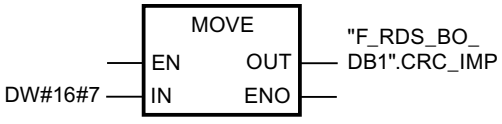
You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set

these in the associated, unspecified S7 connection that you created in *STEP 7 Safety Advanced*.

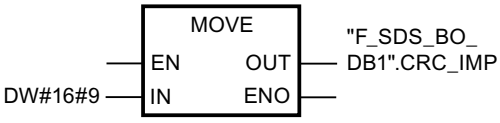
In addition, you must insert a function in your S7 program (in the area reserved in CFC for other applications), in which, for all communication connections for this F-CPU, you transfer the F-communication ID that you assigned in the R_ID input of the associated calls of the F_SDS_BO and F_RDS_BO F-blocks additionally to the CRC_IMP tag in the instance DB of the F_SDS_BO and F_RDS_BO, respectively. You obtain the number of the instance DB from the object properties of the block in CFC. Assign descriptive names for these instance DBs. If you perform a compress operation in CFC, you must check whether the numbers of these instance DBs have changed.

Program example:

Network 1: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP



Network 2: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP



You must then import the function in CFC as block type and insert your standard user program in a chart. In the run sequence, make sure that the associated standard runtime group is processed before the F-runtime group.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in "Safety-related communication via S7 connections" (Page 230).

Particularity: In *STEP 7 Safety Advanced*, you must create the F-communication DB with exactly 32 data elements of data type BOOL.

For the F-CPU in *S7 F/FH Systems*, you must create and specify an unspecified S7 connection. You can find information on this in the *STEP 7* help, under "Creating an unspecified connection" or "Specifying an unspecified connection".

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 F Systems*.

If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

9.2 Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500):

9.2.1 Overview

Introduction

This section gives an overview of the options for safety-related communication using the SENDDP/RCVDP instructions in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

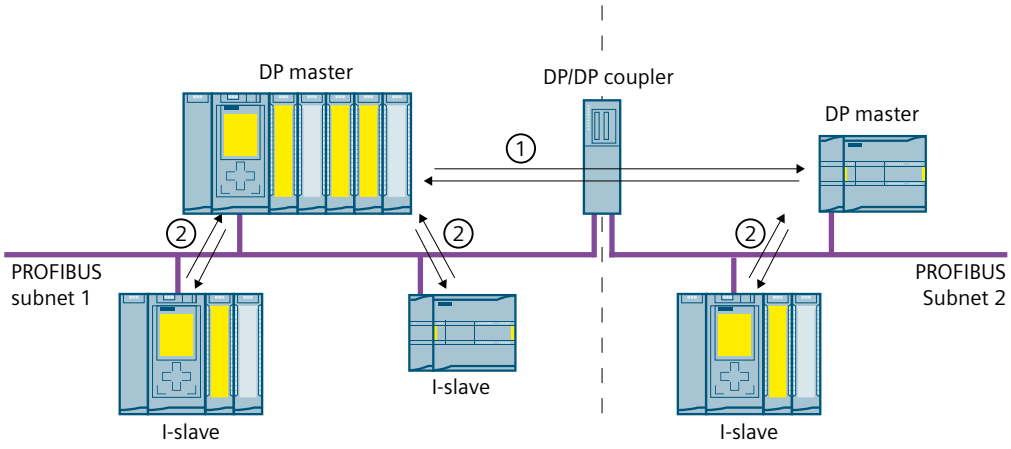
Safety-related CPU-CPU communication	On subnet	Additional hardware required	Required instructions
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP
IO controller-IO controller communication for *S7 Distributed Safety*	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication for *S7 Distributed Safety*	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP

NOTE
The options for safety-related communication depend on the F-CPUs used.

NOTE
Safety-related communication with S7-1200 G1 F-CPUs is only permitted as of firmware V4.1.2.

Overview of safety-related communication via PROFIBUS DP

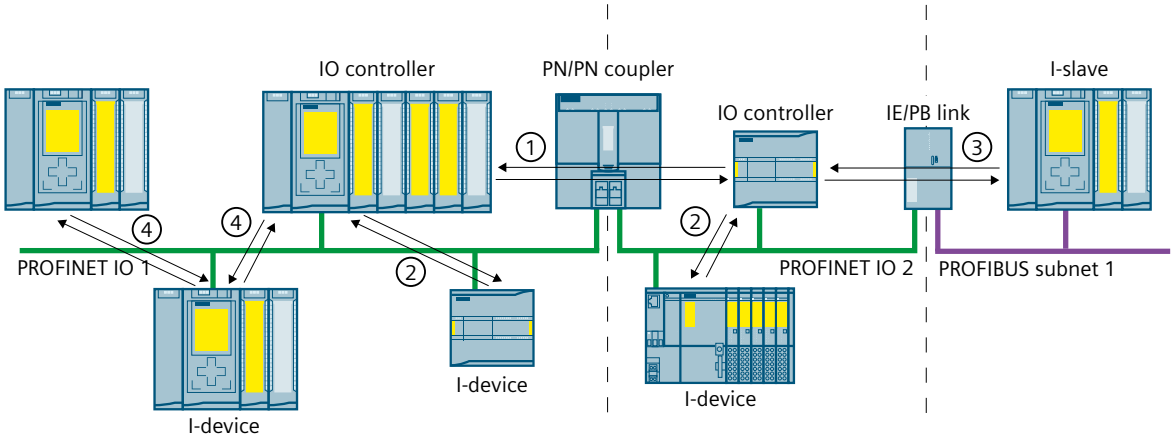
The figure below provides an overview of the options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.



① Safety-related master-master communication
② Safety-related master-I-slave communication

Overview of safety-related communication via PROFINET IO

The figure below provides an overview of the options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.



① Safety-related IO controller-IO controller communication
② Safety-related IO controller-I-device communication
③ Safety-related IO controller-I-slave communication
④ Safety-related IO controller-I-device communication (shared I-device)

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of data of the data type BOOL or INT (DINT as alternative) is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. The hardware identifier (HW identifier) defines the transfer areas configured.

Safety-related CPU-CPU communication for *S7 Distributed Safety*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety*.

9.2.2 Safety-related IO controller-IO controller communication

9.2.2.1 Configure safety-related IO controller-IO controller communication

Introduction

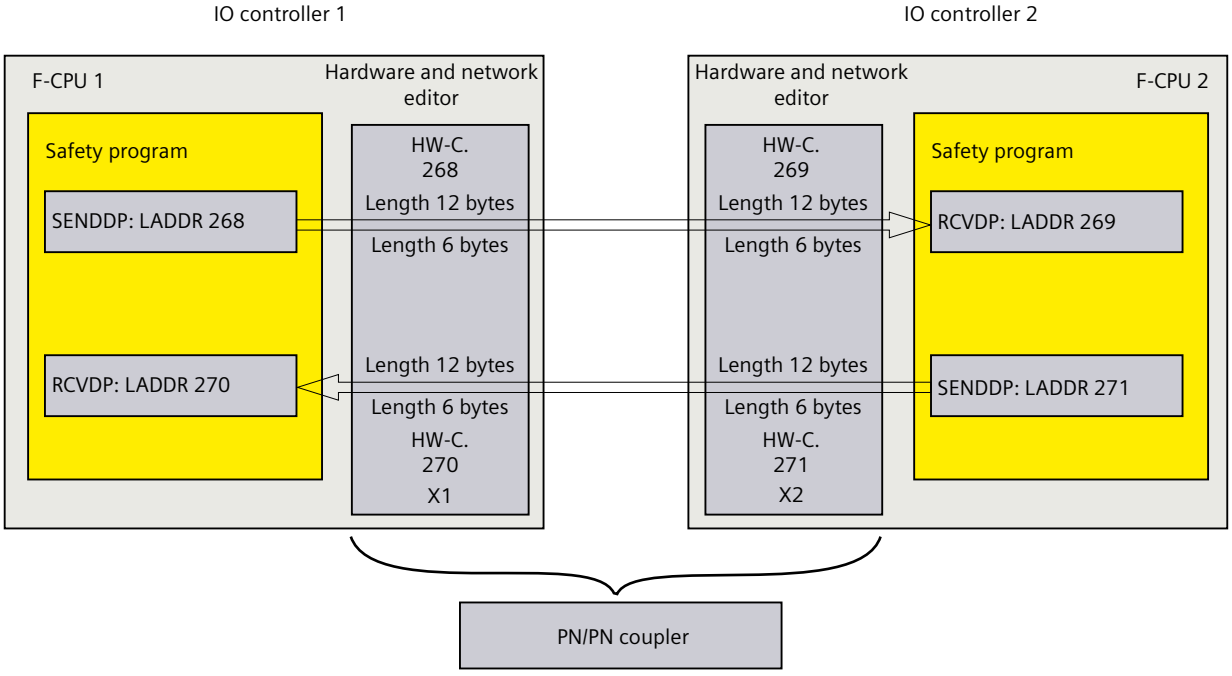
Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

NOTE

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication).



Rules for defining transfer areas

Data to be sent:
A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

Data to be received:
A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

NOTE

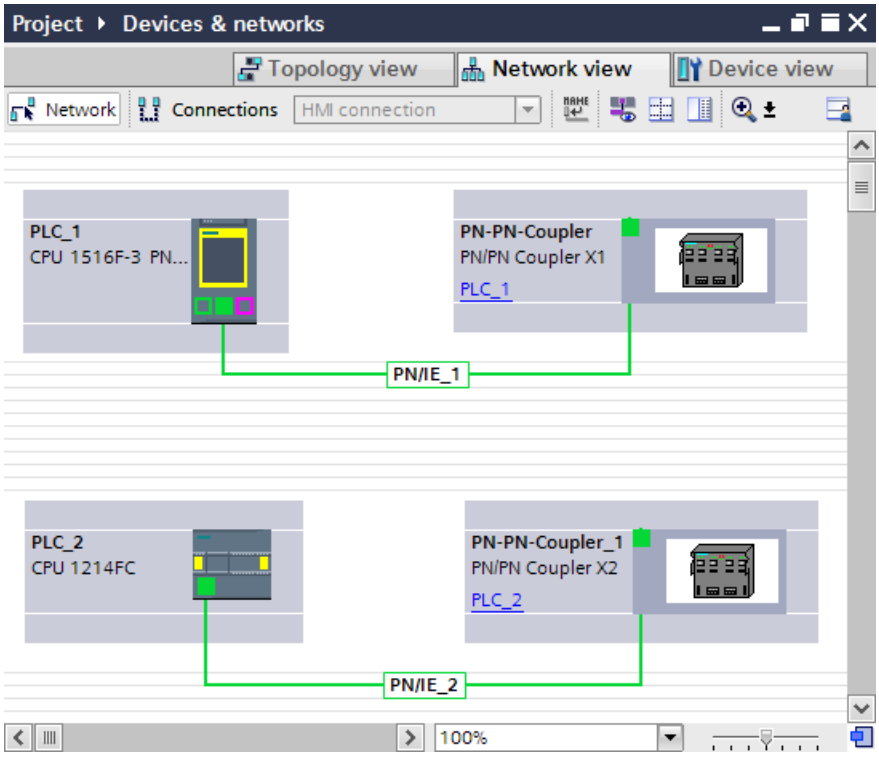
PN/PN Coupler article number 6ES7158-3AD10-0XA0
When configuring the transfer areas for the output and input data, proceed as described in the "SIMATIC bus links PN/PN coupler (https://support.industry.siemens.com/cs/ww/en/view/44319532)" manual, section "Configuring the PN/PN Coupler with STEP 7 TIA Portal".

Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.



5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

NOTE

The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

Device overview

Module	...	Rack	Slot	I address	Q address	Type	Article n...	Firmware
PN-PN-Coupler		0	0	8186*		PN/PN Coupler X1	6ES7 158...	V03.00.00
PN-IO-01		0	0 X1	8185*		PN-PN-Coupler		
IN/OUT 6 Byte / 12 Byte_1		0	1	0...5	0...11	IN/OUT 6 Bytes ...		
IN/OUT 12 Byte / 6 Byte_1		0	2	6...17	12...17	IN/OUT 12 Byte...		

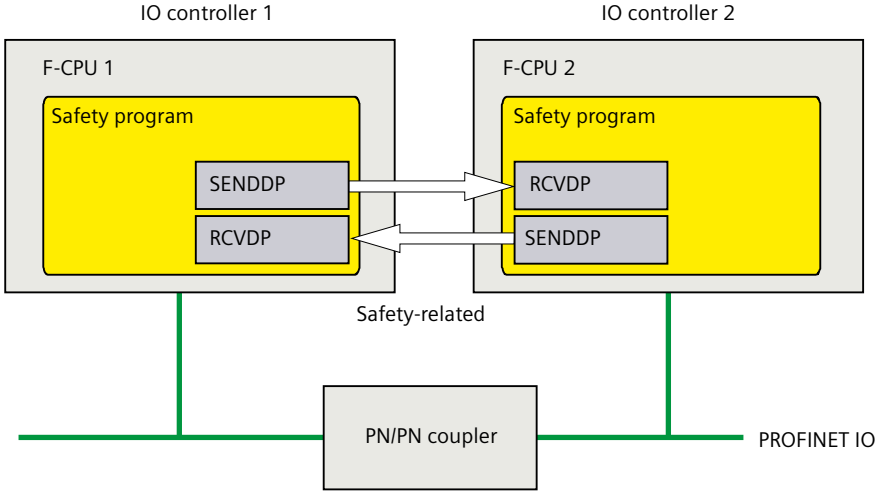
6. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:
   - One "IN/OUT 12 bytes / 6 bytes" module and
   - One "IN/OUT 6 bytes / 12 bytes" module

Device overview

Module	...	Rack	Slot	I address	Q address	Type	Article n...	Firmware
PN-PN-Coupler_1		0	0	8186*		PN/PN Coupler X2	6ES7 158...	V03.00.00
PN-IO-02		0	0 X2	8185*		PN-PN-Coupler		
IN/OUT 12 Byte / 6 Byte_1		0	1	0...11	0...5	IN/OUT 12 Byte...		
IN/OUT 6 Byte / 12 Byte_1		0	2	12...17	6...17	IN/OUT 6 Bytes ...		

9.2.2.2 Program safety-related IO controller-IO controller communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

Programming procedure

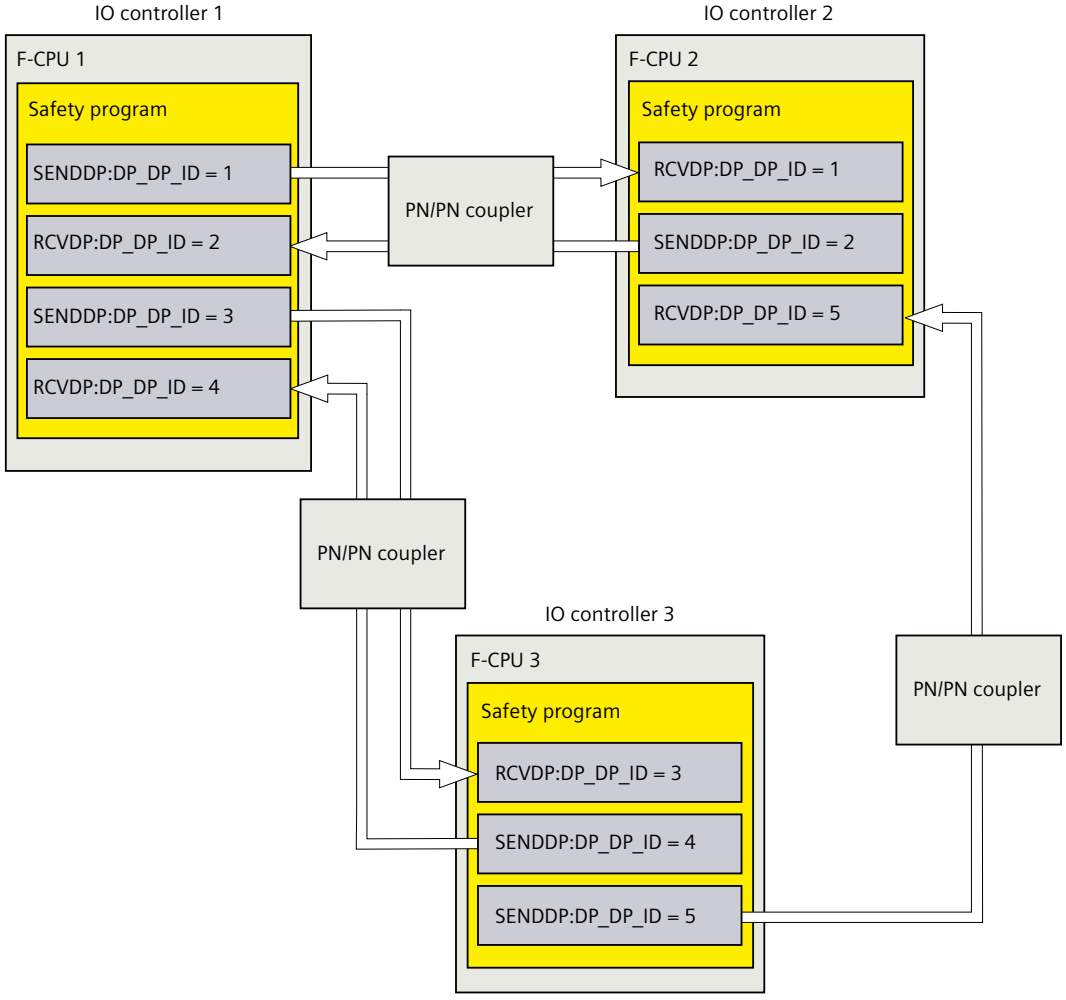
You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 599) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 599) for receiving at the start of the main safety block.
3. Assign the HW identifiers (system constants in the default tag table) of the transfer areas for output and input data of the PN/PN coupler that are configured in the hardware and network editor to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related IO controller-IO controller communication relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via

PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.
8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

⚠ WARNING

Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   ⚠ WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).
10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.
13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 386).

9.2.2.3 Safety-related IO controller-IO controller communication - Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional communication connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.2.3 Safety-related master-master communication

9.2.3.1 Configure safety-related master-master communication

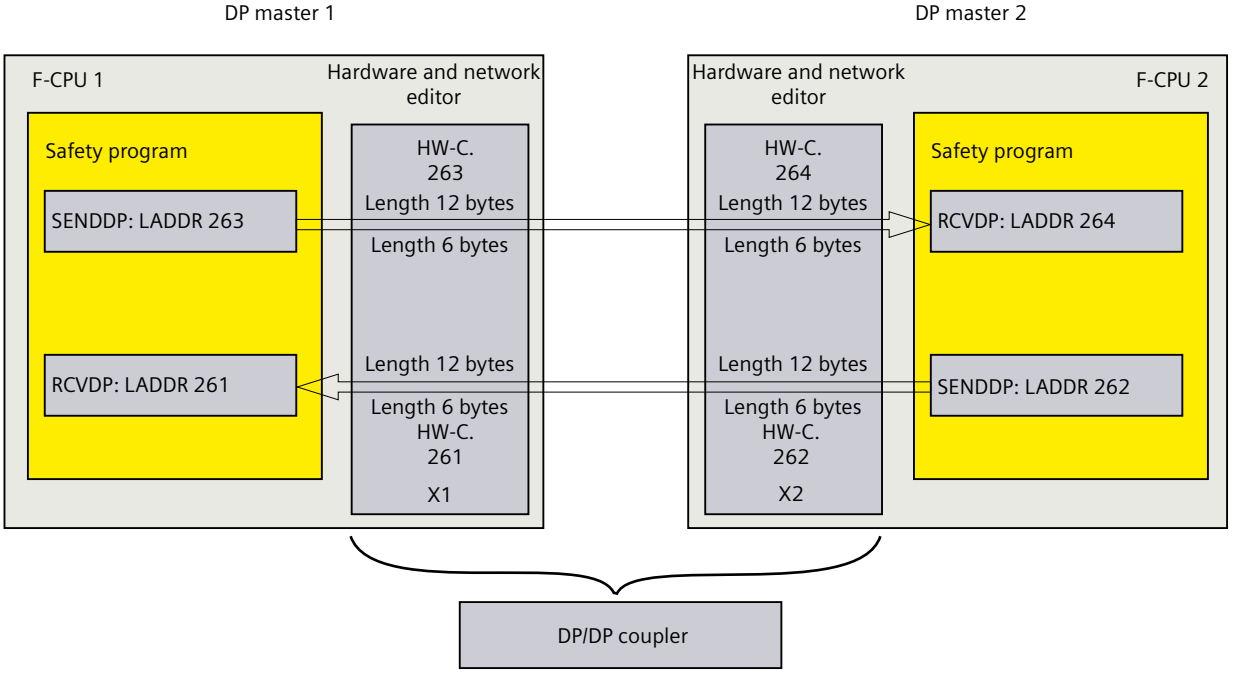
Introduction

Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

NOTE
Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



Rules for defining transfer areas

Data to be sent:
A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

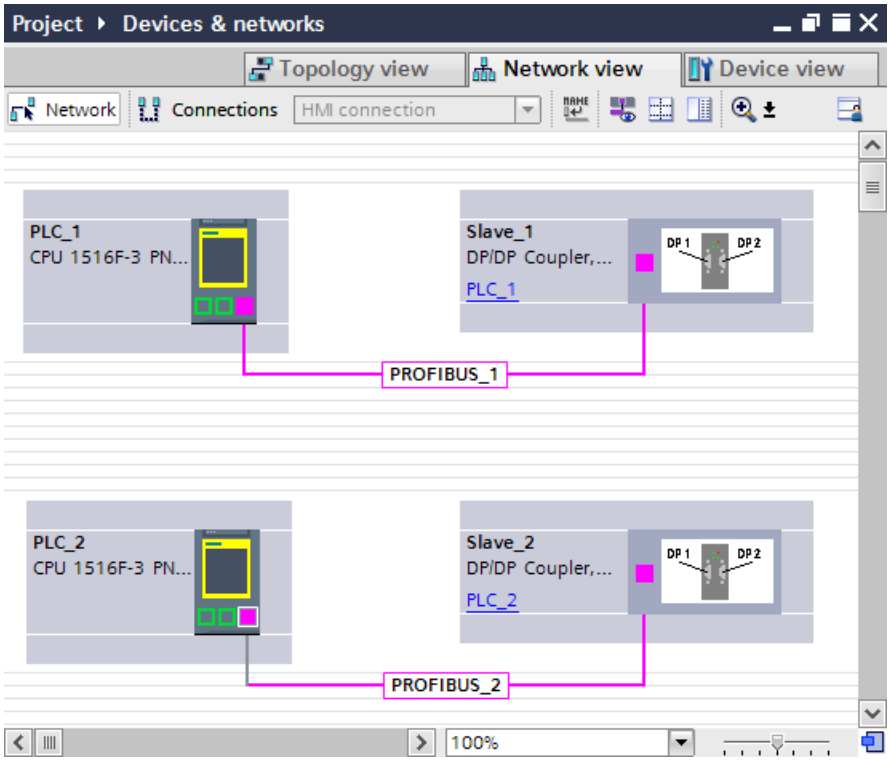
Data to be received:
A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

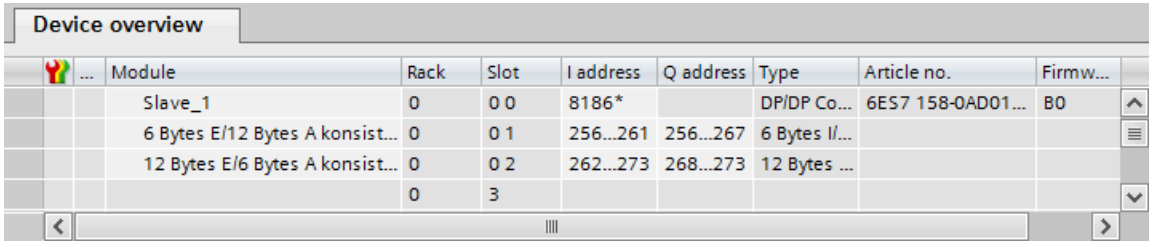
Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.
4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.

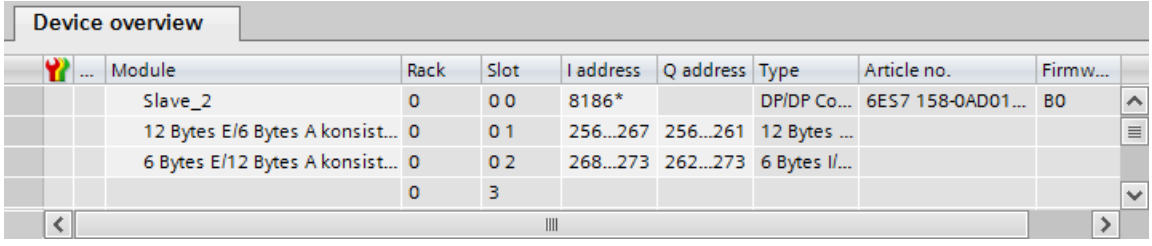


6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler, either via the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (https://support.industry.siemens.com/cs/ww/en/view/1179382) manual).
7. Switch to the device view of the DP/DP coupler PLC1 for bidirectional communication connections i.e. where each F-CPU should both send and receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab of the DP/DP coupler:
   - One "6 bytes I/12 bytes Q consistent" module, and
   - One "12 bytes I/6 bytes Q consistent" module

NOTE
The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

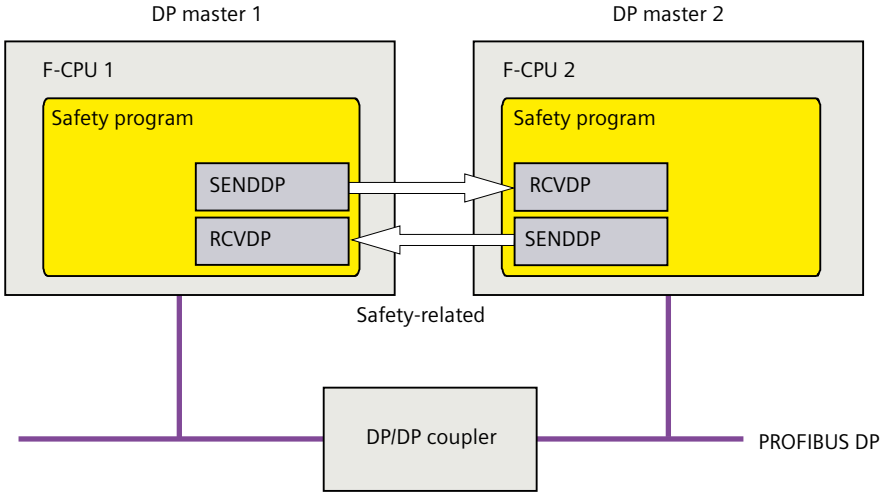


8. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   - One "12 bytes I/6 bytes Q consistent" module, and
   - One "6 bytes I/12 bytes Q consistent" module



9.2.3.2 Program safety-related master-master communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The address areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

You program safety-related master-master communication as follows:

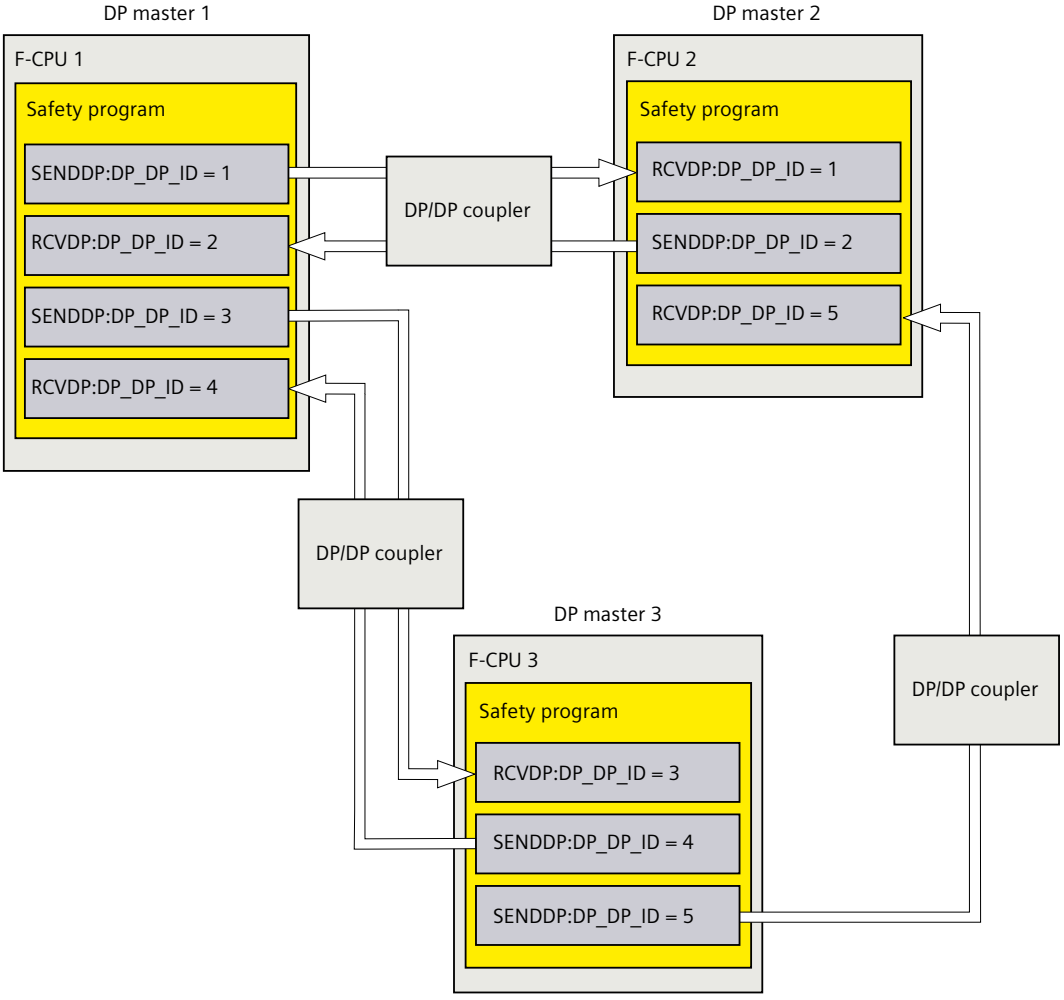
1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 599) for sending at the end of the main safety block or a separate F-FC/F-FB.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 599) for receiving at the start of the main safety block or a separate F-FC/F-FB.

3. Assign the HW identifiers for the output and input data of the DP/DP coupler configured in the *hardware and network editor* (constant in the tag table) to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related master-master communications relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via

PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.
8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

⚠ WARNING

Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.
13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 386).

9.2.3.3 Safety-related master-master communication:Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.2.4 Safety-related IO controller-I-device communication

9.2.4.1 Configuring safety-related communication between IO controller and I-device

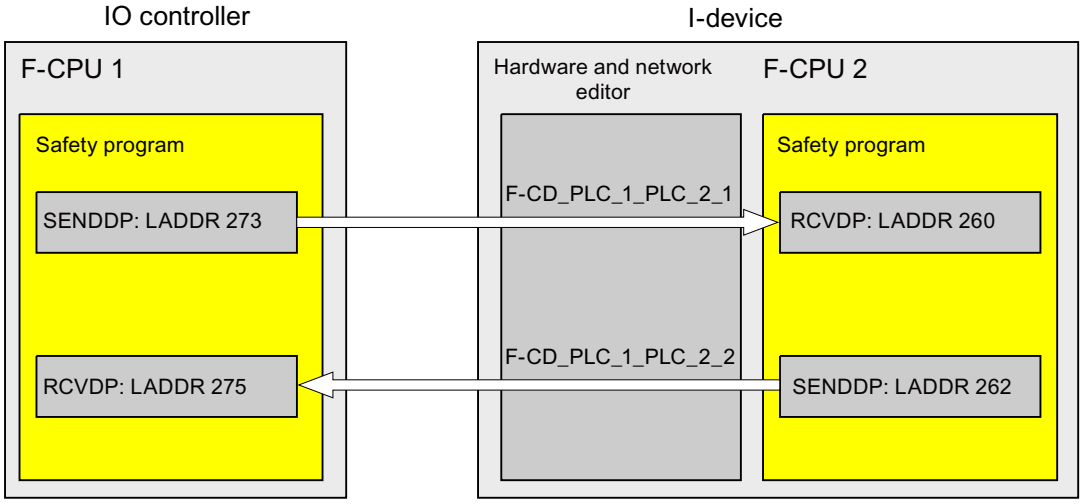
Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (F-CD) in PROFINET IO, as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the IO controller and in the F-CPU of the I-device. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

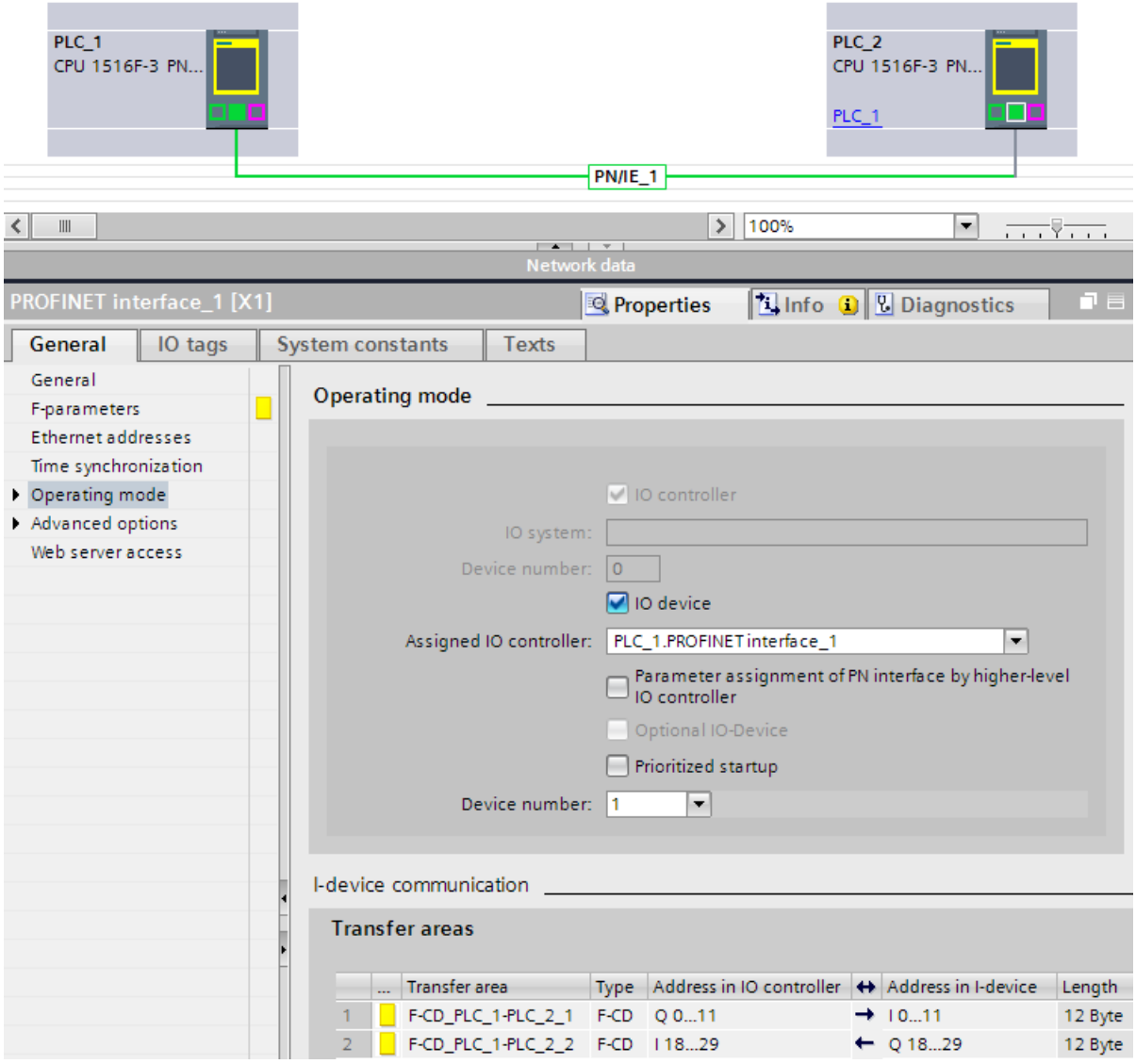
The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for receiving from the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned are displayed.

   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
4. Create an additional F-CD connection for sending to the IO controller.

5. In the transfer area you just created, click on the arrow to change the transfer direction to sending to the IO controller (←).



NOTE

You can assign up to four IO controllers in separate projects to the shared I-device, as in standard systems. To do this, export the I-device as a GSD file and import the GSD file into the projects of the IO controllers. Proceed as described in the *STEP 7 help* under "Configuring an I-device as a shared device".

Configuration procedure for an S7-1500 F-CPU as of firmware V3.1 or S7-1200 G2 F-CPU as I-device

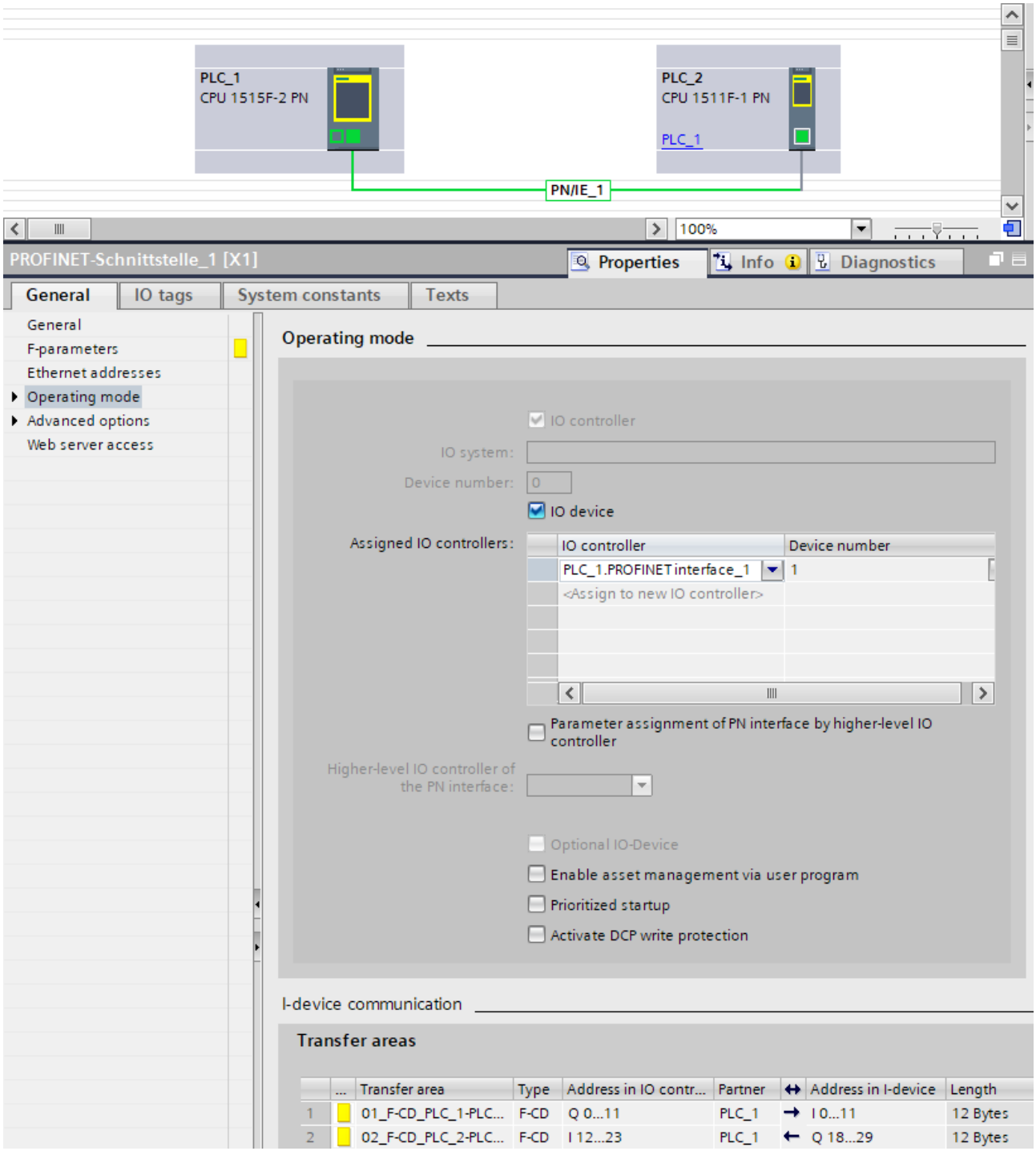
The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. From the "Hardware catalog" task card, insert any S7-1200/1500 F-CPU into the project as F-CPU 1.
2. From the "Hardware catalog" task card, insert an S7-1200 G2/S7-1500 F-CPU as of firmware V3.1 into the project as F-CPU 2 (I-device).
3. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
4. Assign F-CPU 1 as an IO controller under "Assigned IO controllers".
5. Under "Transfer areas", you create an F-CD connection (type "F-CD") for receiving from the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned are displayed.

   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
6. Create an additional F-CD connection for sending to the IO controller.

7. In the transfer area you just created, click on the arrow to change the transfer direction to sending to the IO controller (←).



NOTE

Shared I-device

If you use S7-1500 F-CPUs as of firmware V3.1 or S7-1200 G2 F-CPUs as IO controller, you can divide different transfer areas of an I-device (S7-1500 F-CPU as of firmware V3.1 or S7-1200 G2 F-CPU) between two IO controllers within the project. As of *STEP 7 Safety V20*, you can divide between four IO controllers within the project, if the I-device is an S7-1500 F-CPU with firmware V3.1 or higher.

To do this, assign the I-device to a second IO controller under "Assigned IO controllers". Select the desired IO controller (partner) for each transfer area.

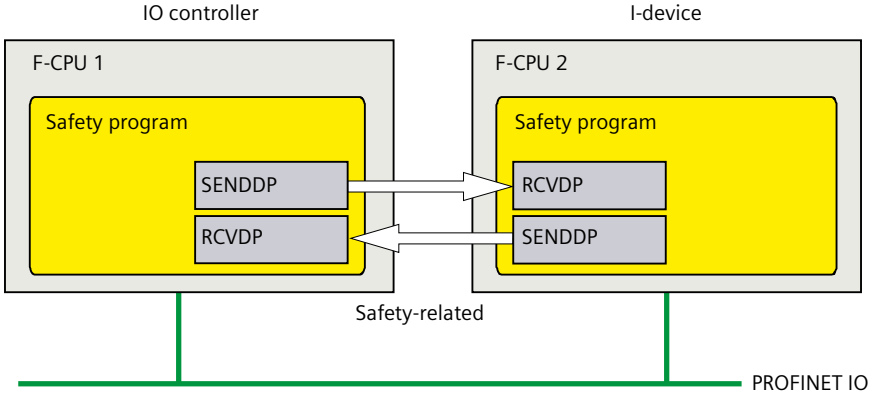
More information can be found in the *STEP 7 help*.

NOTE

You have the option to assign up to four additional IO controllers to the shared I-device, like in the standard. To do this, export the I-device as a GSD file and import the GSD file into the projects of the IO controllers. Proceed as described in the *STEP 7 help* under "Configuring an I-device as a shared device".

9.2.4.2 Programming safety-related IO controller I-device communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirement for programming

The transfer areas must be configured.

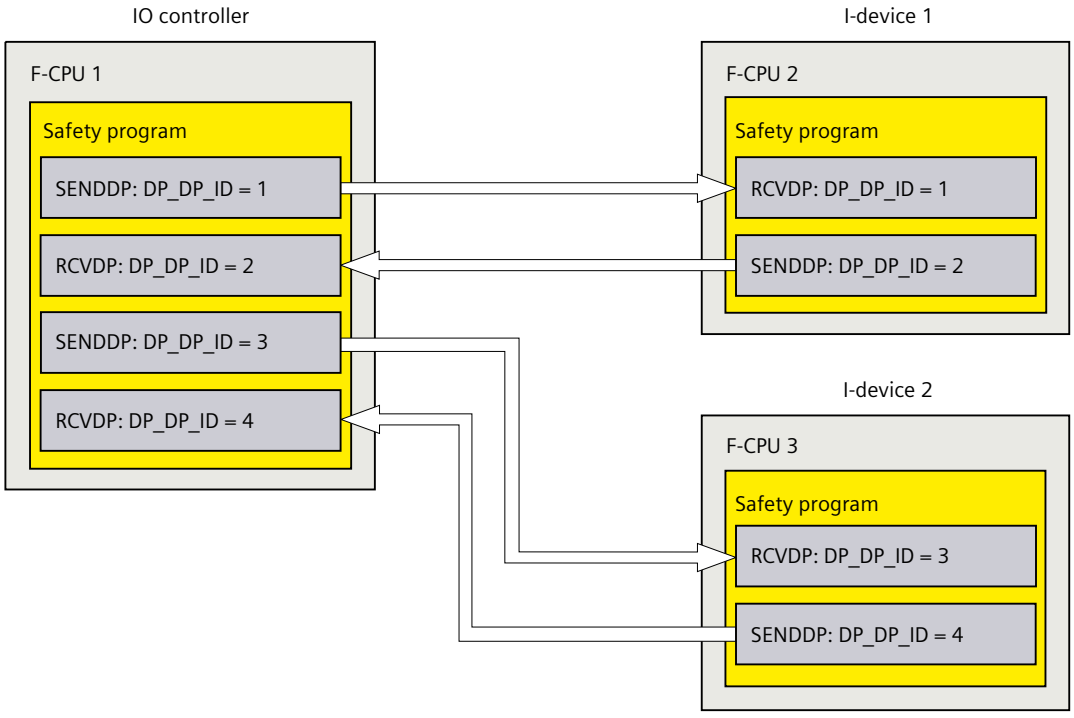
Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 246)).

The assignment of the HW identifiers (system constants in the standard tag table) of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table:

Instruction	HW identifier
SENDDP in the IO controller	Hardware identifier of the transfer area in the IO controller
RCVDP in the IO controller	Hardware identifier of the transfer area in the IO controller
SENDDP in the I-device	Hardware identifier of the transfer area in the I-device
RCVDP in the I-device	Hardware identifier of the transfer area in the I-device

The figure below contains an example of how to specify the F-communication IDs for the inputs of the SENDDP and RCVDP instructions for 4 safety-related IO controller-I-device communication relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time.*(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

9.2.4.3 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

You can find more information on the transfer areas in the *STEP 7 help* under "Rules for creating transfer areas".

9.2.5 Safety-related master-I-slave communication

9.2.5.1 Configuring safety-related master-I-slave communication

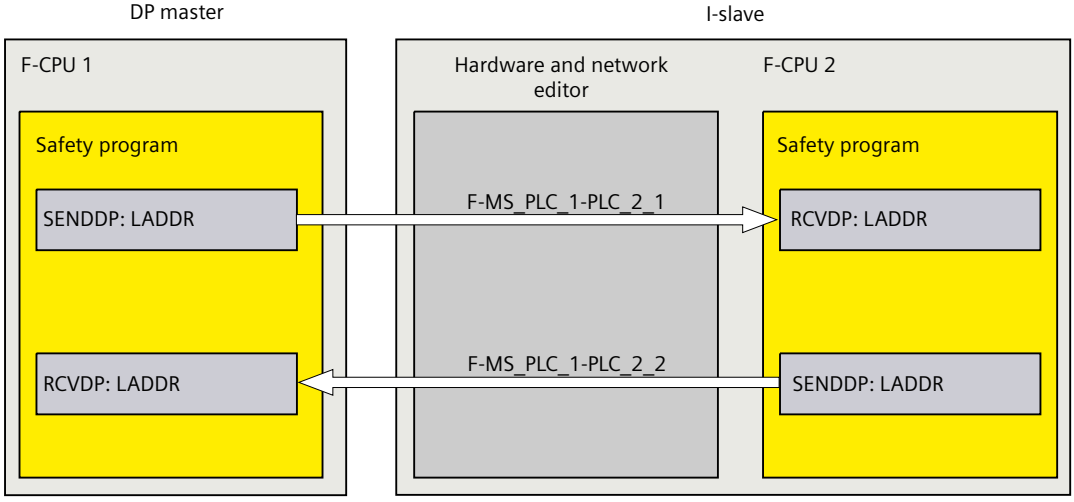
Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).



The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the DP master and in the F-CPU of the I-slave. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

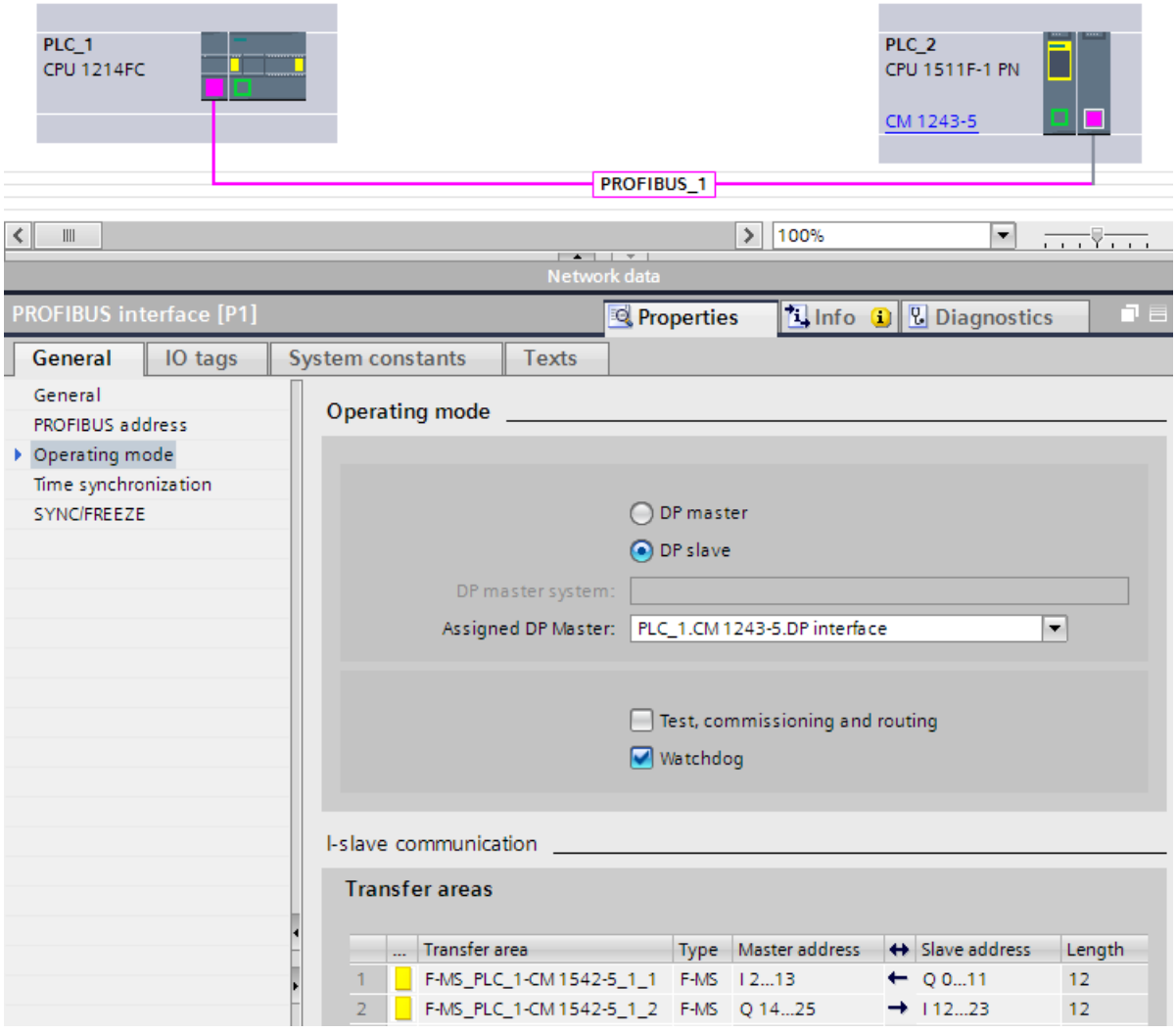
The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. If the F-CPU which is to be operated as DP master (F-CPU 1) does not have an integrated PROFIBUS DP interface, insert an PROFIBUS-CM, for example.
3. From the device view of the F-CPUs which are to be operated as I-slaves (F-CPU 2), insert a suitable CM DP module or CP DP module.
4. If necessary, enable "DP-slave" (I-slave) mode in the properties for the CM/CP DP module.
5. Assign the DP interface of the CM/CP to a DP interface of F-CPU 1.
6. Select the PROFIBUS interface of F-CPU 2 or of the CM. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the assigned transfer areas in the I-slave and DP master are displayed.

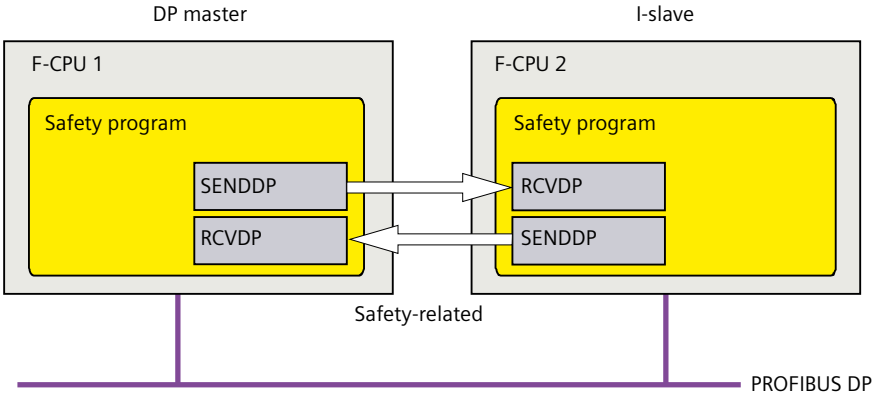
   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").
7. Create an additional F-MS connection for receiving from the DP master.

8. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).



9.2.5.2 Programming safety-related master-I-slave communication

Communication via SENDDP and RCVDP instructions



Safety-related communication between the F-CPUs of the DP master and an I-slave makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 599).

Requirements

The transfer areas must be configured.

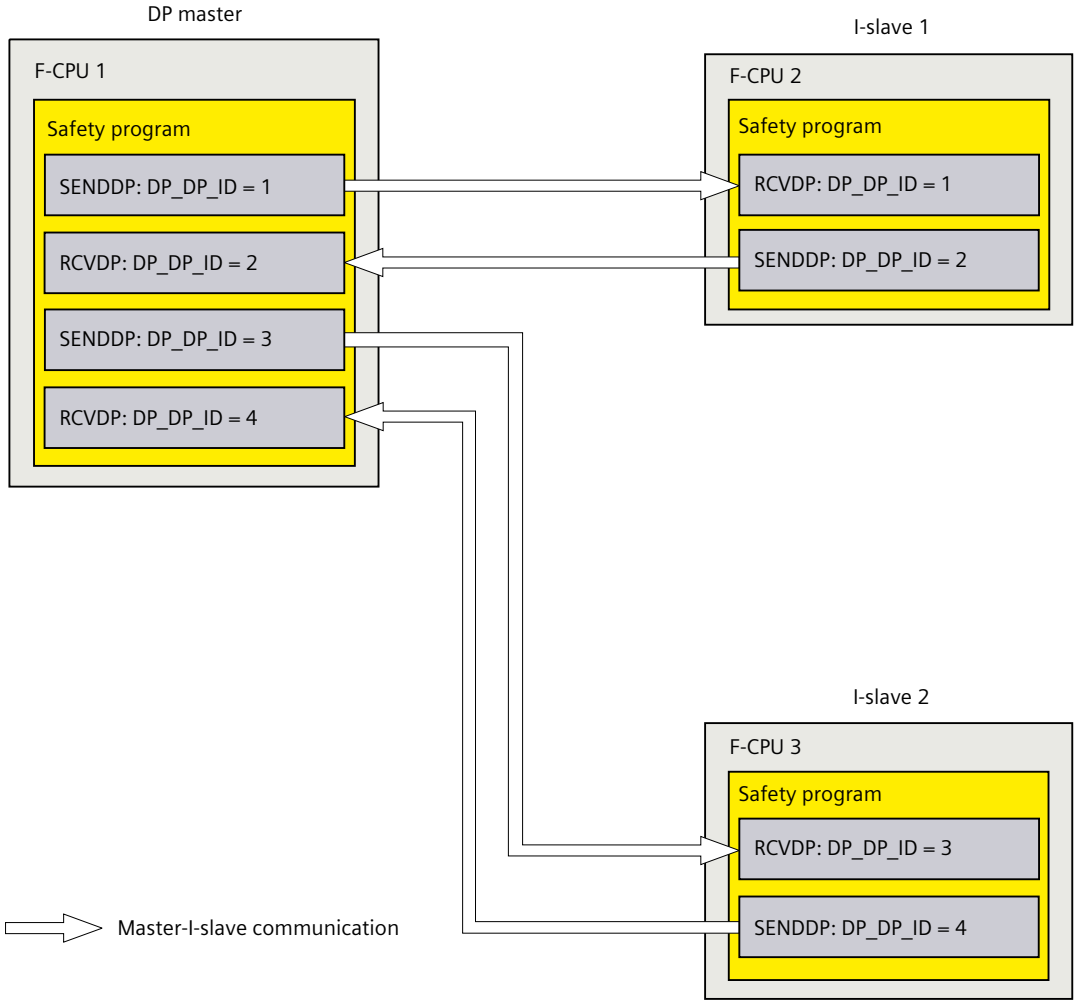
Programming procedure

The procedure for programming safety-related master-I-slave communication is the same as that for programming safety-related master-master communication (see Safety-related master-master communication (Page 251)).

The assignment of the HW identifiers of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	HW identifier
SENDDP in the DP master	Hardware identifier of the respective transfer area in the DP master
RCVDP in the DP master	Hardware identifier of the respective transfer area in the DP master
SENDDP in the I-slave	Hardware identifier of the transfer area in the I-slave
RCVDP in the I-slave	Hardware identifier of the transfer area in the I-slave

The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for four safety-related master-I-slave communication relationships.



WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 615).

9.2.5.3 Limits for data transfer of safety-related master-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		DP master		I-slave	
		Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS and MS). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.2.6 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

NOTE

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 615)).
Note that the Excel file for calculating response times (https://support.industry.siemens.com/cs/ww/en/view/109783831) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 267) also applies.

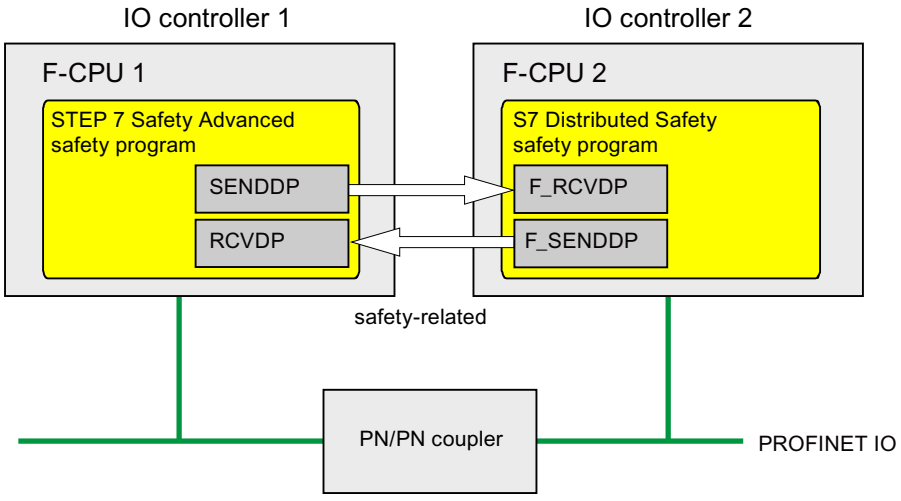
9.2.7 Safety-related communication to S7 F-System S7 Distributed Safety

Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible, via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs, as IO controller-IO controller communication or master-master communication.

9.2.7.1 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

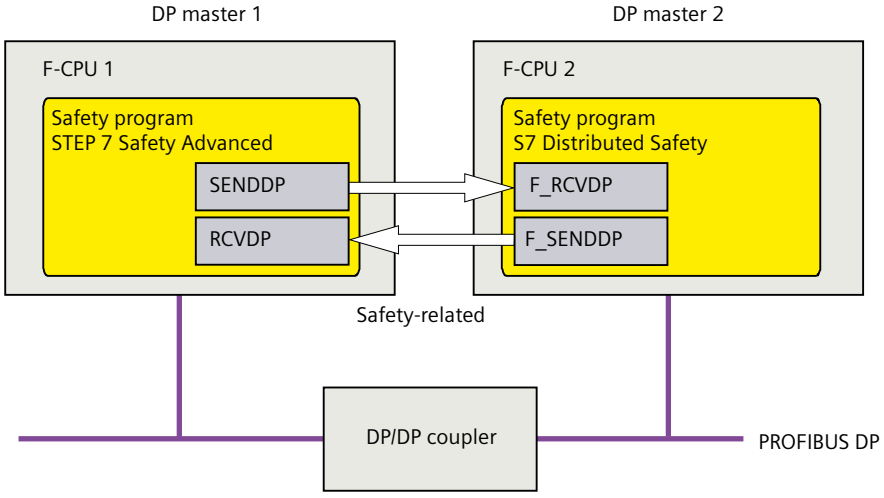
At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related IO controller-IO controller communication (Page 243).

9.2.7.2 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:



Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in the section "Safety-related master-master communication" of the "S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)" manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related master-master communication (Page 251).

9.3 Communication via SENDDP/RCVDP instructions between S7-300/400 and S7-1200/1500 F-CPUs

Introduction

This section provides an overview of the options for safety-related communication using SENDDP/RCVDP instructions between S7-300/400 F-CPUs and S7-1200/1500 F-CPUs in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

Safety-related communication	On subnet	Additional hardware required	Required instructions
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP

Basic procedure for configuring and programming

Configure and program safety-related communication between S7-300/400 F-CPUs and S7-1200/1500 F-CPUs as described in Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 196) and Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 241) for your application.

To program an S7-300/400 F-CPU, use the start addresses of the transfer areas. To program an S7-1200/1500 F-CPU, use the HW identifiers of the transfer areas.

9.4 Communication via SENDDP/RCVDP instructions: IO controller and I-device in different projects

9.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (F-CD) in PROFINET IO, as in standard systems.

The following section describes particular aspects when the IO Controller and the I-device are located in different projects.

Requirement

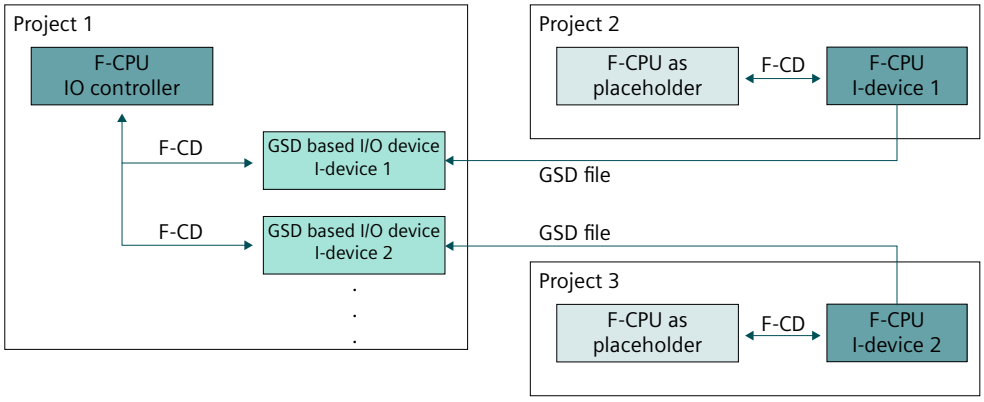
- The IO Controller is an S7-1200/1500 F-CPU that supports the IO Controller functionality.
- The I-device is an S7-300/400/1200/1500 F-CPU that supports the I-device functionality.
- The project in which the I-device is located, must have been created with *S7 Distributed Safety V5.4*, *STEP 7 Safety V13* or later.

Configuring

1. Configure the safety-related communication in the project with the I-device as described under "Configuring safety-related communication between IO controller and I-device (Page 214)" (S7-300, S7-400) or "Configuring safety-related communication between IO controller and I-device (Page 258)" (S7-1200, S7-1500) respectively. In this case the F-CPU 1 (IO Controller) is only a placeholder for the F-CPU in the project of the IO Controller.

   NOTE
   When creating with *STEP 7 Safety* < V14 SP1 avoid a subsequent change from the transfer areas from CD to F-CD.
   When creating with *S7 Distributed Safety V5.4* create the application transfer areas of the address type "Output" and "Input" directly after each other.

2. Export the I-device as a GSD file. Proceed as described in the *STEP 7* help under "Configuring an I-device".
3. Import the GSD file in the project with the IO Controller. Proceed as described in the *STEP 7* help under "Installing a GSD file".
4. Insert the I-device from the "Hardware catalog" task card into the project with the IO Controller.
5. Assign the F-CPU of the IO Controller to the I-device.



9.4.2 Programming safety-related IO Controller I-device communication

Programming procedure

To program the safety-related communication between the IO controller and I-device for an F-CPU S7-300/400, analogously follow the procedure described under "Programming safety-related IO controller I-device communication (Page 217)". To program an S7-300/400 F-CPU, use the start addresses of the transfer areas.

To program the safety-related communication between the IO controller and I-device for an F-CPU S7-1200/1500, analogously follow the procedure described under "Programming safety-related IO controller I-device communication (Page 263)". To program an S7-1200/1500 F-CPU, use the HW identifiers of the transfer areas.

9.5 Communication with OPC UA Safety (S7-1500)

With OPC UA Safety, you can exchange a defined data structure between an F-CPU S7-1500 and another F-CPU S7-1500 F-CPU or a device of a third-party manufacturer in a safety-related manner that supports OPC UA Safety. Optionally, you can also transfer non-safety-related data.

OPC UA Safety enables the configuration of static and dynamic connections. In the case of static connections, the communication relationship is already specified in the TIA Portal. In the case of dynamic connections, the communication relationship is only specified during runtime.

OPC UA Safety is specified by the OPC Foundation in OPC UA Specification OPC 10000-15 and is based on the mechanisms of OPC UA. SIMATIC Safety supports OPC UA client/server communication. More information can be found in the *STEP 7* help under "OPC UA communication".

For OPC UA Safety, the OPC Foundation provides a basic information model with the data types and methods needed for OPC UA Safety via a nodeset.

Based on this nodeset, you create the information model for your individual data structure as a nodeset as well.

OPC UA Safety designates a server interface that makes the safety-related data available as a SafetyProvider, and a corresponding client interface that reads the safety-oriented data from a SafetyProvider as a SafetyConsumer.

For a bidirectional communication connection, each communication partner must implement a SafetyProvider and a SafetyConsumer.

OPC UA Safety communication requires special parameter assignments, which you make using the Safety Parameter Interface (SPI). For communication with your Safety program or standard user program, the Safety Application Program Interface (SAPI) is available.

The following sections describe the Safety Parameter Interface (SPI) and the Safety Application Program Interface (SAPI) and the configuration and programming actions needed for an S7-1500 F-CPU for OPC UA Safety communication. All descriptions as well as the implementation of OPC UA Safety in the SIMATIC Safety F-system are based on the Version 1.05.04 of the OPC UA specification OPC 10000-15. For information on the procedure for devices of a third-party manufacturer, refer to the documentation of the device manufacturer.

NOTE

During simulation with *S7-PLCSIM*, the time monitoring that generates an error message after expiration when communication with real communication partners is interrupted (e.g. by setting a CPU to STOP) is not activated. This is why no error message is displayed in this case.

NOTE

The OPC UA Specification OPC 10000-15 specifies for the transfer of values of the BOOL data type that these be transferred in Byte format.

- "TRUE" is transferred as "0x01"
- "FALSE" is transferred as "0x00"

Since OPC UA Safety does not provide qualifier bits, they must be modeled, transferred and evaluated as part of the safety-related user data if necessary. The OPC UA Specification OPC 10000-15 prescribes the following semantics:

- "TRUE" or "0x01" corresponds to the "valid value" state
- "FALSE" or "0x00" corresponds to the "invalid value" state

Restrictions

The following *STEP 7 Safety* functions cannot be used together with OPC UA Safety:

- Safety program in RUN mode (S7-1200, S7-1500) (Page 399) (Fast Commissioning)
- Safety program in Software Unit (Safety Unit) (S7-1500) (Page 113)
- Consistent upload from the F-CPU (Page 89)

9.5.1 Configuration and programming interfaces

Introduction

A Safety Parameter Interface (SPI) and Safety Application Program Interface (SAPI) is available for each SafetyConsumer or SafetyProvider.

You must make special parameter assignments, which are required for the safety-related data transfer, in the SPI for each OPC UA Safety communication. To facilitate this, values are automatically assigned to the parameters whenever possible.

The SAPI forms the interface to your Safety program (or standard user program).

9.5.1.1 Safety Parameter Interface (SPI) of the SafetyProvider

The SPI of a SafetyProvider is shown in the properties of the SafetyProvider in the editor for server interfaces either during the creation of the information model with the special OPC UA modeling tool SiOME (Page 302) or later after import of the information model into TIA Portal (Page 307).

The following table shows the parameters of the SPI of a SafetyProvider.

Parameter	Data type	Changeable in TIA Portal	Description
SafetyProviderIDConfigured	UDINT	x	ID for authentication of a SafetyProvider
SafetyBaseIDConfigured	GUID	x	ID for authentication of a SafetyProvider
SafetyProviderLevel	BYTE	-	Safety Integrity Level (SIL) that can be achieved with the specific implementation of the SafetyProvider
SafetyStructureSignature	UDINT	-	Signature via the data structure of the OPC UA data type of the fail-safe data to be transferred
SafetyStructureSignatureVersion	UINT	-	Version of the algorithm for forming the SafetyStructureSignature

Parameter	Data type	Changeable in TIA Portal	Description
SafetyStructureIdentifier	STRING	-	Identifier of the OPC UA data types of the fail-safe data to be transferred (max. length 128 characters)
SafetyProviderDelay	UDINT	-	Maximum time in µs between the request of a SafetyConsumer and the response of a Safety-Provider
SafetyServerImplemented	BOOL	-	1=SafetyProvider supports OPC UA Client/Server communication
SafetyPubSubImplemented	BOOL	-	1=SafetyProvider supports OPC UA PubSub communication

The values of the SPI parameters of a SafetyProvider are always assigned automatically during import of the information model (Page 302) if a value has not yet been entered for a parameter in the information model. Previously entered values are applied if permissible. If there are impermissible values, an error message is output.

SafetyProviderIDConfigured/SafetyBaseIDConfigured

The SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are used to uniquely and safely authenticate a SafetyProvider. For applications with changing communication partners (Page 327) or series machines (Page 326), you can overwrite the values of these SPI parameters using the SAPI parameters SafetyProviderID and SafetyBaseID (Page 284). The value that is actually in effect during runtime of the Safety program is referred to in this document as the "active SafetyBaseID" or "active SafetyProviderID".
Different combinations are conceivable with regard to the unique authentication:

- The active SafetyBaseID is identical for all SafetyProviders within a certain area of the system. The unique authentication within this plant area must take place through different active SafetyProviderIDs.
- The active SafetyProviderID is identical for all SafetyProviders. The unique authentication must then take place solely through different active SafetyBaseIDs.
- Neither the active SafetyProviderIDs nor the active SafetyBase IDs of all SafetyProviders within a specific area are identical. The unique authentication only takes place through different combinations of active SafetyProviderIDs and active SafetyBaseIDs.

In the case of automatic assignment, the following values are entered. The uniqueness is achieved solely using the SafetyBaseIDConfigured:

- **SafetyProviderIDConfigured:** If no local data mapping is available for the SAPI parameter SafetyProviderID, the value "1" is assigned. Otherwise, the value "0" is assigned.
- **SafetyBaseIDConfigured:** If no local data mapping is available for the SAPI parameter SafetyBaseID, a randomly generated value is assigned that fulfills the safety requirements of OPC UA Specification OPC 10000-15. Otherwise, the value "0" is assigned.

⚠ WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **
If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***
You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 325)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

⚠ WARNING

If you have not defined any value for the SPI parameter of a SafetyProvider in the NodeSet for the SPI parameter, a sufficiently clear UUIDV4 is made available from the system as a value for the parameter of the respective SafetyProvider when importing the NodeSet into the TIA Portal.
Through subsequent copying of a SafetyProvider (e.g. copying the NodeSet to another F-CPU, copying the F-CPU or copying the project), values provided by the system are not generated again and are therefore not unique anymore.
If such a copy is used to configure a new communication relationship, you yourself need to ensure the uniqueness. To do this, open the properties tab of all affected SafetyProvider and generate the value of SafetyBaseIDConfigured again by clicking on the "Generate" button.
The uniqueness must be checked in the safety summary during acceptance. *(S110)*

SafetyProviderLevel

The SafetyProviderLevel SPI parameter is used to publicize the Safety Integrity Level (SIL) that can be achieved by a specific SafetyProvider implementation.

With automatic assignment, the value "3" is entered. This corresponds to the maximum SIL achievable with SIMATIC Safety and is the only permissible value.

SafetyStructureSignature

The SafetyStructureSignature SPI parameter is used to protect and identify the data structure at the SafetyData of the OPC UA data type of the SAPI parameters via a signature.

With automatic assignment, the value is calculated according to the algorithm prescribed in OPC UA Specification OPC 10000-15.

SafetyStructureSignatureVersion

The SafetyStructureSignatureVersion SPI parameter is used to specify the version of the algorithm used to calculate the SafetyStructureSignature.

With automatic assignment, the value "1" is entered. This corresponds to the only permissible value at the present time.

SafetyStructureIdentifier

With the SPI parameter SafetyStructureIdentifier the identifier of the OPC UA data types of the SAPI parameter SafetyData is publicized. The SafetyStructureIdentifier is included in the calculation of the SafetyStructureSignature.

With automatic assignment, the name of the OPC UA data type that describes the data structure at the SafetyData SAPI parameter is entered.

SafetyProviderDelay

The SafetyProviderDelay SPI parameter is used to publicize the maximum time (in µs) that can elapse between the reception of the request of a SafetyConsumer and the sending of the response of a SafetyProvider under worst-case conditions. For more details, refer to OPC UA Specification OPC 10000-15.

In the case of automatic assignment, the value "0" is entered at the present time.

SafetyServerImplemented

The SafetyServerImplemented SPI parameter is used to publicize whether the SafetyProvider supports OPC UA Client/Server communication mechanisms.

In the case of automatic assignment, the value "TRUE" is entered. This corresponds to the only permissible value since SIMATIC Safety supports only OPC UA client/server communication.

SafetyPubSubImplemented

The SafetyPubSubImplemented SPI parameter is used to publicize whether the SafetyProvider supports OPC UA PubSub communication mechanisms.

With automatic assignment, the value "FALSE" is entered. This corresponds to the only permissible value since SIMATIC Safety does not support OPC UA PubSub communication.

9.5.1.2 Safety Application Program Interface (SAPI) of the SafetyProvider

The SAPI of a SafetyProvider is shown in the properties of the SafetyProvider in the editor for server interfaces either when the information model is created in SiOME (Page 302) or after the information model is imported into TIA Portal (Page 307). These properties are stored in the internal F-OPC-UA-Provider-DB. The name is shown in the SAPI interface and listed in the safety summary.

The following table shows the parameters of the SAPI of a SafetyProvider.

SAPI parameters	Data type of the mapped local data element	Mapping to a local data element of the Safety program	Mapping to a local data element of the standard user program	Description
SafetyData	UDT	x	-	Data that is made available to a SafetyConsumer in a safety-related manner
NonSafetyData	UDT	-	x	Data that is made available to a SafetyConsumer in a non-safety-related manner
InputSignals	UDT			Summary of the following SAPI parameters
OperatorAck-Provider	BOOL	x	-	1=User acknowledgment at SafetyProvider end
ActivateFSV	BOOL	x	-	1=SafetyConsumer to output substitute values
EnableTest-Mode	BOOL	x	-	1=Current values at the SafetyData SAPI parameter are test data
OutputSignals	UDT			Summary of the following SAPI parameters
OperatorAck-Requested	BOOL	-	x	1=Acknowledgment request at the SafetyConsumer side is pending
Monitoring-Number	UDINT	-	x	Current MonitoringNumber
SafetyCon-sumerID	UDINT	-	x	ID for authentication of the connected SafetyConsumer
SafetyProviderID	UDINT	x	-	ID for authentication of a SafetyProvider
SafetyBaseID	GUID	-	x	ID for authentication of a SafetyProvider

To establish a connection of your Safety program (or standard user program) to a SafetyProvider, you must map all required SAPI parameters to a local data element of your Safety program (or standard user program) in SiOME (Page 302) ("Local data mapping").

SafetyData

The SAPI parameter SafetyData is used to transfer the data of your Safety program that you want to make available to a connected SafetyConsumer in a safety-related manner. The data structure of this data must be described in an F-compliant PLC data type (UDT) which agrees with the data structure of the OPC UA data type of SafetyData. This F-compliant PLC data type (UDT) may only contain the BOOL, INT and DINT data types.

⚠ WARNING

During communication with OPC UA Safety, it is only ensured that a signal state to be transferred is acquired and transferred to the receiver if it is pending for at least twice as long as the assigned monitoring time (SafetyConsumerTimeout). *(S109)*

⚠ WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.
To identify the communication connection, note the following points:

- For static connections:
  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:
  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

NonSafetyData

The SAPI parameter NonSafetyData is used to transfer the data of your standard user program that you want to make available to a connected SafetyConsumer in a non-safety-related manner synchronously with the SafetyData. The data structure of this data must be written in a PLC data type (UDT) which agrees with the data structure of the OPC UA data type of NonSafetyData.

This PLC data type (UDT) can only contain the data types BOOL, SINT, INT, UINT, DINT, UDINT, LINT, ULINT, REAL, LREAL, WSTING, LDT and nested PLC data types (UDTs).

InputSignals

The SAPI parameter InputSignals is used to summarize the SAPI parameters OperatorAckProvider, ActivateFSV and EnableTestMode. These SAPI parameters enable you to trigger certain actions on the connected SafetyConsumer or communicate certain status information about the SafetyData to the SafetyConsumer.

An F-compliant PLC data type (UDT) that contains all the InputSignals listed in the above table is needed to use these SAPI parameters:

- **OperatorAckProvider**
  With the OperatorAckProvider SAPI parameter, you also have the option of performing user acknowledgment on the SafetyProvider side and informing the Safety program on the SafetyConsumer side (see also SAPI parameters OperatorAckConsumer and OperatorAckProvider (Page 293) of the SafetyConsumer).

  ⚠ WARNING

  A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

- **ActivateFSV**
  With the ActivateFSV SAPI parameter, you can instruct a connected SafetyConsumer to output the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) instead of the current values at the SafetyData SAPI parameter. In order for the current values to be output at the SAPI parameter SafetyData again after ActivateFSV is reset, a user acknowledgment may be required.
- **EnableTestMode**
  With the SAPI parameter EnableTestMode, you can inform a connected SafetyConsumer that the current values at the SAPI parameter SafetyData are test data and, thus, were not formed in a safety-related manner.

OutputSignals

The SAPI parameter OutputSignals is used to summarize the SAPI parameters OperatorAckRequested, MonitoringNumber and SafetyConsumerID. These SAPI parameters allow you to evaluate certain information of the connected SafetyConsumer.

A PLC data type (UDT) that contains all the OutputSignals listed in the above table is needed to use these SAPI parameters:

- **OperatorAckRequested**
  You can use the OperatorAckRequested SAPI parameter to evaluate whether there is an acknowledgment request on the SafetyConsumer.
- **MonitoringNumber**
  With the SAPI parameter MonitoringNumber, you can evaluate the current MonitoringNumber for diagnostic purposes. More information can be found in the OPC UA Specification OPC 10000-15.
- **SafetyConsumerID**
  With the SAPI parameter SafetyConsumerID, you can evaluate the SafetyConsumerID of the SafetyConsumer for diagnostic purposes. More information can be found in the OPC UA Specification OPC 10000-15.

SafetyProviderID/SafetyBaseID

With the SAPI parameters SafetyProviderID and SafetyBaseID, you can uniquely and reliably authenticate a SafetyProvider at dynamic connections. For more information, refer to the sections "Series machines (Page 326)" and "Changing communication partners (Page 327)".

SafetyProviderID and/or SafetyBaseID are initialized with values matched to the specific situation in the system during runtime of the Safety program (or standard user program). As long as the relevant value <> 0, the value assigned to the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured is overwritten.

If the active SafetyProviderID or SafetyBaseID is "0", no communication with a SafetyConsumer can take place.

NOTE

The instructions "Random", "Get_IM_Data", "RD_SYS_T" and "SHA2" are available for generating a SafetyBaseID. These instructions enable the safety requirements of OPC UA Specification OPC 10000-15 regarding randomly generated values to be fulfilled.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

⚠ WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **
If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***
You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 325)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

⚠ WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
Note that these program sections are therefore not captured by the Collective F-Signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

9.5.1.3 Safety Parameter Interface (SPI) of the SafetyConsumer

The SPI of a SafetyConsumer is displayed to you after adding a SafetyProvider in the SafetyProvider list of the client interface (Page 315) in the properties of the SafetyConsumer in the editor for client interfaces (Page 319).

The following table shows the parameters of the SPI of a SafetyConsumer.

Parameter	Data type	Changeable in TIA Portal	Description
SafetyProviderIDConfigured	UDINT	x	ID for authentication of the intended SafetyProvider
SafetyBaseIDConfigured	GUID	x	ID for authentication of the intended SafetyProvider

Parameter	Data type	Changeable in TIA Portal	Description
SafetyConsumerIDConfigured	UDINT	x	ID for authentication of a SafetyConsumer
SafetyProviderLevel	BYTE	x	Safety Integrity Level (SIL) expected from the specific implementation of the connected SafetyProvider
SafetyStructureSignature	UDINT	-	Signature via the data structure of the OPC UA data type of the fail-safe data to be transferred
SafetyStructureSignatureVersion	UINT	-	Version of the algorithm for forming the SafetyStructureSignature
SafetyStructureIdentifier	STRING	-	Identifier of the OPC UA data types of the fail-safe data to be transferred (max. length 128 characters)
SafetyConsumerTimeout	UDINT	x	Monitoring time in µs: Maximum permissible time between the request from a SafetyConsumer and the receipt of the response from a SafetyProvider in the SafetyConsumer
SafetyOperatorAckNecessary	BOOL	x	1=Acknowledgment required
SafetyErrorIntervalLimit	INT	x	Minimum time in min. between two communication errors
SafetyClientImplemented	BOOL	-	1=SafetyConsumer supports OPC UA client/server communication mechanism
SafetyPubSubImplemented	BOOL	-	1=SafetyConsumer supports OPC UA PubSub communication mechanism

The values of individual SPI parameters of a SafetyConsumer are automatically assigned when the intended SafetyProvider is added to the SafetyProvider list of the client interface (Page 315) if no value has yet been entered for these parameters in the OPC UA SafetyProvider information model or if the parameters do not exist at the SafetyProvider. Previously entered values are applied if permissible. If necessary, you have to adjust the values in the properties of the SafetyConsumer in the editor for client interfaces (Page 315). An error message is displayed for invalid values.

SafetyProviderIDConfigured/SafetyBaseIDConfigured

The SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are used to uniquely and safely authenticate a SafetyProvider. For applications with changing communication partners (Page 327) or series machines (Page 326), you can overwrite the values of these SPI parameters in the F-OPC-UA-Consumer-DB (Page 297) using the SAPI parameters SafetyProviderID and SafetyBaseID. The value that is actually in effect during runtime of the Safety program is referred to hereinafter as the "active SafetyBaseID" or "active SafetyProviderID".

If the active SafetyProviderID or SafetyBaseID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) to the Safety program instead of the current values at the SafetyData SAPI parameter.

If the correct values are not yet present in the SafetyProvider list of the client interface (Page 315) when adding the intended SafetyProvider, you must enter these in the properties of the SafetyConsumer in the editor for client interfaces (Page 315).

⚠ WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.
When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

SafetyConsumerIDConfigured

The SafetyConsumerIDConfigured SPI parameter can be used to uniquely authenticate a SafetyConsumer, particularly for diagnostic purposes in applications with Safety Multicast (Page 325). For more details, refer to OPC UA Specification OPC 10000-15.

For applications with changing communication partners (Page 327) or series machines (Page 326), you can overwrite the value of this SPI parameter via the SafetyConsumerID (Page 293) SAPI parameter. The value that is actually in effect at runtime of the Safety program is referred to below as the "active SafetyConsumerID".

If the active SafetyConsumerID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) to the Safety program instead of the current values at the SafetyData SAPI parameter.

When the foreseen SafetyProvider is added to the SafetyProvider list of the client interface (Page 315), a randomly generated value is assigned.

SafetyProviderLevel

The SafetyProviderLevel SPI parameter sets an expected value of the safety integrity level (SIL) achievable from the specific implementation of the connected SafetyProvider.

With automatic assignment, the value "3" is entered. This corresponds to the maximum SIL achievable with SIMATIC Safety. You may need to adapt this value to your individual application.

If the value does not match the value of the connected SafetyProvider, a communication error is detected (error code "0x14", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 297)).

SafetyStructureSignature

The SafetyStructureSignature SPI parameter is used to protect the data structure of the OPC UA data type at the SafetyData SAPI parameter via a signature.

With automatic assignment, the value is calculated according to the algorithm prescribed in OPC UA Specification OPC 10000-15.

SafetyStructureSignatureVersion

The SafetyStructureSignatureVersion SPI parameter is used to specify the version of the algorithm used to calculate the SafetyStructureSignature.

With automatic assignment, the value "1" is entered. This corresponds to the only permissible value at the present time.

SafetyStructureIdentifier

With the SPI parameter SafetyStructureIdentifier the identifier of the OPC UA data types of the SAPI parameter SafetyData is publicized. The SafetyStructureIdentifier is included in the calculation of the SafetyStructureSignature.

With automatic assignment, the name of the OPC UA data type that describes the data structure at the SafetyData SAPI parameter is entered.

SafetyConsumerTimeout

The SafetyConsumerTimeout SPI parameter specifies the maximum time (in µs) that may elapse between the request from a SafetyConsumer and the response from the connected SafetyProvider.

If this monitoring time expires before a response from the connected SafetyProvider arrives, a communication error is detected (see DIAG variable in the F-OPC-UA-Consumer-DB (Page 297)) and the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) at the SafetyData SAPI parameter instead of the current values.

With automatic assignment, the value "2500000" (2.5 s) is currently entered as the default value. You must adapt this value to your individual application. More information can be found in the section "Response Times of Safety Functions (Page 621)".

⚠ WARNING

During communication with OPC UA Safety, it is only ensured that a signal state to be transferred is acquired and transferred to the receiver if it is pending for at least twice as long as the assigned monitoring time (SafetyConsumerTimeout). *(S109)*

SafetyOperatorAckNecessary

The SafetyOperatorAckNecessary SPI parameter is used to specify whether a manual user acknowledgment is required before the current values are output again at the SafetyData SAPI parameter instead of the substitute values from the F-OPC-UA-Consumer-DB (Page 297) after the following states have passed:

- Communication error "Timeout" (error code "0x08", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 297)).
- ActivateFSV SPI parameter of the connected SafetyProvider is "1" (error code "0x20", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 297)).

In the case of automatic assignment, the value "TRUE" is entered. You can adapt this value to your individual application if necessary.

SafetyErrorIntervalLimit

The SafetyErrorIntervalLimit SPI parameter specifies the minimum time (in minutes) that must elapse between two consecutive communication errors.

If this time is not reached, the SafetyConsumer outputs the substitute values from the F-OPC-UA-Consumer-DB (Page 297) at the SafetyData SAPI parameter instead of the current values. If this time is maintained, the SafetyConsumer tolerates a communication error by discarding the bad response from the SafetyProvider and waiting for the next error-free response. However, this can lead to a "Timeout" communication error if the monitoring time on the SafetyConsumerTimeout SPI parameter does not allow any reserves for repeats.

The value influences the probability of failure values (Page 439) ($PFD_{avg.}$ and PFH values) that you must take into account for communication with OPC UA Safety.

With automatic assignment, the value "600" is entered. This value achieves the lowest possible probability of failure values.

SafetyClientImplemented

The SafetyClientImplemented SPI parameter is used to indicate whether the SafetyConsumer supports OPC UA client/server communication mechanisms.

In the case of automatic assignment, the value "TRUE" is entered. This corresponds to the only permissible value since SIMATIC Safety supports only OPC UA client/server communication.

SafetyPubSubImplemented

The SafetyPubSubImplemented SPI parameter is used to indicate whether the SafetyConsumer supports OPC UA PubSub communication mechanisms.

With automatic assignment, the value "FALSE" is entered. This corresponds to the only permissible value since SIMATIC Safety does not support OPC UA PubSub communication.

9.5.1.4 Safety Application Program Interface (SAPI) of the SafetyConsumer in the F-OPC UA Consumer DB

The SAPI of a SafetyConsumer is available in the F-OPC-UA-Consumer-DB. The F-OPC-UA-Consumer-DB is automatically generated when the intended SafetyProvider is added to the SafetyProvider list of the client interface (Page 315). You can read or write directly to the corresponding variables in the F-OPC-UA-Consumer-DB.

You can find the name automatically assigned to the F-OPC-UA-Consumer-DB in the properties of the SafetyConsumer in the editor for client interfaces. If necessary, you can also adapt the name there. You can find the F-OPC-UA-Consumer-DB in the folder "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety" folder in the project tree.

The following table shows the parameters of the SAPI of a SafetyConsumer.

SAPI parameter	Tag in the F-OPC-UA-Consumer-DB	Data type	Access to in the Safety program	Access in the standard user program	Description
Tags that you can or must write					
Enable	ENABLE	BOOL	x	-	1=Activation of communication to the connected SafetyProvider
OperatorAckConsumer	OPERATOR_ACK_CONSUMER	BOOL	x	-	1=User acknowledgment at SafetyConsumer end
SafetyProviderID	SAFETY_PROVIDER_ID	DINT	x	-	ID for authentication of the intended SafetyProvider
SafetyBaseID	SAFETY_BASE_ID	GUID	-	x	ID for authentication of the intended SafetyProvider
SafetyConsumerID	SAFETY_CONSUMER_ID	DINT	x	-	ID for authentication of a SafetyConsumer
Tags that you can/must evaluate					
SafetyData	SAFETY_DATA	UDT	x	(x)	Data provided by the connected SafetyProvider in a safety-related manner
NonSafetyData	NON_SAFETY_DATA	UDT	-	x	Data that is not made available by the connected SafetyProvider in a safety-related manner
FSV_Activated	FSV_ACTIVATED	BOOL	x	(x)	1=SafetyConsumer outputs substitute values
OperatorAckRequested	OPERATOR_ACK_REQUESTED	BOOL	x	(x)	1=Acknowledgment request is pending
OperatorAckProvider	OPERATOR_ACK_PROVIDER	BOOL	x	(x)	1=User acknowledgment at SafetyProvider end
TestModeActivated	TEST_MODE_ACTIVATED	BOOL	x	(x)	1=Current values at the SafetyData SAPI parameter are test data

(x) can also be evaluated non-safety-related in the standard user program if required

Enable

The Enable SAPI parameter is used to activate communication with OPC UA Safety to the connected SafetyProvider. If Enable = 0, no SafetyData/NonSafetyData is requested from the connected SafetyProvider. Instead of the current values, the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) at the SafetyData SAPI parameter.

With Enable = 0, for example, you can delay the start of communication with OPC UA Safety until the underlying OPC UA communication is ready (e.g. after switching the power supply

on). This allows you to avoid communication errors such as "timeout" in this phase (see SafetyConsumerTimeout (Page 288) SPI parameter).

NOTE
When changing from Enable = 1 to Enable = 0, the output of substitute values at the SafetyData SAPI parameter only take effect after the next data package has been received or after the monitoring time parameterized via SafetyConsumerTimeout.

OperatorAckConsumer

The OperatorAckConsumer SAPI parameter is used to perform user acknowledgment. This requires a positive edge after an acknowledgment request has been made at the OperatorAckRequested SAPI parameter.

Once the user acknowledgment has been carried out, the SafetyConsumer outputs the current values at the SafetyData SAPI parameter again instead of the substitute values from the F-OPC-UA-Consumer-DB (Page 297).

⚠ WARNING

A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

SafetyProviderID/SafetyBaseID

With the SafetyProviderID and SafetyBaseID SAPI parameters, you can uniquely and reliably authenticate the foreseen SafetyProvider for dynamic connections. For more information, refer to the sections "Series machines (Page 326)" and "Changing communication partners (Page 327)".

SafetyProviderID and/or SafetyBaseID are initialized with values matched to the specific situation in the system during runtime of the Safety program (or standard user program). As long as both values <> 0, the values assigned to the SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are overwritten.

If the active SafetyProviderID or SafetyBaseID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) to the Safety program instead of the current values at the SafetyData SAPI parameter.

NOTE
A changed value at the SAPI parameters SafetyProviderID and SafetyBaseID only becomes effective after a positive edge at the Enable SAPI parameter.

⚠ WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

⚠ WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.
When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

SafetyConsumerID

You can also use the SafetyConsumerID SAPI parameter to uniquely authenticate a SafetyConsumer in use cases with changing communication partners (Page 327) or series machines (Page 326).

The SafetyConsumerID is then only supplied with a value adapted to the specific system situation during the runtime of the Safety program. As long as the relevant value <> 0, the value assigned to the SafetyProviderIDConfigured PI parameter is overwritten.

If the active SafetyConsumerID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) to the Safety program instead of the current values at the SafetyData SAPI parameter.

NOTE

A changed value at the SAPI parameter SafetyConsumerID only becomes effective after a positive edge at the Enable SAPI parameter.

SafetyData

The SafetyData SAPI parameter provides the data that is made available by the connected SafetyProvider in a safety-related manner for evaluation in your Safety program.

⚠ WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.
To identify the communication connection, note the following points:

- For static connections:
  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:
  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

NonSafetyData

The NonSafetyData SAPI parameter provides the data that is not made available by the connected SafetyProvider in a safety-related manner for evaluation in your standard user program.

FSV_Activated

You can use the FSV_Activated SAPI parameter to evaluate whether the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 297) at the SafetyData SAPI parameter instead of the current values.

OperatorAckRequested

You can use the OperatorAckRequested SAPI parameter to evaluate whether there is an acknowledgment request on the SafetyConsumer.

OperatorAckProvider

You can use the OperatorAckProvider SAPI parameter to evaluate whether there is a user acknowledgment on the side of the connected SafetyProvider.

To use this as an alternative (or in addition) to your acknowledgment signal on the SafetyConsumer side, you must link the OperatorAckProvider SAPI parameter with the OperatorAckConsumer SAPI parameter (possibly OR-linked with the acknowledgment signal on the SafetyConsumer side).

TestModeActivated

You can use the TestModeActivated SAPI parameter to evaluate whether the connected SafetyProvider "only" provides test data, i.e. non-safety-related data, at its SafetyData SAPI parameter.

This is the case if the EnableTestMode SAPI parameter has been set to "1" on the connected SafetyProvider.

If the connected SafetyProvider is located on an F-CPU S7-1500, TestModeActivated is also set to "1" if the Safety program belonging to the connected SafetyProvider is running in disabled safety mode or on an *S7-PLCSIM*. For information on the behavior of devices of a third-party manufacturer, refer to the documentation of the device manufacturer.

⚠ WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

9.5.1.5 Other variables in the F-OPC UA Consumer DB

In addition to the SAPI of a SafetyConsumer, the F-OPC-UA-Consumer-DB also provides you with other variables that you need for communication with OPC UA Safety in the *SIMATIC Safety* F-system and the underlying OPC UA communication ("client instructions"):

Tag in the F-OPC-UA-Consumer-DB	Data type	Access in the Safety program:	Access in the standard user program	Description
Tags that you can or must write				
RESPONSE_SPDU	STRUCT	-	x	Tag for the in-out parameter (InOut) OutputArguments of the client instruction OPC_UA_MethodCall
METHOD_CALL_DONE	BOOL	-	x	Variable for the Done output of the client instruction OPC_UA_MethodCall
METHOD_CALL_BUSY	BOOL	-	x	Variable for the Busy output of the client instruction OPC_UA_MethodCall
METHOD_CALL_ERROR	BOOL	-	x	Variable for the Error output of the client instruction OPC_UA_MethodCall

Tag in the F-OPC-UA-Consumer-DB	Data type	Access in the Safety program:	Access in the standard user program	Description
METHOD_RESULT	DWORD	-	x	Tag for the in-out parameter (InOut) MethodResult of the client instruction OPC_UA_MethodCall
Tags that you can/must evaluate				
REQUEST_SPDU	STRUCT	-	x	Tag for the in-out parameter (InOut) InputArguments of the client instruction OPC_UA_MethodCall
METHOD_CALL_REQUEST	BOOL	-	x	Tag for the REQ input of the client instruction OPC_UA_MethodCall
DIAG	BYTE	-	x	Non-fail safe service information
SAFETY_PROVIDER_ID_ACTIVE	UDINT	-	x	Active SafetyProviderID
SAFETY_BASE_ID_ACTIVE	GUID	-	x	Active SafetyBaseID
SAFETY_CONSUMER_ID_ACTIVE	UDINT	-	x	Active SafetyConsumerID
Variables for which you can/must assign start values				
PASS_VALUES	UDT (analog SafetyData)	-	-	Substitute values for SafetyData

RESPONSE_SPDU

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 323), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

METHOD_CALL_DONE, METHOD_CALL_BUSY, METHOD_CALL_ERROR, METHOD_RESULT

You need these variables to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 323), these variables are automatically interconnected with the OPC_UA_MethodCall instruction.

REQUEST_SPDU

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 323), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

METHOD_CALL_REQUEST

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 323), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

DIAG

The DIAG variable is used to provide a non-fail-safe code for communication errors/states that have occurred for service purposes up to the user acknowledgement. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program.

Error code	Cause	Bad response from the SafetyProvider discarded *	Output of substitute values FSV_Activated = 1	User acknowledgment required
0x01	Discrepancy detected with active SafetyProviderID or SafetyBaseID	x	-	-
0x11	Discrepancy with active SafetyBaseID detected	-	x	x
0x12	Discrepancy with active SafetyProviderID detected	-	x	x
0x13	Discrepancy with SafetyStructureSignature or SafetyStructureSignatureVersion or SafetyStructureIdentifier detected	-	x	x
0x14	Discrepancy detected with SafetyProviderLevel	-	x	x
0x05	CRC error detected	x	-	-
0x15	CRC error detected	-	x	x
0x06	Discrepancy with active SafetyConsumerID detected	x	-	-
0x16	Discrepancy with active SafetyConsumerID detected	-	x	x
0x07	MonitoringNumber error detected	x	-	-
0x17	MonitoringNumber error detected	-	x	x
0x08	Timeout error detected	-	x	(-)
0x09	Enable SAPI parameter of the SafetyConsumer = 0	-	x	-
0x0A	SafetyConsumer SPI parameters are invalid.	-	x	-
0x20	SAPI parameter ActivateFSV of the SafetyProvider = 1	-	x	(-)

(-): A user acknowledgment is required for the SafetyOperatorAckNecessary SPI parameter of the SafetyConsumer = 1.

* More information can be found in the section "Safety Parameter Interface (SPI) of the SafetyConsumer (Page 288)" under "SafetyErrorIntervalLimit".

SAFETY_PROVIDER_ID_ACTIVE/SAFETY_BASE_ID_ACTIVE/SAFETY_CONSUMER_ID_ACTIVE

You can use these variables to evaluate the active SafetyProviderID, SafetyBaseID or SafetyConsumerID for diagnostic purposes.

These variables are also required for the correct display of all data of the SafetyConsumerTypes (Page 331).

PASS_VALUES

You use this variable to define the substitute values as start values in the F-OPC-UA-Consumer-DB, which the SafetyConsumer outputs instead of the current values at the SafetyData SAPI parameter in the following cases (for details see DIAG variable):

- Communication error detected.
- Enable SAPI parameter of the SafetyConsumer is "0"
- ActivateFSV SAPI parameter of the connected SafetyProvider is "1"

NOTE

If you do not explicitly define any start values in the PASS_VALUES variable in the F-OPC-UA-Consumer-DB, the default values of the PLC data type (UDT) automatically created by *STEP 7 Safety* for this data structure are used as start values. If necessary, you can adapt these default values. For further details see "Configuring properties of a SafetyConsumer (Page 319)".

9.5.2 Configuring and programming a SafetyProvider

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The following function right is available for the "SafetyAdmin" role: OPC UA server access. More information can be found in the help for *STEP 7* under "Users and roles with OPC UA function rights (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/configuring-the-opc-ua-server-s7-1500-s7-1500t/users-and-roles-with-opc-ua-function-rights-s7-1500-s7-1500t)".
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA server is activated.

Configuring and programming a SafetyProvider

Proceed as follows to configure and program a SafetyProvider. Repeat the following steps for each data structure that you want to make available to a SafetyConsumer.

9.5.2.1 Preparing the Safety program (or standard user program) for creation of an OPC UA SafetyProvider information model

You must make the following preparations in your Safety program (or standard user program) before creating an OPC UA SafetyProvider information model.

1. Create an F-compliant PLC data type (UDT) that describes the data structure of your safety message frame that you want to make available to a SafetyConsumer in a safety-related manner.
2. Create a tag with the previously created F-compliant PLC data type (UDT) in an F-shared DB.

3. Optional:

   Create a PLC data type (UDT) that describes the data structure of the data of your standard user program that you want to make available to a SafetyConsumer in a non-safety-related manner "synchronously" with the data of your Safety program.

   Create a tag with the previously created PLC data type (UDT) in a shared DB.

4. Optional:

   If you want to trigger certain actions on a SafetyConsumer or communicate certain status information to the SafetyConsumer, create an F-compliant PLC data type (UDT) that describes the data structure of the SAPI parameter InputSignals.

   Order, names and data types are specified as follows:

   – OperatorAckProvider: BOOL
   – ActivateFSV: BOOL
   – EnableTestMode: BOOL

   Create a tag with the previously created F-compliant PLC data type (UDT) in an F-shared DB.

5. Optional:

   If you want to evaluate certain information of a SafetyConsumer, create a PLC data type (UDT) that describes the data structure of the SAPI parameter OutputSignals.

   Order, names and data types are specified as follows:

   – OperatorAckRequested: BOOL
   – MonitoringNumber: UDINT
   – SafetyConsumerID: UDINT

   Create a tag with the previously created PLC data type (UDT) in a shared DB.

6. Optional:

   If you want to change the value of the active SafetyProviderID of a SafetyProvider at runtime, create a tag with the data type DINT in an F-shared DB.

7. Optional:

   If you want to change the value of the active SafetyBaseID of a SafetyProvider at runtime, create a tag with the GUID data type in a shared DB.

8. Compile the Safety program and, if applicable, the standard user program.

9.5.2.2 Creating an OPC UA SafetyProvider information model for an individual data structure

You create an OPC UA SafetyProvider information model for your individual data structure based on a nodeset file provided by the OPC Foundation for OPC UA Safety and using SiOME. For this purpose, you must map all the SAPI parameters you require in your Safety program (or standard user program) to the designated local data (local data mapping).

You then export the OPC UA SafetyProvider information model created in this way to an XML file (nodeset file).

Requirements

The individual data structures have been created as (F-compliant) PLC data types (UDTs).

The local data needed for the local data mapping of the SAPI parameters is available and compiled in your Safety program (or standard user program).

In order to connect SiOME (https://support.industry.siemens.com/cs/ww/en/view/109755133) to the TIA project, Openness must be installed and set up.

Creating an OPC UA SafetyProvider information model

Proceed as follows to create an OPC UA SafetyProvider XML file (nodeset file).

1. First, download the nodeset file "Opc.Ua.Safety.NodeSet2.xml" of the OPC UA Safety Specification V1.05.04 from the GitHub website of the OPC Foundation. You can find the download link here (https://github.com/OPCFoundation/UA-Nodeset/tree/Safety-1.05.04-2025-02-05/Safety).

   The "Opc.Ua.Safety.NodeSet2.xml" file serves as the basis for your individual nodeset file. It contains the type and method definitions you need to create an OPC UA SafetyProvider XML file.
2. Start SiOME.
3. First, import the namespace "http://opcfoundation.org/UA/Safety".

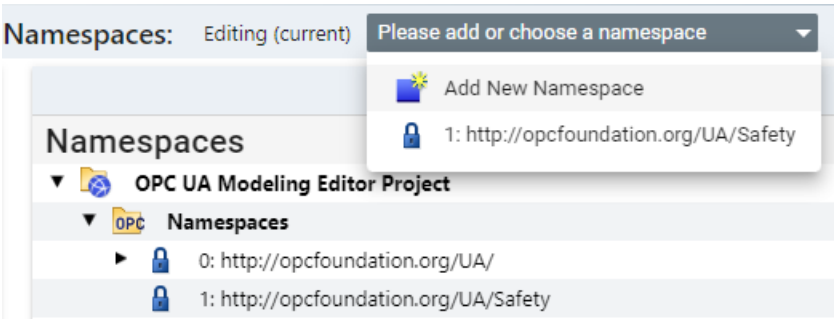
   To do so, click the "Import XML" button in the SiOME menu.

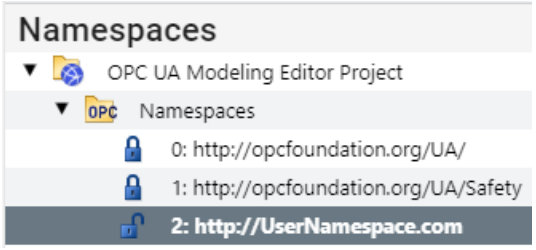
   SiOME displays the dialog for opening files.
4. Select the "Opc.Ua.Safety.NodeSet2.xml" file and click the "Open" button to import it.

   Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/Safety" in the "Namespaces" area.

5. Create your own namespace for your project.
   To do so, click "Add New Namespace" in the "Namespaces: Editing (current)" area in the SiOME menu.



   SiOME opens the "Add Namespace" dialog.
6. Enter the name of the new namespace.
   The namespace "UserNamespace.com" is used in the example.
   SiOME additionally shows the new namespace:



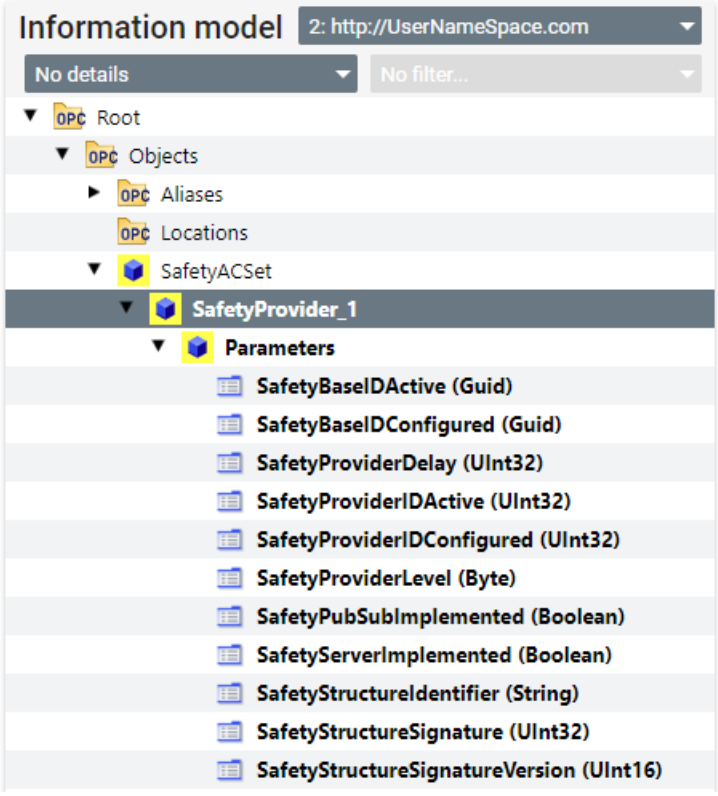
7. Create an instance from the object type "SafetyProviderType" of the OPC UA Safety Specification.
   To do so, right-click the folder "Root/Objects/SafetyACSet" in the "Information model" area and select "Add Instance".

   NOTE

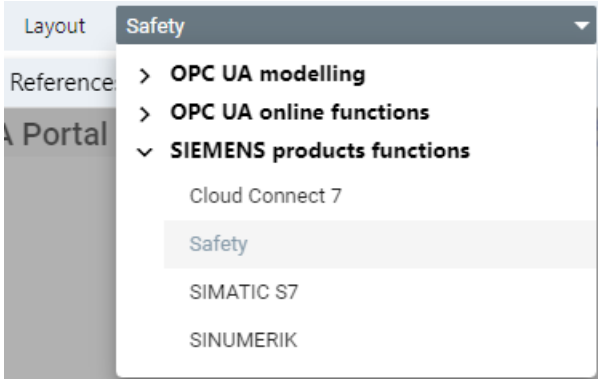
   Instances of the "SafetyProviderType" object type must always be located in the folder "SafetyACSet".

   SiOME displays the dialog "Add Instance".
8. Enter a descriptive name for the new instance for "Name".
   The name "SafetyProvider_1" is used in the example.
   For "TypeDefinition", select "SafetyProviderType". You can find the type under "BaseObjectTypes/SafetyObjectsType".

9. Click "OK".
   SiOME shows the new instance "SafetyProvider_1" under "SafetyACSet" in the "Information model" area. This instance already contains the SPI parameters required for communication with OPC UA Safety:

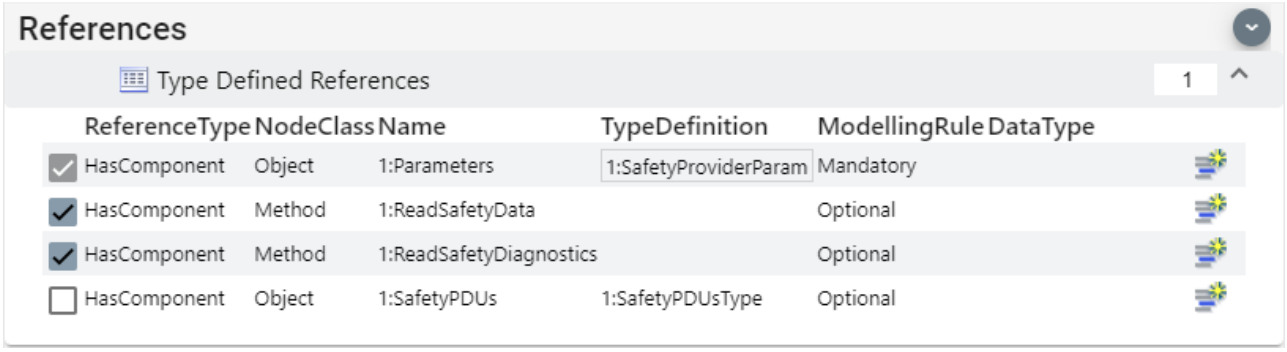


10. Select the Safety layout.
    To do so, select the "Safety" layout under "SIEMENS products functions" in the "Layout" area of the SiOME menu.



SiOME now shows the "Safety Configuration" area.

11. Add the "ReadSafetyData" and "ReadSafetyDataDiagnostics" methods. These methods are required for client access of the communication with OPC UA Safety.
    Select the corresponding check boxes for this in the "Attributes/References" area.

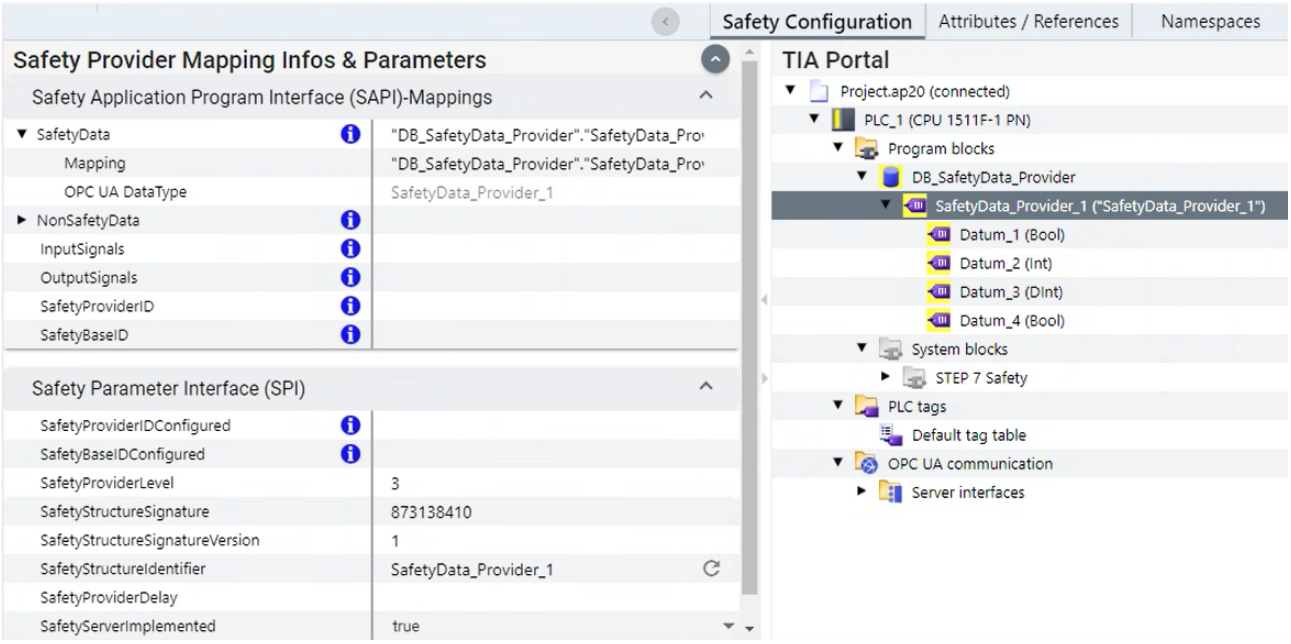


12. In SiOME, connect to the TIA project in which you created the data structures and local data.
    To do so, click the "Open TIA Portal project" button in the "Safety Configuration" area.

    – If a project is already opened in TIA Portal, SiOME shows the dialog "Attach to already opened TIA Portal project".
    – If no project is opened in TIA Portal, the dialog for opening of TIA Portal projects is displayed.
13. Select the project and click "Attach to selected project" or "Open". If required, enable the access in parallel in TIA Portal.
    SiOME displays the project tree of the project.
    Note: If the project contains more than one (F-)CPU, SiOME first displays the dialog "Select PLC". In this case, select the desired F-CPU.
14. Perform the mapping for SafetyData in the Safety Application Program Interface (SAPI).
    To do so, use drag-and-drop to move the variable with the data structure of the data to be sent from the F-DB to the SafetyData parameter in the SAPI. Answer "Yes" to the displayed question "Do you want to generate the OPC UA DataTyp.".
    SiOME generates the associated OPC UA data type.

15. Optional:
    Perform the mapping for NonSafetyData, InputSignals, OutputSignals, SafetyProviderID and/or SafetyBaseID accordingly. The maximum length for strings is 128 characters.

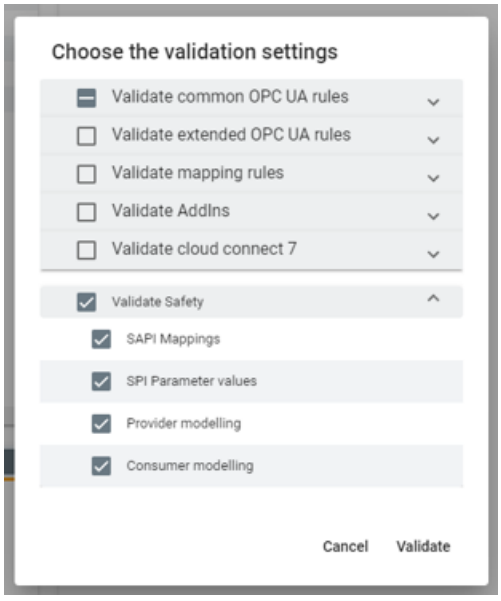


16. Optional:
    Validate the now available nodeset.
    To do so, click the "Validate information model" button in the SiOME menu.



    SiOME displays the dialog "Choose the validation settings".

17. Select the desired settings and click "Validate".

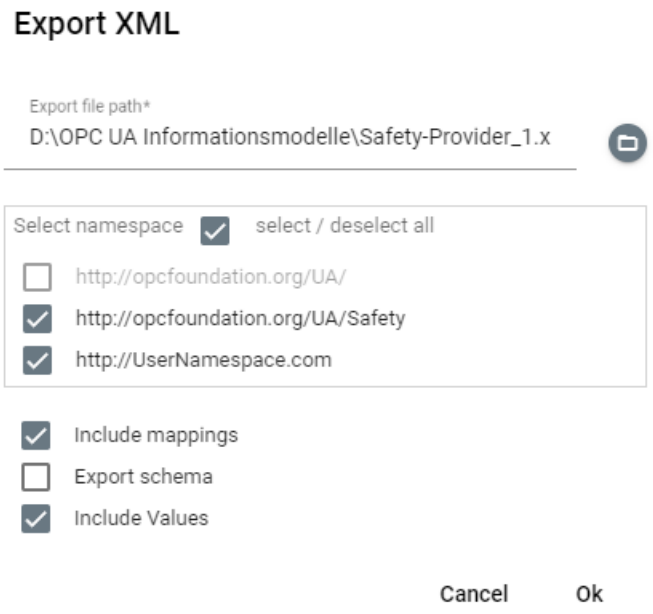


    SiOME displays the result of the validation in the "Validation" area.

18. Export the XML file.
    To do so, click the "Export XML" button in the SiOME menu.



    SiOME displays the dialog "Export XML".
    Select the path for the export and a descriptive name for the file. The name "SafetyProvider_1" is used in the example.
    Have all namespaces activated and click "OK".



9.5.2.3 Creating a server interface for an OPC UA SafetyProvider information model

You create a server interface for an OPC UA SafetyProvider information model in a similar way as a server interface for a companion specification. More information can be found in the *STEP 7* help under "Creating a server interface for a companion specification (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/opc-ua-server-interface-configuration-s7-1500-s7-1500t/creating-a-server-interface-for-companion-specification-s7-1500-s7-1500t)".

WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

NOTICE

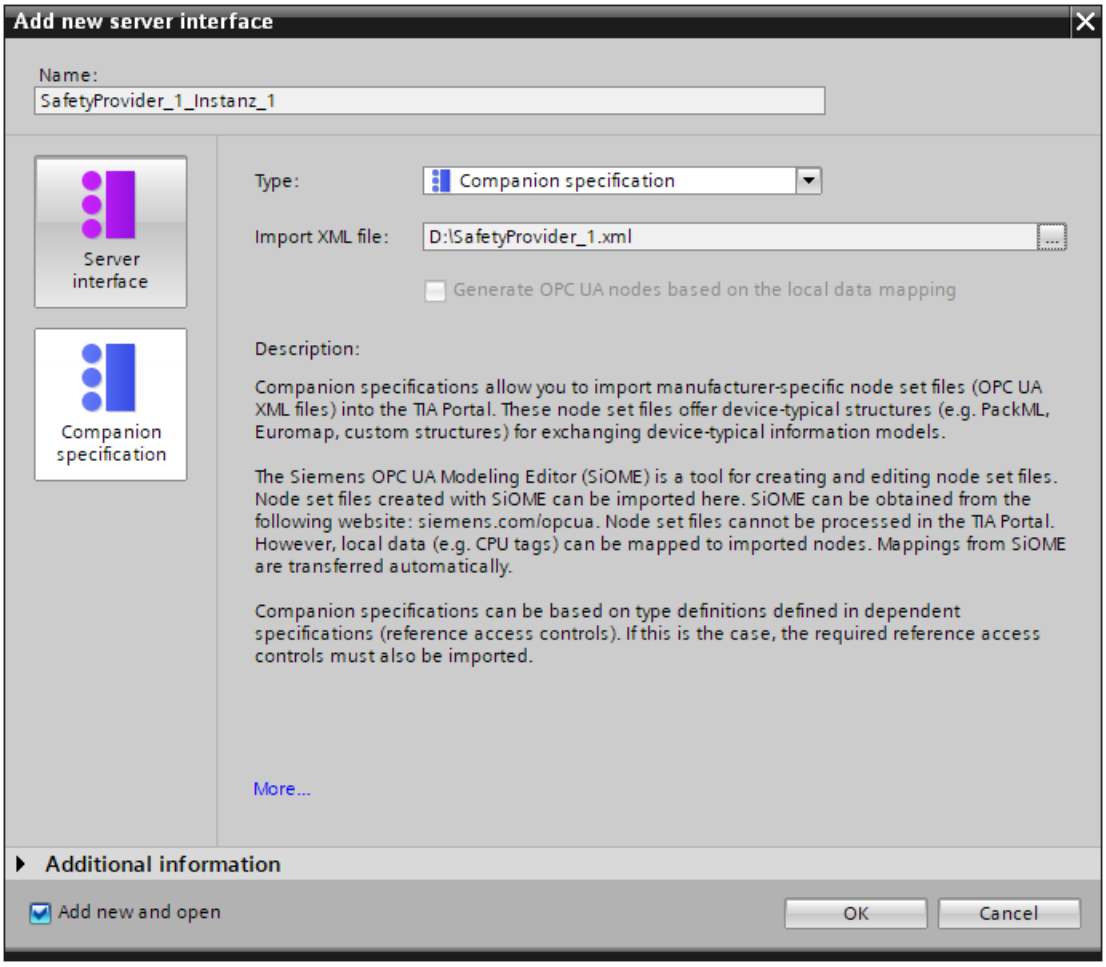
When making various changes in your user program, note that the OPC UA server of the F-CPU may need to be restarted. This can lead to an interruption of the safety-related communication with OPC UA Safety, which means that all connected SafetyConsumer output substitute values. In this case, the received process values are only output again after a user acknowledgement.
More information can be found in the *STEP 7* help under "Behavior of the OPC UA server during operation (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/interesting-information-about-the-opc-ua-server-of-the-s7-1500-cpus-s7-1500-s7-1500t/runtime-behavior-of-the-opc-ua-server-s7-1500-s7-1500t)".

Creating a server interface for an OPC UA SafetyProvider information model

Proceed as follows to create a server interface for a companion specification with *STEP 7 (TIA Portal)*:

1. Select the F-CPU you are using as the OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select the type of this server interface, click the "Companion specification" button.
   A general name for the new interface, e.g. "Server_Interface_1", is entered in the dialog.

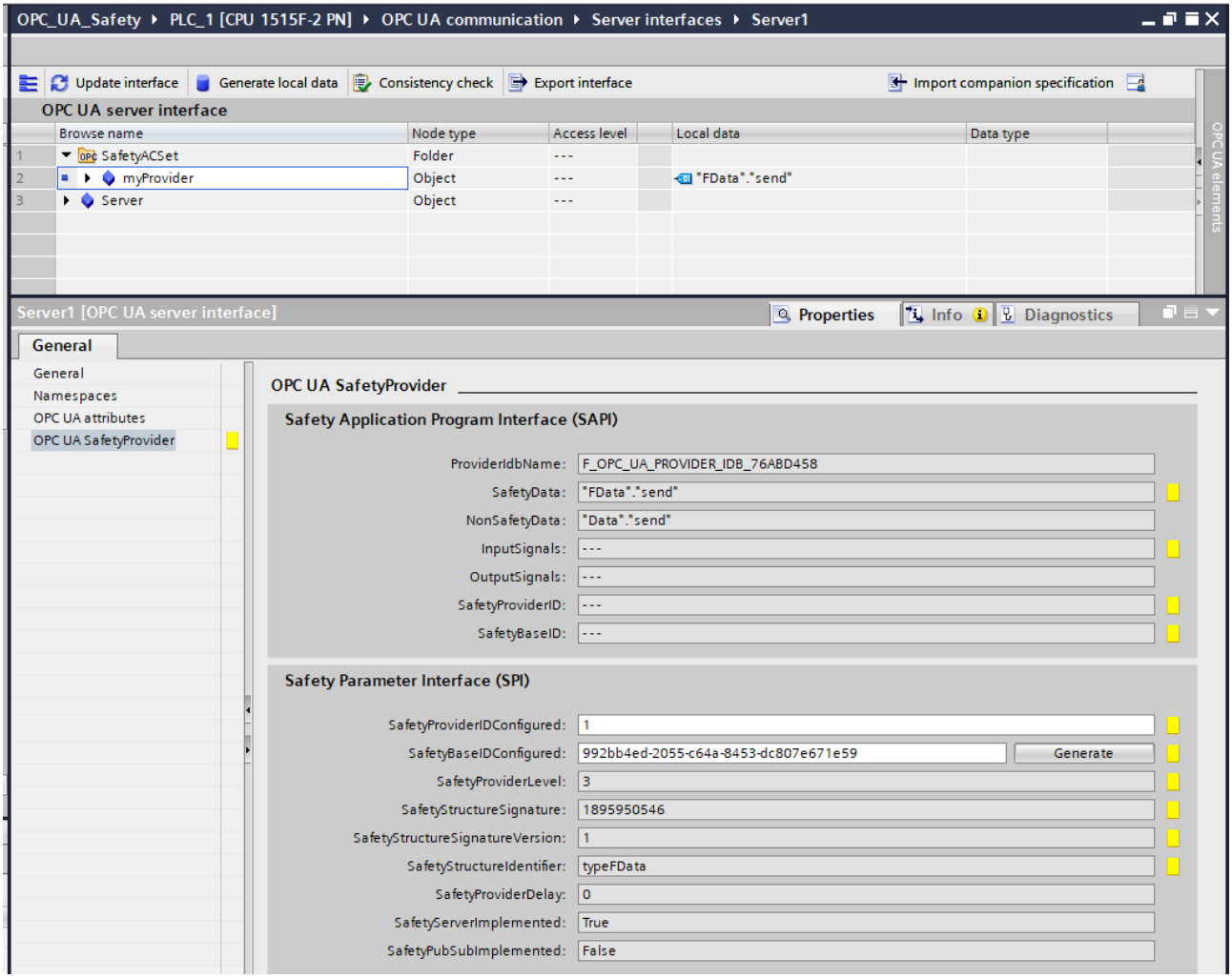
5. Change the name of the new server interface to a descriptive name in your project.
   The name "SafetyProvider_1_Instance_1" is used in the example.



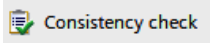
6. In the "Import XML file" field, select the OPC UA SafetyProvider XML file that was created and exported in SiOME (Page 302) and contains the description of the information model for your individual data structure.
7. Click the "OK" button.
   STEP 7 (TIA Portal) imports the information model described in the selected XML file.
8. Select your SafetyProvider instance in the OPC UA server interface.
   Under "OPC UA Safety Provider" on the "Properties" tab, you see the local data of your Safety program (or standard user program) that was mapped to the SAPI parameters and the values of the SPI parameters that you assigned or that were assigned automatically during import.

NOTE

You performed the mapping of your local data previously when creating your OPC UA Safety XML file in SiOME. It is not necessary to create and map further local data with the "Generate local data" button.



9. Optional:
   Check the imported server interface for consistency.
   To do so, select your SafetyProvider instance in the OPC UA server interface and click the "Consistency check" button.

   STEP 7 displays the result of the consistency check on the "Info > General" tab.
10. Optional:
    Change the values of the SPI parameter SafetyProviderIDConfigured and/or SafetyBaseIDConfigured according to the requirements of your specific application.
    To do this, open the editor for the server interface and select "OPC UA Safety Provider" select the "Properties" tab.
    - SafetyProviderIDConfigured: Overwrite a previously entered value.
    - SafetyBaseIDConfigured: Click the "Generate" button.
      STEP 7 Safety generates a random value that fulfills the safety requirements of OPC UA Specification OPC 10000-15.

⚠ WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **
If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***
You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 325)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

9.5.2.4 Programming the initialization or evaluation of SAPI parameters in your safety program (or standard user program)

Programming procedure

You program the initialization or evaluation of SAPI parameters as follows:

1. Initialize the local data in your Safety program that you have mapped to the SafetyData SAPI parameter with the current values that you want to make available to a connected SafetyConsumer in a safety-related manner.
2. Optional:
   Initialize the local data in your standard user program that you have mapped to the NonSafetyData SAPI parameter with the current values that you want to make available to a connected SafetyConsumer in a non-safety-related manner.

3. Optional:
   If you want to perform user acknowledgment required on the connected SafetyConsumer on the SafetyProvider side:
   Initialize the local data element in your Safety program that you have mapped to the InputSignals.OperatorAckProvider SAPI parameter with your acknowledgment signal.
   For this purpose, you can also evaluate the local data element that you have mapped to the InputSignals.OperatorAckProvider SAPI parameter in your standard user program. You can then, for example, have an operator control and monitoring system display that there is an acknowledgment on the connected SafetyConsumer.

   ⚠ WARNING

   A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

4. Optional:
   If a connected SafetyConsumer should use the designated substitute values from the F-OPC-UA-Consumer-DB instead of the current values at the SafetyData SAPI parameter:
   Initialize the local data element in your Safety program that you have mapped to the InputSignals.ActivateFSV SAPI parameter with "TRUE".

   NOTE
   Always set the date to "TRUE" if you cannot provide any safety-related values for the SafetyData SAPI parameter, while, for example, the F-CPU with the associated SafetyConsumer is already integrated in a productive operation.
   Non-safety-related values are present, for example, if your Safety program with the SafetyProvider is in disabled Safety mode during a test phase, is running on an *S7-PLCSIM* or is still incomplete.

5. Optional:
   If you want to inform a connected SafetyConsumer that the current values at the SAPI parameter SafetyData are test data and, thus, were not formed in a safety-related manner:
   Initialize the local data element in your safety program that you have mapped to the InputSignals.EnableTestMode SAPI parameter with "TRUE".

   NOTE
   The EnableTestMode SAPI parameter is also set internally to "TRUE" by the Safety program if it is in disabled Safety mode or is running on an *S7-PLCSIM*.

6. Optional:
   Applications with changing communication partners (Page 327) or series machines (Page 326):
   Initialize the local data element in your Safety program that you have mapped to the SafetyProviderID SAPI parameter with a SafetyProviderID matched to the specific situation in the system.
7. Optional:
   Applications with changing communication partners (Page 327) or series machines (Page 326):
   Initialize the local data element in your standard user program that you have mapped to the SafetyBaseID SAPI parameter with a SafetyBaseID matched to the specific situation in the system.

⚠ WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **
If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***
You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 325)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
Print the relevant program sections and supplement your safety summary with this printout.
(S103)

9.5.3 Configuring and programming a SafetyConsumer

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA client is activated.
- An OPC UA SafetyProvider information model for your individual data structure has been created or supplied for the device from a third-party manufacturer.

Configuring and programming a SafetyConsumer

Proceed as follows to configure and program a SafetyConsumer. Repeat the following steps for each SafetyProvider from which you want to evaluate data.

9.5.3.1 Creating a client interface for an OPC UA SafetyProvider information model

You create a client interface for an OPC UA SafetyProvider information model using the editor for client interfaces as in the standard. More information can be found in the *STEP 7* help under "Creating client interfaces (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-as-an-opc-ua-client-s7-1500-s7-1500t/creating-client-interfaces-s7-1500-s7-1500t)".

Only the special features of OPC UA Safety are described below.

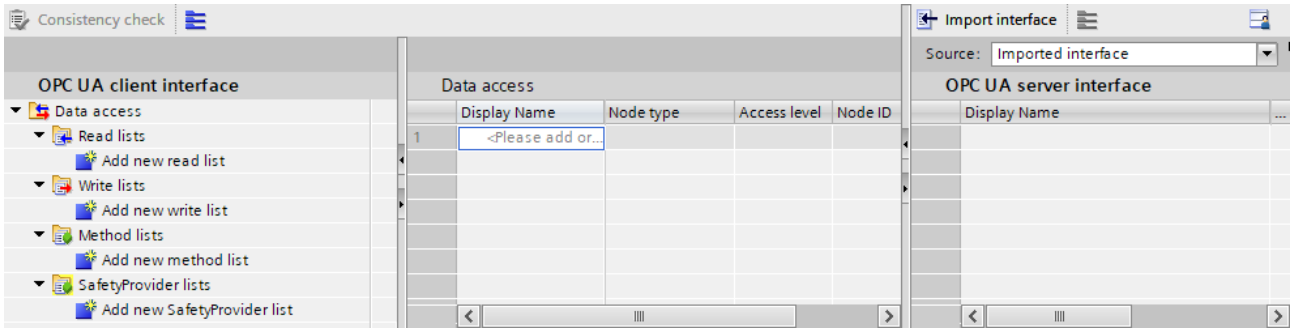
⚠ WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

Creating a client interface for an OPC UA SafetyProvider information model

To create a client interface for an OPC UA SafetyProvider information model with *STEP 7 (TIA Portal)*, proceed as follows:

1. Select the F-CPU you are using as the OPC UA client.
2. In the project tree, click "OPC UA communication > Client interfaces".
3. Double-click on "Add new client interface".
   STEP 7 creates a new client interface and displays it in the editor:

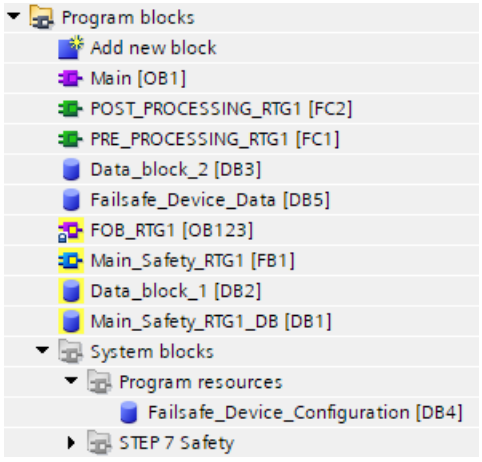


STEP 7 calls the new interface "Client interface_1".

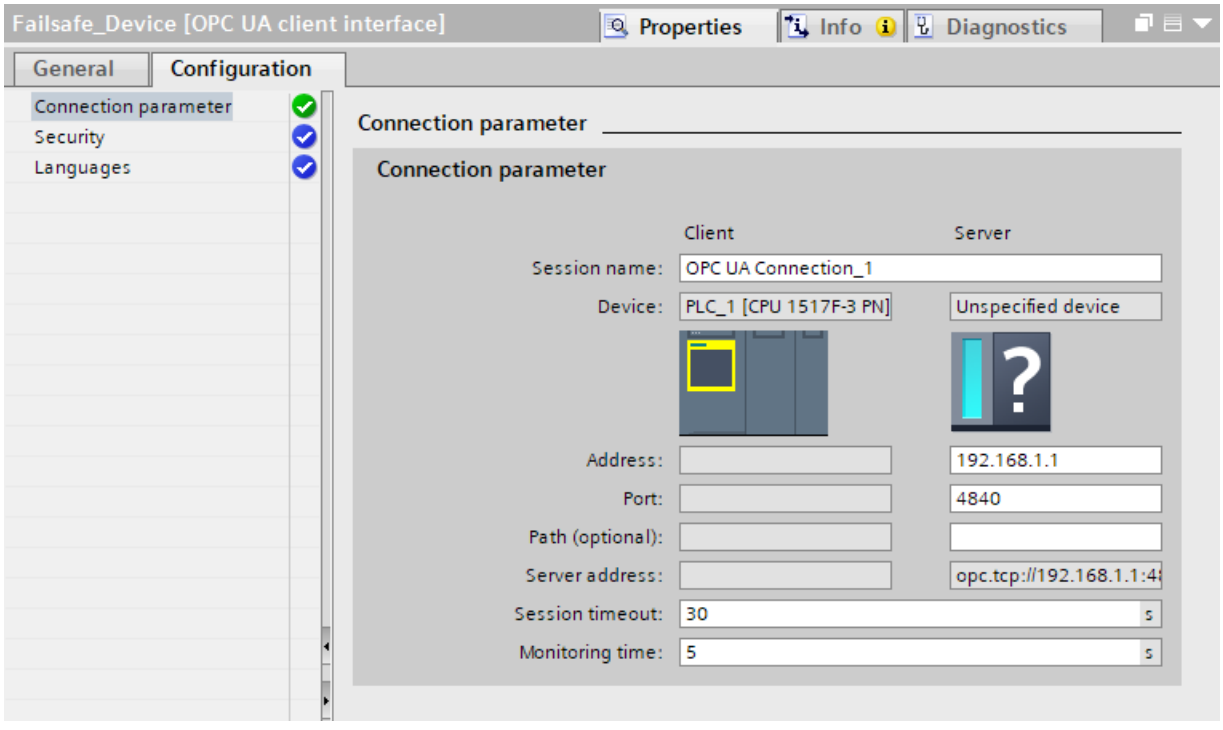
STEP 7 also generates the following data blocks:

- **Client interface_1_Configuration**
  The data block contains variables that require to call the client instructions for the underlying OPC UA communication.
  When using the F-OPC-UA-Consumer-Com-FB (Page 323), these variables are automatically interconnected with the OPC_UA_MethodCall instruction.
- **Client interface_1_Data**
  This data block is not required for OPC UA Safety.

4. Change the name of the new client interface to a descriptive name in your project.
   The name "Failsafe_Device" is used in the example.
   This also changes the names of the associated data blocks to:
   – Failsafe_Device_Data
   – Failsafe_Device_Configuration



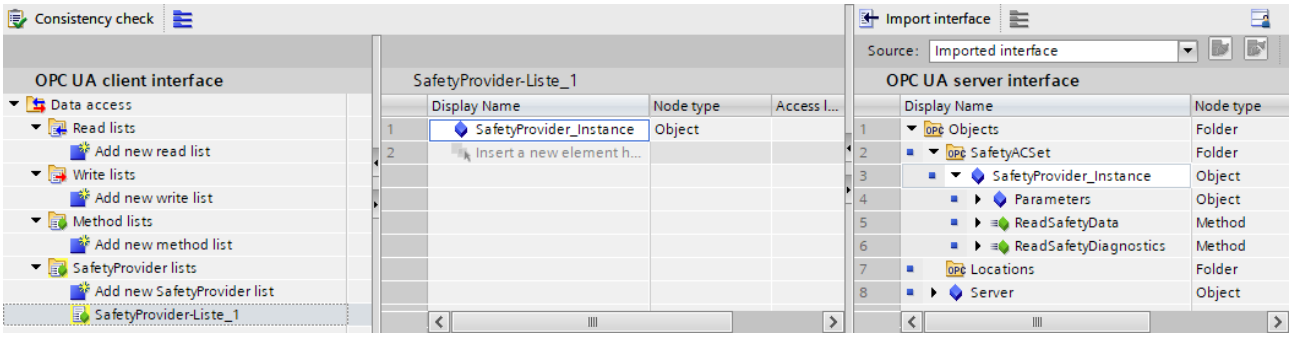
5. In the dialog that appears, specify the IP address of the desired OPC UA server in the Properties/Configuration tab under Connection parameters.



6. To import an OPC UA server interface, click the "Import interface" button at the top right of the editor when it is selected.
   Alternatively: You determine the server interface of a connected OPC UA server online. More information can be found in the STEP 7 online help under "Determining the server interface online (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-

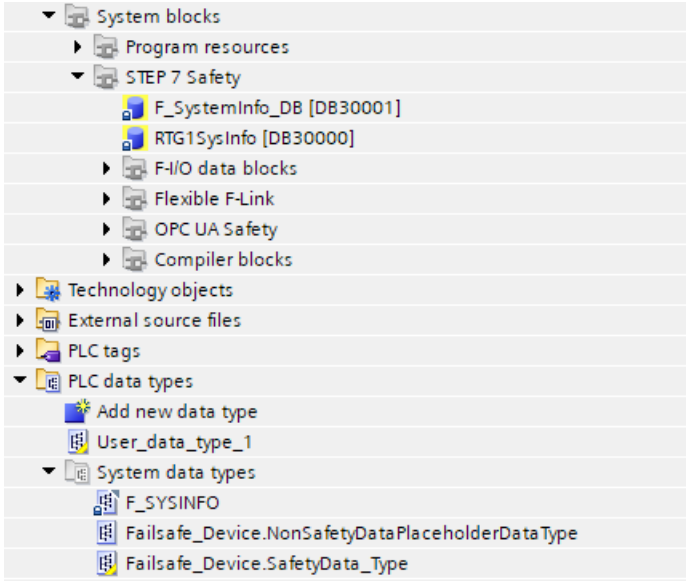
as-an-opc-ua-client-s7-1500-s7-1500t/determine-server-interface-online-s7-1500-s7-1500t)".

7. In the "Import XML file" field of the dialog that appears, select the exported OPC UA SafetyProvider XML file (Page 302) created and exported in SiOME or the OPC UA SafetyProvider XML file supplied for a device by a third-party manufacturer, in which the information model of the intended SafetyProvider is described.
8. Generate a SafetyProvider list in this client interface.
   To do this, click on "Add new SafetyProvider list" in the left section of the editor.
   STEP 7 adds a new list with the name "SafetyProvider list_1".
9. Add the intended SafetyProvider to the new SafetyProvider list.
   To do this, drag-and-drop the SafetyProvider from the OPC UA server interface to the "SafetyProvider list_1" SafetyProvider list in the middle field of the editor.
   In the example, the SafetyProvider has the name "SafetyProvider_Instance".



STEP 7 Safety generates the following program blocks and PLC data types:

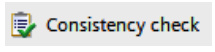
- F-OPC-UA-Consumer-DB (Page 297)
  (for example F_OPC_UA_CONSUMER)
- F-OPC-UA-Consumer-Com-FB (Page 323)
  (for example F_OPC_UA_CONSUMER_COM)
- UDT for the SafetyData SAPI parameter (Page 293) and the PASS_VALUES in the F-OPC-UA-Consumer-DB (Page 297)
  (for example Failsafe_Device.SafetyData_Type)
- UDT for the NonSafetyData SAPI parameter (Page 293)
  (for example Failsafe_Device_NonSafetyDataPlaceholderDataType)



10. Optional:

    Check the imported client interface for consistency.

    To do this, select your SafetyProvider list in the OPC UA client interface and click the "Consistency check" button.

    STEP 7 displays the result of the consistency check on the "Info > General" tab.

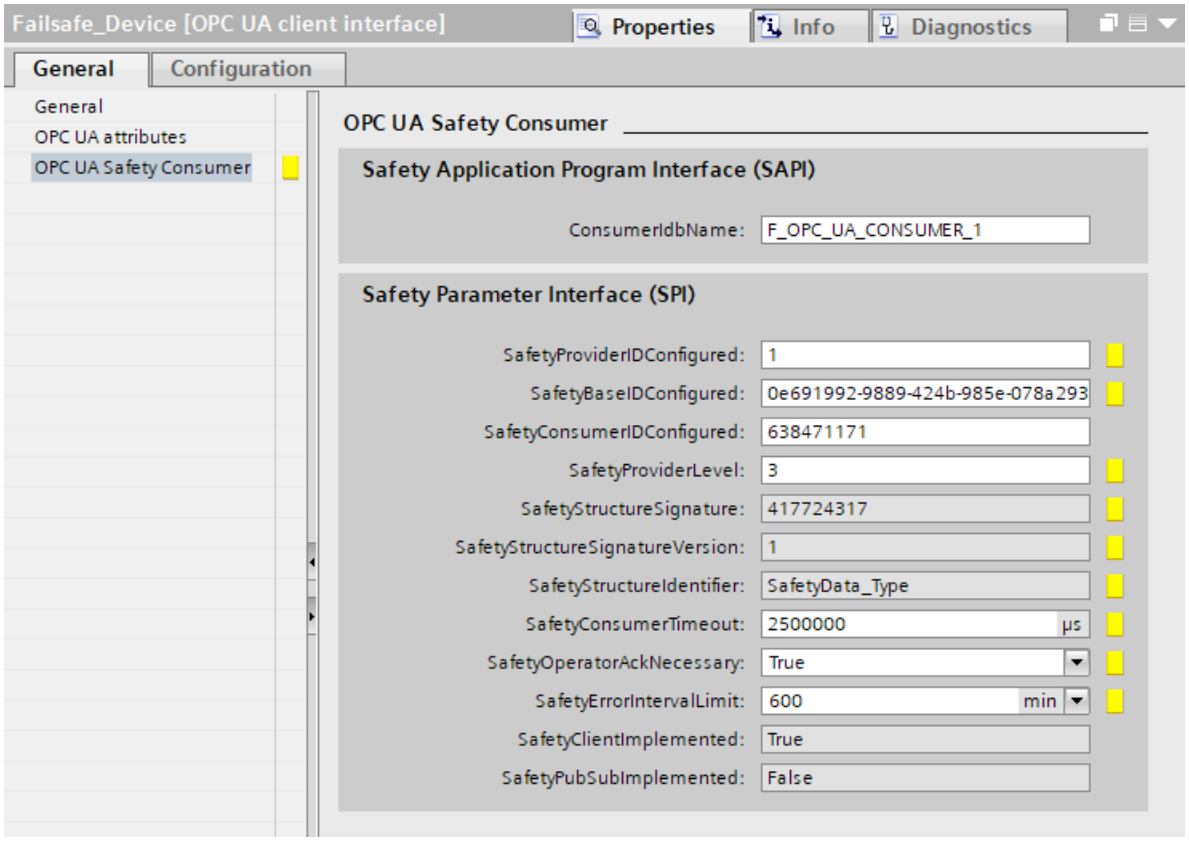
9.5.3.2 Configuring properties of a SafetyConsumer

You configure the properties of a SafetyConsumer in the "Properties" tab in the editor for client interfaces or in the F-OPC UA Consumer DB. Note the requirements of your specific application.

Configuring properties of a SafetyConsumer

To configure the properties of a SafetyConsumer, proceed as follows:

1. Select the intended SafetyProvider in the SafetyProvider list.
   In the "Properties/General" tab, the F-OPC UA Consumer DB is displayed under "OPC UA Safety Consumer" as a substitute for the SAPI parameters and the SPI parameters.



2. Optional:
   Change the name of the F-OPC UA Consumer DB.

3. Specify the values of the SPI parameters SafetyProviderIDConfigured (Page 288) and SafetyBaseIDConfigured (Page 288). The values must match the corresponding values of the intended SafetyProvider.

   ⚠ WARNING

   For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.
   When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

   * If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.
4. Optional:
   Change the value of the SPI parameter SafetyConsumerIDConfigured (Page 288).
5. Specify the value of the SafetyProviderLevel (Page 288) SPI parameter. The value must match the value on the connected SafetyProvider.
6. Change the value of the SPI parameter SafetyConsumerTimeout (Page 288).
   More information can be found in the section "Response Times of Safety Functions (Page 621)".
7. Optional:
   Change the value of the SafetyOperatorAckNecessary (Page 288) SPI parameter to "FALSE" if your specific system situation allows the values on the SafetyData SAPI parameter to be switched from substitute values to current values without manual user acknowledgment.
8. Optional:
   Change the value of the SafetyErrorIntervalLimit (Page 288) SPI parameter if your specific system situation requires this **as an exception**.
   Note the effects on the probability of failure values (PFDavg and PFH values) (Page 439).
9. Define the substitute values that are to be output instead of the current values at the SafetyData SAPI parameter in certain communication states.
   To do this, open the F-OPC UA Consumer DB belonging to your SafetyConsumer. You can find this in the project tree in the folder "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety".
   Define the substitute values as start values in the PASS_VALUES (Page 297) variable. The data structure of the PASS_VALUES variable corresponds exactly to the data structure of your SafetyData and is specified by an automatically created PLC data type (UDT).
   Alternatively:
   If you use multiple SafetyConsumers with identical data structure (combination of SafetyData and NonSafetyData) and want to define identical substitute values for all locations of use, you can alternatively proceed as follows:
   Open the automatically created PLC data type (UDT). You can find this in the project tree in the folder "PLC data types/system data types".
   Define the substitute values as default values in this PLC data type (UDT).

9.5.3.3 Programming the initialization or evaluation of SAPI parameters in your Safety program (or standard user program)

Programming procedure

You program the initialization or evaluation of SAPI parameters as follows:

1. In your Safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if you want to activate communication with OPC UA Safety to the connected SafetyProvider.
   Set the ENABLE variable to "0" if you want to deactivate an active communication to the connected SafetyProvider.

   NOTE
   When changing from Enable = 1 to Enable = 0, the output of substitute values at the SafetyData SAPI parameter only take effect after the next data package has been received or after the monitoring time parameterized via SafetyConsumerTimeout.

2. Optional:
   If you want to perform user acknowledgment on the SafetyConsumer side: In your Safety program, supply the OPERATOR_ACK_CONSUMER variable in the F-OPC-UA-Consumer-DB with your acknowledgment signal.
   You can evaluate the OPERATOR_ACK_REQUESTED variable for this. This allows you, for example, to display whether an acknowledgment request has been received on an operator control and monitoring system.

   ⚠ WARNING

   A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

3. Applications with changing communication partners (Page 327) or series machines (Page 326):
   In your Safety program, supply the SAFETY_PROVIDER_ID variable in the F-OPC-UA-Consumer-DB with the corresponding value of the currently intended SafetyProvider.

4. Applications with changing communication partners (Page 327) or series machines (Page 326):
   In your standard user program, supply the SAFETY_BASE_ID variable in the F-OPC-UA-Consumer-DB with the corresponding value of the currently intended SafetyProvider.

   ⚠ WARNING

   For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.
   When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

   * If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

   ⚠ WARNING

   Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
   Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
   For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
   Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

5. Applications with changing communication partners (Page 327) or series machines (Page 326):
   In your Safety program, supply the SAFETY_CONSUMER_ID variable in the F-OPC-UA-Consumer-DB with a SafetyConsumerID that is adapted to the specific system situation.
6. In your Safety program, evaluate the SAFETY DATA variable in the F-OPC-UA-Consumer-DB. This supplies the SafetyData currently provided by the SafetyProvider in a safety-related manner or, in an error case, the intended substitute values from the PASS VALUES variable.
7. Optional:
   In your standard user program, evaluate the NON_SAFETY_DATA variable in the F-OPC-UA-Consumer-DB with the NonSafetyData currently not provided by the SafetyProvider in a safety-related manner.
8. Optional:
   Use the FSV_ACTIVATED variable in the F-OPC-UA-Consumer-DB to evaluate whether current values or substitute values are output at the SAFETY_DATA variable.

9. Optional:
   Use the TEST_MODE_ACTIVATED variable in the F-OPC UA consumer DB to evaluate whether "only" test data, i.e. data not created for safety-related purposes, is available at the SAFETY_DATA variable.

⚠ WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

9.5.3.4 Programming underlying OPC UA communication ("client instructions") using the F-OPC UA Consumer Com FB

OPC UA Safety is based on the mechanisms of OPC UA. SIMATIC Safety supports OPC UA client/server communication. To use OPC UA Safety communication, you first need to call the required client instructions in the standard user program for each SafetyConsumer (see *STEP 7* help "Useful information about the client instructions (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-as-an-opc-ua-client-s7-1500-s7-1500t/useful-information-about-the-client-instructions-s7-1500-s7-1500t)" and "Client instructions (https://docs.tia.siemens.cloud/r/en-us/v20/communication-s7-1200-s7-1500/opc-ua-s7-1200-s7-1500/client-instructions-s7-1500)).

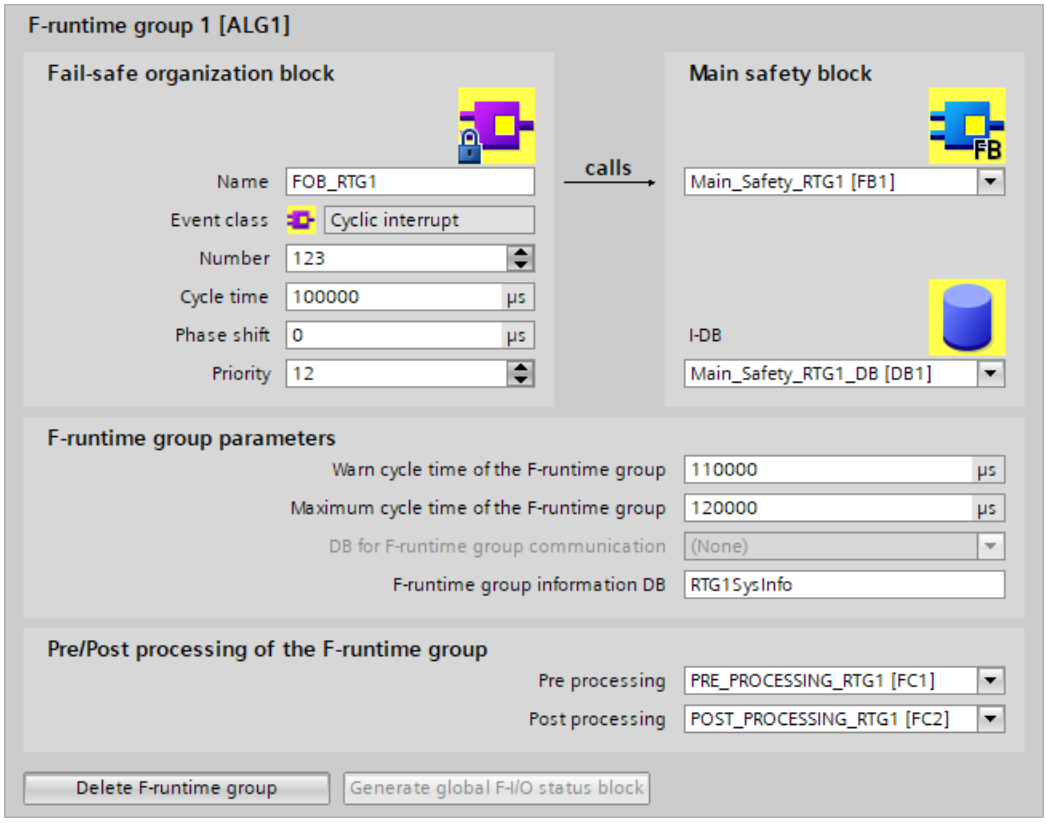
To make handling in the context of OPC UA Safety easier for you, *STEP 7 Safety* has already automatically generated an F-OPC UA Consumer-Com FB when adding the foreseen SafetyProvider in the SafetyProvider list of the client interface (Page 315). This already contains the call of the
client instruction OPC_UA_MethodCall required for a specific SafetyConsumer and can be used by you.

In the project tree, you will find the F-OPC-UA-Consumer-Com-FB in the "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety" folder.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

Programming calls of the F-OPC-UA-Consumer-Com-FB

1. If no pre-processing or post-processing module (Page 85) exists in your F-runtime group, first create the corresponding standard FCs and select them in the *Safety Administration Editor* for your F-runtime group.
   The FCs PRE_PROCESSING_RTG1 or POST_PROCESSING_RTG1 are used in the example.



2. Call the F-OPC-UA-Consumer-Com-FB in the pre-processing module. To do this, set the IsPre input to "TRUE".
3. Call the F-OPC-UA-Consumer-Com-FB in the post-processing module. To do this, set the IsPre input to "FALSE".

NOTE

If you also use OPC UA "Standard" communication, you may want to organize the call of the client statements differently. You can find examples on this in the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

WARNING

You may only use the Excel file for response time calculation or for timeout calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) when using OPC UA Safety communication, if you have observed the following rules with regard to the standard instruction OPC_UA_MethodCall:
You must call up the standard instruction OPC_UA_METHODCALL to receive the data in the pre-processing of the F-runtime group (Page 85) and to send the request in the post-processing of the F-runtime group (Page 85). The REQ input of the instruction must be supplied with a positive signal edge during preprocessing. You can use the F-OPC-UA-Consumer-Com-FB provided by the system. *(S112)*

9.5.4 Special use cases for communication with OPC UA Safety

9.5.4.1 Introduction

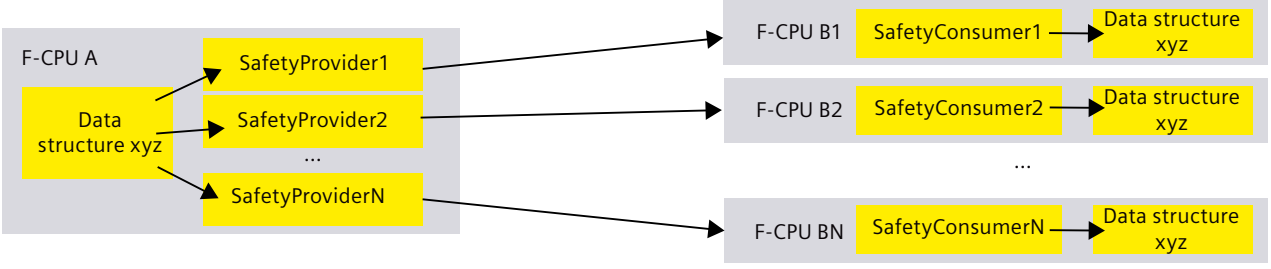
This section describes some special use cases in the context of communication with OPC UA Safety. However, the details of implementation depend on your specific application. The following descriptions are therefore to be understood as suggestions and do not claim to be exhaustive. When implementing your specific application, you must observe the corresponding warnings in this manual.

9.5.4.2 Safety Multicast

In a multicast, a communication partner provides data of several communication partners on different devices at the same time.

If you want to provide data on a F-CPU via Safety Multicast, you have to set up an individual SafetyProvider for each receiver (SafetyConsumer).

If all SafetyConsumers communicate with a shared SafetyProvider, timeout errors might occur because of competing SafetyConsumer requests.



Procedure

Proceed as follows:

1. Create a SafetyProvider by copying the underlying SafetyProviderType correspondingly often for each SafetyConsumer that evaluates it from the same associated OPC UA Safety information model on the F-CPU that provides the multicast data.

   NOTE
   As the underlying SafetyProvider already contains the mapping for SafetyData in the Safety Application Program Interface (SAPI), these SafetyProviders automatically use the same data from their Safety program.

2. Create a server interface (Page 307) on the basis of this OPC UA Safety information model.

   NOTE
   All SafetyProviders belonging to a multicast may use the same combination of active SafetyProviderID and active SafetyBaseID.

3. Create a client interface (Page 315) on each F-CPU that evaluates the multicast data and add the SafetyProvider from one of the created server interfaces (Page 307) ("SafetyConsumer_x") to a SafetyProvider list.

   NOTE
   Use a different one of the created SafetyProviders for each SafetyConsumer.

9.5.4.3 Series machines

In the context of series machines, there is usually a series machine project with a configured maximum configuration, from which different variants for a series machine can then be loaded. When a real machine is commissioned, the corresponding variant is then activated.

If the series machine project includes a Safety program, there is usually a requirement that the collective F-signature from the series machine project remains unchanged after the commissioning of a real machine.

In the context of communication with OPC UA Safety, however, it is necessary for each OPC UA Safety communication connection to have a unique combination of active SafetyProviderID and active SafetyBaseID. This means that the series machine project cannot yet contain the final values for a real machine, e.g. by defining them via the SPI parameters SafetyProviderIDConfigured and/or SafetyBaseIDConfigured.

Possible solutions:

1. Use the value "1" for the SafetyProviderIDConfigured SPI parameter in the series machine project for all OPC UA Safety communication connections.

   Note: The value is usually assigned automatically by *STEP 7 Safety*.

2. Use the value "0" for the SafetyBaseIDConfigured SPI parameter in the series machine project for all OPC UA Safety communication connections.

3. In the standard user program in the series machine project, program a block that generates a randomly generated value once for each OPC UA Safety communication connection during commissioning of a real machine and assigns it to the associated SAPI parameter SafetyBaseID.

   For this purpose, use the "Random", "Get_IM_Data", "RD_SYS_T" and "SHA2" instructions to ensure that the safety requirements of the OPC UA Specification OPC 10000-15 regarding randomly generated values are fulfilled.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

9.5.4.4 Changing communication partners

There are changing communication partners when, during the runtime of a Safety program,

- a SafetyProvider is to communicate with changing SafetyConsumers
- a SafetyConsumer with changing SafetyProviders

with identical data structures of the parameters SafetyData and, if applicable, NonSafetyData.

In these situations, you must pay particular attention to the correct handling of the active SafetyProviderID, SafetyBaseID, SafetyConsumerID and the Enable SAPI parameter of the SafetyConsumer.

SafetyProvider with changing SafetyConsumers

SafetyProvider:

- Specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.

  Note: The values are usually assigned automatically by *STEP 7 Safety*.

SafetyConsumer:

- Specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured. The values must match the corresponding values of the intended SafetyProvider.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter. Use different values for each SafetyConsumer.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" once the underlying OPC UA communication to the SafetyProvider has been established.
- In your safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before terminating the underlying OPC UA communication to the SafetyProvider.

SafetyConsumer with changing SafetyProviders for a known number of SafetyProviders.

The SafetyConsumer knows all possible SafetyProviders and their SafetyProviderIDConfigured and SafetyBaseIDConfigured and can determine the system state of the foreseen SafetyProvider.

SafetyProvider:

- For each SafetyProvider, specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.

  Note: The values are usually assigned automatically by *STEP 7 Safety*.

SafetyConsumer:

- Specify the value "0" for the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- Save the SafetyProviderIDConfigured and SafetyBaseIDConfigured of all possible SafetyProviders in an F-DB or Standard DB.
- On the basis of the current system state, select the value of the SafetyProviderIDConfigured of the foreseen SafetyProvider in your safety program and copy this into the variable SAFETY_PROVIDER_ID of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- On the basis of the current system state, select the value of the SafetyBaseIDConfigured of the foreseen SafetyProvider in your safety program and copy this into the variable SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if the values of the foreseen SafetyProvider are pending and the underlying OPC UA communication to the SafetyProvider has been established at the variables SAFETY_PROVIDER_ID and SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB.
- In your safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before terminating the underlying OPC UA communication to the SafetyProvider.

SafetyConsumer with changing SafetyProvider for unknown number of SafetyProviders

Not all possible SafetyProviders and their active SafetyBase ID are known to the SafetyConsumer, since, for example, additional SafetyProviders are added during running system operation.

In this case, you must use a different method (e.g. via an RFID system) to make the active SafetyBaseID of the foreseen SafetyProvider, depending on the system status, known to the SafetyConsumer.

SafetyProvider:

- Constantly and identically specify the SafetyProviderID for each SafetyProvider via the SPI parameter SafetyProviderIDConfigured.

  Note: The value is usually assigned automatically by *STEP 7 Safety*.
- For each SafetyProvider specify the SafetyBaseID analogously to the use case for series machines (Page 326). Specify the value "0" at the SPI parameter SafetyBaseIDConfigured.

SafetyConsumer:

- Constantly specify SafetyProviderIDConfigured for the SafetyProviderID via the SPI parameters. The value must match the corresponding value of the SafetyProvider setting.
- Specify the value "0" for the SPI parameter SafetyBaseIDConfigured.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- In your safety program, copy the value of the active SafetyBaseID of the intended SafetyProvider determined via the diversity path into the SAFETY_BASE_ID variable of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if the value of the foreseen SafetyProvider is pending and the underlying OPC UA communication to the SafetyProvider has been established at the variable SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB.
- Set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before closing the underlying OPC UA communication to the SafetyProvider.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

9.5.5 Avoiding connection resource bottlenecks

Note that influences on the lower-level OPC UA communication may cause extended response times. As a result, "Timeout" communication errors can occur.

In particular, use of encrypted communication can lead to significantly extended response times on low and medium performance class F-CPUs.

The following factors can also affect the response times:

- Utilization of the F-CPU
- Number of OPC UA and OPC UA Safety connections
- Number of implemented server methods
- Open user communication
- Web server
- S7 connections

Take this into account when configuring the OPC UA Safety connection.

Also refer to the *STEP 7* help under "Details on OPC UA client/server connections (https://docs.tia.siemens.cloud/r/en-us/v20/editing-devices-and-networks/configure-networks/communication-via-connections/working-with-connections/connection-resources/connection-resources-s7-1500-s7-1500/details-about-opc-ua-client/server-connections-s7-1500)".

9.5.6 Using diagnostic options when communicating with OPC UA Safety

Introduction

You have all diagnostic options of OPC UA at your disposal. For example, you can diagnose the OPC UA server of the F-CPU online with common OPC UA clients, such as UaExpert. In addition, you can access nodes in the OPC UA address space and thus on SafetyProvider or SafetyConsumer in your standard user program in order to evaluate the content for diagnostic purposes.

⚠ WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

NOTICE

Writing online access to nodes in the OPC UA address space, which have a connection to variables of your Safety program, are not permitted and can lead to a STOP of the F-CPU or to communication errors.

9.5.6.1 ReadSafetyDiagnostics

For diagnostic purposes, one OPC UA server method ReadSafetyDiagnostics is available for each SafetyProvider.

You can call the method via the OPC UA server interface. It transfers the input and output data of the last processing of the associated SafetyProvider.

More information can be found in the OPC UA Safety Specification OPC 10000-15.

9.5.6.2 SafetyConsumerType

Configuring and programming a SafetyConsumerType

In accordance with the OPC UA Safety specification OPC 10000-15 a SafetyConsumerType should be provided for each SafetyConsumer in an OPC UA information model. The SafetyConsumerType is not necessary for a functioning client-server-communication. More information can be found in the OPC UA Safety Specification OPC 10000-15.

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The following function right is available for the "SafetyAdmin" role: OPC UA server access. More information can be found in the help for *STEP 7* under "Users and roles with OPC UA function rights (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/configuring-the-opc-ua-server-s7-1500-s7-1500t/users-and-roles-with-opc-ua-function-rights-s7-1500-s7-1500t)".
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA server is activated.

Configuring and programming a SafetyConsumerType

Proceed as follows to configure and program a SafetyConsumerType. Repeat the following steps for each SafetyConsumer that you want to make available to a SafetyConsumerType.

Creating an OPC UA SafetyConsumerType information model

You create an OPC UA SafetyConsumer information model for a SafetyConsumer on the basis of a nodeset file provided by the OPC Foundation for OPC UA Safety using SiOME. To do this you have to create the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafetyProviderIDActive of the SafetyConsumerType local data mappings on the SafetyConsumer previously created in TIA Portal and transfer the SPI parameters of each SafetyConsumer manually into the information model.

You then export the OPC UA SafetyConsumerType information model created in this way to an XML file (nodeset file).

Requirements

You require the name of the F-OPC-UA-Consumer-DB (Page 319) for the local data mapping of the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafetyProviderIDActive. It is assigned automatically during the creation of a SafetyConsumer and can be modified subsequently.

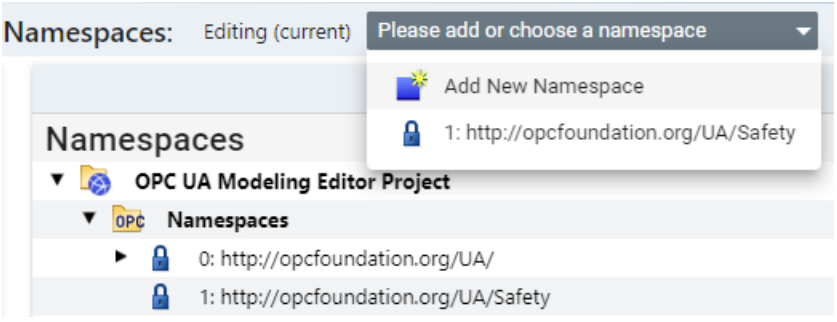
Creating an OPC UA SafetyConsumerType information model

Proceed as follows to create an OPC UA SafetyConsumerType XML file (nodeset file).

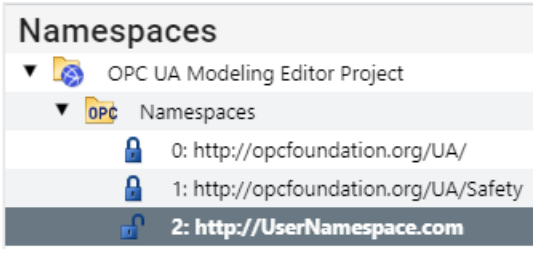
1. First, download the nodeset file "Opc.Ua.Safety.NodeSet2.xml" of the OPC UA Safety Specification V1.05.04 from the GitHub website of the OPC Foundation. You can find the download link here (https://github.com/OPCFoundation/UA-Nodeset/tree/Safety-1.05.04-2025-02-05/Safety).
   The "Opc.Ua.Safety.NodeSet2.xml" file serves as the basis for your individual nodeset file. It contains the type and method definitions you need to create an OPC UA SafetyConsumerType XML file.
2. Start SiOME.
3. First, import the namespace "http://opcfoundation.org/UA/Safety".
   To do so, click the "Import XML" button in the SiOME menu.

   SiOME displays the dialog for opening files.
4. Select the "Opc.Ua.Safety.NodeSet2.xml" file and click the "Open" button to import it.
   Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/Safety" in the "Namespaces" area.
5. Create your own namespace for your project.
   To do so, click "Add New Namespace" in the "Namespaces: Editing (current)" area in the SiOME menu.

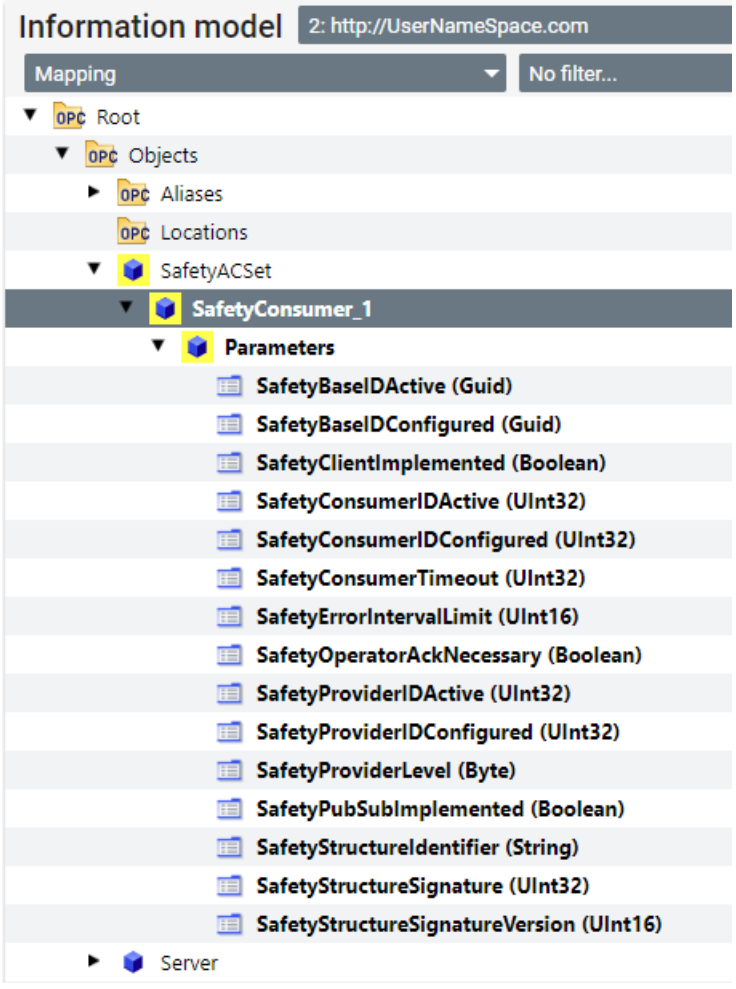
   SiOME opens the "Add Namespace" dialog.
6. Enter the name of the new namespace.
   The namespace "UserNamespace.com" is used in the example.
   SiOME additionally shows the new namespace:

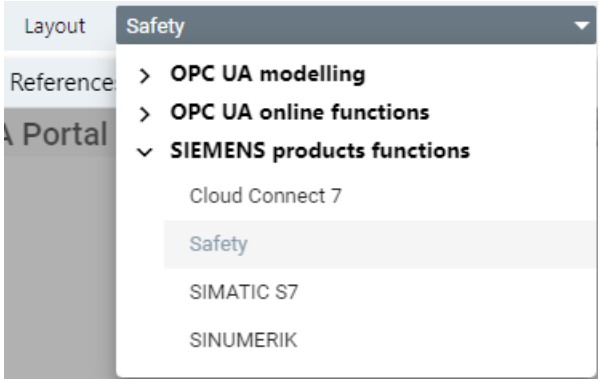
7. Create an instance from the object type "SafetyConsumerType" of the OPC UA Safety Specification.
   To do so, right-click the folder "Root/Objects/SafetyACSet" in the "Information model" area and select "Add Instance".

   NOTE
   Instances of the "SafetyConsumerType" object type must always be located in the folder "SafetyACSet".

   SiOME displays the dialog "Add Instance".
8. Enter a descriptive name for the new instance for "Name".
   The name "SafetyConsumer_1" is used in the example.
   For "TypeDefinition", select "SafetyConsumerType". You can find the type under "BaseObjectTypes/SafetyObjectsType".
9. Click "OK".
   SiOME shows the new instance "SafetyConsumer_1" under "SafetyACSet" in the "Information model" area. This instance already contains the required parameters:



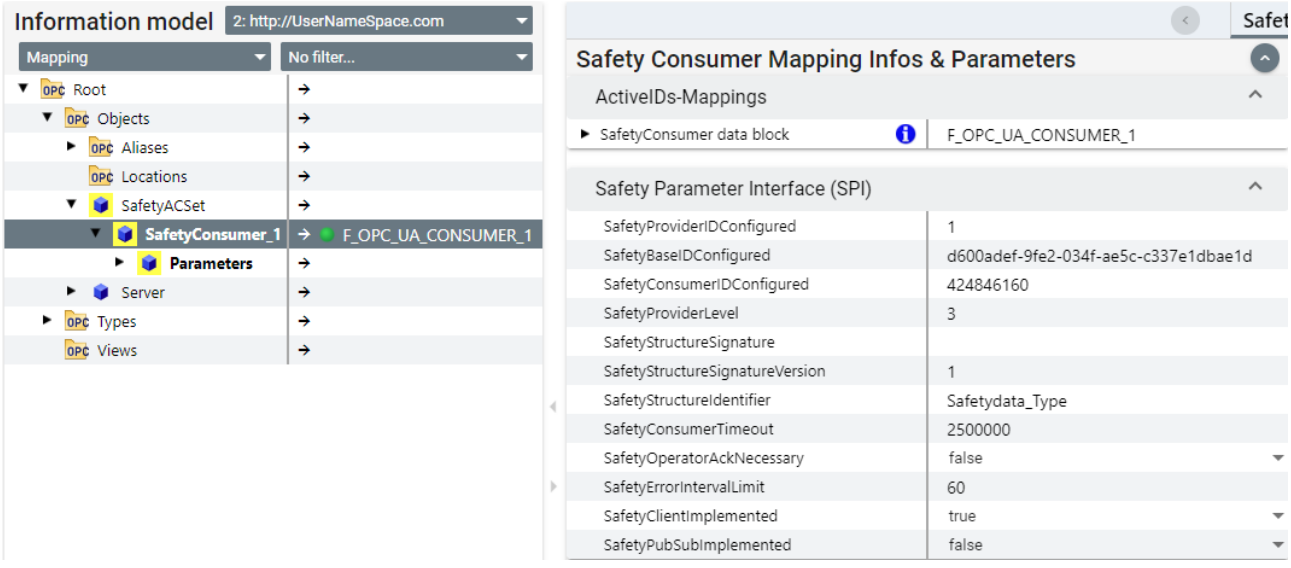
10. Select the safety layout.
    To do so, select the "Safety" layout in the SiOME menu in the "Layout" area under "SIEMENS products functions".



    SiOME now shows the "Safety Configuration" area.

11. Create the local data mapping for the ActiveIDs by entering the name of the F-OPC-UA-Consumer-DB in the designated field in the "ActiveIDs-Mappings" section.
    SiOME automatically generates the associated mappings for the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafeyProviderIDActive.

12. Optional:
    Transfer the values of the Safety Parameter Interface (SPI) from the SafetyConsumer from TIA Portal (Page 319) manually to the Safety Parameter Interface (SPI) of SiOME, so that this data can be queried via the OPC UA information model after completion of the configuration.

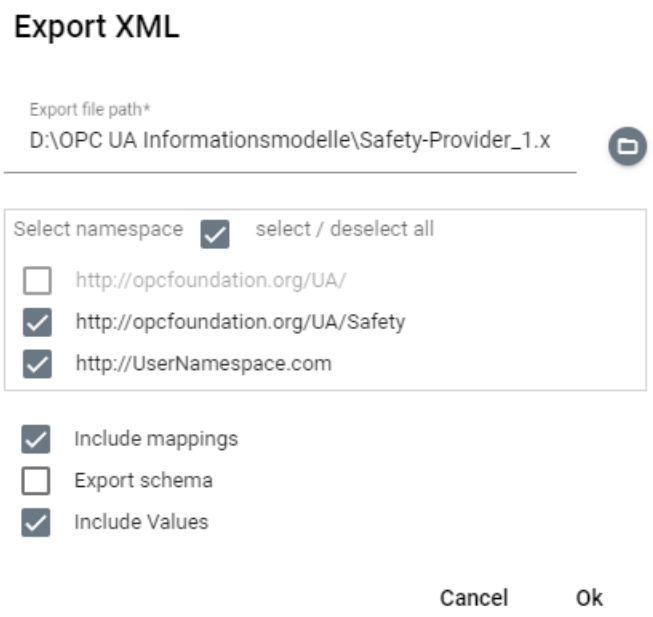


13. Export the XML file.
    To do so, click the "Export XML" button in the SiOME menu.



    SiOME displays the dialog "Export XML".
    Select the path for the export and a descriptive name for the file. The name "SafetyConsumer_1" is used in the example.

Have all namespaces activated and click "OK".



Creating a server interface for an OPC UA SafetyConsumerType information model

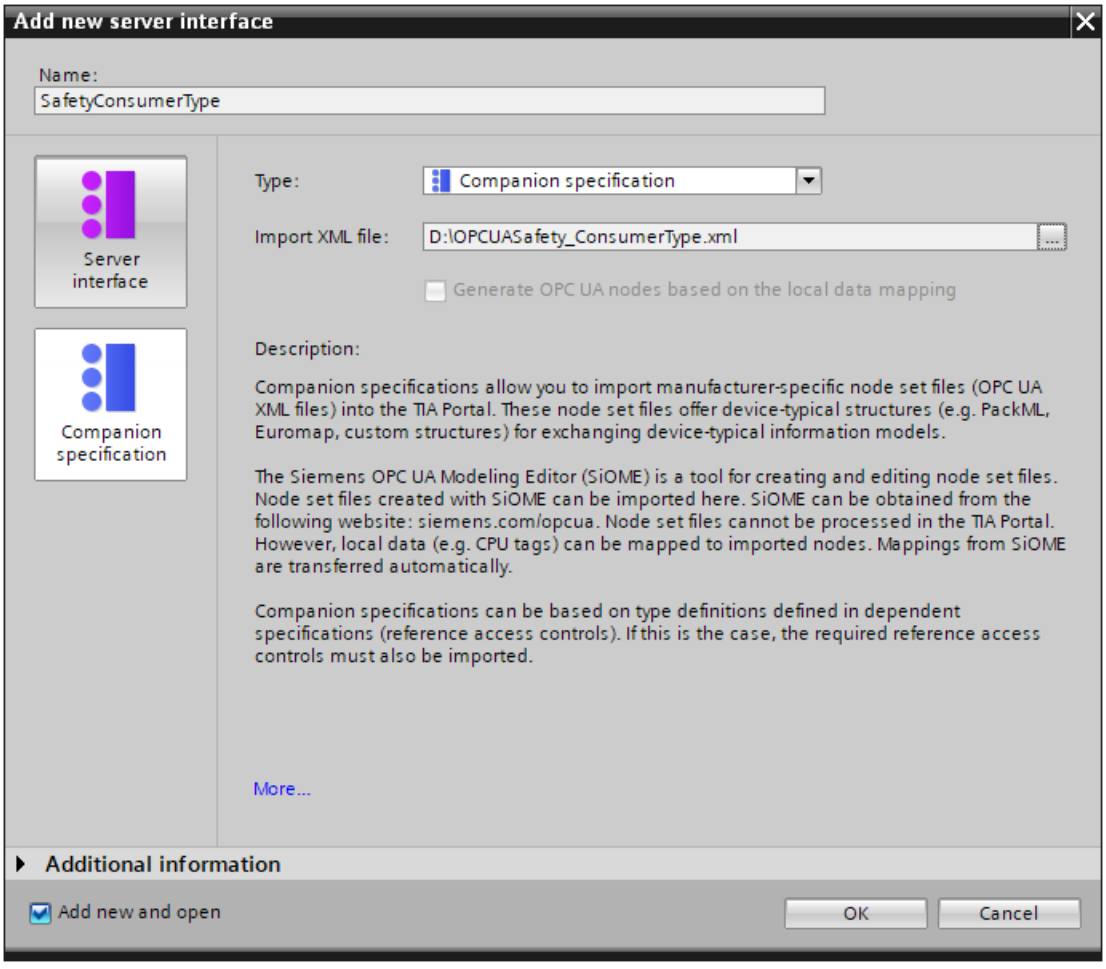
You create a server interface for an OPC UA SafetyConsumerType information model in a similar way as a server interface for a companion specification. More information can be found in the *STEP 7* help under "Creating a server interface for a companion specification".

Creating a server interface for an OPC UA SafetyConsumerType information model

Proceed as follows to create a server interface for a companion specification with *STEP 7 (TIA Portal)*:

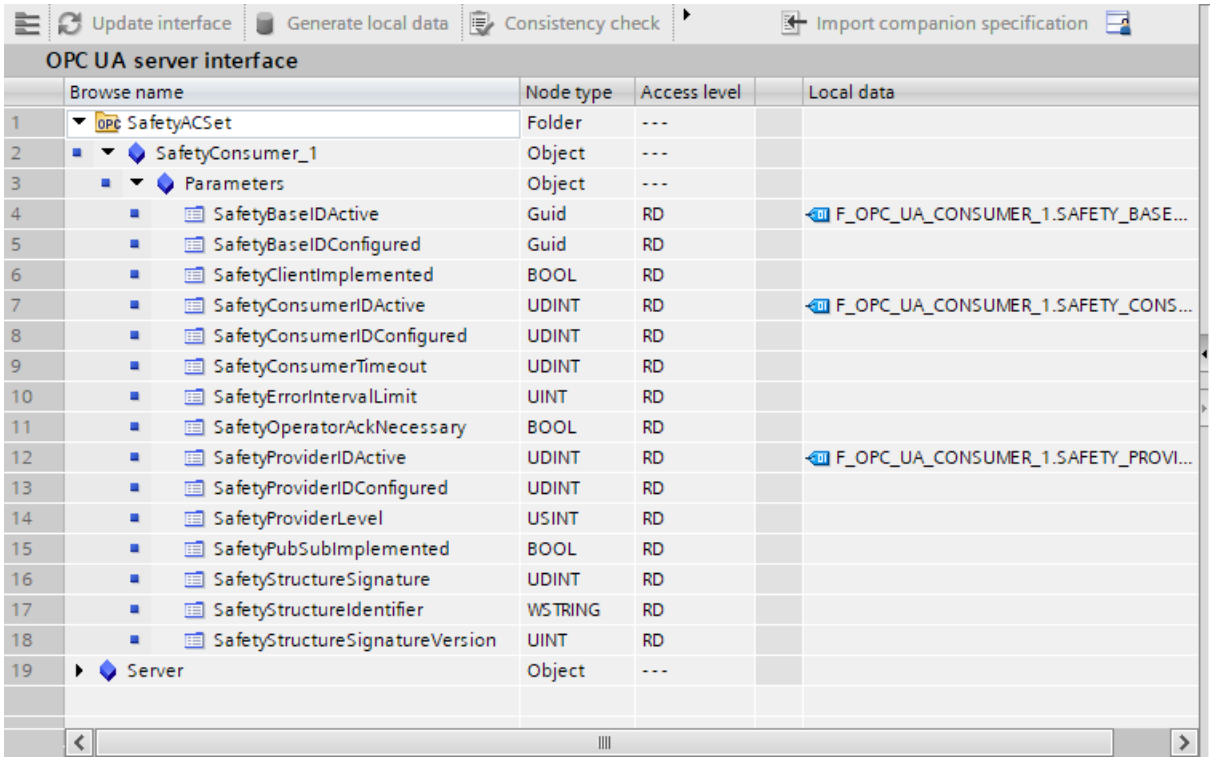
1. Select the F-CPU you are using as the OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select the type of this server interface, click the "Companion specification" button.
   A general name for the new interface, e.g. "Server_Interface_1", is entered in the dialog.

5. Change the name of the new server interface to a descriptive name in your project.
   In the example the name "SafetyConsumerType" is used.



6. In the "Import XML file" field, select the OPC UA SafetyConsumerType XML file that was created and exported in SiOME (Page 331) and contains the description of the information model for your individual data structure.

7. Click the "OK" button.
   STEP 7 (TIA Portal) imports the information model described in the selected XML file.



NOTE

You performed the mapping of your local data previously when creating your OPC UA Safety XML file in SiOME. It is not necessary to create and map further local data with the "Generate local data" button.

With this OPC UA server interface, you can request information on the associated SafetyConsumer with any OPC UA clients (e.g. UaExpert).

9.6 Communication with Flexible F-Link (S7-1200, S7-1500)

9.6.1 Flexible F-Link

Introduction

The fail-safe CPU-CPU communication "Flexible F-Link" is available for S7-1200 and S7-1500 F-CPUs. This means fail-safe data can be easily exchanged as fail-safe arrays with standard communication mechanisms between F-CPUs.

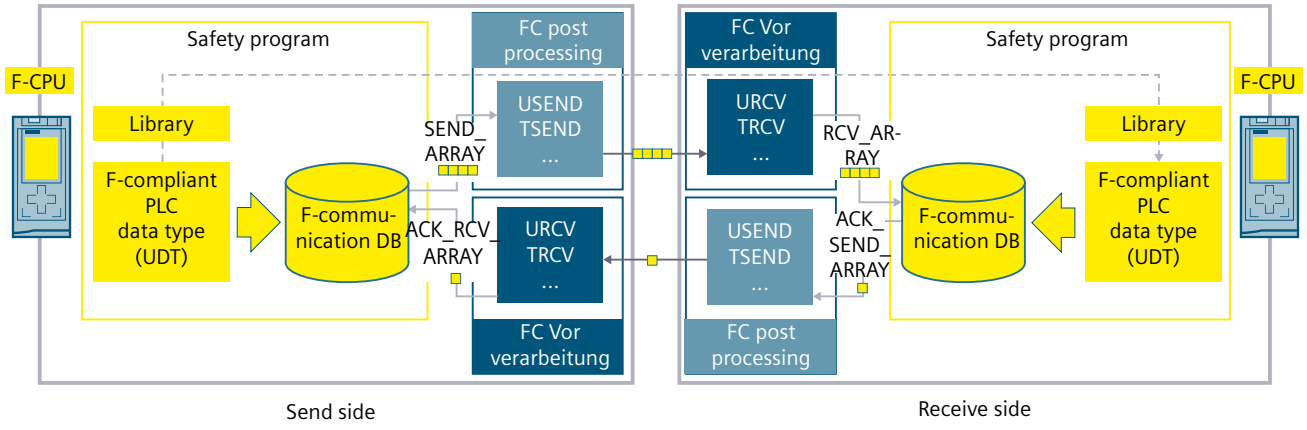
Flexible F-Link offers a series of advantages for exchanging fail-safe data:

- Collection of fail-safe data to be transmitted in F-compliant PLC data types (UDTs)
  (Nested F-compliant PLC data types (UDT) are not supported.)
- Up to 1500 bytes of fail-safe data per UDT, including a maximum of 800 elements of data type BOOL.
- Easy parameter assignment and automatic generation of fail-safe communication DBs
- Transmission of fail-safe data with standard communication blocks also across network limits
- F-runtime group communication (Page 94) for F-CPUs 1200/1500
- System-integrated and globally sufficiently unique F-communication UUID
- Separate F-communication address signature for easy detection of changes to the F-communication UUID

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- As of safety system version V2.2

Principles of communication via Flexible F-Link



Proceed as follows on the **send side**:

1. Create an F-compliant PLC data type (UDT) for the data to be sent. The size is up to 1500 bytes, including a maximum of 800 elements of data type BOOL.
2. Create safety-related communication with the "Send" direction in the *Safety Administration Editor* (Page 94).

   A new F-communication DB (Page 341) is created for the safety-related communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".
3. Set the F-monitoring time (Page 621) for the safety-related communication.
4. In the Safety program, supply the tags for the send data (SEND_DATA) in the F-communication DB (Page 341) of the safety-related communication.
5. Create standard blocks in which the fail-safe arrays created automatically in the F-communication DB are sent with the send data and received with the acknowledgment data. For processing the process values in the correct chronological order, you can make use of the F-OB Pre-/post-processing (Page 85). When using the communication instructions, ensure that the fail-safe arrays are available consistently at the time of evaluation and that the F-monitoring time (Page 621) is observed. Observe the note below.

Proceed as follows on the **receive side**:

1. Create an F-compliant PLC data type (UDT) with the same structure as on the send side.

   To do so, copy the F-compliant PLC data type (UDT) from the send side or use the project library or global library.
2. Create safety-related communication with the "Receive" direction in the *Safety Administration Editor* (Page 94).

   A new F-communication DB is created for the safety-related communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".
3. Copy the F-communication UUID of the safety-related communication from the send side.
4. Set the same F-monitoring time as for the send side.
5. In the Safety program, evaluate the tags for the receive data (RCV_DATA) at the F-communication DB (Page 341).
6. Create standard blocks in which the fail-safe arrays automatically created in the F-communication DB are received with the receive data and sent with the acknowledgment data. For processing the process values in the correct chronological order, you can make use of the F-OB Pre-/post-processing (Page 94). When using the communication instructions, ensure that the fail-safe arrays are available consistently at the time of evaluation and that the F-monitoring time (Page 621) is observed. Observe the note below.

NOTE

When using non-deterministic communication protocols (e.g. TCP/IP), you must take into account the following:

- Increased communication load can fundamentally impair the availability of your application (runtime of the F-monitoring time of the F-communication connection). This holds true especially when OPC UA and Secure Open User Communication (OUC) are used in parallel.
- Communication buffer overflows can adversely affect the availability of your application and should be avoided.
  Refer to the following application example for more helpful information: "Configuring Flexible F-Link Communication (https://support.industry.siemens.com/cs/ww/en/view/109768964)".

NOTE

The compilation time increases with increasing data frame size. The compilation times can rise significantly when the maximum frame length of 1500 bytes is fully used.

NOTE

During simulation with *S7-PLCSIM*, the time monitoring that generates an error message after expiration when communication with real communication partners is interrupted (e.g. by setting a CPU to STOP) is not activated. This is why no error message is displayed in this case.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

⚠ WARNING

If the SENDMODE tag in the F-communication DB (Page 341) is set to "1" for receiving during communication with Flexible F-Link, you can no longer assume that the data at the RCV_DATA tag is formed in a safety-related manner.
During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with SENDMODE = 1 instead of the data in the RCV_DATA tag. *(S086)*

WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

WARNING

For each communication connection via Flexible F-Link, you must check that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides when you accept the Safety program. You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

See also

F-runtime group communication (S7-1200, S7-1500) (Page 141)

9.6.2 F-communication DB (S7-1200, S7-1500)

F-communication DB for sending

The following table shows you the interface of the F-communication DB for the communication connection with the direction "Send":

Section	Name	Data type	Initial value	Description
Input	SEND_DATA	F-compliant PLC data type (UDT)	As in the F-compliant PLC data type (UDT).	User data to be sent.
	ACK_RCV_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the received raw data.
Output	ERROR	BOOL	False	Signals currently pending communication errors or communication errors not acknowledged yet at the receiver (not in the initial start). 1=Communication error
	ACTIVATE_FV	BOOL	True	Communication passivated, in the initial start (for example receiver not started), or HOST sends ACTIVATE_FV. DEVICE sends status bit: FV_ACTVATED, but no 0-values. 1=The communication uses fail-safe values

Section	Name	Data type	Initial value	Description
Output	DIAG	Byte	16#0	Error bits (Timeout or CRC error currently still pending, or communication after error not depassivated yet) Bit 3: Acknowledgement request active at the receiver Bit 4: Timeout detected Bit 6: CRC error detected
	SEND_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the raw data to be sent.
	ACK_RCV_LENGTH	UInt	0	Length information to ACK_RCV_ARRAY in bytes
	SEND_LENGTH	UInt	0	Length information to SEND_ARRAY in bytes
InOut	—	—	—	—
Static	—	—	—	—

F-communication DB for receiving

The following table shows you the interface of the F-communication DB for the communication connection with the direction "Receive":

Section	Name	Data type	Initial value	Description
Input	PASS_ON	BOOL	False	This way you can passivate the output data (output of the passivation values) 1=Enable passivation
	ACK_REI	BOOL	False	Reintegration (in case of reintegration request) by means of positive edge 1=Acknowledgment for reintegration
	RCV_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the received raw data
Output	RCV_DATA	F-compliant PLC data type (UDT)	As in the F-compliant PLC data type (UDT).	Output data (PASS_VALUES or data received).
	ERROR	BOOL	False	Signals currently pending communication errors or communication errors not acknowledged yet (not in the initial start). 1=Communication error
	PASS_OUT	BOOL	True	At PASS_OUT=1 the PASS_VALUES are output Could be: ERROR, PASS_ON, in the initial start (e.g. sender not started), or ACK_REQ is pending (error not acknowledged)
	ACK_REQ	BOOL	False	Reintegration requirement (communication stable again after error, substitute values are still output) 1=Acknowledgment request for reintegration

Section	Name	Data type	Initial value	Description
Output	SENDMODE	BOOL	False	1=The Safety program on the sender side is in disabled Safety mode or is running on an S7-PLCSIM.
	DIAG	Byte	16#0	Error bits (Timeout or CRC error) Bit 0: Timeout detected by the sender Bit 1: Communication error currently pending in the sender Bit 2: CRC error detected by the sender Bit 4: Timeout detected by the receiver Bit 6: CRC error detected by the receiver
	ACK_SEND_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the raw data to be sent.
	RCV_LENGTH	UInt	0	Length information of RCV_ARRAY in bytes
	ACK_SEND_LENGTH	UInt	0	Length information of ACK_SEND_ARRAY in bytes
InOut	—	—	—	—
Static	PASS_VALUES	F-compliant PLC data type (UDT)	Same as the F-compliant PLC data type (UDT) or in the I/O DB	Passivation or substitute values

Compiling and commissioning a safety program 10

10.1 Compiling the safety program

To get a consistent Safety program, follow these steps:

1. Select the "Program blocks" folder or the Safety Unit folder or a higher level.
2. Start the compile.

   To do this, proceed essentially in the same way as when compiling a standard user program. You can start at various points to accomplish this in *STEP 7*. The basics for compiling user programs can be found in the *Help on STEP 7*.

NOTE

Please note that following a safety-related change to the hardware configuration that not only this, but also the Safety program has to be recompiled and downloaded. This also applies for changes to the F-I/O which are not used in the Safety program.

NOTE

The following applies for S7-300/400 F-CPUs:
If you want to compile a know-how-protected F-block after a change, you must remove the know-how protection for this F-block before compiling.

Reporting compiling errors

You can recognize whether or not the compilation was successful based on the message in the inspector window under "Info > Compile", error messages and warnings are output.

For information on the procedure you must follow to eliminate compiling errors, see "Eliminating compiling errors" in the *Help on STEP 7*.

10.2 Safety program work memory requirements (S7-300, S7-400)

Estimation

You can estimate the work memory requirement for the safety program as follows:

Work memory required for the safety program

32 KB for F-system blocks
+ 4.4 KB for safety-related communication between F-runtime groups
+ 4.5 x work memory requirement for all F-FB/F-FCs/main safety blocks

+ 4.5 x work memory requirement of all utilized instructions, which are shown in the "Instructions" task card with the block icon.
(except SENDDP, RCVDP, SENDS7, and RCVS7)
+ Work memory requirement of the utilized SENDDP and RCVDP instructions (4.3 KB each)
+ Work memory requirement of the utilized SENDS7 and RCVS7 instructions (8.5 KB each)

Work memory required for data

5 x work memory requirement for all F-DBs (including F-communication DB, but excluding DB for F-runtime group communication) and I-DBs for main safety block/F-FB

+ 24 x work memory requirement for all DBs for F-runtime group communication
+ 2.3 x work memory requirement for all I-DBs of instructions (except SENDDP, RCVDP, SENDS7 and RCVS7)
+ Work memory requirement of all I-DBs of instructions SENDDP (0.2 KB), RCVDP(0.3 KB), SENDS7 (0.6 KB), and RCVS7 (1.0 KB)
+ 0.7 KB per F-FC
+ 0.7 KB per F-I/O (for F-I/O DBs, etc.)
+ 4.5 KB

Block size of automatically generated F-blocks

Do not utilize the entire maximum size of an F-block, because the automatically generated F-blocks are larger and as a result, the maximum possible size may be exceeded in the F-CPU. If the block size is exceeded, this triggers a corresponding error message with information on which F-blocks are too large. These must be divided up, if necessary.

10.3 Downloading project data

Introduction

Once you have successfully compiled your safety program, you can download it together with the standard application program to the F-CPU.

(S7-1500) If the safety program is in a Safety Unit, you can load the Safety Unit independently into the F-CPU.

To download a safety program, you follow essentially the same approach as for downloading a standard user program, via different starting points in *STEP 7*.

- In the "Load preview" dialog, enter data (e.g. password for the F-CPU) and set the requirements for downloading (e.g. that the F-CPU is switched to STOP mode before downloading).
- The "Load results" dialog shows the results after loading.

We will show you the options for downloading the safety program later. For basic information on downloading, refer to the *Help on STEP 7*.

Rules for downloading the project data into an F-CPU

⚠ WARNING

(S7-300, S7-400) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by **the same programming device or PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU:
Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.
Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety-related project data to an F-CPU, existing access permission for any other F-CPU must first be cancelled.
- The last download of the safety-related project data prior to switching to productive operation must be made with enabled access protection. *(S021)*

⚠ WARNING

(S7-1200, S7-1500) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by the **same PG/PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU or that safety mode is deactivated in the correct F-CPU:

- Enter the serial number of the specific F-CPU in the *Safety Administration Editor*.

Depending on the respective CPU type (see documentation of the CPU), you have several possibilities for determining the serial number of an F-CPU:

- Print of the serial number on the housing of the F-CPU.
- Scanning of the ID link on the F-CPU.
- Display of the F-CPU
- Web server*
- Industrial Edge application user interface under /SIMATIC_MC/system/serialno* and via the UI or API of the Industrial Edge application
- TIA Portal (I&M data)*

Note the following when downloading:

- If the "Load preview" window does not contain a warning, the connection to the correct F-CPU has been established. You can confirm the download of the safety-related project data without an additional check.
- If a serial number has not yet been entered in the *Safety Administration Editor* or if the connected F-CPU has a different serial number, check the proposed serial number of the F-CPU in the "Load preview" window or "Disable safety mode" window. If you determine an error, cancel the download or the disabling of safety mode. Otherwise, you can confirm the procedure.
- When the serial number is confirmed (online), it is always applied in the *Safety Administration Editor* and any existing entry is overwritten.
  (S099)

* To make use of these possibilities, you must ensure a connection to the expected F-CPU. You achieve this through:

- A point-to-point connection to the respective F-CPU
- Verification of the flashing of the F-CPU after selecting the "Flash LED" check box in the online and diagnostics view of the F-CPU.
- Unplugging the network cable to the respective F-CPU
- For an S7-1500 F Virtual Controller, a unique connection can be achieved by a targeted switch to STOP of the Industrial Edge application.

NOTE

You can perform the downloading of a consistent safety program only in STOP mode.

NOTE

If *STEP 7 Safety* detects an inconsistent safety program during startup of the F-CPU, the F-CPU startup is prevented, provided the F-CPU supports this detection. (see product information for the respective S7-300/400 F-CPU. This is always supported with S7-1200/1500 F-CPUs.) A corresponding diagnostics event is entered in the diagnostics buffer of the F-CPU.
If the F-CPU does not support this detection function, the F-CPU can go to STOP mode if an inconsistent safety program is executed in activated safety mode.
The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

When downloading the safety program, ensure that the "Consistent download" action is set for the "Safety program" selection in the "Load preview" dialog.

Inconsistent downloading is only possible in disabled safety mode.

Password prompt before downloading to an F-CPU

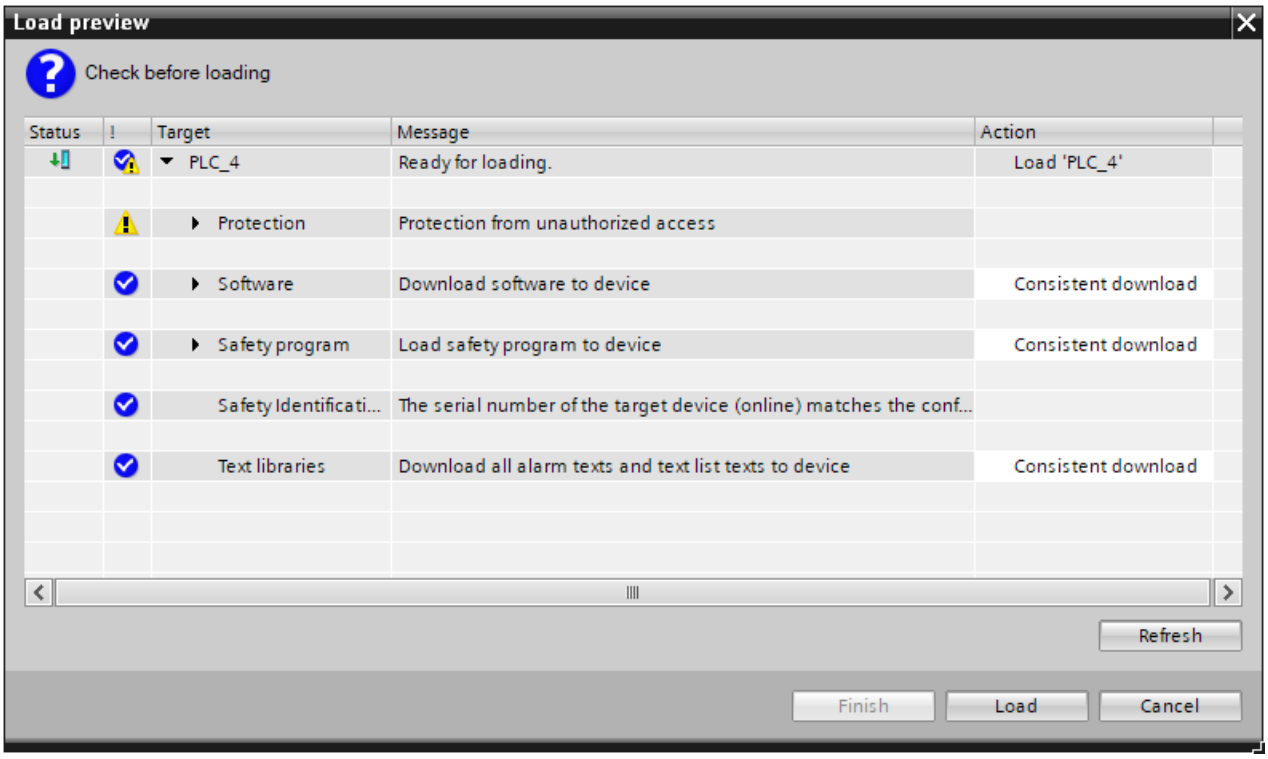
Before the download or, at the latest, during the download (in the "Load preview" dialog), you must gain access permission (Page 100) through legitimation with a user with F-right.

Check of serial number before the download to an S7-1200/1500 F-CPU

Before loading, the serial number of the F-CPU to be loaded is compared with the serial number entered in the *Safety Administration Editor*. If the serial numbers match, you can continue loading. If the serial numbers do not match or no serial number was entered in the *Safety Administration Editor*, you must check whether the serial number of the expected F-CPU is shown. If this is the case, confirm this with a check box in the "Load preview" dialog. The serial number is entered in the *Safety Administration Editor* for subsequent load processes.

"Load preview" dialog

For an F-CPU, the "Load preview" dialog also contains the section "Safety program".



Make the following selection:

- In order to download a consistent safety program, select the "Consistent download" action under target "Safety program".
- (S7-300, S7-400) To download individual F-blocks selectively (Page 351), select the "Download selection" action under the target "Safety program", and then select the required F-blocks. If necessary, you will be prompted to disable safety mode under "Disable safety mode". This setting is only suitable for the online test of individual F-blocks.
- (S7-300, S7-400) In order to download the safety program only, select the "Consistent download" action under target "Safety program" and the "Download selection" action under target" Standard software", and then select only the standard blocks that call the main safety block.
- (S7-300, S7-400) To download no safety program, for example, because you do not know the password of the F-CPU, select the "No action" action under target "Safety program".

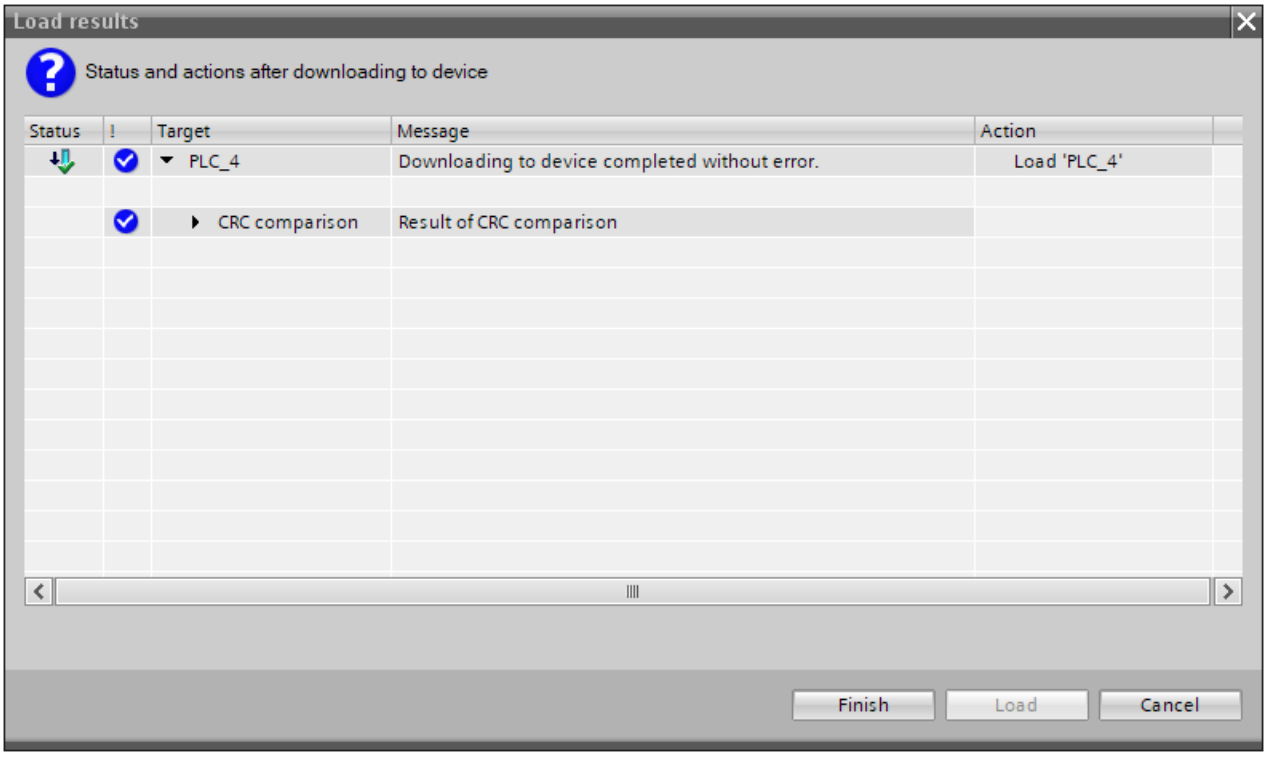
For S7-1200/1500 F-CPUs, only the "Consistent download" value is possible as an action in the "Load preview" dialog. You cannot change the selection of program parts to be loaded in this dialog. The selection is made automatically based on the selection in the project tree when starting the loading process.

NOTE

If the function "Security Logging" is activated, the event "Download fail-safe program to a CPU" is entered as a log entry during the download.
For more information on the "Security Logging" function and its activation, refer to the help on STEP 7 under "Using Security Logging".

Dialog "Load results"

After downloading into the F-CPU, the dialog "Load results" is opened. This dialog shows you the status and the necessary actions after downloading.



Verify that the "Downloading to device completed without error" message appears in the "Load results" dialog. If not, repeat the download operation.

10.3.1 Downloading project data to an S7-300/400 F-CPU

10.3.1.1 Downloading project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro memory card or flash card)

When you download project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro Memory Card for S7-300 or flash card for S7-400), you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that no "old" safety-related project data is stored in the F-CPUs:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline).
- Perform a memory reset of the F-CPU using the mode switch or via the PG/PC. During the reset, after the work memory has been deleted, the project data is again transferred from the load memory (memory card, SIMATIC Micro Memory Card for S7-300 F-CPUs, flash card for S7-400 F-CPUs) to the work memory. *(S022)*

10.3.1.2 Downloading project data to an S7-400 F-CPU without flash card inserted

When you download project data to an S7-400 F-CPU without flash card inserted, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Perform a memory reset of the F-CPU using the **mode switch** or via the **PG/PC**.
- Download the safety-related project data to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S023)*

10.3.1.3 Downloading individual F-blocks to an S7-300/400 F-CPU

Download F-blocks in disabled safety mode.

You can download F-blocks and standard blocks simultaneously to the F-CPU via the project tree. However, as soon as F-blocks are to be downloaded, a check is carried out to determine whether or not the F-CPU is in STOP mode or disabled safety mode. If not, you have the option of switching to disabled safety mode or placing the F-CPU in STOP mode.

If you want to load individual F-blocks into the F-CPU, e.g. to test changes, make sure that you have not selected the "Program blocks" folder or the F-CPU in the project navigation, but only the blocks to be loaded.

Only then will you be prompted in the "Load preview" dialog to disable Safety mode once you have changed the option from "Consistent download" to "Download selection" and have changed the option "Stop modules" to "No action".

If you fail to observe this prompt, the blocks will be downloaded without disabling safety mode, which can lead to STOP of the F-CPU.

You can also deactivate the safety mode explicitly in the *Safety Administration Editor* before you start the download.

Be aware that the consistency of the safety program in the F-CPU cannot be guaranteed when individual F-blocks are downloaded. For a consistent safety program, always download the entire safety program to the F-CPU.

Rules for downloading individual F-blocks

The following rules apply to downloading of individual F-blocks:

- Downloading is only possible in disabled safety mode or when the F-CPU is in STOP mode.
- F-blocks can only be downloaded to an F-CPU to which a safety program has already been downloaded.

Consequently, you have to download the entire safety program when initially downloading the safety program and after changing the password for the safety program.

NOTE

If you are downloading F-blocks only, the blocks in which the main safety blocks are called (e.g., cyclic interrupt OB 35) are not downloaded. To do so, select the "Selection" option under "Standard software" in the preview dialog, and select the necessary blocks.

NOTE

Downloading of individual F-blocks is only suitable for testing F-blocks. Prior to the transition to productive mode, you must download the safety program consistently to the F-CPU.

10.3.1.4 Downloading project data to a memory card and inserting at an F-CPU S7-300/400

Follow the same procedure as for a standard CPU to load project data of an F-CPU to a memory card (flash card for S7-400, SIMATIC Micro Memory Card for S7-300) or save it to a file folder. You must also observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.
Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a memory card (flash card for S7-400 or SIMATIC Micro Memory Card for S7-300) with project data of an F-CPU, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 378) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

When you insert a memory card (flash card for S7-400 or SIMATIC Micro Memory Card for S7-300) into S7-300/400 F-CPUs, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when inserting the memory card to ensure that no "old" safety-related project data is stored in the F-CPUs:

- Switch off the power to the F-CPU. For F-CPUs with battery backup (e.g. CPU 416F-2), remove any battery. (To ensure that the F-CPU is de-energized, wait for the buffer time of the power supply you are using or, if this is not known, remove the F-CPU.)
- Remove the memory card with the old safety-related project data from the F-CPU.
- Insert the memory card with the new safety-related project data into the F-CPU.
- Switch on the F-CPU again and reinsert the battery, if it was removed.

(S026)

10.3.2 Downloading project data into an F-CPU S7-1200

10.3.2.1 Downloading project data to an S7-1200 F-CPU without program card inserted

When you download project data to an S7-1200 F-CPU without program card inserted, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 378). *(S042)*

10.3.2.2 Downloading project data to an S7-1200 F-CPU with program card inserted

When you download project data to an S7-1200 F-CPU G2 with program card inserted, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 F-CPU G2:

1. Check whether the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup **when the card slot is empty.** If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as external load memory), step 3 is skipped and you can skip step 5.
2. Insert the program card into the F-CPU.
   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If the internal load memory contains project data, **the STOP/RUN LED (yellow) and the maintenance LED must flash after the restart**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 5 can be skipped.
   Use one of the following variants to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Remove and insert the program card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then performs a restart.
4. After the restart, the program card is evaluated. The F-CPU then enters the startup mode (RUN or STOP) that was set up for the F-CPU (variant 1 of step 3) or remains in STOP (variant 2 or 3 of step 3 or if step 3 is skipped because the internal load memory was empty).
5. Perform a program identification. *(S106)*

When you download project data to an S7-1200 F-CPU G1 with program card inserted, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 G1 F-CPU:

1. Check to see whether **the STOP/RUN LED (yellow) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as external load memory) and you can skip steps 3 and 5.
2. Insert the program card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program card has to be evaluated or that the internal load memory has to be deleted.
3. Use one of the following methods to delete the internal load memory:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (no longer contains any "old" safety-related project data) and step 5 can be skipped.
4. Use one of the following methods to trigger evaluation of the program card on the F-CPU:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.
   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S061)*
5. Perform a program identification.

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Yellow/Green	ERROR Red	MAINT Yellow
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (yellow) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

When you download project data to an S7-1200 F-CPU with program card inserted, you must observe the following warning:

⚠ WARNING

If you use a programming device/PC to download F-blocks to an S7-1200 F-CPU with inserted program card (external load memory), you must ensure that the transfer takes place to the external load memory. This can be accomplished by the following measure:

- Insert a program card whose memory size is different from the size of the internal load memory. Check in the project tree under "Online & Diagnostics > Diagnostics > Memory" if the memory size displayed for the load memory matches the memory size of the program card. *(S058)*

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 378). *(S042)*

10.3.2.3 Loading project data of an F-CPU S7-1200 with a transfer card into the internal load memory

When you insert a transfer card into an S7-1200 F-CPU G2, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory when you copy the safety-related project data to an S7-1200 F-CPU G2 using a transfer card:

1. Check whether the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup **when the card slot is empty.** If this is the case, the internal load memory of the F-CPU has already been deleted, step 3 is skipped and you can skip step 7.
2. Insert the transfer card into the F-CPU.
   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If the internal load memory contains project data, **the STOP/RUN LED (yellow) and the maintenance LED must flash after the restart**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 7 can be skipped.
   Use one of the following variants to evaluate the transfer card (transfer from the transfer card to the internal load memory):
   - Turn the F-CPU off and back on.
   - Remove and insert the transfer card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then performs a restart.
4. After restart of the F-CPU and evaluation of the SIMATIC Memory Card, the F-CPU copies the project data to the internal load memory of the F-CPU. Once the copy process is complete, the maintenance LED on the F-CPU is flashing to indicate that you can remove the transfer card.
5. Remove the transfer card from the F-CPU. The F-CPU then performs an automatic restart.
6. The F-CPU remains in STOP after the restart.
7. Perform a program identification. *(S105)*

When you insert a transfer card into an S7-1200 F-CPU G1, you must observe the following warning:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory when you copy the safety-related project data to an S7-1200 F-CPU G1 using a transfer card:

1. Check whether **the STOP/RUN LED (yellow) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted and you can skip steps 3 and 6.
2. Insert the transfer card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the transfer card has to be evaluated or that the internal load memory has to be deleted.
3. Use one of the following methods to delete the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (no longer contains any "old" safety-related project data) and step 6 can be skipped.
4. Use one of the following methods to evaluate the transfer card (transfer from the transfer card to the internal load memory):
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and evaluation of the SIMATIC Memory Card, the F-CPU copies the project data to the internal load memory of the F-CPU. Once the copy process is complete, the maintenance LED on the F-CPU is flashing to indicate that you can remove the transfer card.
5. Remove the transfer card from the F-CPU.
6. Perform a program identification.
7. Use one of the following methods to initiate evaluation of the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S059)*

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Yellow/Green	ERROR Red	MAINT Yellow
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (yellow) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

When you want to update the project data on an S7-1200 F-CPU using a transfer card, you must observe the following warning:

WARNING

If you run an update of the safety-related project data on an S7-1200 F-CPU using a transfer card, you must ensure that the transfer to the internal load memory took place correctly by means of a subsequent program identification (Page 378). *(S060)*

10.3.2.4 Downloading project data of an S7-1200 F-CPU from the internal load memory to an empty SIMATIC Memory Card

When you download project data from the internal load memory of an S7-1200 F-CPU G2 to an empty SIMATIC Memory Card, you must observe the following warning:

⚠ WARNING

To ensure that the safety program is downloaded from the internal load memory of the F-CPU to the SIMATIC Memory Card when plugging an empty SIMATIC Memory Card into an S7-1200 F-CPU G2 and that the internal load memory of the F-CPU is deleted afterward, you must observe the following procedure:

1. Make sure that you are using an empty SIMATIC Memory Card, for example, by checking in the Windows Explorer that the "SIMATIC.S7S" folder and the "S7_JOB.S7S" file are deleted.
2. Insert the empty SIMATIC Memory Card into the F-CPU.
   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If copying the project data from the internal to the external load memory is permitted, this will be performed automatically after the restart. The internal load memory is then deleted (therefore no longer contains any "old" safety-related project data) and **the STOP/RUN LED (yellow) and the maintenance LED must flash**. The SIMATIC Memory Card is now a program card. If copying the project data is not permitted, the error LED flashes and the project data remains in the internal load memory.
4. Use one of the following variants to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Remove and insert the program card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.
   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU (variant 1) or remains in STOP (variant 2 or 3). *(S107)*

When you download project data from the internal load memory of an S7-1200 F-CPU G1 to an empty SIMATIC Memory Card, you must observe the following warning:

⚠ WARNING

To ensure that the safety-related project data is transferred from the internal load memory of the F-CPU to the SIMATIC Memory Card when plugging an empty SIMATIC Memory Card into an S7-1200 F-CPU G1 and that the internal load memory of the F-CPU is deleted afterward, you must observe the following procedure:

1. Make sure that you are using an empty SIMATIC Memory Card, for example, by checking in the Windows Explorer that the "SIMATIC.S7S" folder and the "S7_JOB.S7S" file are deleted.
2. Insert the empty SIMATIC Memory Card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program can be copied from the internal load memory to the SIMATIC Memory Card and that the internal load memory is deleted afterward.
3. Use one of these methods to trigger copying from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and copying of the project data from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must flash**. In this case, the internal load memory of the F-CPU is deleted and no longer contains any safety-related project data. The SIMATIC Memory Card is now a program card.
4. Use one of the following methods to trigger evaluation of the program card on the F-CPU:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.
   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S057)*

NOTE

Also observe the setting "Disable copying from internal load memory to external load memory" in the hardware configuration of your F-CPU.

10.3.2.5 Downloading project data to a SIMATIC Memory Card and inserting it at an F-CPU S7-1200

When loading project data of an F-CPU to a SIMATIC Memory Card or saving it to a file folder, follow the same procedure as for a standard CPU. You must also observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.
Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a SIMATIC Memory Card with project data from an F-CPU, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 378) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

10.3.3 Downloading project data to an S7-1500 F-CPU

10.3.3.1 Downloading project data to an S7-1500 F-CPU

When you download project data to an S7-1500 F-CPU, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 378). *(S042)*

10.3.3.2 Downloading project data into a redundant S7-1500HF system

With a redundant S7-1500HF system, a consistent safety program can only be downloaded in STOP mode of the redundant S7-1500HF system.

To do this, you must heed one of the following warnings:

- Loading the redundant S7-1500HF system in STOP.

⚠ WARNING

If the function test of the safety program is not performed in the redundant destination system S7-1500HF, you must adhere to the following procedure when downloading the safety-related project data to the HF-CPUs with a PG/PC. This way you ensure that no "old" safety-related project data is stored in the HF-CPUs:

1. Switch the two HF-CPUs to STOP.
2. If you did not program restart/startup protection in your previous safety program (Programming startup protection (Page 150)), you must format the SIMATIC Memory Card or delete the program, for example, via the display for both HF-CPUs.
3. Download the safety-related project data to one of the two HF-CPUs.
4. Switch the HF-CPU, to which you have downloaded the new safety-related project data, to RUN mode.
5. Switch the second HF-CPU to RUN mode.
6. As soon as the RUN-Redundant mode is reached, perform a program identification on one of the two HF-CPUs (i.e. check whether the Collective F-Signatures match online and offline).
   If you have programmed restart/startup protection in your new safety program, you may only acknowledge this after successful program identification.*(S090)*

- Loading the redundant S7-1500HF system with reduced STOP time.

⚠ WARNING

If the function test of the safety program is not performed in the redundant destination system S7-1500HF, you must adhere to the following procedure when downloading the safety-related project data to the HF-CPUs with a PG/PC. This way you ensure that no "old" safety-related project data is stored in the HF-CPUs:

1. Switch one of the two HF-CPUs to STOP.
2. If you did not program restart/startup protection in your previous safety program (Programming startup protection (Page 150)), you must format the SIMATIC Memory Card or delete the program, for example, via the display for the HF-CPU in STOP mode.
3. Download the safety-related project data to the HF-CPU, which is in STOP mode (to the backup CPU with the context menu command "Load into backup CPU").
4. Switch the HF-CPU that is still in RUN mode to STOP mode.
5. If you did not program restart/startup protection in your previous safety program, you must format the SIMATIC Memory Card or delete the program, for example, via the display for the HF-CPU recently switched in STOP mode.
6. Switch the HF-CPU with the newly downloaded safety-related project data to RUN mode.
7. Switch the second HF-CPU to RUN mode.
8. As soon as the RUN-Redundant mode is reached, perform a program identification on one of the two HF-CPUs (i.e. check whether the Collective F-Signatures match online and offline).
   If you have programmed restart/startup protection in your new safety program, you may only acknowledge this after successful program identification. *(S091)*

10.3.3.3 Downloading project data to an S7-1500 F Software Controller

When you download project data to an S7-1500 F Software Controller, you must observe the following warnings:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 378). *(S042)*

The following warning applies to an S7-1500 F Software Controller with firmware ≤ V21.9.x on an IPC 627E, IPC 647E, IPC 677E, or IPC 847E:

⚠ WARNING

When you download the safety program, you must perform a POWER OFF/POWER ON afterwards before you run a program identification for acceptance. *(S097)*

The following warning applies to an S7-1500 F Software Controller with firmware < V30.1

⚠ WARNING

For safety reasons, the password of an S7-1500 F Software Controller is stored in a separate memory in addition to the load memory.
Unlike the load memory, this separate memory is not deleted. This means the previous passwords are once again active after deleting the S7-1500 F Software Controller followed by a start-up.
For this reason, note the following:

- The S7-1500 F Software Controller is deleted in case of the following download scenarios of the PC station:
  - Downloading a PC station with revised interface assignment.
  - Downloading a PC station with revised storage location for retentive data.
- We recommend that you do not set up F-access protection until after commissioning. If you still have to change the interface assignment of the PC station or the storage location for retentive data, you do not have to enter the F-password during the subsequent mandatory download of the S7-1500 F Software Controller.
- We recommend that you remove the F-access protection from an S7-1500 F Software Controller that is no longer in use. If you use the S7-1500 F Software Controller later and don't remember the password, the F-password can only be removed by performing an uninstall/install/repair, installing an image file or importing a configuration file. *(S076)*

See also

Downloading project data (Page 345)
Software Controller (https://support.industry.siemens.com/cs/ww/en/view/109249299)

10.3.3.4 Downloading project data to a SIMATIC Memory Card or removable storage device and inserting it into an F-CPU S7-1500

When loading project data of an (H)F-CPU to a SIMATIC Memory Card or saving it to a file folder, follow the same procedure as for a standard CPU. You must also observe the following warning:

⚠ WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.
Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a SIMATIC Memory Card or an S7-1500 F Software Controller removable disk with project data of an (H)F-CPU, you must observe the following warning:

⚠ WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 378) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

Inserting SIMATIC Memory Cards in a redundant S7-1500HF system

⚠ WARNING

When inserting **two** new SIMATIC Memory Cards with new safety-related project data for a redundant S7-1500HF system, proceed as follows:

1. Switch the two HF-CPUs to STOP.
2. Replace the SIMATIC Memory Cards of both HF-CPUs with
   - Two SIMATIC Memory Cards, each with the new safety-related project data, or
   - One SIMATIC Memory Card with the new safety-related project data and one empty SIMATIC Memory Card

Procedure for ensuring correct safety-related project data through program identification:

1. Check on both HF CPUs in STOP mode, e.g. via the display, whether the correct safety-related project data is located on the SIMATIC Memory Card and that the second SIMATIC Memory Card is empty.
2. After a successful check, switch the HF-CPUs to RUN mode. If the new safety-related project data is only available on one SIMATIC Memory Card, you must first switch the HF-CPU with the new safety-related project data to RUN mode and then the HF-CPU with the empty SIMATIC Memory Card.

Procedure when it is ensured with clear identifiers that the correct safety-related project data is stored on the SIMATIC Memory Cards:

1. Switch the F-CPUs to RUN mode. If the new safety-related project data is only available on one SIMATIC Memory Card, you must first switch the HF-CPU with the new safety-related project data to RUN mode and then the HF-CPU with the empty SIMATIC Memory Card. *(S092)*

⚠ WARNING

When inserting **one** new SIMATIC Memory Card with new safety-related project data for a redundant S7-1500HF system, proceed as follows:

1. Switch the two HF-CPUs to STOP.
2. Remove the SIMATIC Memory Card on one of the two HF-CPUs.
3. Format the SIMATIC Memory Card or delete the program, for example via the display, for the HF-CPU that you did not remove.
4. Insert the SIMATIC memory card with the new safety-related project data into the HF-CPU without SIMATIC Memory Card.
5. If you cannot ensure by other suitable measures (e.g. by clear labeling of the SIMATIC Memory Card) that the correct safety-related project data is located on the SIMATIC Memory Card, you have to carry out a program identification on the HF-CPU with the new safety-related project data.
6. Switch the HF-CPU with the new safety-related project data to RUN mode.
7. Switch the second HF-CPU to RUN mode. *(S093)*

10.3.4 Restoring a backup of the safety program to an F-CPU

You have the option of backing up an F-CPU in the same way as a standard CPU and then restoring it. You can find information on backing up a CPU in the *help on STEP 7* under "Creating a backup of an S7-CPU". Saving an F-CPU S7-400 is only possible with an inserted flash card.

Note the following warnings when restoring the software and hardware configuration of an F-CPU:

⚠ WARNING

Once you have restored a backup of an F-CPU, you must perform a program identification (Page 378).
In a redundant S7-1500HF system, you must perform the program identification (Page 378) in RUN-Redundant mode. *(S055)*

NOTE

We recommend that you use the Collective F-Signature that is included in the name of the backup file for program identification. You must not change the Collective F-Signature in the name in this case.

⚠ WARNING

(S7-1200 G1, S7-1200 G2 as of FW 4.1, S7-1500) If several F-CPUs with activated web server can be accessed from a PG/PC, you must ensure through additional measures that the safety program is restored in the correct F-CPU when safety-relevant project data is restored via the web server. Use unique identifiers for this, such as the Collective F-Signature, serial number, station name or plant designation. *(S065)*

NOTE

When restoring, you must enter the previous password for the F-CPU.

10.3.5 Specifics on creating and installing an image file of an S7-1500 F Software Controller

Creating an image file

⚠ WARNING

When creating image files (for example, of an image) with safety-related project data, you must comply with the following points:

- You must take organizational measures to limit access to an S7-1500 F Software Controller to persons who are authorized to create image files.
- Before creating an image file, you must ensure through program identification (Page 378) that the correct safety-related project data is located in the S7-1500 F Software Controller.
- Image files with safety-related project data must be created on an empty data storage medium (deleted or formatted). Existing image files on a data storage medium or in a file system must be explicitly deleted; you are not permitted to overwrite an existing image file.
- After creating the image file, remove the data storage medium containing the image file or remove the image file from the file system.
- Clearly label the data storage medium or image file (e.g. with the Collective F-Signature). *(S073)*

Installing an image file

⚠ WARNING

When installing an image file (for example, of an image) with safety-related project data, you must comply with the following points:

- You must take organizational measures to limit access to an S7-1500 F Software Controller to persons who are authorized to install image files.
- When installing an image file via LAN, remote access or comparable access, you must ensure access protection (for example, using Windows administrator rights (ADMIN) or the Linux root user). Note, however, that only authorized persons are set up as users.
- To ensure that the image file is written to the correct S7-1500 F Software Controller, you must make sure when installing that the safety-related project data is installed in the correct device (for example, by comparing the serial number or the hardware identification of the device determined by the operating system).
- You must ensure that the image file contains the correct safety-related project data, for example, by checking the labeling of the data storage medium or image file.
- Remove the image file once you have installed it in the S7-1500 F Software Controller. Also remove any copies.

The following applies to firmware version as of V40.0 of the S7-1500 F Software Controller:

- After installing the image file, you must ensure through program identification (Page 378) that the correct safety-related project data is in the S7-1500 F Software Controller, for example with the display or with the command line command "GetCollectiveFSignature".

The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:

- After installing the image file, you must ensure that the correct safety-related project data is in the S7-1500 F Software Controller through a program identification, for example, by reading out the Collective F-Signature with the command line command "GetCollectiveFSignature" or the display.
- Then you must enter and confirm the expected Collective F-Signature with the command line command "ConfirmCollectiveFSignature".

The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:

If the safety-related project data in the image file and the safety-related project data on the S7-1500 F Software Controller is different, the installed Safety program would not start up. In this case, you must download the project data to the F-CPU once again. For example, with TIA Portal. Therefore, you should always keep up-to-date backups of the image file.

In the same way that you can start up a Safety program from another CFast card, you can also install and run the image file created by another device or data storage medium.

(S074)

10.3.6 Loading project data (including safety-related project data) from an F-CPU into a PG/PC (S7-1500/S7-1200 G2 V4.1)

The "Upload from device (software)" or "Upload device as new station (hardware and software)" function is only possible for S7-1500/S7-1200 G2 V4.1 F-CPUs if the "Enable consistent upload from the F-CPU" option is activated for the F-CPU in the *Safety Administration Editor* and the project data is loaded to the F-CPU afterwards.

To load the project data (including safety-related project data) to a programming device or PC, proceed as in the standard scenario.

If "Delayed transfer" (internal value 0x7C6) was set for the F-BaseID in the original hardware configuration in the F-CPU, the actually assigned value is read when loading from the F-CPU and the option "Delayed transfer" is activated at the same time in the hardware configuration of the F-CPU. For connected F-I/Os of PROFIsafe address type 3, the setting "Delayed transfer" (internal value 0x7C6) remains in the hardware configuration.

When the data is downloaded to the F-CPU again, the actually assigned value for F-BaseID is thus retained and is transferred again to the F-I/O of PROFIsafe address type 3. If this behavior is not desired, you must deactivate the "Delayed transfer" option and generate the F-BaseID again, if necessary. The value for F-BaseID set in the hardware configuration then takes effect directly in the F-CPU and F-I/O of PROFIsafe address type 3 after a new compile and download of hardware and software.

If multiple F-CPUs can be reached over a network (e.g. Industrial Ethernet) by the programming device / PC, you have to ensure that the project data is uploaded from the correct F-CPU. For example, with "Online & diagnostics" > "Online access " > "Flash LED".

After successful loading from the device you can continue working as with a project that was created offline.

⚠ WARNING

If you want to carry out an acceptance with the project data loaded to the programming device / PC or want to carry out changes to the safety-related project data, you must ensure that the safety program is executable before loading.
This is fulfilled when loading from an F-CPU if the F-CPU is in RUN mode and in activated safety mode or can be set to RUN before loading. If the F-CPU remains in STOP, you are not allowed to perform acceptance or changes with the safety-related project data.
When loading from a memory card, it must have been in a suitable S7-1500/S7-1200 G2 V4.1 CPU beforehand. The same conditions apply as for loading from an F-CPU. *(S080)*

You can upload individual F-blocks into a PG/PC irrespective of the "Enable consistent upload from the F-CPU" option.

You cannot upload individual know-how protected F-blocks to a programming device / PC.

As of STEP 7 Safety V18, loading the project data from a memory card is possible as a new station (hardware and software) and device (software).

See also

"Settings" area of the Safety Administration Editor (Page 89)

10.3.7 Loading project data (including safety-related project data) from a memory card into a PG/PC (S7-1500/S7-1200 G2 V4.1)

The "Upload from device (software)" or "Upload device as new station (hardware and software)" function is only possible for S7-1500/S7-1200 G2 V4.1 F-CPUs if the "Enable consistent upload from the F-CPU" option is activated for the F-CPU in the *Safety Administration Editor* and the project data is loaded to the memory card afterwards.

To load the project data (including safety-related project data) to a programming device or PC, proceed as in the standard scenario.

If "Delayed transfer" (internal value 0x7C6) was set for the F-BaseID in the original hardware configuration in the F-CPU, the actually assigned value is read when loading from the F-CPU and the option "Delayed transfer" is activated at the same time in the hardware configuration of the F-CPU. For connected F-I/Os of PROFIsafe address type 3, the setting "Delayed transfer" (internal value 0x7C6) remains in the hardware configuration.

When the data is downloaded to the F-CPU again, the actually assigned value for F-BaseID is thus retained and is transferred again to the F-I/O of PROFIsafe address type 3. If this behavior is not desired, you must deactivate the "Delayed transfer" option and generate the F-BaseID again, if necessary. The value for F-BaseID set in the hardware configuration then takes effect directly in the F-CPU and F-I/O of PROFIsafe address type 3 after a new compile and download of hardware and software.

After successful loading from the memory card, you can continue working as with a project that was created offline.

⚠ WARNING

If you want to carry out an acceptance with the project data loaded to the programming device / PC or want to carry out changes to the safety-related project data, you must ensure that the safety program is executable before loading.
This is fulfilled when loading from an F-CPU if the F-CPU is in RUN mode and in activated safety mode or can be set to RUN before loading. If the F-CPU remains in STOP, you are not allowed to perform acceptance or changes with the safety-related project data.
When loading from a memory card, it must have been in a suitable S7-1500/S7-1200 G2 V4.1 CPU beforehand. The same conditions apply as for loading from an F-CPU. *(S080)*

See also

"Settings" area of the Safety Administration Editor (Page 89)

10.3.8 Loading a PC system configuration file for S7-1500 F software controllers

You can save the entire configuration of your S7-1500 F Software Controller in a configuration file, transport it and load it to a target system. The entire configuration of your S7-1500 F Software Controller is saved from the TIA Portal in a configuration file with the extension *.psc.

Saving and loading of the configuration file is supported as of:

- *STEP 7 Safety V15*
- S7-1500 F Software Controller V2.5

Example

You can find a detailed example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109759142).

Identification parameters

The identification parameters include:

- File name
- Information in the project and the station that was stored from the TIA Portal in the PSC file in the metadata.

  For example:

  – Project version
  – Plant designation
  – Station comment

Save the identification parameters in a file, if necessary, that you store on the target system.

For evaluating and testing these identification parameters via script, you must store this information directly in the script or save the identification parameters in a separate file, if necessary, that you store on the target system.

10.3.8.1 Creating a configuration file

1. In TIA Portal create a new configuration file with "Project > Memory Card file > New > PC system configuration file (.psc)".
   The configuration file is created in the project tree under "Card Reader/USB memory".
2. Use the Collective F-Signature and, if necessary, the F-BaseID to check in the *Safety Administration Editor* that you have selected the correct project/station.
3. Use your mouse to drag the selected PC station to the configuration file.
   This loads the PC station to the configuration file.

⚠ WARNING

Instead of program identification, you can use a unique name for the PC system configuration file *.psc (**P**C **S**ystem **C**onfiguration) to ensure that the correct safety-related project data is located in the configuration file.
In addition, you have to observe the following when creating a configuration file:
When creating a configuration file with the safety-related project data, an existing file must not be used. You have to create a new file.
You should also delete configuration files with incorrect safety-related project data from the data storage.
You must limit access to the configuration file (*.psc) through organizational measures to persons who are authorized to import and modify the configuration file. *(S081)*

10.3.8.2 Importing the configuration file

You have the following options for importing the configuration file:

- Via the PC Station Panel menu (Import configuration file) **(only FW < V30.0)**
- By means of a script

Import via the PC Station Panel menu (only possible with firmware < V30.0)

Requirement

If you want to start the import of the configuration file via the menu in the PC Station Panel of an S7-150xS(P) F, the executing user must be in the Windows user group "Failsafe Operators".

Procedure

⚠ WARNING

If the import operation was successful, you will receive a positive feedback. If you do not receive a positive message, you must assume that the import operation was not successful and that the old safety-related project data is still present.
When a configuration file with safety-related project data is imported, you must adhere to the following points:

- Use the unique name of the configuration file to check that you have selected the required configuration file.
- To ensure that a configuration file imported via LAN is imported to the correct S7-1500 F Software Controller, use the following measures:
  - Remove the physical connections and possible routings to other S7-1500 F Software Controllers.
  - Use unique computer names and unique user logins or use other identification options. *(S084)*

Import by means of a script

⚠ WARNING

You must check in the script based on the specified identification parameters whether the import of the configuration file is permitted for the respective target system (e.g. by evaluating the F-CPU name, project name or using the plant designation).
In addition, it may be necessary or useful to check the respective instance of the target system. This means a diversity check of your addressing and/or checking the version of the configuration file, for example, only higher versions or the exclusion of specific versions (block list).
Example of checking the respective version for validity:

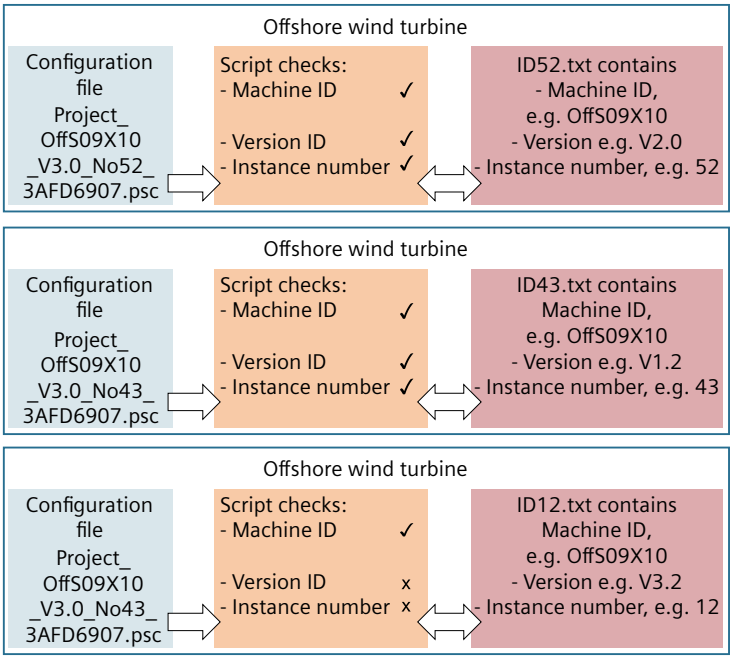
- The script evaluates the information about the version and only allows configuration files of a higher version, for example.

As a machine manufacturer, you must ensure that the script is protected against manipulation (unauthorized change of content or name).
If, as a machine manufacturer, you only make available the configuration files, you have to ensure that no incorrect configuration file is imported during import. You achieve this through technical measures (extended checks in the script) and training of the machine operators. *(S082)*

The script checks for:

- Matching machine ID
- Version ID greater than current one. If so, the new version is written to the txt file.
- Instance number

The figure below contains a systematic overview of checking the configuration file in the script with the help of an identification parameter stored in a separate file (shown in violet in the figure below):



⚠ WARNING

You must determine whether the safety-related project data was successfully imported via the script by evaluating the corresponding return value (0x51A3 or 20899). If the corresponding return value is not returned, the import has failed and the old safety-related project data may still be present.
If the import operation is triggered by a server, feedback about the positive return value must also be given.
For traceability we recommend that you document the import operation in a log file.
The following applies to firmware versions V40.0 and higher of the S7-1500 F Software Controller:
To have the return value 0x51A3 displayed after the import, you must call the import command with extension "/v" for verbose.
After a successful import, you must perform a program identification (for example, manually or via a script).
The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:
To have the return value 0x51A3 displayed after the import, you must call the import command with extension "/v" for verbose.
After successful import, you must read out the Collective F-signature from the meta file (PSC file) and enter and confirm it with the command line command "ConfirmCollectiveFSignature". This confirmation is required to restart the safety program.
The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:
To ensure that the return value is not from the previous import, you must reset the return value to 0x3FF ("PCSystem_Control /ImportConfig" without entering a file name) before the import. Then check whether the return value was reset to 0x3FF (enter "PCSystem_Control/GetStatus /ImportConfig" and then enter "echo %errorlevel%". This instruction must deliver the return value 0x3FF).
If the configuration file is imported manually via the Windows command line (via script command), you need to do one of the following:

- Reset the return value to 0x3FF and check it before the import (see above).
  - Carry out the import.
  - Evaluate return value (enter "PCSystem_Control /GetStatus /ImportConfig" and then enter "echo %errorlevel%". This instruction must return the return value 0x51A3 or 20899).
- Carry out the import.
  - Perform a manual program identification, for example, using the display of the F-CPU.

(S083)

NOTE

The positive return value when importing a configuration file via script is "0x51A3" for an S7-1500 F Software Controller, in contrast to the S7-1500 Software Controller, in which case it is "0x0000".

When the file is imported via script, the authorization should be moved to the script. This means that the executing user does not need a higher authorization level, since the script that was made available to the user by the machine manufacturer contains the necessary authorizations (user group "Failsafe Operators").

The rights are assigned via script by assignment of the Windows service to the corresponding user group. This initial installation must be performed beforehand by the Windows administrator on every computer with S7-150xS(P) F. The Windows service can be called by the executing user and the Windows service executes the script.

10.4 Program identification

You use the program identification to determine that the correct safety-related project data has been downloaded to the F-CPU To do so, you compare the Collective F-Signature with an expected value. The expected value can be, for example, the offline Collective F-Signature from the *Safety Administration Editor* or from the safety summary.

For S7-1500 F-CPUs with firmware < V3.1 and S7-1200 G1 F-CPUs with firmware < V4.7, you also compare the "F-admin" right online and offline in the *Safety Administration Editor*.

F-I/Os of PROFIsafe address type 3 (with active F-BaseID or the value "Delayed transfer") can be used for S7-1500 and S7-1200 G2 F-CPUs with firmware V4.1 or higher, or S7-1500 F-Software Controllers with firmware V40.1 or higher, as well as Safety System Version V2.8. The F-BaseID is not part of the Collective F-Signature and may need to be checked separately. In general, this is not necessary because the F-I/Os passivate if inconsistencies occur. Checking the F-BaseID could be useful if, for example, you want to check which value is active online.

For information on the F-BaseID, see also sections "Configuring an F-CPU (Page 39)" and "PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68)". To check the F-BaseID using the *Safety Administration Editor*, see the section "General" area of the *Safety Administration Editor* (Page 81).

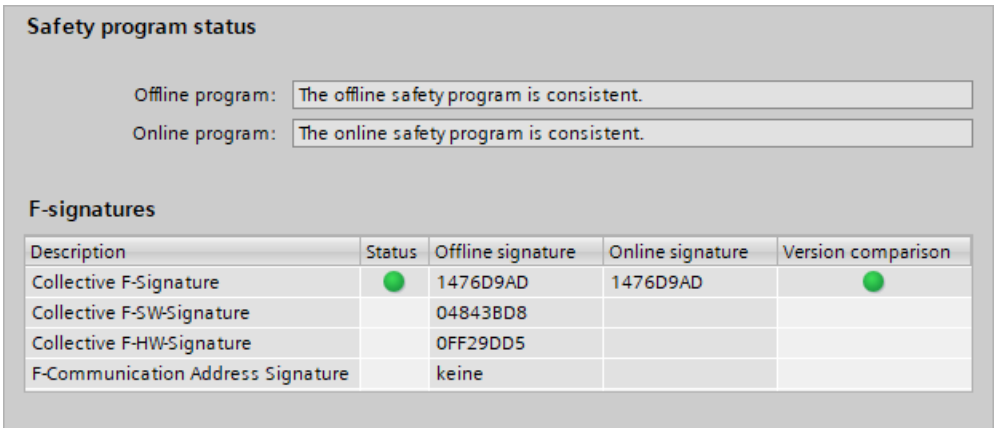
Use organizational measures to ensure that the safety-related project data is not downloaded by any other TIA Portal (on a separate programming device or PC) during the program identification.

With the *Safety Administration Editor*

For a program identification using the *Safety Administration Editor* (Page 78), follow these steps:

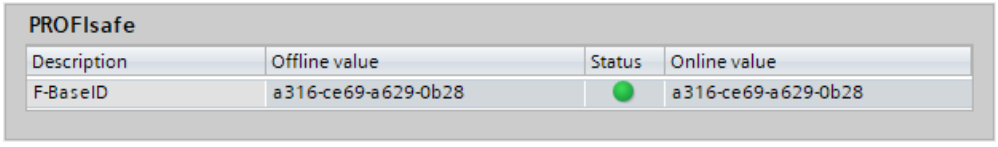
1. Open the *Safety Administration Editor* of the F-CPU you want to check.
2. Connect online with the F-CPU you want to check.
3. Compare the Collective F-Signature displayed online with the expected value in the "General" section.
4. Check whether the offline and online program are consistent (Page 424).

5. Check whether the green symbol is displayed in the column "status" and "Version comparison".



6. For S7-1500 F-CPUs with firmware < V3.1 and S7-1200 G1 F-CPUs with firmware < V4.7: Check in the "Web server F-admins" section whether only authorized users have the "F-admin" right offline and online.
7. If the check of the F-BaseID is required:

   Check in the "General" area of the *Safety Administration Editor* under "PROFIsafe" to see if the F-BaseID is the same offline and online. If it is the same, this is indicated by the green icon. (For information on checking the F-BaseID using the *Safety Administration Editor*, see also section "General" area of the Safety Administration Editor (Page 81).)



With HMI

For a program identification using the HMI, follow these steps:

1. Read the Collective F-Signature of the safety program from the F_PROG_SIG tag of the F-global DB (Page 148) (S7-300, S7-400) or the F_SYSINFO.F_PROG_SIG tag of the F-runtime group information DB (Page 149) (S7-1200, S7-1500).
2. Compare the value of the F_PROG_SIG tag with the expected value.
3. If the check of the F-BaseID is required:

   Compare the value of parameter BASEID_ACTIVE at the F-I/O DB of any F-I/O of PROFIsafe address type 3 of the relevant F-CPU with the expected value of the F-BaseID (e.g. from the safety summary). For information regarding BASEID_ACTIVE, see also section BASEID_ACTIVE (Page 165).

With the display of an S7-1500 F-CPU

For a program identification using the display of an F-CPU, follow these steps:

1. In the display menu, go to "Overview > Fail-safe".
2. Compare the displayed Collective F-Signature with the expected value.
3. If the check of the F-BaseID is required:
   Compare the displayed F-BaseID with the expected value (e.g. from the safety summary).

With the web server of an S7-1200 G1/S7-1200 G2 F-CPU as of V4.1/S7-1500

For a program identification with the web server of an S7-1200 G1/S7-1200 G2 F-CPU as of V4.1/S7-1500, follow these steps:

1. Read the Collective F-Signature on the homepage of the Web server.
2. Compare the displayed Collective F-Signature with the expected value.
3. If the check of the F-BaseID is required:
   Compare the displayed F-BaseID with the expected value (e.g. from the safety summary).

With the application UI of the S7-1500VF

For program identification using the UI of the S7-1500VF application, follow these steps:

1. Open the UI of the S7-1500VF by clicking on the app icon.
2. Compare the displayed Collective F-Signature with the expected value.

10.5 Comparing Safety Programs

Compare safety programs as in standard

You can use the *comparison editor* in *STEP 7* for offline-online or offline-offline comparison of safety programs. The procedure is the same as for standard user programs. The contents of F-blocks are also compared for the comparison of safety programs. As a result, an offline-offline comparison can also be used for an acceptance of changes (Page 427). You enable this comparison by selecting the "Safety" comparison criterion and disabling all other comparison criteria.

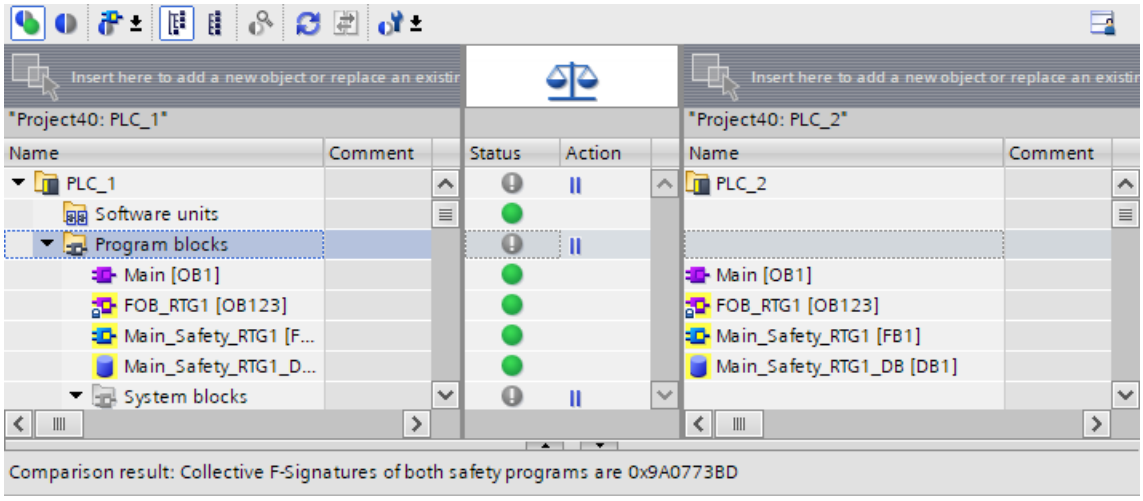
NOTE

You must not use the *Comparison editor* to detect changes offline-online in the safety program/configuration of the F-IOs when accepting changes. Only the offline-offline comparison is suitable for this purpose. To accept changes, proceed as described under Acceptance of Changes (Page 427).

Comparison result for safety programs

The representation of the comparison result corresponds to the representation of *STEP 7*.

Please note:
The status symbol of the "Program blocks" folder merely summarizes the comparison result of all lower-level program blocks, without taking into account the comparison values of program consistency and the collective F-signature.
To establish whether the two Safety programs are the same, you need to click the "Program blocks" folder on the left of the comparison editor. Then the collective F-signatures of both Safety programs are shown under "Comparison result". You also receive information about whether the safety program is consistent.



If you click on an F-block, you can see the respective signatures and interface signatures in addition to the standard information.

NOTE

If you interrupt the connection to the F-CPU during the online/offline comparison, the comparison result will be incorrect.

Comparison filter options

You can use filters in the *comparison editor* to limit the comparison result to the following block groups:

- Compare only F-blocks
- Compare only F-blocks relevant for certification
- Compare only standard blocks

You also have the *STEP 7* filter options "Show only objects with differences" and "Show identical and different objects".

For comparison of safety programs, F-blocks in the "System blocks" folder are also relevant.

Comparison criteria

Make sure that under only the comparison criterion "Safety" is enabled.

Classification of displayed changes

Regardless of whether you carried out an offline/online or offline/offline-comparison, the following changes could account for the indicated changes to the automatically generated F-blocks:

- Changing in the maximum cycle time of the F-runtime group and warning limit F-cycle time of the
  F-runtime group
- Change in F-parameters of the F-CPU
- (S7-1200/1500) Modified Safety system version
- (S7-300, S7-400) Change in the F-runtime group communication, for example, change in the number of a DB for F-runtime group communication
- Change in main safety block, F-FB, F-FC, F-DB
- Change of the hardware configuration for the F-I/O addressed in the safety program
- (S7-1200, S7-1500) Change in the communication with Flexible F-Link
- (S7-1500) Change in the communication with OPC UA Safety

It is possible that a block is displayed as changed, but no changes are displayed in the detailed comparison of the block content. This is not a display problem but means that changes of addresses in the tag table, for example, have an effect on this block. Test this block in case of doubt.

Document the result of the comparison

The comparison result can be printed via "Project > Print" in the menu bar or the "Print" icon in the toolbar or create a PDF file. Select "Print objects/area" "All" and "Properties" "All".

10.6 Creating a safety summary

The documentation of the safety-related project data (safety summary) serves, in addition to other system documentation, as the basis for checking the correctness of the individual components of the system. Correctness is a prerequisite for system acceptance.

The Collective F-Signature in the footer on the pages of the safety summary guarantees unambiguous assignment of the safety summary to a Safety program.

Bear in mind, however, that the F-BaseID does not enter into the Collective F-Signature. If this parameter is relevant to your archiving, you must separately check that the right F-BaseID was printed.

The safety summary can be created in printed or electronic form, for example, as a PDF file.

Procedure for creating the safety summary

To create the safety summary, follow these steps:

1. Open the *Safety Administration Editor* (Page 81) of the F-CPU whose safety summary you want to create.
2. Under "Safety summary" in the "General" section, press the "Create safety summary" button.

   In the displayed dialog, you can make layout settings for the printout and specify the scope of the printout (all/subset), among other things.

   Alternatively, you can select an F-CPU in the project tree and open the dialog using "Print" in the shortcut menu, "Project > Print" in the menu bar or the print button in the toolbar.
3. If you want to print the safety summary on paper, we recommend one of the ISO formats, e.g. "DocuInfo_Simple_A4_Portrait_Small_Footer" or "DocuInfo_ISO_A4_Portrait".

   In these formats, the summary contains page numbers with which you can verify the completeness of the summary.
4. Select the "All" option, if the F-blocks and F-compliant PLC data types (UDT) are to be shown in the printout. This is necessary, for example, to document the program code for the acceptance (see Acceptance of system (Page 407)). Select the "Compact" option to exclude the source code from the printout.
5. Click the "Print" button.

As a result, you receive the safety summary for the F-CPU.

After printing, make sure that all pages were printed. Incomplete printouts (e.g. lines cut off, insufficient toner when printing to paper) must not be used for an acceptance.

Overview of the contents of the safety summary

The information included in the safety summary is summarized below:

- General information on program identification, signatures, software versions, access protection, settings of the Safety program (from the "Settings" work area of the *Safety Administration Editor*), for example safety system version.
- System library elements used in Safety program (from the "Instructions" task card) along with their versions
- Information about the F-runtime groups (e.g. cycle time warning limit of the F-runtime group, maximum cycle time of the F-runtime group)
- List of F-blocks within the "Program blocks" folder (e.g. name, function, associated F-runtime group, signature)
- (S7-1200, S7-1500) List of the know-how protected F-blocks used in the Safety program (e.g., name, signature, used safety system version, used versioned instructions, named value types (NVT) or called F-blocks).
- (S7-1200, S7-1500) List of F-compliant PLC data types (UDT) used in the Safety program, if these exist in the Safety program.
- (S7-1200, S7-1500) List of the definitions of all named-value types (NVT) used in the safety program and all named-value types (NVT) that can be used in the safety program via a relation to another software unit.
- (S7-1200, S7-1500) List of all named-value types (NVT) used in the Safety program.
- (S7-1200, S7-1500) List of all system NVTs used in the safety program.
- List of all global constants used in the Safety program.

- Data from the standard user program that are evaluated in the Safety program
- Block parameters of the safety-related CPU-CPU communication by means of the instructions SENDDP/RCVDP or SENDS7/RCVS7
- (S7-300, S7-400) Absolute addresses and names of the F-shared DB tags that can be accessed from the standard user program.
- Information on the F-CPU used (e.g. firmware version, central F-source address, F-BaseID) Information on the F-I/O used (e.g. firmware version, general and specific parameters)
- Information on the printout (print date, number of pages)
- Parameters of the safety-oriented communication with OPC UA Safety
- Parameters of the safety-oriented communication with Flexible F-Link

Content of the footer of the safety summary

Based on the footer of the safety summary, you can see whether the printed safety-related project data is consistent and whether all pages of the safety summary belong to the same Safety program and the same version (the same Collective F-Signature in the footer of every page means that the safety summary belongs to the Safety program with this Collective F-Signature).

The footer is only added to the source code of the F-blocks if the "All" option was selected when creating the Safety program. If F-blocks are printed by other means, the footer is omitted, and you can no longer easily identify whether the block printout belongs to the current Safety program version.

Safety summary for a migrated project

You can only create the safety summary for a project migrated from *S7 Distributed Safety V5.4 SP5* if the project was compiled with *STEP 7 Safety Advanced* and the new program structure for safety programs (main safety block) was thereby applied. Otherwise, the safety documentation cannot be created and you will receive a corresponding error message.

We recommend that you create a safety summary for your project in *S7 Distributed Safety V5.4 SP5* before the migration.

10.7 Testing the safety program

10.7.1 Overview of Testing the Safety Program

Complete function test or test of changes

After creating a safety program, you must carry out a complete function test in accordance with your automation task.

For changes made to a safety program that has already undergone a complete function test, only the changes and that there is no effect on the parts of the safety program that were not changed need be tested.

Monitoring

Read-only test functions (such as monitoring tags of the safety program) are available for safety programs as in the standard.

Modifying

Read and write test functions (such as controlling tags of the safety program) are only available to a limited extent for safety programs and only in disabled safety mode.

Simulation via *S7-PLCSIM*

You can test the safety program using *S7-PLCSIM*. You use *S7-PLCSIM* in the same way as for standard user programs.

You start the simulation with *S7-PLCSIM* using menu item "Online > Simulation > Start"

Rules for testing

- Forcing of F-I/O inputs and F-I/O outputs is not possible.
- Controlling F-I/O outputs in connection with the function "Enabling F-I/O outputs" is not possible.
- Setting breakpoints in the standard user program will cause errors in the safety program (see also Testing the safety program (Page 390)).
- Changes in the configuration of F-I/O or safety-related CPU-CPU communication can only be tested after the hardware configuration has been saved and downloaded, and after the safety program has been compiled and downloaded to the F-CPU.

See also

Disabling safety mode (Page 386)

10.7.2 Disabled safety mode

The safety program generally runs in the F-CPU in safety mode after a STOP/RUN transition. This means that all fault control measures are activated. The safety program cannot be modified during operation (in RUN mode) in safety mode. You must disable safety mode of the safety program to, for example, modify tags in the safety program in RUN mode. Safety mode remains disabled until the F-CPU is next switched from STOP to RUN mode.

As of Safety system version V2.4, disabled safety mode for S7-1200/1500 CPUs is time-limited.

After the time limit has expired, the F-CPU or the redundant S7-1500HF system automatically goes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You can avoid an unplanned STOP of the F-CPU after the time limit has expired as follows:

- Ending the disabled safety mode through a targeted STOP/RUN transition.
- Resetting the remaining runtime. Resetting can be used as often as needed.

10.7.2.1 Configuring the time limit for disabled safety mode (S7-1200, S7-1500)

Introduction

You can configure the duration of the time limit.

Requirements

- In the *Safety Administration Editor*, the "Safety mode can be disabled" option is activated.
- The minimum Safety system version is set to V2.4.

Procedure for configuring the runtime

To configure the time limit, follow these steps:

1. Open the *Safety Administration Editor* of the F-CPU.
2. Open the "Settings (Page 89)" area in the area navigation.
3. Under "Runtime for the deactivated safety mode", configure the time limit for the safety mode. The default time is 4 hours. You have the option to configure the time limit to a maximum of 8 hours and a minimum of 1 minute.

NOTE
The value of the configured time is not included in the Collective F-Signature.

10.7.2.2 Disabling safety mode

Requirements

- In the *Safety Administration Editor*, the "Safety mode can be disabled" option is activated.
- (S7-1200, S7-1500) The serial number of the F-CPU (Page 81) has been entered in the *Safety Administration Editor*.
- The project is loaded to the F-CPU.
- The F-CPU is in RUN.
- The Safety program runs in safety mode.

Rules for disabling safety mode

⚠ WARNING

When safety mode is disabled, you must take the following into consideration:

- Disabling of safety mode is intended for test purposes, commissioning, etc. While safety mode is disabled, plant security must be ensured by organizational measures.
  After the test or commissioning, safety mode must be enabled again. To do this, execute a STOP/RUN transition of the F-CPU.
  In a redundant S7-1500HF system you have to set both HF-CPUs or the redundant system S7-1500HF to STOP before you restart the HF-CPUs.
- A disabling of the safety mode must be displayed.
  Use the MODE tag in the F-shared DB ("F_GLOBDB".MODE) for S7-300/400 F-CPUs or in the F-runtime group information DB (e.g. RTG1SysInfo.F_SYSINFO.MODE) for S7-1200/1500 F-CPUs, which you can evaluate to read the operating mode (1 = Disabled safety mode).
- It must be possible to verify that safety mode has been disabled. A log is required, if possible by recording and, if applicable, archiving alarms to the operator control and monitoring system or, if need be, through organizational measures. In addition, it is recommended that a disabling of the safety mode be indicated on the operator control and monitoring system.
- With safety-related communication, you must also take into account a possible deactivation of Safety mode on the communication partner's side*. You can then no longer assume that the data provided by the communication partner is formed in a safety-related manner.
  During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program instead of the received data.

(S027)

*You can determine whether Safety mode has been deactivated on the communication partner's side as follows:

- Communication via SENDDP/RCVDP instructions: SENDMODE output at RCVDP (Page 599)
- Communication via SENDS//RCVS7 instructions: SENDMODE output at RCVS7 (Page 608)
- Communication with OPC UA Safety: TEST_MODE_ACTIVATED variable in the F-OPC UA Consumer DB
- Communication with Flexible F-Link: SENDMODE tag in the F-Communication DB (Page 341) for receiving

⚠ WARNING

(S7-1200, S7-1500) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by the **same PG/PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU or that safety mode is deactivated in the correct F-CPU:

- Enter the serial number of the specific F-CPU in the *Safety Administration Editor*.

Depending on the respective CPU type (see documentation of the CPU), you have several possibilities for determining the serial number of an F-CPU:

- Print of the serial number on the housing of the F-CPU.
- Scanning of the ID link on the F-CPU.
- Display of the F-CPU
- Web server*
- Industrial Edge application user interface under /SIMATIC_MC/system/serialno*
- TIA Portal (I&M data)*

Note the following when downloading:

- If the "Load preview" window does not contain a warning, the connection to the correct F-CPU has been established. You can confirm the download of the safety-related project data without an additional check.
- If a serial number has not yet been entered in the *Safety Administration Editor* or if the connected F-CPU has a different serial number, check the proposed serial number of the F-CPU in the "Load preview" window or "Disable safety mode" window. If you determine an error, cancel the download or the disabling of safety mode. Otherwise, you can confirm the procedure.
- When the serial number is confirmed (online), it is always applied in the *Safety Administration Editor* and any existing entry is overwritten.
  (S099)

* To make use of these possibilities, you must ensure a connection to the expected F-CPU. You achieve this through:

- A point-to-point connection to the respective F-CPU
- Verification of the flashing of the F-CPU after selecting the "Flash LED" check box in the online and diagnostics view of the F-CPU.
- Unplugging the network cable to the respective F-CPU
- For an S7-1500 F Virtual Controller, a unique connection can be achieved by a targeted switch to STOP of the Industrial Edge application.

Procedure for disabling safety mode

To disable safety mode, follow these steps:

1. Open the *Safety Administration Editor* of the corresponding F-CPU.
2. Open the "General (Page 81)" area in the area navigation.
3. Click the "Disable safety mode" button.
4. If access protection is set up for the F-CPU, enter the password for the F-CPU or legitimate yourself again as a user with F-right.
5. Only for S7-300/400 F-CPUs for which access protection is **not** set up:
   Make sure that you disable safety mode of the desired F-CPU by checking the Collective F-Signature in the dialog that is displayed next.
6. Confirm the deactivation.

Safety mode is then disabled.

The remaining runtime until an S7-1200/1500 F-CPU goes into STOP starts immediately after the safety mode is disabled. The remaining runtime is displayed in the *Safety Administration Editor* in the "General (Page 81)" area in online mode. In addition, the remaining runtime is displayed in the web server of an S7-1500 F-CPU as of firmware V2.9.

Reset remaining runtime until the F-CPU goes to STOP

To avoid the expiration of the remaining runtime and the associated STOP of the F-CPU, you can reset the remaining runtime in the *Safety Administration Editor*. This resets the remaining runtime to the configured value and starts it running again immediately after that.

Proceed as follows:

1. Open the *Safety Administration Editor* of the corresponding F-CPU.
2. Open the "General (Page 81)" area in the area navigation.
3. Click the "Reset remaining runtime" button.
4. If access protection is set up for the F-CPU, enter the password for the F-CPU or legitimate yourself again as a user with F-right.
5. Only for S7-300/400 F-CPUs for which access protection is **not** set up:
   Make sure that you disable the remaining runtime of the correct F-CPU by checking the Collective F-Signature in the dialog that is displayed next.
6. Confirm the reset of the remaining runtime.

NOTE

The remaining runtime is also displayed in the F-runtime group information DB (Page 149) of the respective F-runtime group in the MODE_REMAINING_TIME tag.
In case of two F-runtime groups, different values may be displayed caused by different update times.
The value "0" is not displayed after expiration of the remaining runtime, but the remaining runtime existing in the last cycle.

Enabling safety mode

To enable safety mode, the F-CPU must be switched from STOP to RUN mode.

In a redundant S7-1500HF system you have to set both HF-CPUs or the redundant system S7-1500HF to STOP before you restart the HF-CPUs.

Switching the F-CPU from STOP to RUN mode always enables safety mode, even if the Safety program has been modified or is not consistent.

If you have changed your Safety program, but have not recompiled and downloaded it, the F-CPU can revert to STOP mode.

Evaluating safety mode/disabled safety mode

If you wish to evaluate safety mode/disabled safety mode in the Safety program, you can evaluate the "MODE" tag in the F-shared DB (Page 148) for S7-300/400 F-CPUs or F-runtime group information DB for S7-1200/1500 F-CPUs (1 = Disabled safety mode). You use fully qualified access to access this tag (e.g. "F_GLOBDB".MODE or RTG1SysInfo.MODE).

You can use this evaluation, for example, to passivate F-I/O when the Safety program is in disabled safety mode. To do so, assign the "MODE" tag in the F-shared DB or F-runtime group information DB to all "PASS_ON" tags in the F-I/O DBs of the F-I/O that you wish to passivate.

⚠ WARNING

When the Safety program is in disabled safety mode, the "MODE" tag in the F-shared DB or F-runtime group information DB is also evaluated in disabled safety mode.
Even if the F-I/O is passivated in disabled safety mode by evaluating the "MODE" tag, the safety of the plant must be ensured during disabled safety mode by organizational measures. *(S028)*

See also

Configuring the time limit for disabled safety mode (S7-1200, S7-1500) (Page 386)

10.7.3 Testing the safety program

Introduction

Tags of the safety program can be monitored at any time.

Controlling tags of the safety program is only possible in deactivated safety mode as some fault control measures of the safety program have to be disabled for this.

You can control the following tags of the safety program:

- Inputs and outputs of the F-I/O (channel values and value status (S7-1200, S7-1500))
- Tags in F-global DB (except DB for F-runtime group communication)
- Tags in instance DBs of F-FBs
- Tags in F-I/O DBs (for permitted tags see F-I/O DB (Page 157))

Procedure for monitoring tags of the safety program

Monitor the required tags of the safety program from an open watch table or from the *program editor* (program status).

1. Proceed as in the standard. More information can be found in the *STEP 7 help* in "Testing user programs".

Procedure for controlling tags of the safety program

Control the required tags of the safety program from an open watch table:

1. For modifying, deactivate the safety mode (Page 386) in the automatically shown dialog.
2. Terminate existing modify requests after testing is complete before activating safety mode.

Values in F-DBs can only be modified online in the F-CPU. If the value is also to be changed offline, you must do this by editing the start value offline and compiling the safety program.

Proceed as follows to control tags of F-I/O:

1. Create a separate row for each channel value and value status (S7-1200, S7-1500) to be modified. The control value must correspond to the channel value or value status.
2. Set "start of scan cycle" or "end of scan cycle" and "permanent" or "once".

   Regardless of the trigger point setting, requests to modify inputs (PII) of F-I/O always become effective before the main safety block is executed and requests to modify outputs (PIQ) always become effective after execution of the main safety block.
3. (S7-300, S7-400) Create an additional watch table if you want to control more than 5 inputs/outputs.

NOTE

F-I/O can only be modified in RUN mode of the F-CPU.

You cannot modify a configured F-I/O from which neither a channel value or a value status (S7-1200, S7-1500), nor any tag from the associated F-I/O DB has been used in the safety program. In your safety program, you should therefore always use at least one tag from the associated F-I/O DB or at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be modified.

For inputs (PII), modify requests take priority over fail-safe value output, while for outputs (PIQ), fail-safe value output takes priority over modify requests. For outputs (channels) that are not activated in the properties for the F-I/O, modify requests affect the PIQ only, and not the F-I/O.

NOTE

The following applies for S7-1200/1500 F-CPUs:

To avoid invalid combinations of channel value and status value:

- The value status is set by the F-system automatically to 1 when setting a channel value to a value <> fail-safe value 0
- The fail-safe value 0 is automatically output when setting the value status to 0 for the associated channel value

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⚠ WARNING

You need to specifically reset constant modify requests in the watch table in disabled safety mode.
Note that constant modify requests that are not correctly reset can remain active in the background even after a STOP/RUN transition of the F-CPU.
Because the F-CPU is in safety mode again after a STOP/RUN transition, the constant modify requests are no longer effective and are not shown in the watch table.
The requests become active again as soon as you disable safety mode again.
With a memory reset of the F-CPU, you can make sure that no constant modify requests are active in the background on the F-CPU. *(S029)*

Wiring test using watch table

You can carry out a wiring test for an input by changing an input signal and verifying whether or not the new value arrives in the PII.

You can carry out a wiring test for an output by changing the output with the Modify function and verifying whether the required actuator responds.

For the wiring test, note that a safety program must be running on the F-CPU, in which at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be monitored or modified or one tag from the associated F-I/O DB has been used.

For F-I/O that can also be operated as standard I/O (e.g., S7-300 fail-safe signal modules), you can also carry out the wiring test for outputs using the Modify function in STOP mode by operating the F-I/O as standard I/O rather than in safety mode.

Additional rules for testing (S7-300, S7-400, S7-1500)

Setting breakpoints in the standard user program will cause the following errors in the safety program:

- F-cycle time monitoring has expired
- Error during communication with the F-I/O

  (S7-1500) Fail-safe modules switch to safe mode after the configured F-monitoring time has expired.
- Error during safety-related CPU-CPU communication
- Internal CPU faults

If you nevertheless want to use breakpoints for testing, you must first disable safety mode. This will result in the following errors:

- Error during communication with the F-I/O
- Error during safety-related CPU-CPU communication

Difference between S7-1500 F-CPUs and S7-300/400 F-CPUs:

- If a breakpoint is activated and reached, the F-CPU goes directly to STOP after HOLD.
- If you want to switch to RUN again after HOLD to test your standard user program further, you can simulate this with S7-PLCSIM.

No access protection is initially necessary for test purposes, commissioning, etc. This means you can execute all offline and online actions without access protection, that is, without password prompt.

See also

Changing the safety program in RUN mode (S7-300, S7-400) (Page 397)
Downloading project data (Page 345)

10.7.4 Testing the Safety program with S7-PLCSIM/S7-PLCSIM Advanced

You can test your Safety program together with your standard program on a simulated CPU with *S7-PLCSIM* and without the need for hardware. Also observe warning S030 in the section "Notes on Safety Mode of the Safety Program (Page 435)".

You use *S7-PLCSIM* for SIMATIC Safety F-systems as you would for S7 standard systems. Note the following special features:

Safety mode/disabled safety mode

We recommend that you test your Safety program in safety mode to detect whether the F-CPU goes into STOP as early as in the test phase of your Safety program in *S7-PLCSIM* as a result of, for example, that the results of instructions were outside the permitted range for the data type.

The following simulations can be run in *S7-PLCSIM*, just as on an actual F-CPU, in disabled safety mode only.

- Modifying tags in F-DBs and F-I/O DBs.

(S7-1200, S7-1500) To prevent unintentional modification of tags in F-DBs and F-I/O DBs in Safety mode, we recommend that you do not select the "Enable/disable modification of non-inputs" button in *S7-PLCSIM*

During the simulation with *S7-PLCSIM* , monitoring of the maximum cycle time of the F-runtime group and the cycle time warning limit of the F-runtime group (S7-1200, S7-1500) are disabled.

Differences between a simulated F-CPU and real F-CPU

Note that *S7-PLCSIM* does not fully behave like a real F-CPU down to the individual details. In particular, the startup behavior of an F-I/O cannot be simulated exactly.

Input simulation of F-I/O

Simulation of inputs (channel values) in *S7-PLCSIM:*
You simulate inputs (channel values) of F-I/O in *S7-PLCSIM* as you would inputs (channel values) of standard I/O. Keep in mind the following notes/restrictions:

During the transition of the F-CPU from "STOP" to "RUN" mode in *S7-PLCSIM*, all inputs (channel values) of F-I/O are initialized with 0 in the process image input (PII).

The inputs (channel values) can be simulated starting from the 2nd cycle and are then available in the PII.

Simulation of inputs (value status) in *S7-PLCSIM:*
(S7-1200 G1, S7-1500) By simulating inputs (value status) of F-I/O, you can simulate incoming and outgoing F-I/O / channel faults. Keep in mind the following notes/restrictions:

- To realistically simulate the behavior of the F-I/O, you must note the connection between channel value and value status on the real F-I/O. The combination value status = 0 and channel value <> fail-safe value (0) is invalid and can result in the simulation deviating from the behavior of the real F-CPU.
- During the transition of the F-CPU from "STOP" to "RUN" in *S7-PLCSIM*, all inputs (value status) of F-I/O are initialized with 1 in the process image input (PII). This means you can start with the simulation of inputs (channel values) immediately without simulation of the inputs (value status). For more information, refer to the sections "Addressing F-I/O (Page 151)" and "Value status (S7-1200, S7-1500) (Page 153)".
- The simulation of inputs (value status) in *S7-PLCSIM* does not have an effect on the QBAD and PASS_OUT tags in the F-I/O DB. Note that with real F-I/O, QBAD and PASS_OUT can be 1 as soon as the value status is 0 for at least one channel of the F-I/O (see tags of the F-I/O DB: PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status (Page 162)).
- For F-I/O configured with "Behavior after channel fault" = "Passivation of the complete F-I/O", use the tag PASS_ON in the F-I/O DB for simulation of the passivation of the complete F-I/O for F-I/O / channel faults. If you limit the simulation to passivation of individual inputs (channel value including value status), the behavior of the simulation will deviate from that of the real F-CPU.
- You can also use the PASS_ON tag in the F-I/O DB for F-I/O without value status to simulate the passivation of the entire F-I/O in case of F-I/O or channel faults.
- To simulate an F-I/O / channel fault of the SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4...20 mA HART with configuration "Behavior after channel fault" = "Passivate channel", you must simulate the inputs (channel values) with $7FFF_H$ (for overflow) or 8000_H (for underflow).
- For F-I/O which does not support the "RIOforFA-Safety" profile, you must run a user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB as with a real F-I/O for reintegration after the value status has changed from 0 to 1 or when the channel value has changed from $7FFF_H$/8000_H to unequal $7FFF_H$/8000_H (see above) when ACK_NEC = 1 of the F-I/O DB. Reintegration takes place automatically in all other cases possibly deviating from the real F-I/O.

Update times

Keep in mind that the status of the inputs (channel values or value status (S7-1200 G1, S7-1500)) that you are monitoring in the SIM table in *S7-PLCSIM* is only identical to the status being processed in the Safety program if there is no passivation of the associated F-I/O.

When the F-I/O is passivated, the Safety program operates with substitute values (channel value and value status (S7-1200 G1, S7-1500) =0).

Communication via SENDDP/RCVDP instructions

The following applies for SENDDP/RCVDP (S7-300, S7-400) instructions and SENDDP/RCVDP instructions with Version < 3.0 (S7-1200, S7-1500):

You cannot simulate communication between F-CPUs with the SENDDP and RCVDP instructions in *S7-PLCSIM*. You can, however, use the SENDDP and RCVDP instructions together with *S7-PLCSIM*. During simulation in *S7-PLCSIM*, the RCVDP instruction outputs the

substitute values pending at its inputs SUBBO_xx and SUBI_xx ((S7-1200, S7-1500) or alternatively SUBDI_00). The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON.

For SENDDP/RCVDP instructions with Version >= 3.0 (S7-1200, S7-1500) the following applies:

During the simulation with *S7-PLCSIM* it is possible to simulate the received data and the information "Deactivated Safety Mode" (RCVDP) or respectively the information "Substitute value output" (SENDDP) in the corresponding transfer area for inputs. Note the following notes:

- The simulated values do not become active until you set the SIMULATION bit for the first time in the respective simulation control word (see the following table) after the F-system has started up. Before setting the SIMULATION bit, the RCVDP instruction outputs the fail-safe values that are pending at its inputs SUBBO_xx and SUBI_yy (or alternatively SUBDI_00).
- The setting of the SEND_MODE bit in the simulation control word causes a setting of the SENDMORE output for the RCVDP instruction.
- The setting of the STATUS_SUBS bit in the simulation control word causes a setting of the SUBS_ON output for the SENDDP instruction.
- Reserved bits in the simulation control word always have to be 0.
- During a STOP/RUN transition from *S7-PLCSIM* the most recently simulated values in the transfer area for inputs are kept.

The start address(es) of the configured transfer area for the input and output data can be found in the respective configuration (see also "Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 241)").

Table 2-15 Structure of the relevant transfer area for inputs of the simulation control word (instruction RCVDP)

Byte	Meaning	Comment
0	RD_BO_15 ... RD_BO_08	
1	RD_BO_07 ... RD_BO_00	
	DINTMODE=0:	
2	RD_I_00	Word RD_I_00, MSB[1] first
3		
4	RD_I_01	Word RD_I_01, MSB[1] first
5		
	Alternative DINTMODE=1:	
2	RD_DI_00	High Word from RD_DI_00, MSB[1] first
3		
4		Low Word from RD_DI_00 **XOR 0x8000**, MSB[1] first
5		
6	Simulation control word (High Byte)	Bit 0...6: Reserved Bit 7: SIMULATION: Activating RCVDP simulation
7	Simulation control word (Low Byte)	Bit 0: SEND_MODE: Set output SENDMODE Bit 1...7: Reserved
8 ... 11	Reserved	

[1] MSB: most significant bit

Table 2-16 Structure of the relevant transfer area for inputs of the simulation control word (instruction SENDDP)

Byte	Meaning	Comment
0	Simulation control word (High Byte)	Bit 0: STATUS_SUBS: Set output SUBS_ON Bit 1...6: Reserved Bit 7: SIMULATION: Activating SENDDP simulation
1	Simulation control word (Low Byte)	Bit 0...7: Reserved
2 ... 5	Reserved	

(S7-300, S7-400) Communication via the SENDS7/RCVS7 instructions

You cannot simulate communication between F-CPUs with the SENDS7 and RCVS7 instructions in *S7-PLCSIM*. You can, however, use the SENDS7 and RCVS7 instructions together with *S7-PLCSIM*.

During simulation in *S7-PLCSIM*, the RCVS7 instruction outputs the initial values specified in the communication DB as fail-safe values. The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON.

Communication with OPC UA Safety

You can simulate CPU-CPU communication with OPC UA Safety with S7-PLCSIM Advanced as of V7.0. Use the "TCP/IP Single Adapter" option under "Online Access" for this. Note the following warning if the Safety program associated with the connected SafetyProvider is running on an S7-PLCSIM:

⚠ WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

Communication with Flexible F-Link

Note the following warning if the Safety program on the sender side is running on an S7-PLCSIM:

⚠ WARNING

If the SENDMODE tag in the F-communication DB (Page 293) is set to "1" for receiving during communication with Flexible F-Link, you can no longer assume that the data at the RCV_DATA tag is formed in a safety-related manner.
During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with SENDMODE = 1 instead of the data in the RCV_DATA tag. *(S086)*

Inconsistent Safety program (S7-1200, S7-1500)

If the CPU goes into STOP in *S7-PLCSIM* with the diagnostic entry "Safety program: inconsistent", the F-CPU is not initialized correctly in *S7-PLCSIM* yet. Perform a memory reset of the F-CPU in *S7-PLCSIM* and download the project data once again to the CPU in *S7-PLCSIM*.

See also

F-communication DB (S7-1200, S7-1500) (Page 341)

10.7.5 Changing the safety program in RUN mode (S7-300, S7-400)

Introduction

You make changes to F-blocks offline in the *program editor* in the same way as for a standard program. You download the changed F-blocks in RUN to the F-CPU in the "disabled safety mode (Page 386)".

NOTE

If you do **not** want to make changes to the safety program during operation, see Creating F-blocks in FBD/LAD (Page 145).

Procedure for changing the safety program in RUN mode

To change the safety program, follow these steps:

1. Change the main safety block or F-FB and its associated instance DB, F-FC, or F-DB in the *Program editor*.
2. Download the changed F-block(s) to the F-CPU (for procedure, see Downloading project data (Page 345)). The entire program is then automatically compiled.

3. If safety mode is active, the "Load preview" dialog will prompt you to deactivate it and to enter the password for the safety program.

NOTE
When downloading in disabled safety mode, you can only download the fail-safe blocks created by you (main safety blocks, F-FB, F-FC, or F-DB), F-application blocks, or standard blocks and their associated instance DBs. If you download automatically added F-blocks (F-SBs or automatically generated F-blocks and associated instance DBs, F-shared DB), the F-CPU can go to STOP mode or safety mode can be activated.
Therefore, always select individual blocks only when downloading in disabled safety mode.

Sequence for downloading changes

Changes in the safety program in RUN mode when safety mode is disabled can, for example, cause the status of an actuator to change as a result of program changes.

After changes, start by downloading the safety program and then the function of the standard user program monitored by the safety program.

Restrictions on safety-related CPU-CPU communication

During operation (in RUN mode), you cannot establish new safety-related CPU-CPU communication by means of new SENDDP/RCVDP or SENDS7/RCVS7 instructions.

To establish new safety-related CPU-CPU communication you must always download the relevant safety program consistently to the F-CPU while in STOP mode after inserting a new SENDDP, SENDS7, RCVDP, or RCVS7 instruction.

Restrictions on F-runtime group communication

You cannot make any changes to the safety-related communication between F-runtime groups in RUN mode. This means that you cannot assign, delete, or change any DBs for F-runtime group communication of an F-runtime group.

Following changes in the F-runtime group communication, you must always download the safety program consistently to the F-CPU while in STOP mode.

Restrictions on F-I/O access

If during operation (in RUN mode), you insert an F-I/O access to an F-I/O of which no single channel value or tag from the associated F-I/O DB has yet been used in the safety program, the F-I/O access only becomes effective when the safety program is downloaded consistently to the F-CPU.

Changing the standard user program

You can download changes in the standard user program when the F-CPU is in RUN mode, regardless of whether safety mode is enabled or disabled.

⚠ WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.
With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

Procedure for applying changes to the safety program

If you download individual F-blocks to the F-CPU during operation (in RUN mode), the F-system blocks (F-SBs) and the automatically generated F-blocks are neither updated nor downloaded, resulting in an inconsistent safety program in the F-CPU. Use the following procedure to apply changes to the safety program:

1. Download the safety program consistently to the F-CPU, and activate safety mode by switching the F-CPU from STOP to RUN mode (for procedure, see Downloading project data (Page 345)).
2. Follow the steps described in Acceptance of Changes (Page 427).

10.7.6 Safety program in RUN mode (S7-1200, S7-1500)

Introduction

You make changes to F-blocks offline in the *program editor* in the same way as for a standard program. Loading the changed F-blocks in RUN to the F-CPU is done with the Fast Commissioning mode in deactivated safety mode (Page 386).

The Fast Commissioning mode distinguishes between "Fast Compile" (default setting) and "Consistent Compile".

Fast Commissioning mode with "Fast Compile"can be used for minor software changes to the Safety program, e.g. for testing and commissioning. It enables a fast compile, as only the F-blocks created by the user are compiled here.

In contrast, the Fast Commissioning mode with "Consistent Compile" can be used, for example, at the end of commissioning to compile the safety program consistently and then download it consistently to the F-CPU. In this case, you forego the advantage of the fast compiling, but after downloading the safety program to the F-CPU, you can enable safety mode again immediately with a short STOP-RUN transition of the F-CPU.

NOTE

Do not switch the F-CPU to STOP in Fast Commissioning mode with "Fast Compile". Otherwise, the F-CPU does not restart afterwards because the F-CPU contains an inconsistent safety program.
Solution:

- Download a consistent safety program to the F-CPU and then carry out a STOP-RUN transition. The deactivated safety mode is hereby terminated.
- If your F-CPU supports "Consistent Compile", select "Consistent Compile" and download the safety program consistently to your F-CPU. After that, a STOP-RUN transition is possible.

NOTE

Fast Commissioning mode with "Fast Compile" behaves differently with *S7-PLCSIM* than with a real F-CPU.
An *S7-PLCSIM* restarts after a STOP.

Requirements

To activate and use Fast Commissioning mode, the following requirements must be met:

- You can use Fast Commissioning mode with "Fast Compile" as of Safety System version V2.4. It is available for S7-1200 G2 F-CPUs as of firmware V1.0, S7-1200 G1 F-CPUs as of firmware V4.5 and S7-1500 F-CPUs as of firmware V2.0.
- You can use the Fast Commissioning mode with "Consistent Compile" from Safety System version V2.5. It is available for S7-1200 G2 F-CPUs as of firmware V1.0 and for S7-1500 F-CPUs as of firmware V3.0. With S7-1500 F-Software Controller, it is available as of Safety System version V2.5 only for approved IPCs as of firmware V30.0.

  NOTE

  S7-1500 F Software Controller
  The approved IPCs can be found in the table in the Product information for the F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599).
  If IPCs that have not been approved are used, an error or restart of the F Software Controller occurs. The download must then be repeated in STOP.

- The "Safety mode can be disabled" option must be selected in the "Settings" area of the *Safety Administration Editor*.
- The offline Safety program must be consistent and identical to the online Safety program.
- The F-CPU is in RUN.

Enabling Fast Commissioning mode

You enable Fast Commissioning mode by clicking the "Enable Fast Commissioning" button in the "General" area of the Safety Administration Editor.

Here, "Fast Compile" is selected as the default setting.

Once Fast Commissioning mode with "Fast Compile" is active, the behavior when compiling changes (shortcut menu "Compile > Software (only changes)" and "Compile > Hardware and software (only changes)") switches to the behavior when compiling changes in Fast Commissioning mode with "Fast Compile".

As soon as you change to the "Consistent Compile" setting, you can also compile the safety program consistently and download it to the F-CPU in RUN.

NOTE

After enabling Fast Commissioning mode, all other areas in the *Safety Administration Editor* are grayed out except the "General" area. Write access in the *Safety Administration Editor* is not permitted, also not via Openness. Read access is still possible.
While Fast Commissioning mode with "Fast Compile" is activated, the *Safety Administration Editor* displays the information "Fast Commissioning is activated" as the status of the safety program.
No signatures are calculated in Fast Commissioning mode with "Fast Compile". Therefore, no statement can be made in this mode about the status of the safety program and the F-blocks with regard to the offline-online comparison. The status of the signature comparisons is displayed with the icon in this case.

Downloading changes in Fast Commissioning mode

To download changes to the Safety program to the F-CPU in RUN in Fast Commissioning mode, the following 3 conditions must be met:

- The F-CPU is in RUN.
- Safety mode is deactivated.
- Fast Commissioning is enabled.

If at least one of these 3 conditions is not met, the "Download" dialog displays a note that download in RUN mode is not possible.

NOTE

In case of a connection abort between the PG/PC and the F-CPU during loading in RUN mode, loading to the F-CPU can **not** be completed properly. Even the indicators of the safety program on the display and in the web server of the F-CPU are no longer current.
A subsequent loading in RUN is no longer possible in this case, even though all requirements for Fast Commissioning mode are being met.
Solution: Switch the F-CPU to STOP mode and download a consistent safety program to the F-CPU.

NOTE

If the work memory utilization of the F-CPU is > 80%, a download in RUN mode with "Consistent Compile" may be aborted and the download to the F-CPU may not be properly completed. Even the indicators regarding the safety program on the display and in the web server of the F-CPU are no longer current.
A subsequent download in RUN is no longer possible, even though all requirements for Fast Commissioning mode are met.
Solution: Switch the F-CPU to STOP mode and download a consistent safety program to the F-CPU.

Supported changes in Fast Commissioning mode

While Fast Commissioning mode is enabled, you cannot arbitrarily change your Safety program. The following is an overview of the supported changes.

- Changes to F-FBs/F-FCs/F-DBs. See "Changes not supported" for exceptions.
- Changes to fail-safe-compliant PLC data types. See "Changes not supported" for exceptions.
- Changes to the standard user program that influence the safety program, for example, DBs used in both the standard user program and the safety program.
- Creating and using F-blocks. See "Changes not supported" for exceptions.

Unsupported changes in Fast Commissioning mode with "Fast Compile"

While Fast Commissioning mode with "Fast Compile" is activated, you cannot make changes to your safety program at will. The following is an overview of the changes **not** supported .

Type of change	System response
All changes to the hardware configuration.	A STOP is required for the download to the F-CPU.
Change in an F-FB/F-FC:	
• Insertion of a new call of a time-processing instruction (for example, TON, TOF, TP, MUT_P...) or an ACK_OP/ACK_GL instruction. (Time value parameters can be reassigned in existing calls).	Compiling errors
• Insertion of a new call of a SENDDP/RCVDP instruction.	
• Insertion of a new access to an F-I/O (access to a tag of the F-I/O DB or to the process image) that has not yet been used in the F-runtime group.	
• Insertion of a new access to a communication with Flexible F-Link (access to a tag of the F-communication DB) which has not yet been used in the F-runtime group.	
Deleting in an F-FB/F-FC:	
• Deletion of a call of a time-processing instruction (for example, TON, TOF, TP, MUT_P...) or an ACK_OP/ACK_GL instruction.	Compiling errors when the instances are also deleted
• Delete a call to a SENDDP/RCVDP instruction.	Compiling errors

Type of change	System response
• Deletion of the last access to an F-IO (access to a tag of the F-I/O DB or to the process image) so that it is no longer used in the F-runtime group.	Compiling errors
• Deletion of the last access to a communication with Flexible F-Link (access to a tag of the F-communication DB) so that it is no longer used in the F-runtime group.	
Deleting an F-FB or F-FC when it was called before Fast Commissioning mode was activated. However, a call can be deleted.	Compiling errors
Deleting an F-DB when tags of this F-DB were already being used before Fast Commissioning mode was activated.	Compiling errors
Deleting a standard DB when tags of this DB were already being used for reading before Fast Commissioning mode was activated.	Compiling errors
Deleting a tag from the standard user program when it was already being used for reading before Fast Commissioning mode was activated.	Compiling errors
Structural changes of fail-safe-compliant PLC data types that are referenced in a Flexible F-Link communication.	Compiling errors
Creating library types of blocks	Compiling errors
Adding/deleting of:	
• F-OBs	Compiling errors
• Flexible F-Link communications	Blocking in the Safety Administration Editor
• F-runtime groups (including changes)	
• F-CD/F-MS connections (including changes)	
Inserting an F-FB/F-FC (e.g. from a library or a different F-CPU) with global access to an F-DB.	Compiling errors
Changing the instruction version in the "Instructions" task card.	Compiling errors
Creating and changing instruction profiles	
Downloading a Safety program compiled in Fast Commissioning mode from the F-CPU to the PG/PC.	Interlocking by loading the station from the device
Changes in the "Settings" area of the *Safety Administration Editor*.	Blocking in the *Safety Administration Editor*
Changes to the password for the safety program.	
Renaming of the F-OB	Errors during download
All changes with Openness. (Name area *SafetyAdministration*)	Are rejected with an exception.

NOTE

For the changes marked with "Compiling errors", the compiling of the safety program is aborted in Fast Commissioning mode. An additional note is displayed in the inspector window under "Info > Compile" indicating the F-block containing the unsupported change.

NOTE

The table "Unsupported changes in Fast Commissioning mode with Fast Compile" serves as an aid. When you see errors during compiling that refer to blocks that you have not programmed yourself, an unsupported change was most likely made. In this case, undo the previous changes or exit Fast Commissioning mode and compile the entire safety program.

NOTE

Logging in the F-change history is incomplete when Fast Commissioning mode with "Fast Compile" is activated, the following entries are not recorded:

- Collective F-Signature
- Compiling time stamp
- Compiled F-blocks with signature and time stamp

Unsupported changes in Fast Commissioning mode with "Consistent Compile"

In Fast Commissioning mode with "Consistent Compile", you also cannot change your safety program at will. Compared to "Fast Compile", however, many more changes to the safety program are possible. The following is an overview of the changes **not** supported .

NOTE

Note that the changes mentioned here must not be present when enabling Fast Commissioning mode with "Consistent Compile". Therefore, make sure that the offline safety program is consistent and identical to the online safety program. If you do not observe this, the F-CPU may STOP.

Type of change	System response
All changes to the hardware configuration.	A STOP is required for the download to the F-CPU.
Adding/deleting of:	
• Flexible F-Link communications	Blocking in the *Safety Administration Editor*
• F-runtime groups (including changes)	
Changes in the "Settings" area of the *Safety Administration Editor*.	
Changes to the password for the safety program.	
Renaming of the F-OB	CPU goes to STOP
All changes with Openness. (Name area *SafetyAdministration*)	Are rejected with an exception.
Insertion of a new call of an ACK_GL instruction.	Possible, but results in passivation of all F-I/Os. Reintegration is only possible with a STOP-RUN transition.
Insertion of a new access to an F-I/O (access to a tag of the F-I/O DB or to the process image) that has not yet been used in the F-runtime group.	Possible, but results in passivation of the affected F-I/O. Reintegration is only possible with a STOP-RUN transition.
Deletion of a call to an ACK_GL instruction.	Possible, but results in passivation of all F-I/Os. Reintegration is only possible with a STOP-RUN transition.
Deletion of the last access to an F-IO (access to a tag of the F-I/O DB or to the process image) so that it is no longer used in the F-runtime group.	Possible, but results in a diagnostic buffer entry via a "Profisafe communication error".

Exiting Fast Commissioning mode

To exit Fast Commissioning mode with "Fast Compile" and return to Safety mode, proceed as follows:

1. Click on the "Deactivate Fast Commissioning" button.
2. Compile the Safety program with Software (rebuild all).
3. Download the safety program to the F-CPU. The F-CPU is set to STOP mode by this.
   In a redundant S7-1500HF system, you have to select "Stop R/H system" in the "Load preview" dialog.

After that, the online Safety program is consistent again and the F-CPU can be switched to RUN with Safety mode enabled.

To exit Fast Commissioning mode with "Consistent Compile" and return to Safety mode, proceed as follows:

1. Click on the "Deactivate Fast Commissioning" button.
2. Perform a STOP-RUN transition to enable safety mode again.

10.8 F-change history

Enable the logging of changes of the safety-related project data by using the option "Enable F-change history" in the *Safety Administration Editor*.

An F-change history is created for each F-CPU in the project navigation under "Common data/logs".

The following is logged in the F-change history:

- Collective F-Signature
- User name
- Compile time stamp
- Download of the safety-related project data with time stamp
- Compiled F-blocks with signature and time stamp

The F-change history can contain a maximum of 5000 entries per F-CPU. When the 5000 entries are exceeded, a new F-change history is created using the naming scheme "F-change history <CPU name> YYYY-MM-DD hh:mm:ss".

After a project upgrade, the "Go to" function is not supported anymore for the F-change history of the project for the entries which were created before *STEP 7 Safety* V15.1.

NOTICE
The connection between the F-CPU and the associated F-change history is made through the name of the F-change history. Therefore, do not rename the F-CPU and the F-change history. If you rename the F-CPU or the F-change history, a new F-change history with the current name of the F-CPU is started.

NOTE

You are not permitted to use the F-change history to identify changes of the safety-related project data for acceptance of changes.

To accept changes, proceed as described under Acceptance of Changes (Page 427).

NOTE
We recommend activating the F-change history before changing over to productive operation.

System acceptance

11

11.1 Overview of System Acceptance

Introduction

When performing a system acceptance test, all the standards and guidelines (for example PROFINET Installation Guidelines) relevant to the specific application must be complied with. This also applies to systems that are not "subject to acceptance". For the acceptance, you must consider the requirements in the Certification Report (https://support.industry.siemens.com/cs/ww/en/view/109825198).

As a general rule, the acceptance of an F-System is performed by an independent expert. The independence required of the expert must be defined in the safety plan and depends on the required PL/SIL.

Observe all warnings in this manual.

⚠ WARNING

The configuration of F-CPUs and F-I/Os as well as the programming of F-blocks must be carried out in TIA Portal as described in this documentation. To ensure safe operation with the SIMATIC Safety system, you must comply with the requirements of the relevant standards, such as IEC 61508. The section System acceptance (Page 407) describes procedures and tools of STEP 7 Safety to meet these requirements. *(S056)*

Proof of the correct implementation of the safety-related project data

In order for a system acceptance to be granted, you must assess and document the correctness of the individual components. For documentation of the component characteristics, you must create the safety summary.

The following characteristics must be covered:

- Correctness of the safety program including hardware configuration (including testing) (Page 408)
- Completeness of the safety summary (Page 409)
- Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate (Page 410)
- Compliance of the know-how protected F-blocks used in the Safety program with their safety summary. (Page 411)
- Completeness and correctness of the hardware configuration (Page 412)
- Completeness and correctness of safety-related communication (Page 418)
- Identity of online and offline program (Page 424)
- Other characteristics (Page 425) such as software version, use of data from the standard user program

After the acceptance, you should archive all relevant documents and also the project data so as to make the accepted project available as a reference for a subsequent acceptance.

Safety summary

The safety summary (Page 382) is the documentation of the project that is required for system acceptance

11.2 Correctness of the safety program including hardware configuration (including testing)

The correctness of software cannot only be ensure through tests and verifications during commissioning, but rather already requires the observance of a wide variety of measures during creation. Also see warning S062 on this in chapter "Overview (Page 22)".

Verification/function test

Already during the creation, you will test (Page 384) your safety program and the associated hardware configuration. You must carry out these tests with regard to the specification of your safety functions and document them before you perform the system acceptance.

In order to perform a code review of your safety program and/or document the accepted program code, you can include the source code of all F-blocks in the safety summary (Page 382). To do this, select the "All" option when printing.

If you want to carry out a function test after loading, you have to carry out program identification. More information is available in "Downloading project data (Page 345)".

The correct function of the safety program must be guaranteed by complying with all steps from the "Overview of System Acceptance (Page 407)" chapter before it can be used productively. When using configuration control (option handling), you must ensure correct operation of the safety program for all possible station options by performing appropriate functional tests. You should archive the test reports along with the safety summary and the acceptance documents.

Times, for example monitoring times (Page 615) and delay times, can only be verified to a limited extent with functional tests (Page 345). For this reason, you should check these times selectively to determine whether they are dimensioned correctly, for example, using the safety summary.

Some of these times are itemized specifically in the safety summary, for example, the F-monitoring time (for communication between F-CPU and F-I/O) and the monitoring time of the safety-related CPU-CPU communication (TIMEOUT). To determine the monitoring times derived under normative conditions, the Excel file for response time calculation is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831). These have to be considered together with the practically determined conditions of the application. Note that these monitoring times have an impact on the response times of your safety functions.

Consistency of the safety program

Check in the "General information" section of the safety summary to determine whether the safety program was recognized as "consistent".

This is the case for S7-300/400 F-CPUs only if the following signatures are also identical:

- Collective F-Signature ("General information" section, "Collective F-Signature")
- "Signature of F-blocks with F-attribute" ("General information" section, "Current compilation")

Consistency of the safety program is required for the acceptance. If the signatures are not identical, you have the possibility to establish consistency by recompiling the safety program and re-creating the safety summary.

11.3 Completeness of the safety summary

Introduction

When you have an acceptance-ready version of your safety-related project data, you must perform and document additional checks of the safety summary to prove that the safety summary is complete and belongs to the safety program to be accepted.

Creating a safety summary

Follow the procedures described in Creating a safety summary (Page 382) to create the safety summary. In so doing, select "All" under Properties in the "Print" dialog to include the source code of your F-blocks and their utilized named value data types and PLC data types in the documentation.

Completeness of the safety summary

The safety summary of *STEP 7 Safety* is always created in its entirety. When performing subsequent processing steps (for example, creating copies, inserting (electronic) signatures, comments, etc.), the completeness must continue to be maintained.

If you created the safety summary with the "All" option, the source code of all F-blocks will also be printed. The printout of this source code also includes the footer, which contains the collective F-signature of the associated safety program.

The information "Number of pages in the safety summary" does not include the pages on which the source code of the F-blocks is output.

Association with the safety program

In the "General information" section of the safety summary, check whether the Collective F-Signature corresponds online and offline to the Collective F-Signature of the safety program to be accepted in the work area of the *Safety Administration Editor* under "General". If they are not the same, then the summary and safety program do not match. Bear in mind that the F-BaseID is not included in the Collective F-Signature and, if relevant, must be checked separately.

11.4 Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate

Introduction

STEP 7 Safety contains LAD/FBD instructions for programming of your safety program as well as F-system blocks for creating an executable safety program that have been created and tested by SIEMENS and certified by TÜV. The F-system blocks used are automatically inserted by the F-system based on the set safety system version (see section "Settings" area of the Safety Administration Editor (Page 89)).

To allow you to check whether the used versioned LAD/FBD instructions and F-system blocks correspond to Annex 1 of the Report for the TÜV certificate and to the versions you intend to use, these are listed in the safety summary.

Procedure

To check, download the current Annex 1 of the report for the TÜV certificate "SIMATIC Safety" from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109825198).

Proceed as follows for the check:

⚠ WARNING

- (S7-1200, S7-1500) The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions in Annex 1 of the Report for the TÜV certificate.
- (S7-300, S7-400) The versions, signatures and initial value signatures of the versioned LAD/FBD instructions and F-system blocks listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions, signatures and initial value signatures in Annex 1 of the Report for the TÜV certificate.
- The versions of the versioned LAD/FBD instructions listed in the safety summary must meet the safety requirements of your application.
  Keep in mind possible differences in functionality of different versions specified in the section for the respective instruction.
- The safety system version listed in the safety summary under "Safety program settings" must match the versions in Annex 1 of the Report for the TÜV certificate. *(S054)*

In case of discrepancies, recheck whether you have the correct versions.

(S7-300, S7-400) Differences can also arise when there are F-blocks / instructions in your safety program that are not used.

11.5 Compliance of the know-how protected F-blocks used in the Safety program with their safety summary.

If you use know-how protected F-blocks (for example, from libraries) to program your Safety program, the source code for these is not output in the safety summary.

Therefore, the author of the know-how protected F-block must already carry out acceptance of the F-block and provide the following information:

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-blocks
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

For system acceptance, you must perform the following checks using the safety summary:

- The signature and initial value signature of each know-how protected F-block listed in the safety summary in the section "F-blocks in Safety program" must correspond to the signature and initial value signature documented by the author.
- The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in Safety program" must correspond to the versions of each know-how protected F-block documented by the author or must be functionally identical with them.
- The signatures and initial value signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "F-blocks in Safety program" must correspond to the signatures and initial value signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures and initial value signatures. If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version that was set while setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-FBs/F-FCs in the know-how protected F-block.
- Signatures of all F-DBs accessed by the know-how protected F-block.

For system acceptance, you must perform the following checks using the safety summary:

- The signature of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the signature documented by the author.
- The safety system version of each know-how protected F-block listed in the safety summary under "Know-how protected F-blocks in the Safety program" must correspond to one of the versions listed in Annex 1 of the Report for the TÜV certificate.

- The versions of the versioned LAD/FBD instructions of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the versions documented by the author or must be functionally identical with them.
- The signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures. If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

11.6 Completeness and correctness of the hardware configuration

Introduction

The hardware configuration is an essential component of the project to be accepted. With the configuration of the hardware, you have set properties that can influence the safety of signals. You must document these settings with the safety summary to prove that you fulfill the safety requirements of your application.

The section "Hardware configuration of F-I/O" is available in the safety summary for this. This section consists of several tables:

- A table with information about the F-CPU and about the ranges of F-destination addresses used, the "Central F-source address" and the F-BaseID of the F-CPU.
- Overview tables with the F-I/O used.
- A table for each F-I/O with information on the F-I/O and all parameters of the F-I/O with the configured values.

NOTE

Note that you will find F-I/O that you address via safety-related I-slave-slave communication in the safety summary of the F-CPU of the I-slave and not in the safety summary of the F-CPU of the assigned DP master.

The safety summary of the F-CPU of the DP master contains a note in the overview table for this F-I/O indicating that it is not assigned to this F-CPU.

NOTE

When using shared devices:

Note that F-I/O that you address in a shared device can be found in the safety summary of the F-CPU of the IO controller to which it is assigned.

The safety summary of the other F-CPUs (IO controllers) that share the cross-project shared device contains a note in the overview table for this F-I/O indicating that it is not assigned to this F-CPU.

Procedure for checking that the hardware configuration is complete

Check whether the safety summary contains all the configured F-I/O. Also make sure that there is no F-I/O that you have not configured as belonging to this F-CPU.

NOTE

If configuration control (option handling) is used, the safety summary must contain all the F-I/Os of the maximum configuration. The following checks are to be carried out for al the F-I/Os of the maximum configuration.

Procedure for checking the correctness of the hardware configuration using the safety summary

To check the hardware configuration for correctness, proceed as follows:

1. Check in the "Hardware configuration of F-IO" section to verify the uniqueness of the PROFIsafe addresses.

   Observe the information in sections

   PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 65)

   PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 66)

   PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68)

   Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 37)

   Recommendation for PROFIsafe address assignment (Page 61)

   – For F-CPUs to which F-I/Os of PROFIsafe address type 2 are assigned:

     Check if the "Central F-source address" parameter of the individual F-CPUs differs network-wide.

     (This also applies to F CPUs that have F-I/O of PROFIsafe address type 3 assigned to them, unless an individual active F-BaseID is generated for each F-CPU.)

   – Check that the setting of the F-BaseID parameter is as expected, i.e. inactive (value 0), "Delayed transfer" (value 0x7C6) or an individually generated value for the F-CPU. Observe also warnings S115 and S116.

   – For F-I/Os of PROFIsafe address type 1 check whether the F-destination addresses comply with the following warning:

     ⚠ WARNING

     F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).
     The F-destination address (and therefore also the switch position on the address switch) of the F-I/O of PROFIsafe address type 1 must be unique network-wide* and CPU-wide**/*** (system-wide) **for the entire** F-I/O. For this, the F-I/O of PROFIsafe address type 2 and PROFIsafe address type 3 when F-BaseID is inactive (value = 0) must also be taken into account. *(S051)*

     * A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

– For F-I/Os of PROFIsafe address type 2 check whether the F-destination addresses comply with the following warning:

⚠ WARNING

F-I/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.
The combination of F-source address and F-destination address for each F-I/O of PROFIsafe address type 2 must be unique network-wide* and CPU-wide**/*** (system-wide). In addition, the F-destination address must not be occupied by F-I/O of PROFIsafe address type 1.
If you use a supported configuration (Page 62), you only have to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

– For F-I/O of PROFIsafe address type 3, check whether the F-destination addresses comply with the following warning:

> **⚠ WARNING**
>
> The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.
> With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

– Check whether the PROFIsafe addresses of fail-safe GSD based DP slaves / GSD based I/O devices comply with the following warning:

> **⚠ WARNING**
>
> Check the documentation for your fail-safe GSD based DP slaves / fail-safe GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. For configuring, proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 65), PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 66) or PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 68).
> Set the F-source address for fail-safe GSD based DP slaves / fail-safe GSD based I/O devices according to the manufacturer's specifications. If the F-source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, check the safety summary to verify that the value for the "Central F-source address" parameter corresponds to the value of the F-source address of the fail-safe GSD based DP slave/fail-safe GSD based I/O device. *(S053)*

2. Check the safety-related parameters (including F-monitoring time or F_WD_Time) of all configured F-I/O.

   You can find these parameters in the "Hardware configuration of F-I/O" section in the detailed tables for the F-I/O.

   The table consists of two parts:

   – The left part contains the parameters which refer to the F-I/O itself ("Module data").
   – The right part contains the parameters of the individual channels ("Channel parameters")

   These parameters must be set as prescribed by the safety requirements of your application.

When using fail-safe GSD based DP slaves/GSD based I/O devices, note the relevant documents for the possible additional safety-related (technological) parameters.

NOTE

F-I/O that are to be assigned the same safety-related parameters (except for PROFIsafe addresses) can be copied during configuration. Except for the PROFIsafe addresses, you no longer have to check the safety-related parameters individually. It is sufficient to compare the "F-parameter signature (without addresses)" in the "Hardware configuration of the F-I/O" section in the overview table. This also applies to fail-safe GSD based DP slaves/GSD based I/O devices without i-parameters. For GSD based DP slaves/GSD based I/O devices with i-parameters, it might be that the "F-parameter signature (without addresses)" does not match, even though all safety-related parameters, except for the PROFIsafe addresses, do match. In this case, you need to compare all safety-related parameters.
Exception:
For F-I/Os that do not support the "RIOforFA-Safety" profile, you need to compare the "Behavior after channel fault" parameter, if any, in addition to the "F-parameter signature (without addresses)".

3. Check whether the article numbers of the F-I/O in the safety summary correspond to the article numbers of the F-I/O actually present in the system. If the article numbers are different, the F-I/O present must be compatible as a replacement part for the F-I/O listed in the safety summary.

4. For non-supported configuration, see Configurations supported by the SIMATIC Safety F-system (Page 62).

⚠ WARNING

If you create a configuration that is not one of the supported configurations, you must observe the following in addition to the warnings S051, S052, S053 and S115:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/O in the PROFINET IO environment[1], you must check the safety summary for correctness of the PROFIsafe operating mode parameter (F_Par_Version). V2 mode must be set in the PROFINET IO environment. F-I/O that support only V1 mode must not be used in the PROFINET IO environment.
- Based on the safety summary, you must check whether the components of the PROFIsafe address centrally assigned for the F-CPU were transferred correctly into the respective F-I/Os:
  - PROFIsafe address type 3: F-BaseID from the "F-BaseID" parameter of the F-CPU.
  - PROFIsafe address type 2 and 3: F-source addresses from the "Central F-source address" parameter of the F-CPU.
- You must ensure the CPU-wide[2,3] and/or network-wide[4] unique assignment of the F-destination address for F-I/Os:
  - For F-I/O of PROFIsafe address type 1 or 2 (if you cannot set the F-source address to match the "Central F-source address" parameter of the F-CPU), you must ensure the network-wide[4] uniqueness of the PROFIsafe address through the unique assignment of the F-destination address alone.
  - In an unsupported configuration, you must check the uniqueness of the F-destination address individually for each F-I/O using the safety summary, regardless of the PROFIsafe address type.
    PROFIsafe address type 1: Network-wide[4] and CPU-wide[2,3]
    PROFIsafe address type 2 and 3: Only CPU-wide[2,3].

(S050)

1) The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

2) "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

3) In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

4) A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via

RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

11.7 Completeness and correctness of safety-related communication

Introduction

Safety-related communication is based on the mechanisms of the standard communication of *STEP 7*.

Safety-related communication must also detect and uncover communication errors, which remain undetected in the lower-level standard communication. Further parameters are required for this, which you have to document and check on acceptance.

For this purpose, the "Block parameters for safety-related CPU-CPU communication", "Communications via Flexible F-Link Overview" and "Communications via OPC UA Safety Overview" sections are available in the safety summary.

The section "Block parameters for safety-related CPU-CPU-communication" contains up to two tables (for communication via PROFIBUS DP or PROFINET IO and for communication via S7 connections).

The section "Communications via Flexible F-Link Overview" contains a table with an overview of the connection configurations and a "Communications via Flexible F-Link for UDT" table for each used F-compliant PLC data type (UDT).

The section "Communications via OPC UA Safety Overview" contains multiple tables with an overview of all OPC UA data types used by SafetyProviders or SafetyConsumers, as well as a detailed view of all communication parameters for every SafetyProvider and every SafetyConsumer.

Not all safety-related communication is available for all F-CPUs. More information can be found in the section "Safety-related communication (Page 196)".

NOTE

The statements made regarding communication via Flexible F-Link in this section also apply when this communication is used between F-runtime groups.

11.7.1 Completeness and correctness of safety-related communication

(S7-300, S7-400) Observe the following warning for safety-related communication with the SENDS7/RCVS7 instructions:

⚠ WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.
You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the Safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

Observe the following warning for safety-related communication with the SENDDP/RCVDP instructions:

⚠ WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.
You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

Observe the following warnings for communication via Flexible F-Link:

⚠ WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

⚠ WARNING

For each communication connection via Flexible F-Link, you must ensure that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides during acceptance of the safety program.
You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

11.7.2 Procedure to check the correctness of the configuration of communication with OPC UA Safety

Procedure to check the correctness of the project planning for every SafetyProvider

You must carry out the following verifications for each SafetyProvider in the respective SafetyProvider detail view of your safety summary.

- Check the correctness of the values of the SPI parameters.
- Check the correctness of the assignments of the local data on the SAPI parameters.
- Check whether the necessary uniqueness of the combination of active SafetyProviderID and active SafetyBaseID of all SafetyProviders is available at all times.
  - For static connections:

    The set values can be found in the respective SafetyProvider detail view.

    If the value for SafetyBaseIDConfigured has been generated by the system, you do not have to undergo the SafetyBaseID, since the sufficient uniqueness is ensured by the STEP 7 Safety Engineering. If you have entered the value yourself, you must verify sufficient uniqueness. You will be shown whether this is necessary in the respective SafetyProvider detail view.
  - For dynamic connections:

    Ensure correct implementation of the algorithm for generating the values of the local data that is mapped to the SafetyProviderID and SafetyBaseID SAPI parameters.

Note the following warnings:

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **
If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***
You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 325)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

⚠ WARNING

If you have not defined any value for the SPI parameter of a SafetyProvider in the NodeSet for the SPI parameter, a sufficiently clear UUIDV4 is made available from the system as a value for the parameter of the respective SafetyProvider when importing the NodeSet into the TIA Portal.
Through subsequent copying of a SafetyProvider (e.g. copying the NodeSet to another F-CPU, copying the F-CPU or copying the project), values provided by the system are not generated again and are therefore not unique anymore.
If such a copy is used to configure a new communication relationship, you yourself need to ensure the uniqueness. To do this, open the properties tab of all affected SafetyProvider and generate the value of SafetyBaseIDConfigured again by clicking on the "Generate" button. The uniqueness must be checked in the safety summary during acceptance. *(S110)*

Procedure to check the correctness of the configuration for every SafetyConsumer

You must carry out the following verifications for each SafetyConsumer in the respective SafetyConsumer detail view of your safety summary.

- Check the correctness of the values of the SPI parameters.
- Check for compliance of the active SafetyProviderID and active SafetyBaseID with the SafetyProvider intended for communication.
  - For static connections:
    The set values can be found in the respective SafetyConsumer detail view.
  - For dynamic connections:
    Ensure correct implementation of the algorithm for generating the values of the local data that is assigned to the SAFETY_PROVIDER_ID and SAFETY_BASE_ID variables of the associated F-OPC-UA-Consumer-DB.
- Check the correctness of the substitute value.
- Check that the data structure of SafetyData of the SafetyConsumer matches the data structure of SafetyData of the intended SafetyProvider. This means that at each position of the data structure, the data type must match the data type on the corresponding position on the side of the SafetyProvider on the side of the SafetyConsumer. Different names may be permitted if it is ensured that there are no confusion of the meanings of the individual elements of the data structure. In particular, the correct order of elements of the same data type is relevant.

Note the following warnings:

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.
Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 97)" or "F-CPU access protection (Page 100)".
For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.
Print the relevant program sections and supplement your safety summary with this printout.
(S103)

WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.
When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.
To identify the communication connection, note the following points:

- For static connections:
  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:
  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

11.8 Identity of online and offline program

Once you have checked all properties of the offline safety program you must ensure that the safety program is identical on the F-CPU on which it is supposed to be run.

WARNING

In a redundant S7-1500HF system, you must perform the verification of identity of the online and offline program in RUN-Redundant mode. In so doing, it is sufficient to perform the verification only for one S7-1500 HF-CPU. *(S098)*

1. Connect online with the F-CPU. If multiple F-CPUs can be reached over a network (e.g. Industrial Ethernet) by the programming device / PC, you have to ensure that you are connected with the correct F-CPU. For example with "Online & diagnostics" > "Online accesses " > "Flash LED".
2. Open the *Safety Administration Editor*.
3. Check whether the online and offline Collective F-Signatures correspond to the Collective F-Signature from the safety summary.
4. Now check in the "General" area under "Safety program status" whether the safety programs are identical online and offline.
   Use the "Status" and "Version comparison" display to check which situation you are dealing with and, if necessary, execute the recommended measure:

Status	Version comparison	Statement	Measure
	Not relevant	The safety programs are different.	– Ensure that you are connected to the desired F-CPU. – Download the safety program to the F-CPU.
		The safety programs are identical but different versions of F-blocks are used.	The safety program must be downloaded to the F-CPU for the latest versions to become effective.
		The safety programs are identical.	None

5. If relevant:
   Check in the "General" area under "PROFIsafe" to see if the values for the F-BaseID match offline and online. See also warning S116.

Status	Meaning
	The online and offline F-BaseIDs match.
	The online and offline F-BaseIDs do *not* match.
	The F-BaseID could not be determined online or is not supported.

11.9 Other characteristics

Introduction

In addition, you must check a few more characteristics that are also relevant for the acceptance of the project.

Plausibility check for data transfer from the standard program to the safety program

Check to determine whether a plausibility check was programmed for all data transferred from the standard user program to the safety program. For this purpose, the "Data from the standard user program" section lists all tags of the standard user program that you are reading in the safety program. Tags of the standard user program that you are writing in the safety program are not listed here because a plausibility check is not required for them. For more information, refer to the S015 warning in section "Data Transfer from Standard User Program to Safety Program (Page 194)".

Multiple call of an F-FB or an instruction with the same instance (single instance or multi-instance)

Check whether you used a separate instance for each call of an F-FB or an instruction.

Multiple calls with the same instance are usually not worthwhile and require special care:

For example, if you explicitly transfer an operand (for example, as a constant) in the 1st call to the instance, and there is no explicit transfer in the 2nd call (so that the start value is valid), you must verify which value in the 2nd call is valid for this operand. Also consider startup processes in this regard; higher priority OBs or similar in which the 1st call may be present.

Checking the program version

Check whether the version of *STEP 7 Safety* used to create the summary (in the footer of the printout) is as least as high as the version used to compile the safety program. You can find the latter version in the section "General information" of the safety summary under "Used versions". Both versions must be listed in Annex 1 of the Report for the TÜV certificate.

Ability to disable safety mode

Make sure that safety mode cannot be disabled. For information about this, refer to section "General information" under "Safety program settings". This setting ensures that the safety mode of the safety program cannot be disabled inadvertently. For more information, refer to the S027 warning in section "Disabling safety mode (Page 386)".

Safety system version with an S7-1500 HF-CPU

Check whether the safety system version is V2.4 or higher when using an S7-1500 HF-CPU.

For information about this, refer to section "General information" under "Safety program settings".

Access protection

Check in the "General information" section under "Access protection" to determine whether the setting for access protection is permitted. Note the following warnings.

Otherwise, the project must not be accepted, because the safety program in the F-CPU is not protected against unauthorized accesses.

⚠ WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.
With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

⚠ WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.
If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.
If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.
If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".
Assign different passwords for the individual access levels. *(S041)*

F-Admin right of the web server

For S7-1200 G1 F-CPUs with firmware < V4.7 and S7-1500 F-CPUs with firmware < V3.1, the user management of the web server is part of the hardware configuration.

For S7-1500 F-CPUs as of firmware V3.1 and S7-1200 G1 as of firmware V4.7 or S7-1200 G2 as of firmware V1.0, this right is set in the Runtime rights of the respective F-CPU in the "Users and roles" area.

When downloading for the last time before the transition to productive operation, ensure that only authorized persons have the "F-admin" right for the web server.

After the download, the "F-Admin" right setting can only be checked online in the TIA Portal in the *Safety Administration Editor* (S7-1200 G1 F-CPUs with firmware < V4.7 and S7-1500 F-CPUs with firmware < V3.1) or in the "Security settings\Users and roles" tab (F-CPUs

S7-1500 as of firmware V3.1 and S7-1200 G1 as of firmware V4.7 or S71200 G2 as of firmware V1.0).

WARNING

The "Change parameter of the F-System (F-Admin)" authorization for the web server (including web server API) without password protection (user "Everybody", or user "Anonymous" when using the user management) is intended only for testing, commissioning, etc. This means only when the system is not in productive operation. In this case, you must ensure the safety of the system through other organizational measures.
Before the transition to productive operation, you must remove the rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" from the "Everybody" or "Anonymous" user.
The password of the web server user with "Change parameter of the F-System (F-Admin)" right may only be disclosed to authorized persons. After downloading the hardware configuration, check whether only permitted users of the web server have the "Change parameter of the F-System (F-Admin)" right on the F-CPU. To do so, use the online mode of the *Safety Administration Editor* for an F-CPU without user management or the "Security settings\Users and roles" tab for an F-CPU with user management.
Saving the login file and the password of the web server in the browser is only permitted when usage by unauthorized persons is prevented through other organizational measures.
If you use the ticket mechanism, handling of the tickets must be just as restrictive as handling of the user password of the web server with the "Change parameter of the F-System (F-Admin)" right. *(S064)*

11.10 Acceptance of Changes

Introduction

In general, you can adopt the same approach for the acceptance of changes as the initial system acceptance (see Overview of System Acceptance (Page 407)).

You have to check the entire safety-related project data (Safety program and safety-related hardware configuration) for changes and determine the safety-related project data to be validated and approved as part of an impact analysis.

WARNING

In the case of acceptance of changes, you must check whether the intended changes were made correctly and completely.
You must also check whether unintentional changes may have been made at another location (for example, F-I/O or instructions that were added). *(S072)*

To avoid the acceptance of the entire system in case of negligible changes, *STEP 7 Safety* helps you to identify those parts of your Safety program that have changed.

To accept changes, proceed as follows:

1. Localize the changes in the safety-related project data:
   - changed or newly added F-blocks
   - changed or newly added instructions and F-system blocks
   - safety-related parameters of the changed or newly added F-I/O
   - structure of the safety-related hardware configuration (e.g. slot positions or start addresses of the F-I/Os)
   - changed safety-related communication via Flexible F-Link
   - changed safety-related communication via OPC UA Safety
2. From these changes, determine the safety-related project data affected by them (impact analysis). This can also be safety-related project data that has not been changed.
3. Then you carry out a validation and acceptance of the safety-related project data affected by the changes.

NOTE

Acceptance of changes is not possible after CPU migration.

⚠ WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test (Page 390).
Examples for such changes are:

- Adding F-I/Os
- Changing the start address of F-I/Os
- Changing the slot position of F-I/Os
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Localization of changes in the safety-related project data

To be able to localize relevant changes, you need two TIA projects:

- Reference project: Contains the initially accepted project data. They are the starting point for the upcoming comparison.
- Project to be accepted: Contains the current safety-related project data. It is the result of the reference project and the changes made in it.

To localize changes you have to compare the safety-related project data from the reference project with the safety-related data of the project to be accepted (see Comparing Safety Programs (Page 380)). Use filter setting "Compare only F-blocks relevant for certification". This limits the output of the comparison to the relevant F-blocks.

We recommend adding the summary (possibly as PDF) of the compare result to the acceptance documents.

The Collective F-Signature is a quick first step to determine whether relevant changes have been made. If the signature has changed, relevant changes are present in the safety-related project data.

(S7-1200, S7-1500) You can now use the Collective F-SW-Signature, the Collective F-HW-Signature and the F-Communication Address Signature to narrow down whether these changes are contained in the Safety program (Collective F-HW-Signature changed) and/or in the safety-related hardware configuration (Collective F-HW-Signature) and/or in the communication data (with Flexible F-Link, F-Communication Address Signature).

Bear in mind that the F-BaseID does not enter into any of the specified signatures and, if relevant, must be checked separately (see "Completeness and correctness of the hardware configuration (Page 412)").

Localization of changes in the Safety program

(S7-1200, S7-1500) A quick possibility to detect changes in the Safety program is the comparison of the Collective F-SW-Signature of the safety-related project data in the reference project with the Collective F-SW-Signature in the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the Safety program which need to be validated and, if necessary, accepted.

To localize changes in the Safety program, perform an offline-offline comparison between the Safety program to be accepted of the project to be accepted and the Safety program of the reference project (see Comparing Safety Programs (Page 380)).

⚠ WARNING

Make sure that the comparison criterion "Safety" is enabled and all other comparison criteria are disabled so that the criteria relevant for acceptance of changes are taken into consideration in the comparison. *(S069)*

If additional comparison criteria are enabled, you will see additional changes not relevant for the acceptance of changes (e.g. time stamp).

The status of the comparison helps you to identify which F-blocks were changed.

(S7-1200, S7-1500) As an alternative to the offline-offline comparison, you can localize the changes in the Safety program by comparing the group signatures. Use the safety summary of the reference project and of the project to be accepted for this purpose. Groups with an unchanged signature indicate that no F-blocks in them or lower-level groups have been changed. In groups with a changed group signature, you can localize the changed F-blocks using their changed block signature. Note that the assignment of F-blocks to groups is not recorded by the Collective F-Signature.

Changes to the maximum cycle time of an F-runtime group and F-cycle time warning limit of an F-runtime group are visible during comparison output through changes to the system block F-runtime group info DB.

The following changes do not influence the behavior of the Safety program directly and neither lead to a change of the Collective F-Signature nor are they shown during an offline-offline comparison. In the event of a change acceptance test, you should be able to identify these specifically using the safety summaries:

- Changes to the runtime for the deactivated safety mode
- Changes of the Safety System version
- Changes in the group structuring of the program blocks

Localization of changes in the safety-related hardware configuration

(S7-1200, S7-1500) A quick possibility to detect changes in the safety-related hardware configuration is the comparison of the Collective F-HW-Signature of the safety-related project data in the reference project with the Collective F-HW-Signature of the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the safety-related hardware configuration which need to be validated and, if necessary, accepted.

(S7-1200, S7-1500) If the Collective F-HW-Signature has changed and all F-IOs are unchanged, this indicates that safety-related parameters of the F-CPU have changed, or that the structure of the safety-related hardware configuration has changed, for example, slot positions.

Bear in mind that the F-BaseID does not enter into the Collective F-HW-Signature.

There are two possible ways for localizing safety-related changes in the safety-related hardware configuration:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison

The reference project and the project to be accepted must be consistent and compiled for a comparison. To perform the comparison, see Comparing Safety Programs (Page 380).

1. Navigate in the comparison result to the "System blocks > STEP 7 Safety > F-I/O DBs" folder. All data blocks listed in this folder are F-I/O-DBs and are each assigned to an F-I/O.
   - If the F-I/O-DBs in the comparison result are identical, this means that the safety-related configuration of the assigned F-I/O was also not changed. Standard-parameters might have changed.
   - If the F-I/O-DBs in the comparison result are not identical, this means that the safety-related configuration of the assigned F-I/O was also changed.
   - If F-IO DBs in the comparison result are marked as "not existing", associated F-IOs might have been deleted or added or the name or start addresses of the F-IOs have been changed. In this case, you can find the assignment of an F-I/O DB to a specific F-I/O in the safety summary under "Hardware configuration of F-I/O".
2. If you have found changed F-I/O, you can check the changed parameters in the safety summary as described below.

Note that this method is not suitable for identifying differences for the following parameters: HW ID, slot address, F-BaseID.

Localization by comparison of two safety summaries
Carry out a comparison based on two safety summaries as follows:

1. In the section "Hardware configuration of the F-I/Os" compare the start addresses (I/O addresses), the parameter "Behavior after channel fault" and the slot of the F-I/Os.
2. In the "Hardware configuration of F-I/O" section in the overview table of the F-I/O used, compare the parameter CRCs of the F-I/O with those in the safety summary of the corresponding F-CPU from the reference project.
   - If the "Parameter signature (without addresses)" is different for an F-I/O, this indicates the existence of a change in the safety-related parameters of the F-I/O.

     In this case, check the corresponding detail table of the safety-related parameters of the F-I/O and verify the uniqueness of the PROFIsafe addresses.
   - If the "Parameter signature (w/o addresses)" is identical, only the PROFIsafe addresses have been changed.

     In this case it is sufficient to verify the uniqueness of the PROFIsafe addresses.

Check as described in section "Completeness and correctness of the hardware configuration (Page 412)".

(S7-1200, S7-1500) Detecting changes in the communication with Flexible F-Link

A quick possibility to detect changes in the configuration of the communication with Flexible F-Link is the comparison of the F-communication address signature of the safety-related project data in the reference project with the F-communication address signature of the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the configuration of the communication (UUID only) with Flexible F-Link that must be validated and, if necessary, accepted. Other communication parameters such as timeout or transmission direction are covered by the Collective F-SW-Signature (see "Localization of changes in the Safety program" above).

There are two ways to localize safety-related changes in the communication with Flexible F-Link:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison
The reference project and the project to be accepted must be consistent and compiled for a comparison. For information on performing the comparison, see Comparing Safety Programs (Page 380).

1. Navigate in the comparison result to the "System blocks > STEP 7 Safety > Flexible F-Link" folder. All data blocks listed in this folder are F-communication DBs, and they are each assigned to a Flexible F-Link communication.
   - If F-communication DBs in the comparison result are identical, this means that the safety-related configuration of the assigned Flexible F-Link communication was not changed.
   - If F-communication DBs in the comparison result are different, this means that the safety-related configuration of the assigned Flexible F-Link communication was changed.
   - If F-communication DBs in the comparison result are marked as "not available", associated Flexible F-Link communications might have been deleted or added. In this case, you can find the assignment of an F-communication DB to a specific Flexible F-Link communication in the safety summary in the "Overview of communication via Flexible F-Link" table.
2. If you have identified a changed Flexible F-Link communication, you can check the changed parameters in the safety summary as described below.

Localization by comparison of two safety summaries
To localize changes in the configuration of the communication with Flexible F-Link, compare the section "Communications via Flexible F-Link Overview" of the reference project with that of the project to be accepted in the respective safety summary.

(S7-1500) Detecting changes in the communication with OPC UA Safety

There are two ways to localize safety-related changes in communication with OPC UA Safety:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison
The reference project and the project to be accepted must be consistent and compiled for a comparison. For information on performing the comparison, see Comparing Safety Programs (Page 380).

- For a comparison of SafetyConsumers, follow these steps:
  Navigate in the comparison result to the "System blocks > STEP 7 Safety > OPC UA Safety" folder. All data blocks listed in this folder are F-OPC-UA-Consumer-DBs, and they are each assigned to a SafetyConsumer. You can determine the specific SafetyConsumer based on the safety summary under "OPC UA Safety communication".
  - If F-OPC-UA-Consumer-DBs in the comparison result are identical, this means that the safety-related configuration of the associated SafetyConsumer was not changed.
  - If F-OPC-UA-Consumer-DBs in the comparison result are different, this means that the safety-related configuration of the associated SafetyConsumer was changed.
  - If F-OPC-UA-Consumer-DBs in the comparison result are marked as "not available", associated SafetyConsumers might have been deleted or added.
- You can perform the comparison of SafetyProviders using the F-OPC-UA-Provider-DBs. Follow these steps:
  Navigate in the comparison result to the "System blocks > STEP 7 Safety > Compiler blocks" folder. You can recognize the F-OPC-UA-Provider-DBs from the prefix "F_OPC_UA_PROVIDER_IDB_". Each F-OPC-UA-Provider-DB has been assigned to a SafetyProvider. You can determine the specific SafetyProvider based on the safety summary under "OPC UA Safety communication".
  - If F-OPC-UA-Provider-DBs in the comparison result are identical, this means that the safety-related configuration of the associated SafetyProvider was not changed.
  - If F-OPC-UA-Provider-DBs in the comparison result are different, this means that the safety-related configuration of the associated SafetyProvider was changed.
  - If F-OPC-UA-Provider-DBs in the comparison result are marked as "not available", associated SafetyProviders might have been deleted or added.

If you have identified a changed OPC UA Safety communication, you can check the changed parameters in the safety summary as described below.

Localization by comparison of two safety summaries
To localize changes in the configuration of the communication with OPC UA Safety, compare the detailed views of all SafetyProviders and all SafetyConsumers in the "Communications with OPC UA Safety Overview" area of the reference project with that of the project to be accepted in the respective safety summary.

See also

Accessing tags of the F-I/O DB (Page 165)

Operation and maintenance 12

12.1 Notes on startup of the F-system

In "STARTUP" mode of an F-CPU, the startup of the standard user program occurs as usual.

In the safety program, all DB contents of the F-DBs are generally reset to their start values from the load memory.

An automatic reintegration of the F-I/O (Page 166) takes place starting from the 2nd cycle of the F-runtime group.

NOTE

Resetting the F-DBs to start values from the load memory also triggers the following:

- Any stored error information is reset.
- Edge memory bits in instructions or F-FBs with edge evaluations (e.g. TON instruction) are reset, so that for a signal that already has the "TRUE" state in the 1st cycle of an F-runtime group, a positive signal edge is detected immediately at a query for positive signal edge.

12.2 Notes on Safety Mode of the Safety Program

Introduction

Pay attention to the following important notes on safety mode of the Safety program.

Use of simulation devices/simulation programs

⚠ WARNING

Use of simulation devices/simulation programs in plants
If you operate simulation devices or simulation programs that generate safety message frames, for example, based on PROFIsafe, and make them available to the SIMATIC Safety F-system via the bus system (such as PROFIBUS DP or PROFINET IO), you must ensure the safety of the plant through organizational measures.
Note, for example, that a protocol analyzer is not permitted to perform any function that reproduces recorded message frame sequences with correct time behavior.

- **S7-PLCSIM version < 15.1 or S7-PLCSIM Advanced version < 2.0 SP1 and Safety System version < V2.2**
  If you use *S7-PLCSIM* (Page 384) to simulate Safety programs, the measures mentioned above are not necessary because S7-PLCSIM cannot establish an online connection to a real component.
- **S7-PLCSIM version ≥ 15.1 or S7-PLCSIM Advanced version ≥ 2.0 SP1 or Safety System version ≥ V2.2**
  You must ensure the safety of the plant through organizational measures.
  In addition, the loading of the safety-related project data with Safety System version V2.2 and higher onto an *S7-PLCSIM* is only permissible as of *S7-PLCSIM* V15.1 or *S7-PLCSIM Advanced* V2.0 SP1 and higher.

(S030)

NOTE

For an *S7-PLCSIM* before V15.1 or *S7-PLCSIM Advanced* before V2.0 SP1 and a Safety system version V2.2 and higher, the Safety program changes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Switching F-CPU to STOP mode

⚠ WARNING

Unintentional restart

In contrast to the standard user program, when the Safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.

If an unintentional startup of your process is not allowed, you must program restart/startup protection in the Safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 184)"). This user acknowledgment must not take place until safe output of process values is possible (see "Programming startup protection (Page 150)").

You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:
  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

CRC error in F-I/O or safety-related communication

If you observe that a manual acknowledgment is requested more than once every 100 hours due to a CRC error and this occurs repeatedly, this indicates that the underlying communication infrastructure (cabling, wireless connections, network components, etc.) does not have the required reliability.

CRC errors are present:

- For F-I/O access, the ACK_REQ tag of the F-I/O DB is set and the DIAG tag of the F-I/O DB indicates CRC errors with bit 2 or bit 6.
- For communication with the SENDDP/RCVDP instructions, the ACK_REQ output of the RCVDP instruction is set and the DIAG output of the SENDDP/RCVDP instruction indicates CRC errors with bit 6.
- For communication with the SENDS7/RCVS7 instructions, the ACK_REQ output of the RCVS7 instruction is set and the DIAG output of the SENDS7/RCVS7 instruction indicates CRC errors with bit 6.
- For communication with Flexible F-Link, the ACK_REQ tag of the F-communication DB is set for receiving and the DIAG tag of the F-communication DB for sending/receiving indicates CRC errors with bit 6.

  or

- A CRC error is entered in the diagnostic buffer of the F-CPU.

In this case, the failure probability values (Page 439) (PFD_{avg}/PFH) for safety-related communication no longer apply.

Errors in safety-related communication with OPC UA Safety

The OPC UA Safety communication protocol contains a mechanism that tolerates a communication error within a configurable period of time (see description SafetyErrorIntervalLimit (Page 288) in the SPI of the SafetyConsumer).

If you observe that, despite this mechanism, a manual acknowledgment is requested more than once within 24 hours due to a communication error, this indicates that the underlying communication infrastructure (cabling, wireless connections, network components, etc.) does not have the required reliability.

You can recognize communication errors by the fact that the FSV_ACTIVATED output of an F-OPC UA Consumer DB is set and the DIAG output is set according to the type of error.

In this case, the failure probability values (Page 439) (PFDavg/PFH) for safety-related communication no longer apply.

12.3 Replacing Software and Hardware Components

Introduction

Proceed as in the standard. Also note the following sections.

Replacement of software components

When replacing software components on your programming device or PC, e.g. with a new version of *STEP 7*, you must adhere to the information regarding upward and downward compatibility in the documentation and readme files for these products (e.g. *STEP 7 Safety*).

When replacing *STEP 7 Safety*, check whether the version of *STEP 7 Safety* is listed in Annex 1 of the Report for the TÜV certificate.

Replacement of hardware components

Hardware components for SIMATIC Safety (F-CPU, F-I/O, batteries, etc.) are replaced in the same way as in Standard automation systems.

If you replace an F-I/O in the TIA Portal with an F-I/O with a newer article number that occupies more I/O addresses, the now larger I/O address range may already be occupied by another F-I/O.

For example, if you replace an F module F-DI 8x24VDC HF with part number 6ES7136-6BA00-0CA0 by an F module with 6ES7136-6BA01-0CA0. The end address of the input and output addresses is increased by 1 byte each by the exchange. In this case, *STEP 7* assigns a new free I/O address range to the F module. The corresponding tag in the tag table must then be manually adapted to the new I/O addresses.

Replacement of an HF-CPU in the redundant S7-1500 HF system

Note the following warning when replacing an HF-CPU of a redundant S7-1500HF system:

WARNING

If you replace an F-CPU of a redundant S7-1500HF system (e.g. due to CPU failure, defect, etc.), you must put into operation the replacement F-CPU with the SIMATIC Memory Card of the previous F-CPU or with an empty SIMATIC Memory Card. This ensures that after successful SYNCUP of the replacement F-CPU, only the previous safety program is executed. *(S094)*

Replacement of S7-1500 F Software Controllers

WARNING

The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:
After a CPU module replacement (for example, new PC with data storage medium from old PC), a data storage medium replacement (for example, data storage medium with safety-related project data 1 is replaced by data storage medium with safety-related project data 2) or a UEFI update (if no NVRAM is present), you must ensure that the correct safety program is located in the S7-1500 F Software Controller by reading out the Collective F-signature with the command line command "GetCollectiveFSignature" or the display.
Then you must enter and confirm the expected Collective F-signature with the command line command "ConfirmCollectiveFSignature". This confirmation is required to restart the safety program.
For both command line commands, you must be a member of the "Software Controller Operators" (Windows) or "software_controller_operators" (Linux) user group and the "Failsafe Operators" (Windows) or "failsafe_operators" (Linux) user group.
The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:
After a CPU module replacement (e.g. new PC with data storage medium from old PC), a data storage medium replacement (e.g. data storage medium containing safety program 1 is replaced with data storage medium containing safety program 2) or a UEFI update, you must check via the display whether the correct collective F-signature is displayed or perform a program identification. *(S066)*

Removing and inserting F-I/O during operation

If removing and inserting is possible for standard I/O during operation, it is also possible for the respective F-I/O. However, be aware that replacing an F-I/O module during operation can cause a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 157) or, alternatively, by using the "ACK_GL (Page 520)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

CPU firmware update

Check of the CPU operating system for F-approval: When using a new CPU operating system (firmware update), you must check to see if the CPU operating system you are using is approved for use in an F-system.

The minimum CPU operating system versions with guaranteed F-capability are specified in the appendix of the Certificate. This information and any notes on the new CPU operating system must be taken into account.

Firmware update for interface module

When using a new operating system for an interface module, such as IM 151-1 HIGH FEATURE for ET 200S (firmware update), you must observe the following:

If you have selected the "Activate firmware after update" option for the firmware update (see *Help on STEP 7*, "Online & Diagnostics"), the interface module is automatically reset following a successful download operation and then runs on the new operating system. Note that the firmware update for interface modules during operation causes a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 157) or, alternatively, by using the "ACK_GL (Page 520)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

Preventive maintenance (proof test)

Proof test for complex electronic components generally means replacement with new, unused components.

12.4 PFDavg and PFH values

PFD_{avg} and PFH values for S7-300/400 F-CPUs and F-I/O

You will find a list of the failure probability values (PFD_{avg}, PFH values) for components that can be used in SIMATIC Safety on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481784).

PFD_{avg} and PFH values for S7-1200/1500 F-CPUs

Below are the probability of failure values (PFD_{avg}, PFH values) for S7-1200/1500 F-CPUs with a service life of 20 years and a mission time of 100 hours:

Operation in low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	**Operation in high demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]**
< 2E-05	< 1E-09 up to an operating altitude of 3 000 m or < 2E-09 at an operating altitude above 3 000 m and up to 5 000 m

More information can be found on the operating conditions of the F-CPUs in the PI F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599) and in the PI of the PFD_{avg}, PFH values (https://support.industry.siemens.com/cs/ww/en/view/109481784).

PFD_{avg} and PFH values for safety-related communication without OPC UA Safety

Below you will find the failure probability values (PFD_{avg}, PFH values) for safety-related communication:

Operation in low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	**Operation in high demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]**
< 1E-05*	< 1E-09*

*** Note on S7-300/400 F-CPUs:**
The PFH value is valid under the assumption that a maximum of 100 F-I/Os are involved in a safety function. If you use more than 100 F-I/Os, you have to also add 4E-12 per F-I/O for the safety function.
The PFD_{avg} value is valid for a mission time of 20 years and under the assumption that a maximum of 25 F-I/Os are involved in a safety function. If more than 25 F-I/Os are used, you need to add 3.5E-7 per F-I/O for this safety function.

More information can be found on the operating conditions of the F-CPUs in the PI of the PFD_{avg} and PFH values (https://support.industry.siemens.com/cs/ww/en/view/109478599).

PFD_{avg} and PFH values for safety-related communication with OPC UA Safety (S7-1500)

Below you will find the probability of failure values (PFD_{avg} and PFH values) for safety-related communication via OPC UA Safety:

Operation in low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	**Operation in high demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]**
< 8E-08*	< 4E-11*

*** Note**:
The values listed in the table above apply when configuring the SafetyErrorIntervalLimit (Page 288) SPI parameter of a SafetyConsumer with the value 600.
In exceptional cases, you can consider a lower setting (60 or 6). A lower setting may reduce the risk of false tripping. A lower setting is appropriate if the unnecessary triggering of the safety function or the output of fail-safe substitute values would have particularly serious consequences. However, this also worsens the PFD_{avg}/PFH values as follows:

SafetyErrorIntervalLimit	**PFD_{avg} value**	**PFH value**
60	< 2.5E-07	< 4E-10
6 (not permitted for SIL3)	< 1E-06	< 4E-09

12.5 Guide to Diagnostics

Introduction

Here you find a compilation of diagnostic capabilities that can be evaluated for your system when an error occurs. Most of the diagnostic capabilities are the same as those in standard automation systems. The sequence of steps represents a recommendation.

Steps for evaluating diagnostic capabilities

The following table shows the steps you take to evaluate diagnostic capabilities.

Step	Procedure	Reference
1	**Evaluate LEDs on the hardware (F-CPU, F-I/O):** • BUSF LED on the F-CPU: Flashes when a communication error occurs on PROFIBUS DP/PROFINET IO; On if a programming error occurs when OB 85 and OB 121 are programmed (e.g. instance DB is not loaded) • STOP LED on the F-CPU: illuminates when the F-CPU is in STOP mode • Fault LEDs on the F-I/O: e.g. SF-LED (group error LED) on if any fault occurs in the individual F-I/O	*Manuals for F-CPU and F-I/O*
2	**Evaluate diagnostic buffer of the modules:** You read the diagnostic buffer of a module (F-CPU, F-I/O, CP) in its online and diagnostic view in the "Diagnostic buffer" group under the "Online & Diagnostics" folder.	*Help on STEP 7 and manuals for the F-CPU and F-I/O*
3	**Evaluate stacks of the F-CPU:** when the F-CPU is in STOP mode, read the following successively: • Block stack: Check whether STOP mode of the F-CPU was triggered by an F-block of the Safety program • Interruption stack • Local data stack	*STEP 7 help, Diagnostics Function Manual, system manuals*
4	**Evaluate diagnostic tag of the F-I/O DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** Evaluate the DIAG tag in the F-I/O DB	DIAG (Page 164)
5	**Evaluate diagnostic tag of the F-OPC UA Consumer DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** in the F-OPC UA Consumer DB of the variable DIAG	Other variables in the F-OPC UA Consumer DB (Page 297) OPC UA access to SafetyProvider and SafetyConsumer information models (Page 330)
6	**Evaluate diagnostic tag of the F-communication DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** Evaluate the DIAG tag in the F-communication DB	F-communication DB (S7-1200, S7-1500) (Page 341)
7	**Evaluate diagnostic outputs of the instance DBs of instructions using testing and commissioning functions, using an operator control and monitoring system, or in the standard user program:** • Evaluate the following for MUTING, EV1oo2DI, TWO_H_EN, MUT_P, ESTOP1, FDBACK, SFDOOR in the assigned instance DB: – Output DIAG • Evaluate the following for SENDDP or RCVDP in the assigned instance DB: – Output RET_DPRD/RET_DPWR – Output DIAG • Evaluate the following for SENDS7 or RCVS7 in the assigned instance DB: – Output STAT_RCV – Output STAT_SND – Output DIAG	Instructions

Tip on RET_DPRD/RET_DPWR

The diagnostic information of the RET_DPRD/RET_DPWR outputs of the SENDDP or RCVDP instructions corresponds to the diagnostic information of the RETVAL return value of the "DPRD_DAT" and "DPWR_DAT" instructions. You can find the description in the help on *STEP 7* for the "DPRD_DAT" and "DPWR_DAT" instructions.

Tip: STAT_RCV and STAT_SND

The diagnostic information of the STAT_RCV output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "URCV" instruction. The diagnostic information of the STAT_SND output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "USEND" instruction. You can find the description in the help on *STEP 7* for the instruction "UCRV" or "USEND" .

STEP 7 Safety V21 instructions

13

Overview of instructions for the safety program

When programming an F-block, you can find all instructions available for programming an F-block in LAD or FBD with the configured F-CPU in the "Instructions" task card.

In addition to the instructions that are familiar to you from programming a standard block, there are also special safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, and feedback monitoring and instructions for safety-related CPU-CPU communication.

13.1 Connection of the Enable input EN and Enable output ENO

The enable input EN cannot be connected.

(S7 -300, S7-400) It is not possible to connect the ENO output.

(S7-1200, S7-1500) The ENO output can only be wired with the following instructions:

- ADD: Add (Page 542)
- SUB: Subtract (Page 545)
- MUL: Multiply (Page 548)
- DIV: Divide (Page 551)
- NEG: Create two's complement (Page 554)
- ABS: Form absolute value (Page 556)
- CONVERT: Convert value (Page 566)

13.2 Temporal blurring for instructions with time processing

Observe the following warning for the following instructions with time processing:

- ESTOP1: Emergency STOP/emergency OFF up to stop category 1 (STEP 7 Safety V21) (Page 478)
- TWO_HAND: Two-hand monitoring (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 482)
- TWO_H_EN: Two-hand monitoring with enable (STEP 7 Safety V21) (Page 483)
- MUTING: Muting (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 486)
- MUT_P: Parallel muting (STEP 7 Safety V21) (Page 495)
- EV1oo2DI: 1oo2 evaluation with discrepancy analysis (STEP 7 Safety V21) (Page 505)
- FDBACK: Feedback monitoring (STEP 7 Safety V21) (Page 510)
- TP: Generate pulse (STEP 7 Safety V21) (Page 522)
- TON: Generate on-delay (STEP 7 Safety V21) (Page 524)
- TOF: Generate off-delay (STEP 7 Safety V21) (Page 527)
- ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 591)

⚠ WARNING

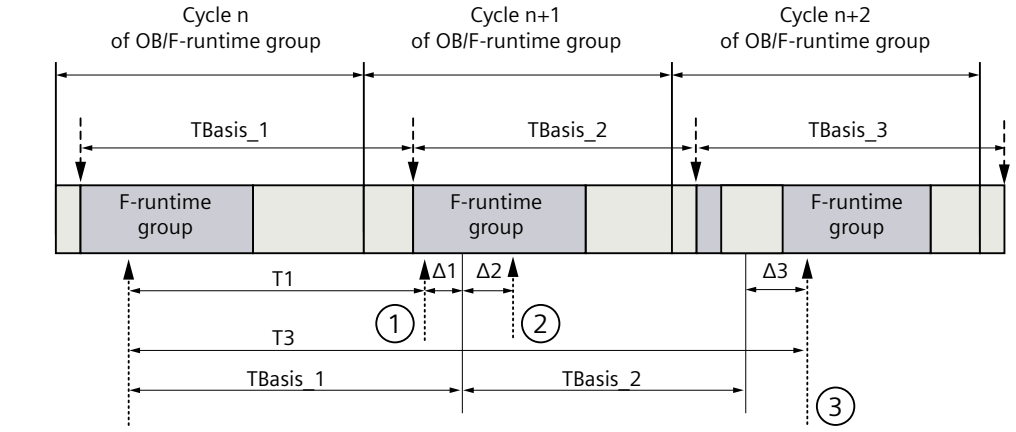
When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- The temporal blurring known from the standard user program, which is caused by the cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value
- Tolerance of internal time monitoring in the S7-1500 HF-CPU
  - For time values up to 500 ms, a maximum of 10 ms
  - For time values greater than or equal to 500 ms, a maximum of 2% of the (assigned) time value
- Tolerance of internal time monitoring in the S7-1500 F Virtual Controller
  Without setup of Virtual Time Service:
  - For time values up to 200 ms, a maximum of 5 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value plus 1 ms

  With setup of Virtual Time Service:
  - For time values up to 200 ms, a maximum of 10 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value plus 6 ms

You must choose the interval between two calls of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Timing imprecision resulting from the update time of the time base used in the instruction:



= Update of the time basis TBasis_n

= Productive operation of an instruction with time processing

① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the Safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

13.3 General

13.3.1 LAD

13.3.1.1 New network (STEP 7 Safety V21)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

NOTE
If you insert an element into the last empty network of the F-block in an LAD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.3.1.2 Empty box (STEP 7 Safety V21)

Requirement

A network is available.

Procedure

To insert an LAD instruction into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.
   A drop-down list is displayed.
5. Select the required instruction from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are

stored. Once it is created, the new instance data block can be found in the "Program resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.3.1.3 Open branch (STEP 7 Safety V21)

Description

Use branches to program parallel connections with the Ladder Logic (LAD) programming language. Branches are inserted into the main current path. You can insert several contacts into the branch, thereby creating a parallel connection from series connections. You can program complex ladder diagrams in this way.

Requirement

- A network is available.
- The network contains elements.

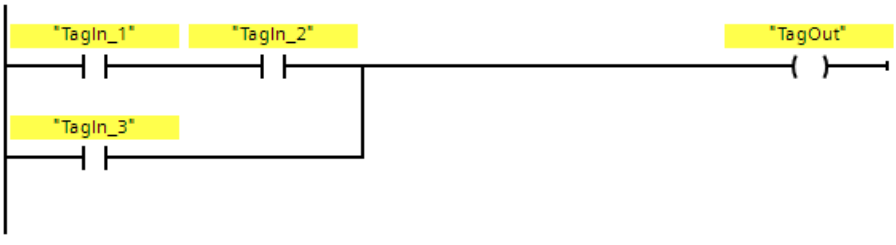
Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Open branch".
3. Use a drag-and-drop operation to move the element to the desired place in the network.
4. If you want to connect the new branch directly to the power rail, drag the element to the power rail.

Example

The following figure provides an example of how to use branches:



13.3.1.4 Close branch (STEP 7 Safety V21)

Description

Branches must be closed again at suitable places. If necessary, branches will be arranged so that they do not cross each other.

Requirement

A branch is available.

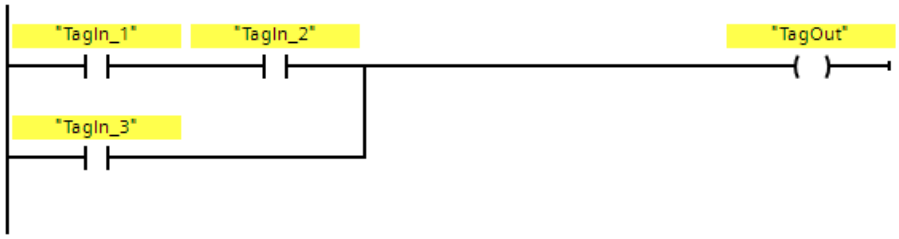
Procedure

To close an open branch, follow these steps:

1. Select the open branch.
2. Press and hold down the left mouse button.
   A dashed line will appear as soon as the cursor is moved.
3. Drag the dashed line to a suitable place on the network. Permissible connections are indicated by green lines.
4. Release the left mouse button.

Example

The figure below provides an example of how to use branches:



13.3.2 FBD

13.3.2.1 New network (STEP 7 Safety V21)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

NOTE

If you insert an element into the last empty network of the F-block in an FBD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.3.2.2 Empty box (STEP 7 Safety V21)

Requirement

A network is available.

Procedure

To insert FBD elements into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.
   A drop-down list is displayed.
5. Select the desired FBD element from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are stored. Once it is created, the new instance data block can be found in the "Program

resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.3.2.3 Open branch (STEP 7 Safety V21)

Description

You use branches, which you insert between the boxes, to program parallel connections with the Function Block Diagram (FBD) programming language You can insert additional boxes in the branch, thereby programming complex function block diagrams.

Requirement

A network is available.

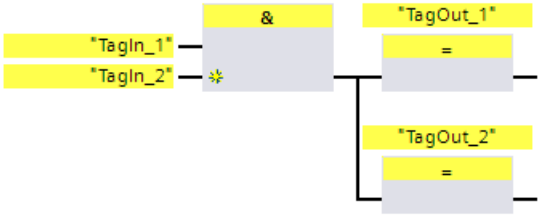
Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate in the pane to "Basic instructions > General > Branch".
3. Use a drag-and-drop operation to move the element to the desired place to a connecting line between two boxes.

Example

The following figure provides an example of how to use branches:



13.3.2.4 Insert binary input (STEP 7 Safety V21)

Description

Use the "Insert binary input" instruction to expand the box of one of the following instructions by a binary input:

- "AND logic operation"
- "OR logic operation"
- "EXCLUSIVE OR logic operation"

You can query the signal state of several operands by expanding the instruction box.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



The box of instruction "AND logic operation" has been expanded by an additional binary input at which the signal state of operand "TagIn_3" is queried. Output "TagOut" is set when the signal state of operands "TagIn_1", "TagIn_2", and "TagIn_3" is "1".

See also

AND logic operation (STEP 7 Safety V21) (Page 465)
OR logic operation (STEP 7 Safety V21) (Page 466)
X: EXCLUSIVE OR logic operation (STEP 7 Safety V21) (Page 467)

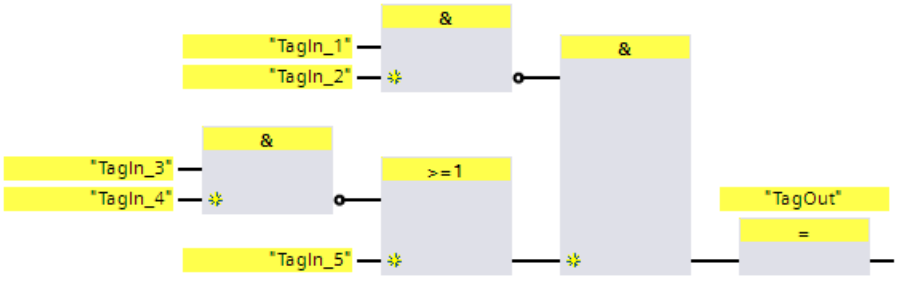
13.3.2.5 Invert RLO (STEP 7 Safety V21)

Description

You can use the "Invert RLO" instruction to invert the result of logic operation (RLO).

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- The "TagIn_1" and/or "TagIn_2" input has the signal state "0".
- The "TagIn_3" or "TagIn_4" input has the signal state "0" or the "TagIn_5" input has the signal state "1".

13.4 Bit logic operations

13.4.1 LAD

13.4.1.1 ---| |---: Normally open contact (STEP 7 Safety V21)

Description

The activation of the normally open contact depends on the signal state of the associated operand. If the operand has signal state "1," the normally open contact is closed. Power flows from the left power rail through the normally open contact into the right power rail and the signal state at the output of the instruction is set to "1".

If the operand has signal state "0," the normally open contact is not activated. The power flow to the right power rail is interrupted and the signal state at the output of the instruction is reset to "0".

Two or more normally open contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally open contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

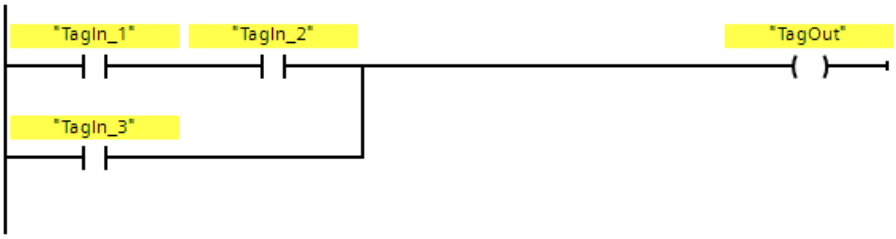
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "1".

13.4.1.2 ---| / |---: Normally closed contact (STEP 7 Safety V21)

Description

The activation of the normally closed contact depends on the signal state of the associated operand. If the operand has signal state "1", the normally closed contact is opened and the signal state at the output of the instruction is reset to "0".

If the operand has signal state "0", the normally closed contact is not activated and the signal state at the output of the instruction is set to "1".

Two or more normally closed contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally closed contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

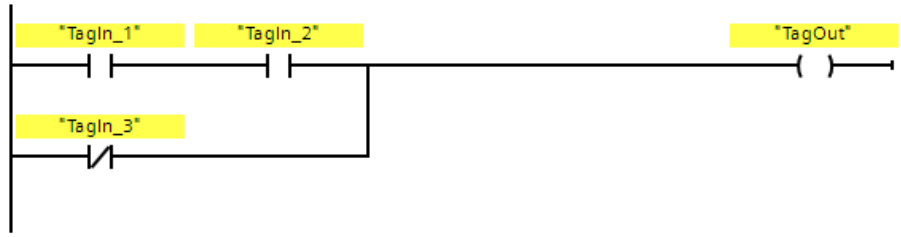
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

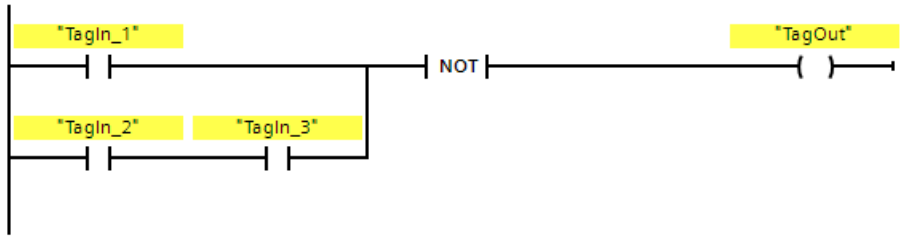
13.4.1.3 --|NOT|--: Invert RLO (STEP 7 Safety V21)

Description

You can use the "Invert RLO" instruction to invert the signal state of the result of logic operation (RLO). When the signal state is "1" at the input of the instruction, the output of the instruction has the signal state "0". When the signal state is "0" at the input of the instruction, the output has the signal state "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operands "TagIn_2" and "TagIn_3" have signal state "1".

13.4.1.4 ---( )---: Assignment (STEP 7 Safety V21)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. When the result of logic operation (RLO) at the input of the coil is "1," the specified operand is set to signal state "1". When the signal state is "0" at the input of the coil, the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the input of the coil is sent immediately to the output.

The "Assignment" instruction can be placed at any position in the network.

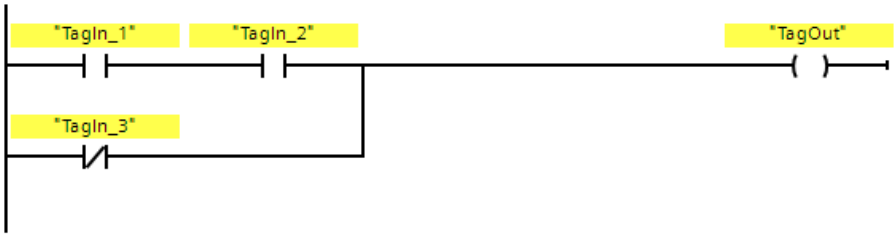
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

13.4.1.5 ---(R)---: Reset output (STEP 7 Safety V21)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If power flows to the coil (RLO is "1"), the specified operand is set to "0". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

NOTE
If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE
If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE
You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

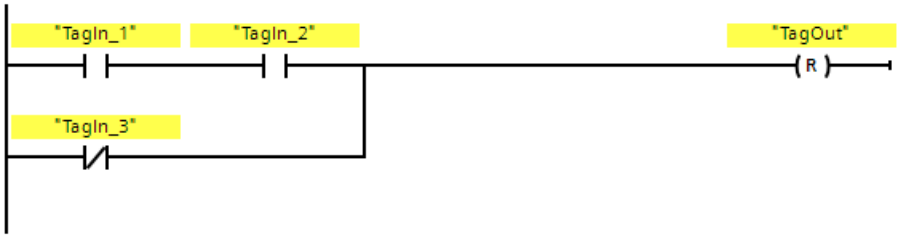
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset when RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.1.6 ---(S)---: Set output (STEP 7 Safety V21)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If power flows to the coil (RLO is "1"), the specified operand is set to "1". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

NOTE

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.
An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

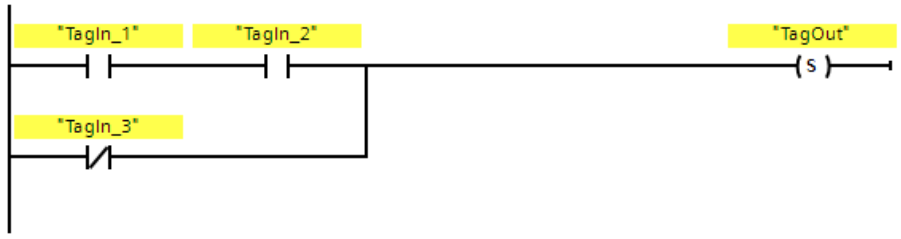
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set when RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.1.7 SR: Set/reset flip-flop (STEP 7 Safety V21)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.
If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

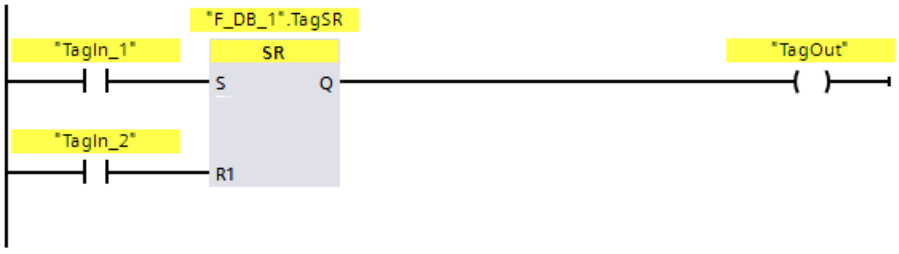
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands ""F_DB_1".TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.1.8 RS: Reset/set flip-flop (STEP 7 Safety V21)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE
You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.
If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

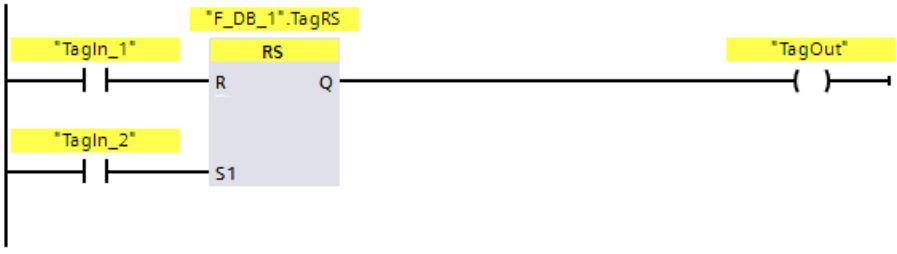
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands ""F_DB_1".TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.1.9 --|P|--: Scan operand for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.
If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

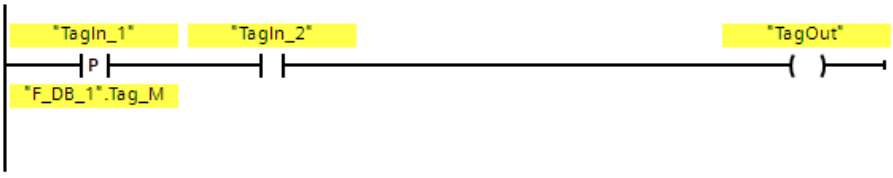
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1". The signal state of the previous query is saved at edge memory bit ""F_DB_1".Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.4.1.10 --|N|--: Scan operand for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.
If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

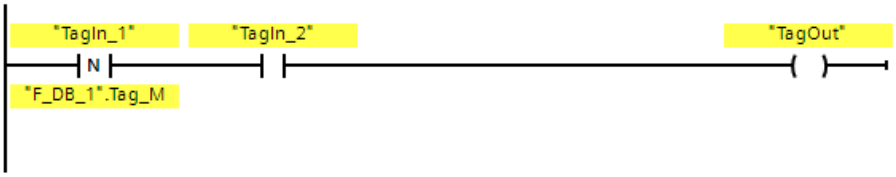
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Operand "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at operand "TagIn_1". The signal state of the previous query is saved at edge memory bit ""F_DB_1".Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.4.1.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation (RLO) with the signal state of the previous query, which is saved in the edge bit memory (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

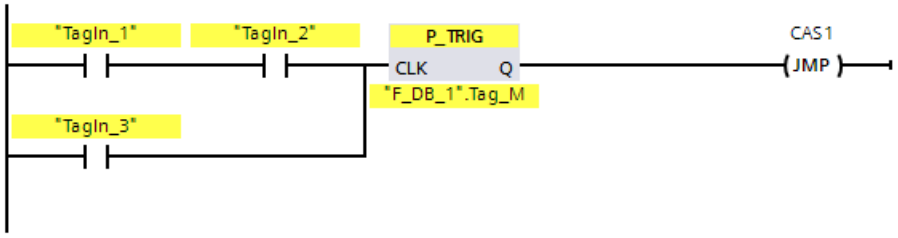
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO from the previous bit logic operation is saved in edge memory bit ""F_DB_1".Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.4.1.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

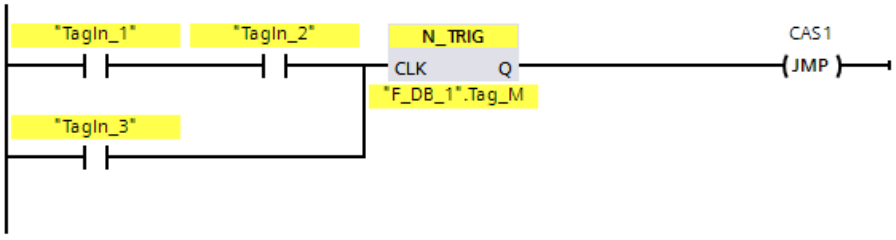
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO of the previous bit logic operation is saved in edge bit memory ""F_DB_1".Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.4.2 FBD

13.4.2.1 AND logic operation (STEP 7 Safety V21)

Description

You can use the "AND logic operation" instruction to query the signal states of two or more specified operands and evaluate them according to the AND truth table.

If the signal state of all the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of one of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "AND logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "AND logic operation" instruction that is not the first instruction in the logic string logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the AND truth table.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of operands "TagIn_1" and "TagIn_2" is "1".

AND truth table

The following table shows the results when linking two operands by an AND logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	1	1
0	1	0
1	0	0
0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 451)

13.4.2.2 OR logic operation (STEP 7 Safety V21)

Description

You can use the "OR logic operation" instruction to get the signal states of two or more specified operands and evaluate them according to the OR truth table.

If the signal state of at least one of the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of all of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "OR logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "OR logic operation" instruction that is not the first instruction in the logic string, logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the OR truth table.

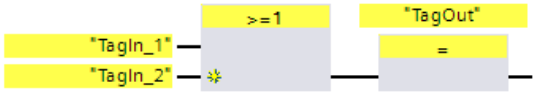
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of operand "TagIn_1" or "TagIn_2" is "1".

OR truth table

The following table shows the results when linking two operands by an OR logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	1
0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 451)

13.4.2.3 X: EXCLUSIVE OR logic operation (STEP 7 Safety V21)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to get the result of a signal state query according to the the EXCLUSIVE OR truth table.

With an "EXCLUSIVE OR logic operation" instruction, the signal state is "1" when the signal state of one of the two specified operands is "1". When more than two operands are queried, the overall result of logic operation is "1" if an odd-numbered quantity of queried operands returns the result "1".

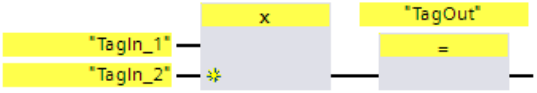
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the signal state of one of the two operands "TagIn_1" and "TagIn_2" is "1". When both operands have signal state "1" or "0" then output "TagOut" is reset.

EXCLUSIVE OR truth table

The following table shows the results when two operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	0
0	0	0

The following table shows the results when three operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Signal state of the third operand	Result of logic operation
1	0	0	1
0	1	1	0
0	1	0	1
1	0	1	0
0	0	1	1
1	1	0	0
1	1	1	1
0	0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 451)

13.4.2.4 =: Assignment (STEP 7 Safety V21)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. If the result of logic operation (RLO) at the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to signal state "1". If the signal state at the box input is "0", the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the box input is assigned directly to the operand located above the Assign box.

The "Assignment" instruction can be placed at any position in the logic operation sequence.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:



Operand "TagOut" at the output of the "Assignment" instruction is set when one of the following conditions is fulfilled:

- Inputs "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at input "TagIn_3" is "0".

13.4.2.5 R: Reset output (STEP 7 Safety V21)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is reset to "0". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

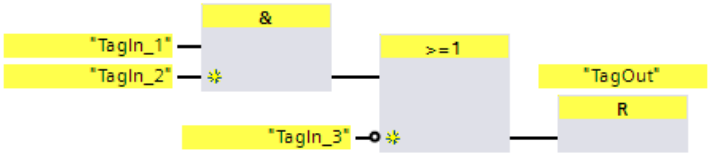
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset with RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.2.6 S: Set output (STEP 7 Safety V21)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to "1". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

NOTE

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.

An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE
You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

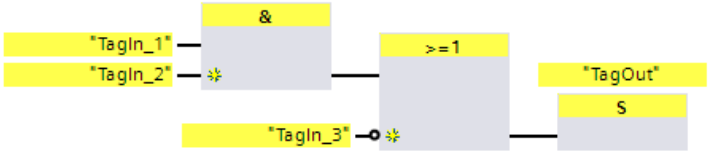
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set when RLO = "1".

Example

The following example shows how the instruction works:



Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.2.7 SR: Set/reset flip-flop (STEP 7 Safety V21)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE
If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE
You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.
If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

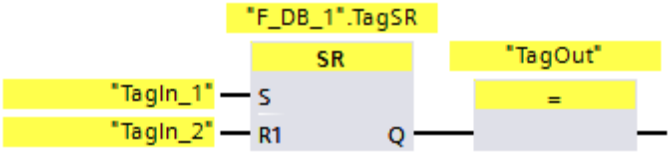
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands ""F_DB_1".TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.2.8 RS: Reset/set flip-flop (STEP 7 Safety V21)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE
If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE
You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.
If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

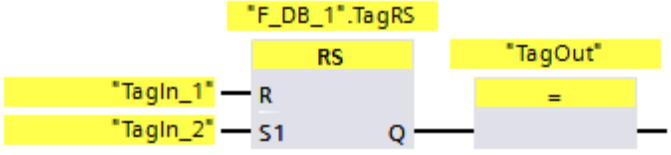
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:



Operands ""F_DB_1".TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.2.9 P: Scan operand for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.
If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

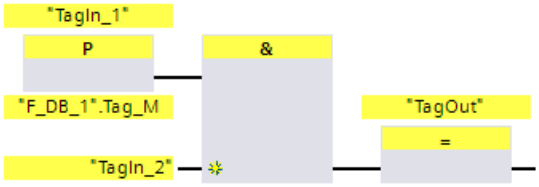
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



"TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.4.2.10 N: Scan operand for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

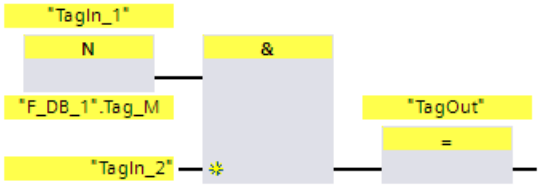
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.4.2.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE
You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.
If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

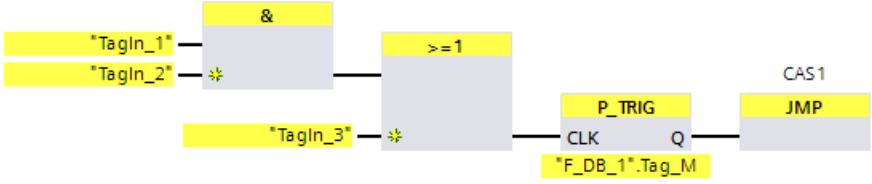
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO from the previous bit logic operation is saved in edge memory bit ""F_DB_1".Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.4.2.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE
The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.
If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

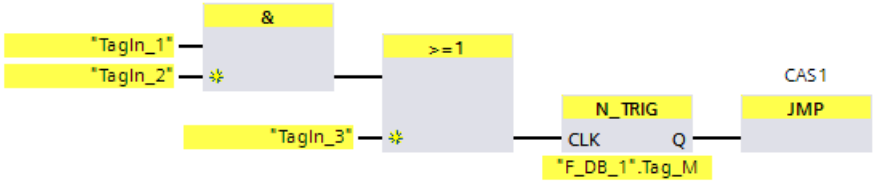
Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:



The RLO of the previous bit logic operation is saved in edge bit memory ""F_DB_1".Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.5 Safety functions

13.5.1 ESTOP1: Emergency STOP/emergency OFF up to stop category 1 (STEP 7 Safety V21)

Description

This instruction supports the implementation of an EMERGENCY STOP/EMERGENCY OFF shutdown with acknowledgment for STOP categories 0 and 1 for the purpose of complying with requirements of IEC 60204 or IEC 61800-5-2. However, additional measures described in the respective standard may have to be taken in order to fully comply with the requirements of the respective standard.

Enable signal Q is reset to 0, as soon as input E_STOP takes a signal state of 0 (Stop category 0). Enable signal Q_DELAY is reset to 0 after the time delay set at input TIME_DEL (Stop Category 1).

Enable signal Q is reset to 1 not before input E_STOP takes a signal state of 1 and an acknowledgment occurs. The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets output ACK_REQ to 1, as soon as input E_STOP = 1.

Following an acknowledgment, the instruction resets ACK_REQ to 0.

Every call of the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ESTOP1_DB_1) or a multi-instance (e.g., ESTOP1_Instance_1) for the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Note: In case of two channels according to category 3.4 of ISO 13849-1:2015 or EN ISO 13849-1:2015, the discrepancy monitoring of the two NC contacts of the EMERGENCY STOP/EMERGENCY OFF must already take place in the F-I/O. The F-I/O has to be configured accordingly (sensor evaluation: two-channel, equivalent), and the result of the evaluation interconnected with the E_STOP input. In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
E_STOP	Input	BOOL	EMERGENCY STOP/EMERGENCY OFF
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	1=Acknowledgment
TIME_DEL	Input	TIME	Time delay
Q	Output	BOOL	1=Enable
Q_DELAY	Output	BOOL	Enable is OFF delayed
ACK_REQ	Output	BOOL	1=Acknowledgment necessary
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder.
1.1	x	—	—	—	These versions have identical functions to version 1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	o	—	o	
1.5	x	x	—	x	
1.6	x	x	x	x	The reaction of the delay time TIME_DEL for F-CPUs S7-1200/1500 was adapted to the reaction of F-CPUs S7-300/400: If the input ESTOP (0 -> 1 (including acknowledgment) -> 0) is changed while the delay time is running, the delay time is restarted.

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Startup behavior

After an F-system startup, when ACK_NEC = 1, you must acknowledge the instruction using a rising edge at input ACK.

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 4 and 5 are saved until you acknowledge at the ACK input.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect TIM_DEL setting	Time delay setting < 0	Set time delay > 0
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Acknowledgment not possible because emergency STOP/emergency OFF is still active	Emergency STOP/Emergency OFF pushbutton is locked	Release Emergency STOP/Emergency OFF pushbutton

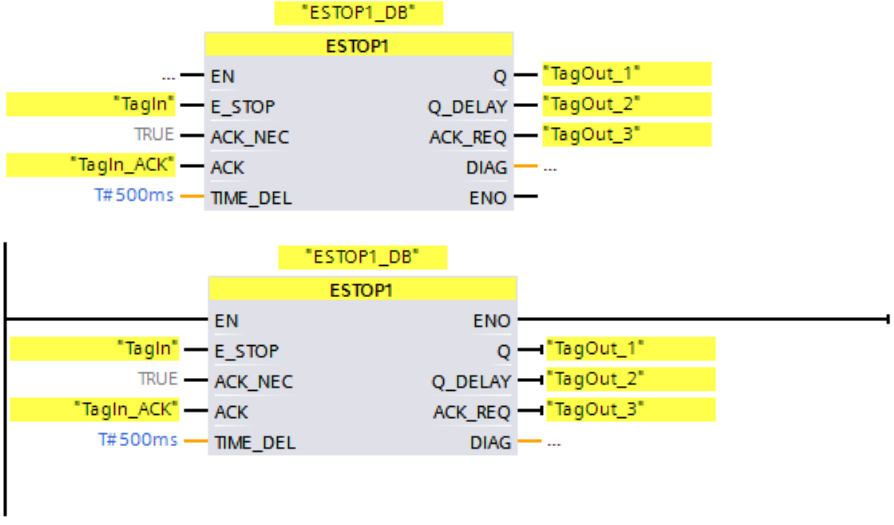
Bit no.	Assignment	Possible error causes	Remedies
Bit 4	Acknowledgment not possible because emergency STOP/emergency OFF is still active	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of emergency STOP/emergency OFF pushbutton	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		Emergency STOP/Emergency OFF pushbutton is defective	Check emergency STOP/emergency OFF pushbutton
		Wiring fault	Check wiring of the emergency STOP/emergency OFF pushbutton
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



13.5.2 TWO_HAND: Two-hand monitoring (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction supports the implementation of two-hand monitoring for the purpose of complying with requirements of ISO 13851. However, additional measures described in the standard may have to be taken in order to fully comply with the requirements of the standard.

NOTE
This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Two-hand monitoring with enable". The application "Two-hand monitoring with enable" replaces the instruction "Two-hand monitoring" with compatible functions.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN2 = 0). Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time. Enable signal Q can never be set to 1 if the discrepancy time is set to values less than 0 or greater than 500 ms.

Every call of the "Two-hand monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_HAND_DB_1) or a multi-instance (e.g., TWO_HAND_Instance_1) for the "Two-hand monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during suitable configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration. If a discrepancy is detected, a fail-safe value of 0 is entered in the process image of the inputs (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 is set in the relevant F-I/O DB. (See also F-I/O access (Page 151))

Parameters

The following table shows the parameters of the instruction:

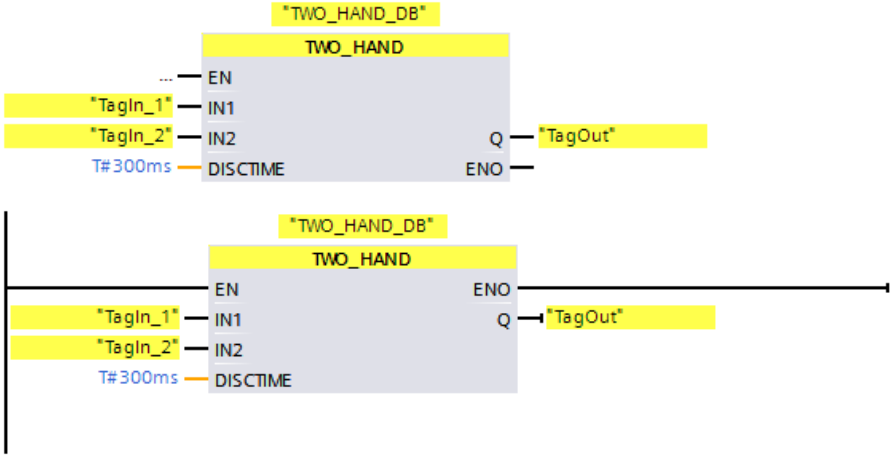
Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms)
Q	Output	BOOL	1=Enable

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction:

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



13.5.3 TWO_H_EN: Two-hand monitoring with enable (STEP 7 Safety V21)

Description

This instruction supports the implementation of two-hand monitoring with enable for the purpose of complying with requirements of ISO 13851. However, additional measures described in the standard may have to be taken in order to fully comply with the requirements of the standard.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1 when existing ENABLE = 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN 2 = 0) or ENABLE = 0. Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time when existing ENABLE = 1.

Every call of the "Two-hand monitoring with enable" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_H_EN_DB_1) or a multi-instance (e.g., TWO_H_EN_Instance_1) for the "Two-hand monitoring with enable" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during corresponding configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, during the configuration of discrepancy behavior, you must configure "Supply value 0".

If a discrepancy is detected, a fail-safe value of 0 is entered in the process image of the inputs (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 or respectively value status = 0 is set in the relevant F-I/O DB.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
ENABLE	Input	BOOL	Enable input
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms) For productive use, select a discrepancy time > 0 ms.
Q	Output	BOOL	1=Enable
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 5 are saved until the cause of the error has been eliminated.

Structure of DIAG

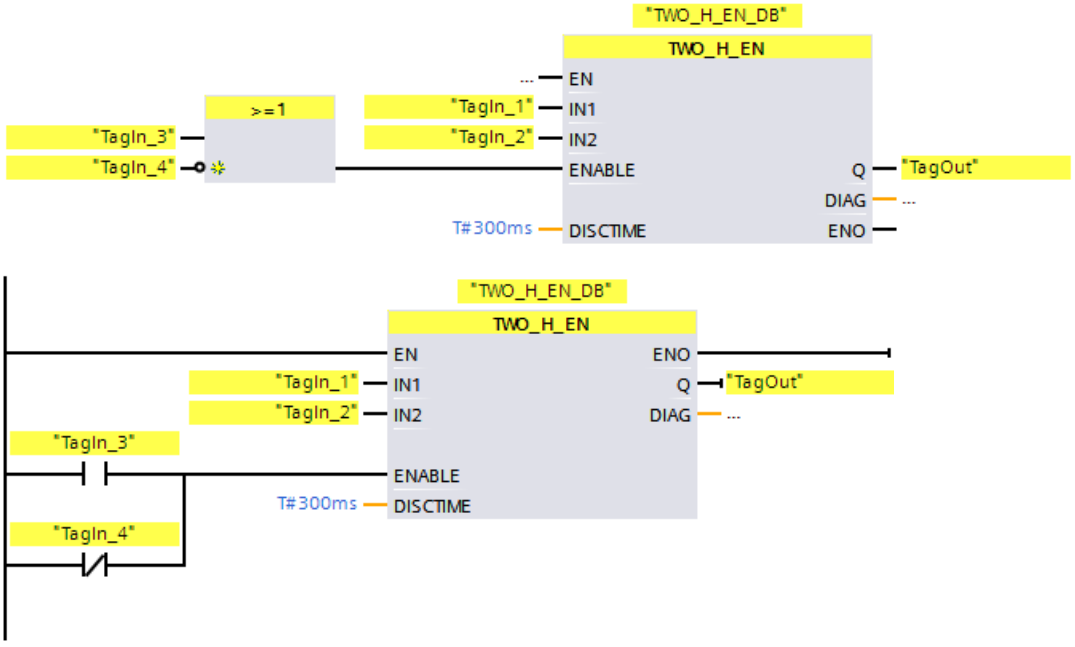
Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect discrepancy time DISCTIME setting	Discrepancy time setting is <0 or > 500 ms	Set discrepancy time in range of 0 to 500 ms
Bit 1	Discrepancy time elapsed	Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Pushbuttons were not activated within the discrepancy time	Release pushbuttons and activate them within the discrepancy time
		Wiring fault	Check wiring of pushbuttons
		Pushbuttons defective	Check pushbuttons
		Pushbuttons are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Incorrect activation sequence	One pushbutton was not released	Release pushbuttons and activate them within the discrepancy time
		Pushbuttons defective	Check pushbuttons
Bit 5	ENABLE does not exist	ENABLE = 0	Set ENABLE = 1, release pushbutton and activate it within the discrepancy time
Bit 6	Reserved	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



13.5.4 MUTING: Muting (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction performs parallel muting with two or four muting sensors.

NOTE

This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Parallel muting (Page 495)". The instruction "Parallel muting" replaces the instruction "Muting" with compatible functions.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUTING_DB_1) or a multi-instance (e.g., MUTING_Instance_1) for the "Muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

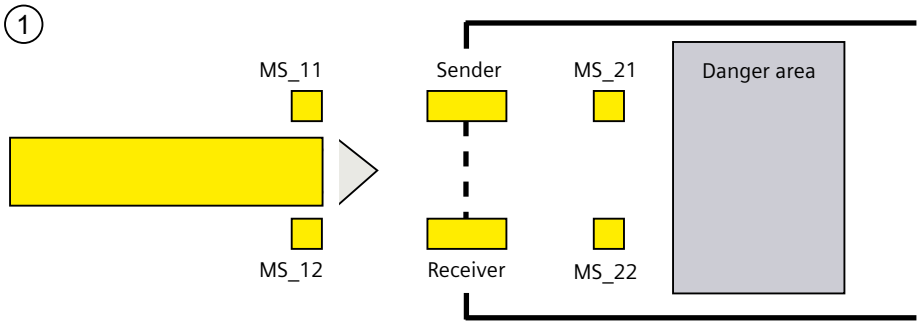
Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 1 of sensor pair 1
MS_12	Input	BOOL	Muting sensor 2 of sensor pair 1
MS_21	Input	BOOL	Muting sensor 1 of sensor pair 2
MS_22	Input	BOOL	Muting sensor 2 of sensor pair 2
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal of the muting lamp channel
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
ACK	Input	BOOL	Acknowledgment of restart inhibit
Q	Output	BOOL	1= Enable, not off
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	BYTE	Non-fail safe service information

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

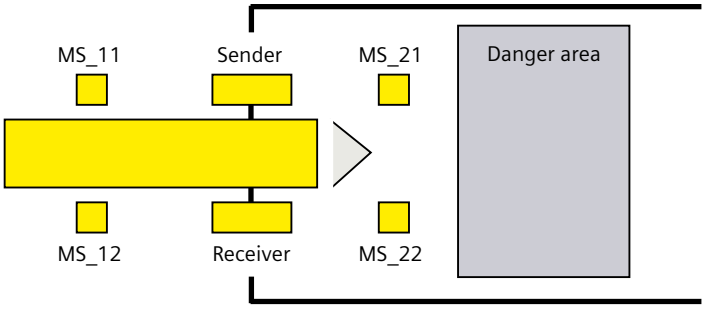


- If both muting sensors MS_11 and MS_12 are activated by the product within DISCTIM1 (apply signal state = 1), the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

NOTE

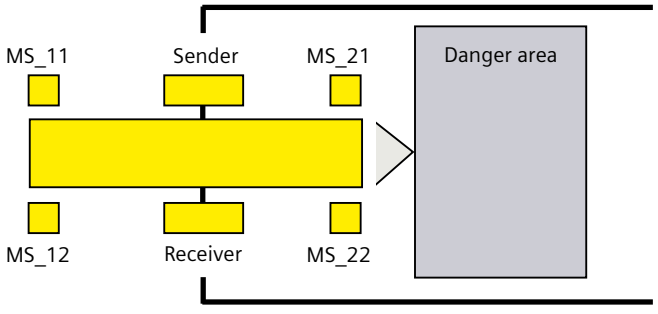
The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.
F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).

②



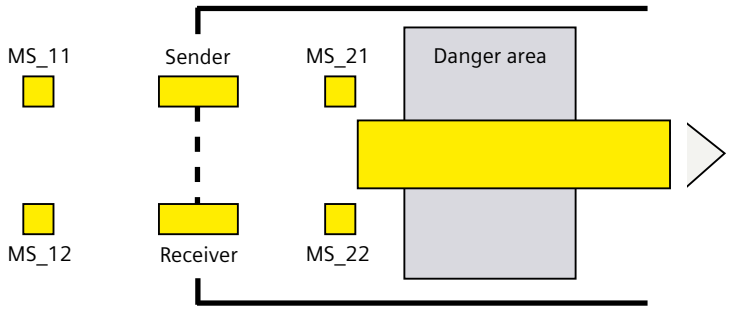
- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop).

③



- The two muting sensors MS_21 and MS_22 must be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

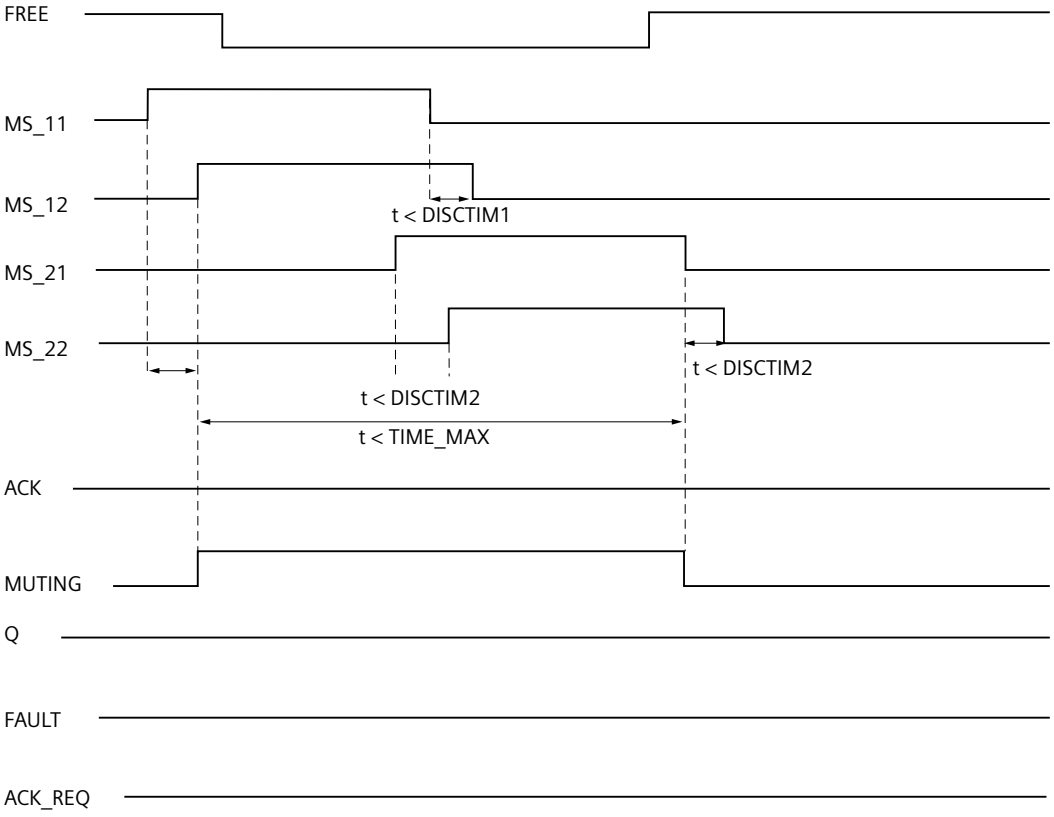


- Only if one of the two muting sensors MS_21 and MS_22 is switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

NOTE

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

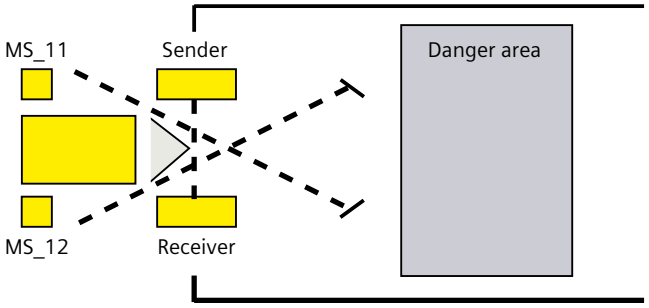


Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.



Restart inhibit upon interruption of light curtain (if MUTING is not active), when errors occur, and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- The muting lamp monitoring function responds at input QBAD_MUT
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

⚠ WARNING

When a valid combination of signal states of muting sensors is immediately detected at startup of the F-system (for example, because the muting sensors are interconnected to inputs of a standard I/O that immediately provide process values during the F-system startup), the MUTING function is immediately started and the MUTING output and enable signal Q are set to 1. The FAULT output (group error) is not set to 1 (no restart inhibit!). *(S035)*

Acknowledgment of restart inhibit

Enable signal Q becomes 1 again, when:

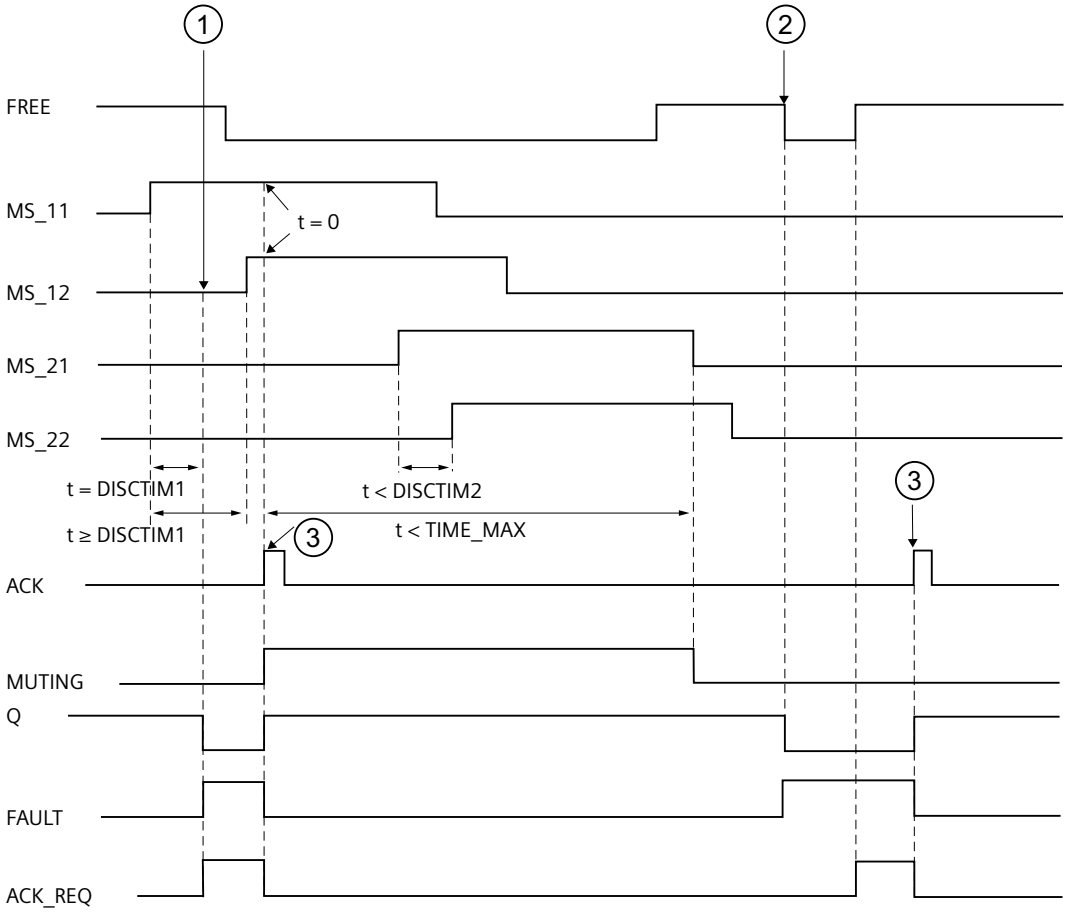
- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)
  and
- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 184)).

The FAULT output is set to 0. Output ACK_REQ = 1 signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK_REQ = 1 as soon as the light curtain is no longer interrupted or the errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

NOTE

Following discrepancy errors and once the maximum muting time has been exceeded, ACK_REQ is immediately set to 1. As soon as a user acknowledgment has taken place at input ACK, discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (if MUTING is not active)



① Sensor pair 1 (MS_11 and MS_12) is not activated within discrepancy time DISCTIM1.

② The light curtain is interrupted even though the MUTING function is not active.

③ Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

You must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

⚠ WARNING

When STOP = 1, the discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, for example, because both muting sensors have adopted signal state 1 in the event of an error, the fault is not detected and the MUTING function can be started unintentionally. *(S036)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min
Bit 3	Light curtain interrupted and muting not active	Light curtain is defective	Check light curtain
		Wiring fault	Check wiring of light curtain (FREE input)

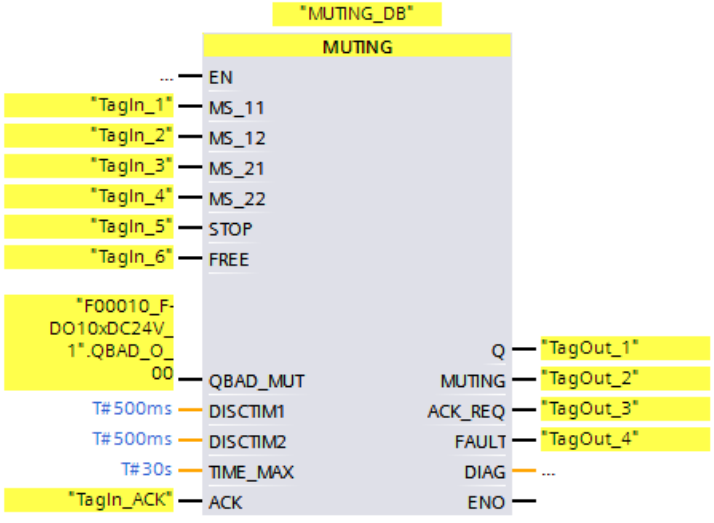
Bit no.	Assignment	Possible error causes	Remedies
Bit 3	Light curtain interrupted and muting not active	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 5	Reserved	—	—
Bit 6	Reserved	—	—
Bit 7	Reserved	—	—

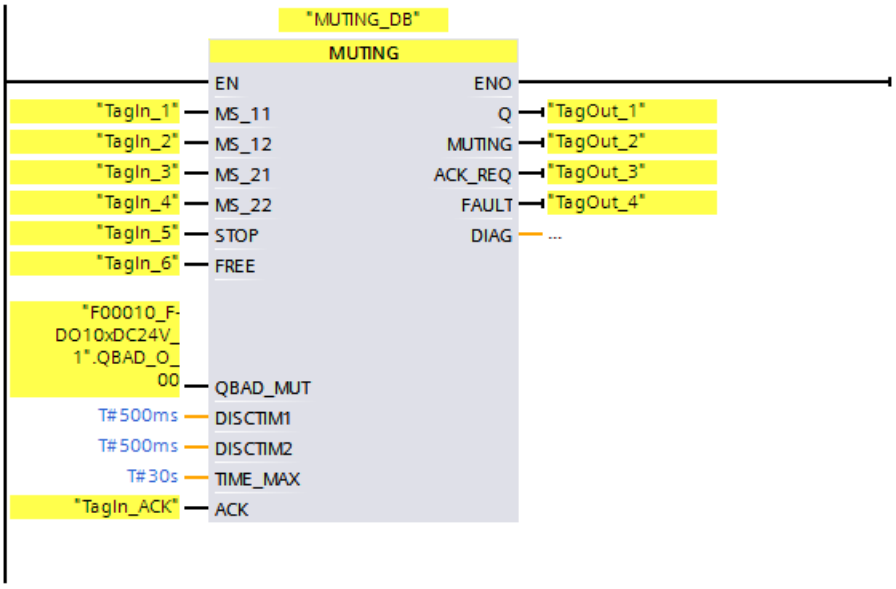
Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction:

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:





13.5.5 MUT_P: Parallel muting (STEP 7 Safety V21)

Description

This instruction performs parallel muting with two or four muting sensors.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Parallel muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUT_P_DB_1) or a multi-instance (e.g., MUT_P_Instance_1) for the "Parallel muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 11
MS_12	Input	BOOL	Muting sensor 12
MS_21	Input	BOOL	Muting sensor 21

Parameter	Declaration	Data type	Description
MS_22	Input	BOOL	Muting sensor 22
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
ENABLE	Input	BOOL	1=Enable MUTING
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the muting lamp channel
ACK	Input	BOOL	Acknowledgment of restart inhibit
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
Q	Output	BOOL	1= Enable, not off
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	WORD	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x*	—	—	—	
1.1	x*	—	—	—	These versions have identical functions to version 1.0. The output DIAG can now be correctly interconnected with the operand of data type WORD.
1.2	x*	—	—	o	
1.3	x*	o	—	o	
1.4	x	x	x	x	

o This version is no longer supported.

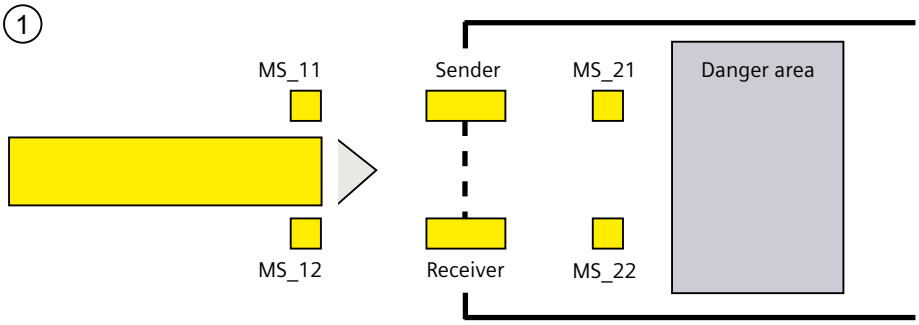
* S7-300/400: When a restart inhibit (output FAULT = 1) and ENABLE = 1 is present, output ACK_REQ is set to 1 even if not at least one muting sensor is activated. Use the DIAG bits 5 and 6 for more information.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

①

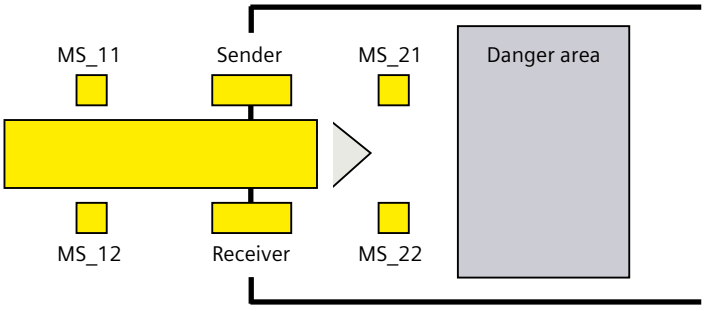


- If muting sensors MS_11 and MS_12 are both activated by the product within DISCTIM1 (apply signal state = 1) and MUTING is enabled by setting the ENABLE input to 1, the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

NOTE

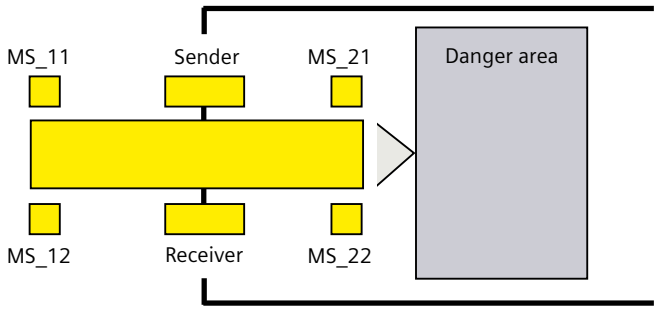
The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / with inverted value statues of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.
F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).

②



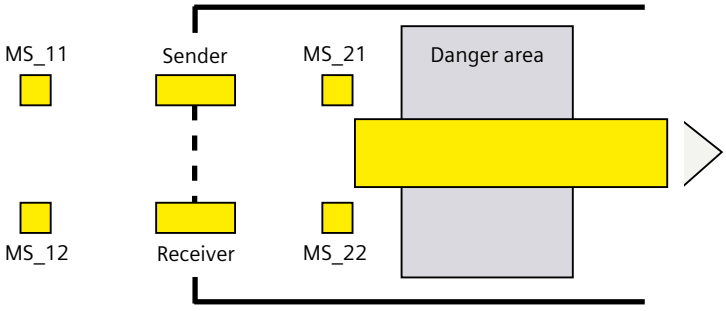
- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop). Each of the two muting sensors MS_11 and MS_12 may be switched to inactive (t < DISCTIM1) for a short time (apply signal state 0).

③



- Muting sensors MS_21 and MS_22 must both be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

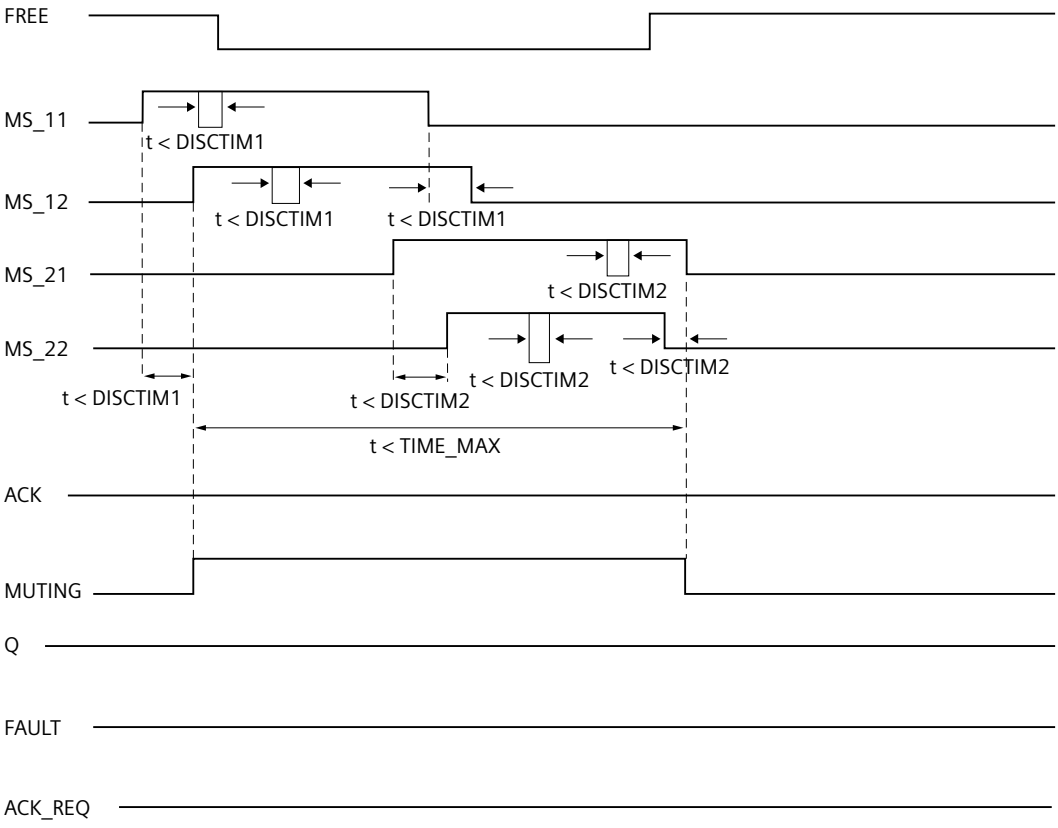


Only if muting sensors MS_21 and MS_22 are both switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

NOTE

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

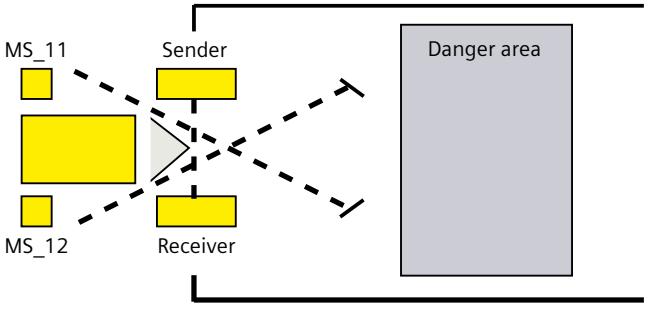


Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.



Restart inhibit upon interruption of light curtain (MUTING is not active), as well as when errors occur and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- Light curtain is (being) interrupted and the muting lamp monitoring at input QBAD_MUT is set to 1
- Light curtain is (being) interrupted and the MUTING function is not enabled by setting input ENABLE to 1
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min
- The F-system starts up (regardless of whether or not the light curtain is interrupted, because the F-I/O is passivated after F-system startup and, thus, the FREE input is initially supplied with 0)

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

User acknowledgment of restart inhibit (no muting sensor is activated or ENABLE = 0)

Enable signal Q becomes 1 again, when:

- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)

  and
- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 184)).

The FAULT output is set to 0. Output ACK_REQ = 1 (and DIAG bit 6) signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK_REQ = 1 as soon as the light curtain is no longer interrupted or the errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

User Acknowledgment of restart inhibit (at least one muting sensor is activated and ENABLE = 1)

Enable signal Q becomes 1 again, when:

- If present, errors are eliminated (see output DIAG)
- FREE function occurs until a valid combination of muting sensors is detected

The FAULT output is set to 0. The MUTING function is restarted, if necessary, and the MUTING output becomes 1 if a valid combination of muting sensors is detected. When ENABLE = 1, output ACK_REQ = 1 (and DIAG-Bit 5) signals that FREE function is necessary for error elimination and for removal of the restart inhibit. Once FREE function has occurred successfully, the instruction resets ACK_REQ to 0.

NOTE

Once the maximum muting time is exceeded, TIME_MAX is reset as soon as the MUTING function is restarted.

FREE function

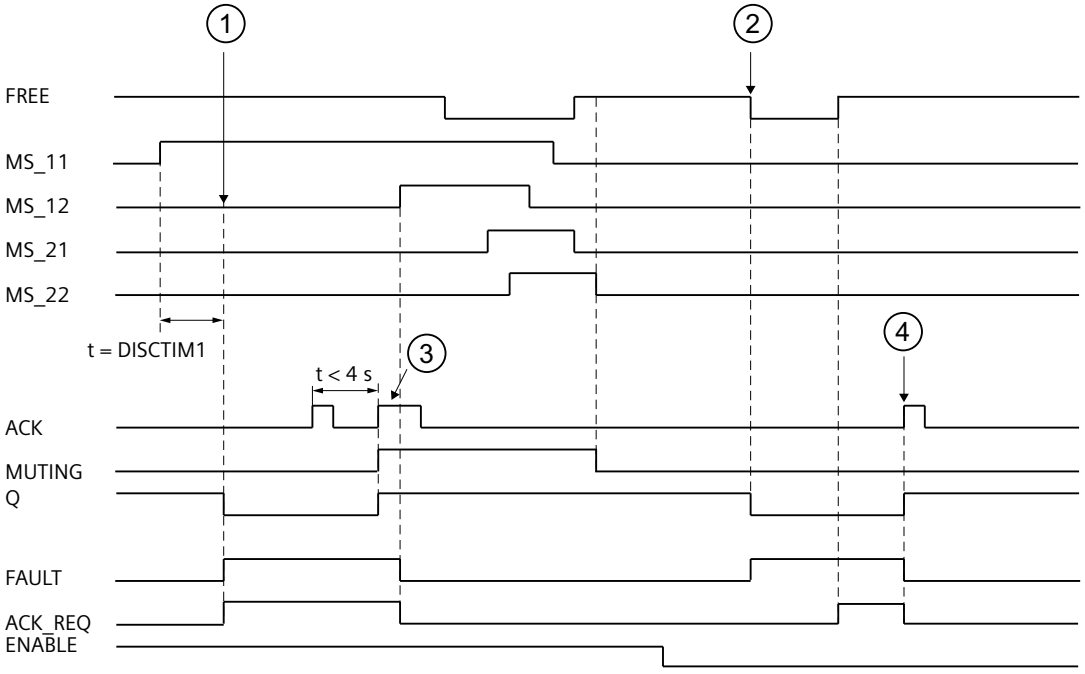
If an error cannot be corrected immediately, the FREE function can be used to free the muting range. Enable signal Q and output MUTING =1 temporarily. The FREE function can be used if:

- ENABLE = 1
- At least one muting sensor is activated
- A user acknowledgment with rising edge at input ACK occurs twice within 4 s, and the second user acknowledgment at input ACK remains at a signal state of 1 (acknowledgment button remains activated)

⚠ WARNING

When using the FREE function, the action must be observed. A dangerous situation must be able to be interrupted at any time by releasing the acknowledgment button. The acknowledgment button must be mounted in such a way that the entire danger area can be observed by the operator. *(S037)*

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (MUTING is not active)



① Sensor pair 1 (MS_11 and MS_22) is not activated within discrepancy time DISCTIM1.

② The light curtain is interrupted even though there is no enable (ENABLE=0)

③ FREE function

④ Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

You must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

⚠ WARNING

When STOP = 1 or ENABLE = 0, discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, for example, because both muting sensors have adopted signal state 1 in the event of an error, the fault is not detected and the MUTING function can be started unintentionally (when ENABLE =1). *(S038)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 6 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min
Bit 3	Light curtain interrupted and muting not active	ENABLE = 0	Set ENABLE = 1
		Light curtain is defective	Check light curtain
		Wiring fault	Check wiring of light curtain (FREE input)
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		Startup of F-system	For FREE function, see DIAG Bit 5
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 5	FREE function is necessary	See other DIAG bits	Two rising edges at ACK within 4 s, and activate acknowledgment button until ACK_REQ = 0

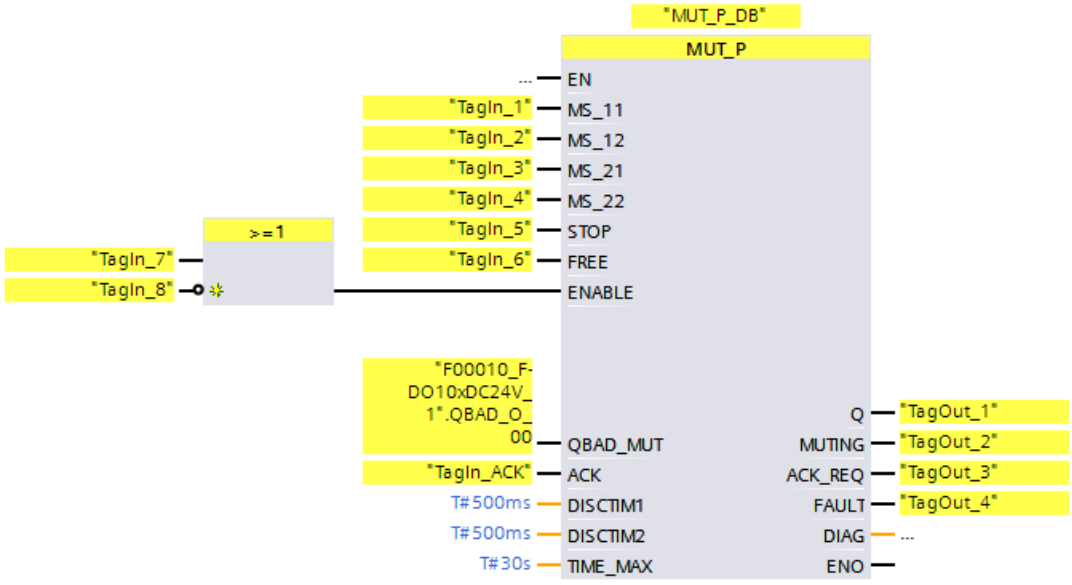
Bit no.	Assignment	Possible error causes	Remedies
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—
Bit 8	State of output MUTING	—	—
Bit 9	FREE function active	—	—
Bit 10	Reserved	—	—
...			
Bit 15	Reserved	—	—

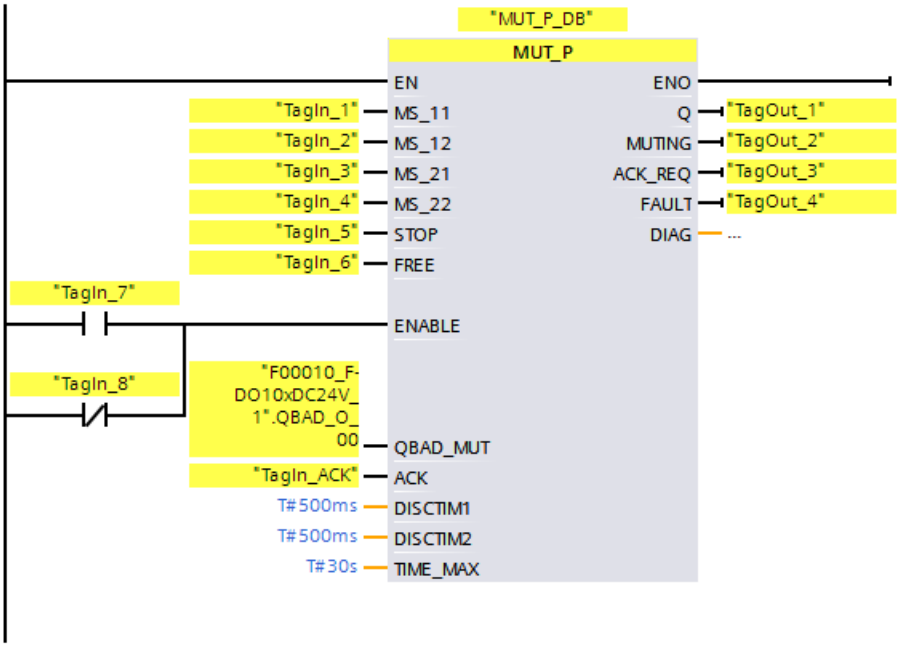
Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:





13.5.6 EV1oo2DI: 1oo2 evaluation with discrepancy analysis (STEP 7 Safety V21)

Description

This instruction implements a 1oo2 evaluation of two single-channel sensors combined with a discrepancy analysis.

Output Q is set to 1, if the signal states of inputs IN1 and IN2 both equal 1 and no discrepancy error DISC_FLT is stored. if the signal state of one or both inputs is 0, output Q is set to 0.

As soon as the signal states of inputs IN1 and IN2 are different, the discrepancy time DISCTIME is started. If the signal states of the two inputs are still different once the discrepancy time expires, a discrepancy error is detected and DISC_FLT is set to 1 (restart inhibit).

If the discrepancy between inputs IN1 and IN2 is no longer detected, the discrepancy error is acknowledged according to the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK to acknowledge the discrepancy error.

The output ACK_REQ = 1 signals that a user acknowledgment at input ACK is necessary to acknowledge the discrepancy error (cancel the restart inhibit). The instruction sets ACK_REQ = 1 as soon as discrepancy is no longer detected. After acknowledgment or if, prior to acknowledgment, there is once again a discrepancy between inputs IN1 and IN2, the instruction resets ACK_REQ to 0.

Output Q can never be set to 1 if the discrepancy time setting is < 0 or > 60 s. In this case, output DISC_FLT is also set to 1 (restart inhibit). The call interval of the safety program (e.g., OB 35) must be less than the discrepancy time setting.

Every call of the "1oo2 evaluation with discrepancy analysis" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., EV1oo2DI_DB_1) or a multi-instance (e.g.,

EV1oo2DI_Instance_1) for the "1oo2 evaluation with discrepancy analysis" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Sensor 1
IN2	Input	BOOL	Sensor 2
DISCTIME	Input	TIME	Discrepancy time (0 to 60 s)
ACK_NEC	Input	BOOL	1 = acknowledgment necessary for discrepancy error
ACK	Input	BOOL	Acknowledgment of discrepancy error
Q	Output	BOOL	Output
ACK_REQ	Output	BOOL	1 = acknowledgment required
DISC_FLT	Output	BOOL	1 = discrepancy error
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

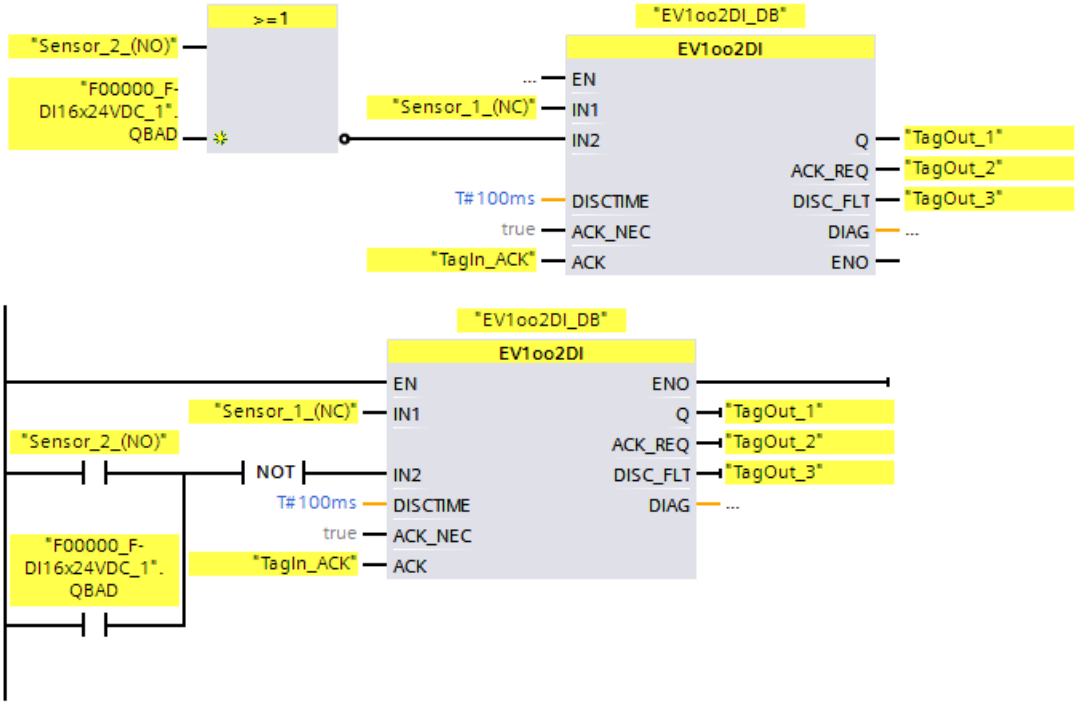
For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Activating inputs IN1 and IN2

Inputs IN1 and IN2 must both be activated in such a way that their safe state is 0.

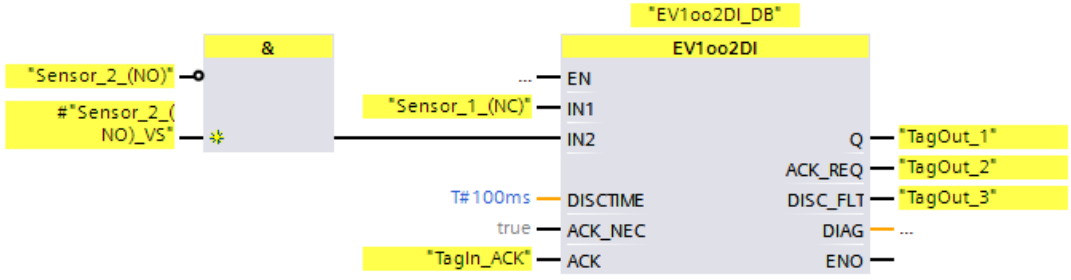
Example with QBAD or QBAD_I_xx signal

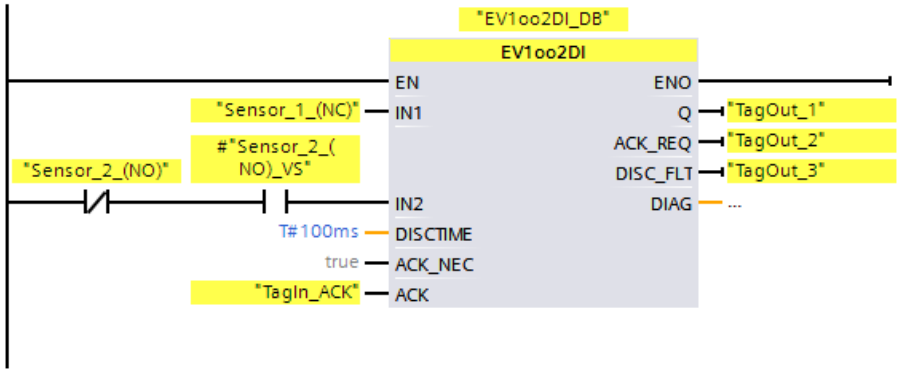
For non-equivalent signals you need to OR the input (IN1 and IN2) with which you assign the encoder signal to the safe state 1, with the QBAD signal of the associated F-I/O or the QBAD_I_xx signal of the associated channel (with S7-300/400 F-CPUs) and negate the result. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.



Example with value status

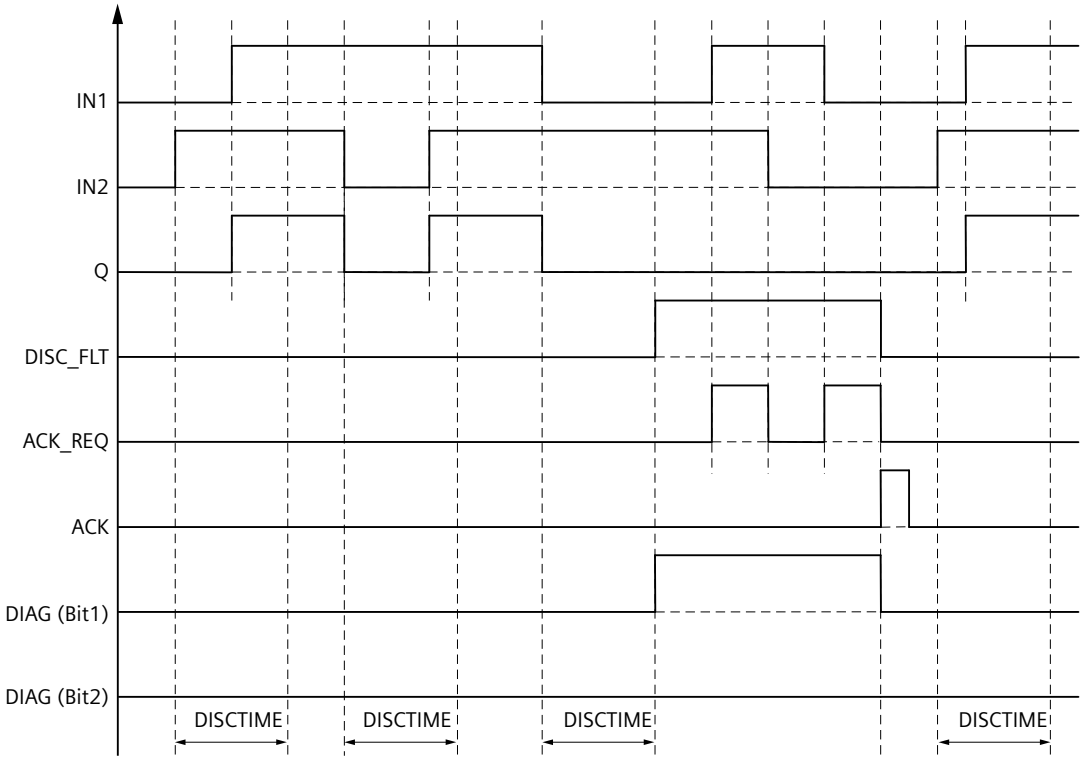
For non-equivalent signals, you have to negate the input (IN1 or IN2) with which you have assigned the encoder signal to a safe state of 1 and AND it with the value status of the associated channel. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.





Timing diagrams EV1oo2DI

If ACK_NEC = 1:



Startup behavior

NOTE

If the sensors at inputs IN1 and IN2 are assigned to different F-I/O, it is possible that the fail-safe values are output for different lengths of time following startup of the F-system due to different startup behavior of the F-I/O. If the signal states of inputs IN1 and IN2 remain different after the discrepancy time DISCTIME has expired, a discrepancy error is detected after the F-system starts up.
If ACK_NEC = 1 you must acknowledge the discrepancy error with a rising edge at input ACK.

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

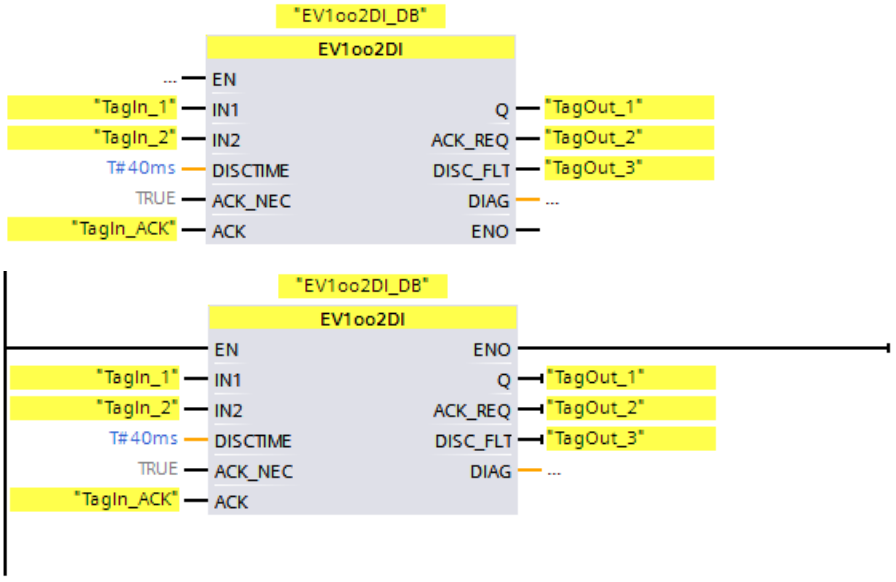
Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time setting (= status of DISC_FLT)	Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 60 s	Set discrepancy time in range between 0 s and 60 s
Bit 1	For discrepancy errors: last signal state change was at input IN1	—	—
Bit 2	For discrepancy errors: last signal state change was at input IN2	—	—
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For discrepancy errors: input ACK has a permanent signal state of 1	Acknowledgment button defective	Replace acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



13.5.7 FDBACK: Feedback monitoring (STEP 7 Safety V21)

Description

This instruction implements feedback monitoring.

The signal state of output Q is checked to see whether it corresponds to the inverse signal state of the feedback input FEEDBACK.

Output Q is set to 1 as soon as input ON = 1. Requirement for this is that the feedback input FEEDBACK = 1 and no feedback error is saved.

Output Q is reset to 0, as soon as input ON = 0 or if a feedback error is detected.

A feedback error ERROR = 1 is detected if the inverse signal state of the feedback input FEEDBACK (to input Q) does not follow the signal state of output Q within the maximum tolerable feedback time. The feedback error is saved.

If a discrepancy is detected between the feedback input FEEDBACK and the output Q after a feedback error, the feedback error is acknowledged in accordance with the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must acknowledge the feedback error with a rising edge at input ACK.

The ACK_REQ = 1 output then signals that a user acknowledgment is necessary at input ACK to acknowledge the feedback error. Following an acknowledgment, the instruction resets ACK_REQ to 0.

To avoid a feedback errors from being detected and acknowledgment from being required when the F-I/O controlled by the Q output are passivated, you need to supply input QBAD_FIO with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / inverted value status of the associated channel.

Every call of the "Feedback monitoring" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., FDBACK_DB_1) or a multi-instance (e.g., FDBACK_Instance_1) for the "Feedback monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ON	Input	BOOL	1= Enable output
FEEDBACK	Input	BOOL	Feedback input
QBAD_FIO	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the Q output
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
FDB_TIME	Input	TIME	Feedback time
Q	Output	BOOL	Output
ERROR	Output	BOOL	Feedback error
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

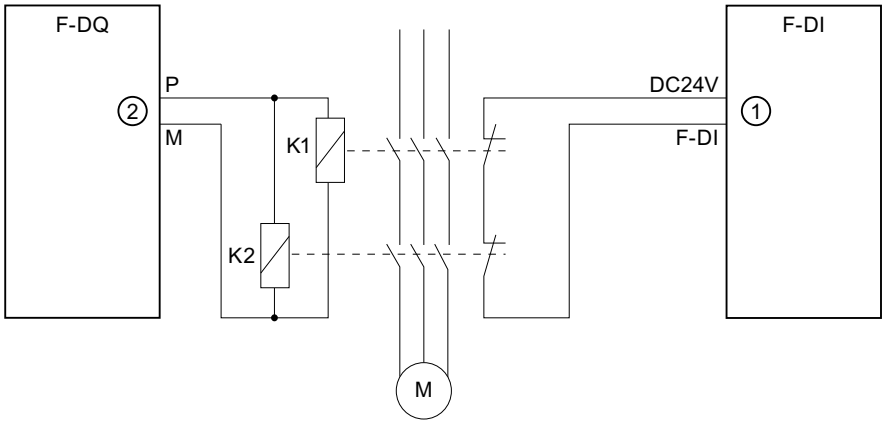
Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder.
1.1	x	—	—	—	These versions have identical functions to version 1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	o	—	o	
1.5	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Interconnection example



① Sent to the FEEDBACK input of the instruction
② from output Q of the instruction

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0, 2, and 5 are saved until acknowledgment at input ACK.

Structure of DIAG

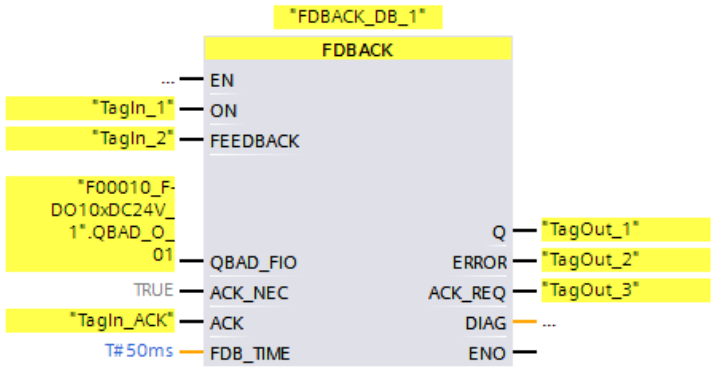
Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Feedback error or incorrect feedback time setting (= state of ERROR)	Feedback time setting < 0	Set feedback time > 0
		Feedback time setting is too low	If necessary, set a higher feedback time
		Wiring fault	Check wiring of actuator and feedback contact
		Actuator or feedback contact is defective	Check actuator and feedback contact
		I/O fault or channel fault of feedback input	Check I/O
Bit 1	Passivation of F-I/O/channel controlled by output Q (= state of QBAD_FIO)	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 2	After feedback error: feedback input has permanent signal state of 0	F-I/O fault or channel fault of feedback input	Check I/O
		Feedback contact is defective	Check feedback contact
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of feedback input	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For feedback error: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

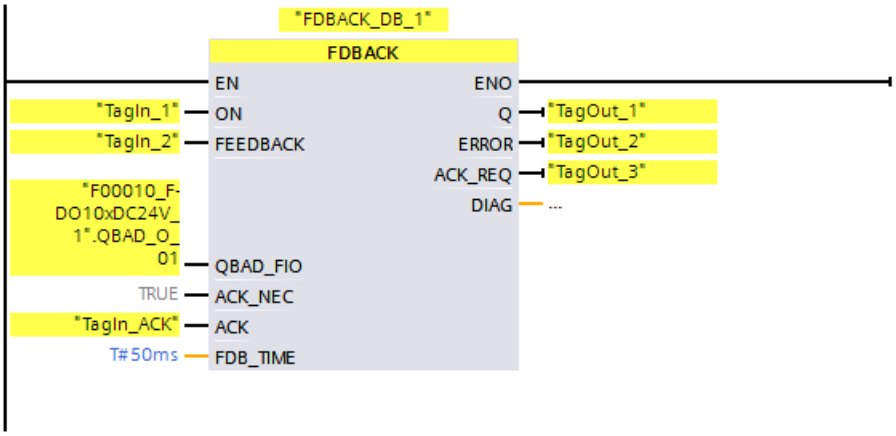
Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

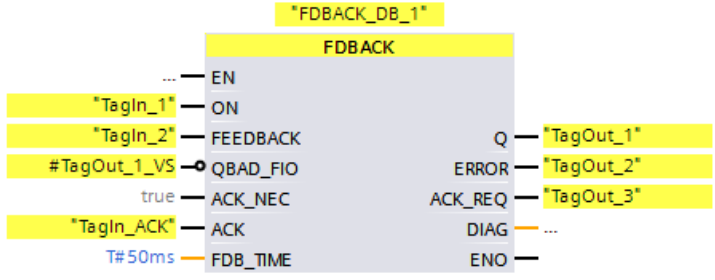
Example

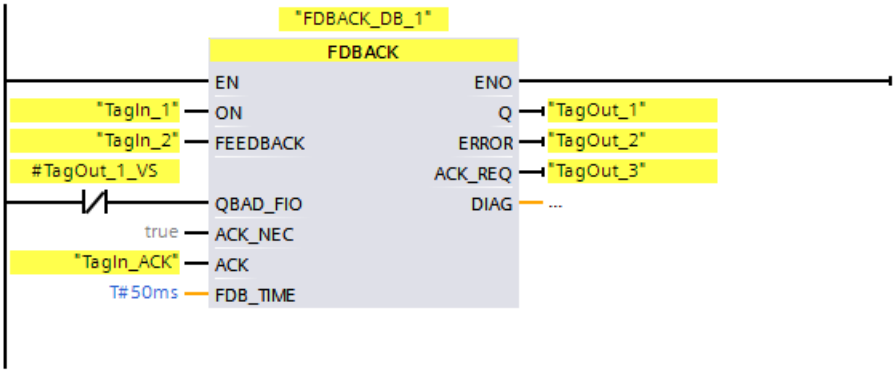
The following example shows how the instruction for S7-300/400 F-CPUs works:





The following example shows how the instruction for S7-1200/1500 F-CPUs works:





13.5.8 SFDOOR: Safety door monitoring (STEP 7 Safety V21)

Description

This instruction implements safety door monitoring.

Enable signal Q is reset to 0 as soon as one of the inputs IN1 or IN2 take a signal state of 0 (safety door is opened). The enable signal can be reset to 1, only if:

- Inputs IN1 and IN2 both take a signal state of 0 prior to opening the door (safety door has been completely opened)
- Inputs IN1 and IN2 then both take a signal state of 1 (safety door is closed)
- An acknowledgment occurs

The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ = 1 is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets ACK_REQ = 1 as soon as the door is closed. Following an acknowledgment, the instruction resets ACK_REQ to 0.

In order for the instruction to recognize whether inputs IN1 and IN2 are 0 merely due to passivation of the associated F-I/O, you need to supply inputs QBAD_IN1 or QBAD_IN2 with the QBAD signal of the associated F-I/O or QBAD_I_xx signal / inverted value status of the associated channel. Among other things, this will prevent you from having to open the safety door completely prior to an acknowledgment in the event the F-I/O are passivated.

Every call of the "Safety door monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SFDOOR_DB_1) or a multi-instance (e.g., SFDOOR_Instance_1) for the "Safety door monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Input 1
IN2	Input	BOOL	Input 2

Parameter	Declaration	Data type	Description
QBAD_IN1	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN1
QBAD_IN2	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN2
OPEN_NEC	Input	BOOL	1= Open necessary at startup
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
Q	Output	BOOL	1= Enable, safety door closed
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

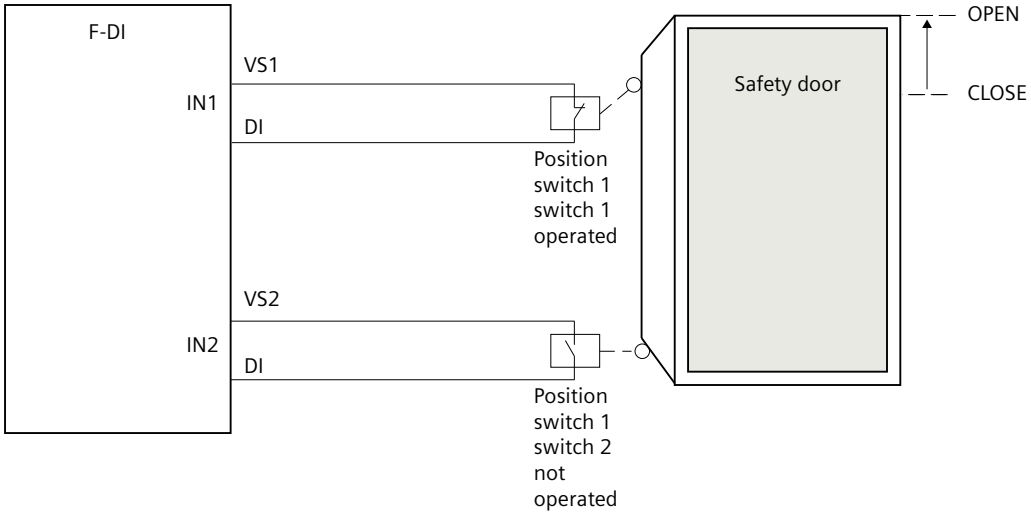
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

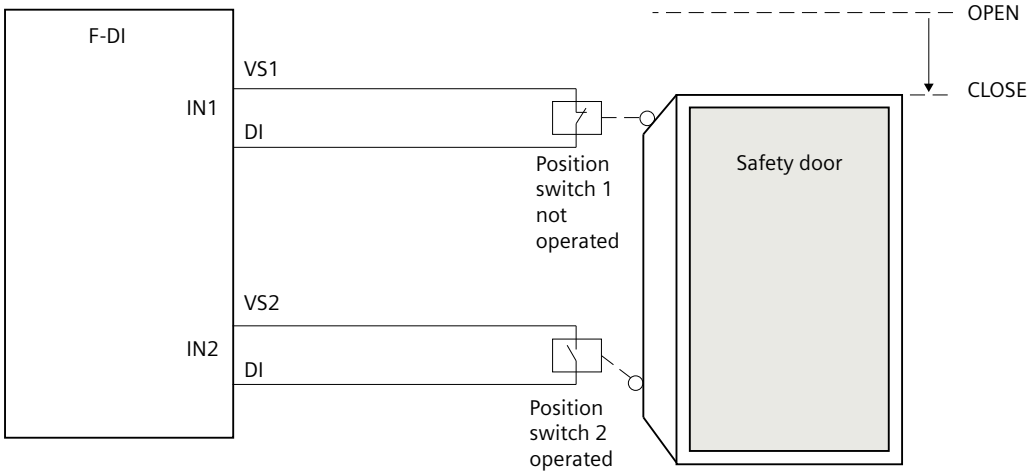
Interconnection example

You must interconnect the NC contact of position switch 1 of the safety door at input IN1 and the NO contact of position switch 2 at input IN2. Position switch 1 must be mounted in such a way that it is positively operated when the safety door is open. Position switch 2 must be mounted in such a way that it is operated when the safety door is closed.

Safety door open:



Safety door closed:



Startup behavior

After an F-system startup, enable signal Q is reset to 0. The acknowledgment for the enable takes place according to the parameter assignment at inputs OPEN_NEC and ACK_NEC:

- When OPEN_NEC = 0, an automatic acknowledgment occurs **independently** of ACK_NEC, as soon as the two inputs IN1 and IN2 take signal state 1 for the first time following reintegration of the associated F-I/O (safety door is closed).
- When OPEN_NEC = 1 **or** if at least one of the IN1 and IN2 inputs still has a signal state of 0 after reintegration of the associated F-I/O, an automatic acknowledgment occurs **according** to ACK_NEC or you have to use a rising edge at input ACK for the enable. Prior to acknowledgment, inputs IN1 and IN2 both have to take a signal state of 0 (safety door has been completely opened) followed by a signal state of 1 (safety door is closed).

⚠ WARNING

The OPEN_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S039)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program.

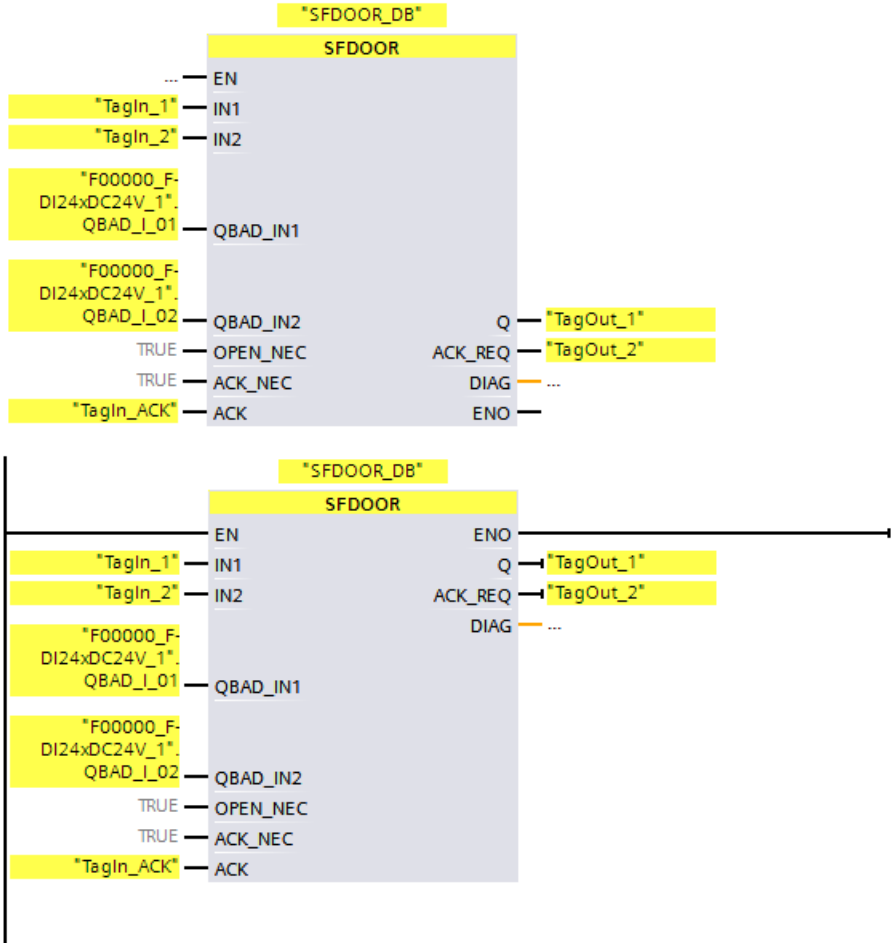
Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Signal state 0 is missing at both IN1 and IN2 inputs	Safety door was not completely opened when OPEN_NEC = 1 after F-system startup	Open safety door completely
		Open safety door was not completely opened	Open safety door completely
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly
Bit 2	Signal state 1 is missing at both IN1 and IN2 inputs	Safety door was not closed	Close safety door
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly
Bit 3	QBAD_IN1 and/or QBAD_IN2 = 1	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O or channel of IN1 and/or IN2	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 164)
Bit 4	Reserved	—	—

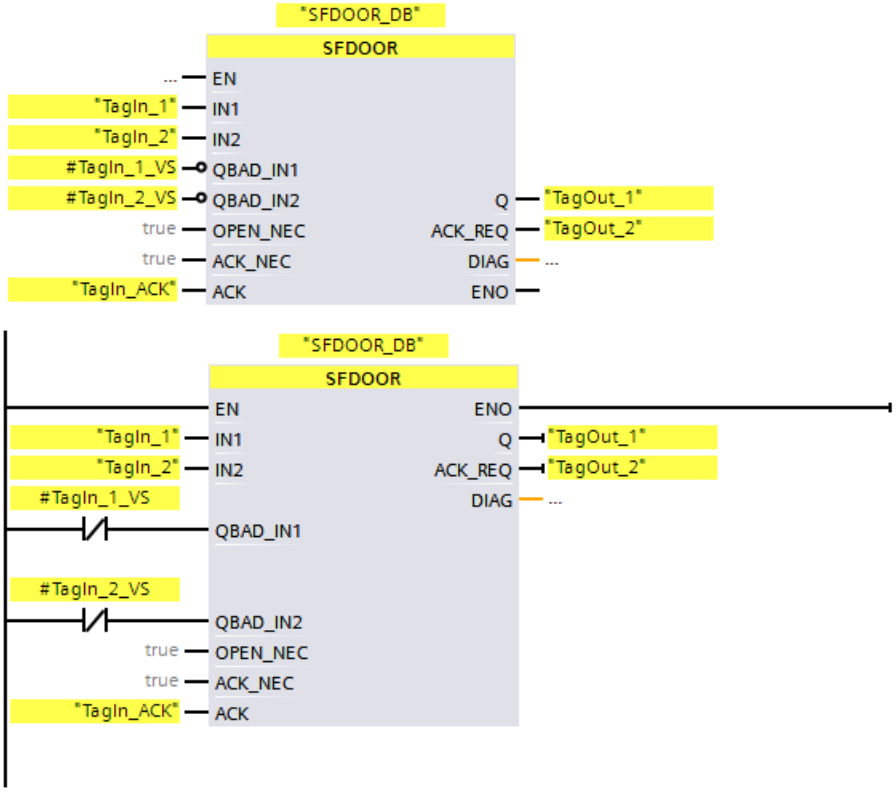
Bit no.	Assignment	Possible error causes	Remedies
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Example

The following example shows how the instruction for S7-300/400 F-CPUs works:



The following example shows how the instruction for S7-1200/1500 F-CPUs works:



13.5.9 ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21)

Description

This instruction creates an acknowledgment for the simultaneous reintegration of all F-I/O or channels of the F-I/O of an F-runtime group after communication errors, F-I/O errors, or channel faults.

A user acknowledgment (Page 184) with a positive edge at input ACK_GLOB is required for reintegration. The acknowledgment occurs analogously to the user acknowledgment via the ACK_REI tag of the F-I/O DB (Page 160), but it acts simultaneously on all F-I/O of the F-runtime group in which the instruction is called.

If you use the instruction ACK_GL, you do not have to provide a user acknowledgment for each F-I/O of the F-runtime group via the ACK_REI tag of the F-I/O DB.

Every call of the "Global acknowledgment of all F-I/O of a runtime group" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_GL_DB_1) or a multi-instance (e.g., ACK_GL_Instance_1) for the "Global acknowledgment of all F-I/O of a runtime group" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

An acknowledgment via the ACK_GL instruction is only possible if the tag ACK_REI of the F-I/O DB = 0. Accordingly, an acknowledgment via the tag ACK_REI of the F-I/O DB is only possible if the input ACK_GLOB of the instruction = 0.
The instruction is only allowed to be called once per F-runtime group.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_GLOB	Input	BOOL	1=acknowledgment for reintegration

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

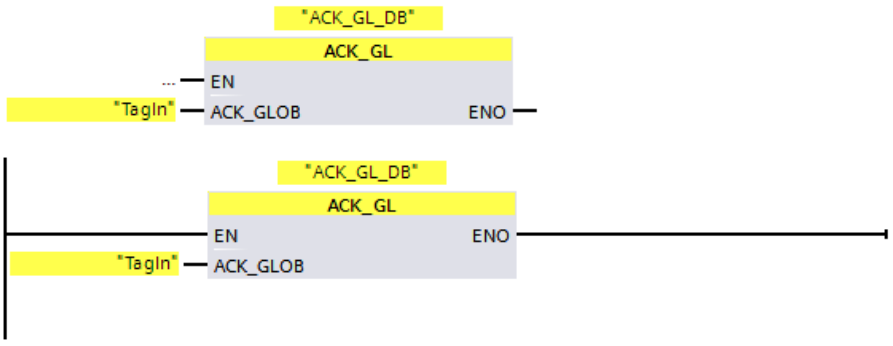
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



13.6 Timer operations

13.6.1 TP: Generate pulse (STEP 7 Safety V21)

Description

You can use the "Generate pulse" instruction to set output Q for a programmed period. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. Output Q is set for period PT, regardless of the subsequent sequence of the input signal. Also the detection of a new positive signal edge does not influence the signal state at output Q as long as period PT runs.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. If period PT is reached and the signal state at input IN is "0", output ET is reset.

Every call of the "Generate pulse" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate pulse" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate pulse" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TP instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the pulse, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of pulse; must be positive.
Q	Output	BOOL	Pulse output
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

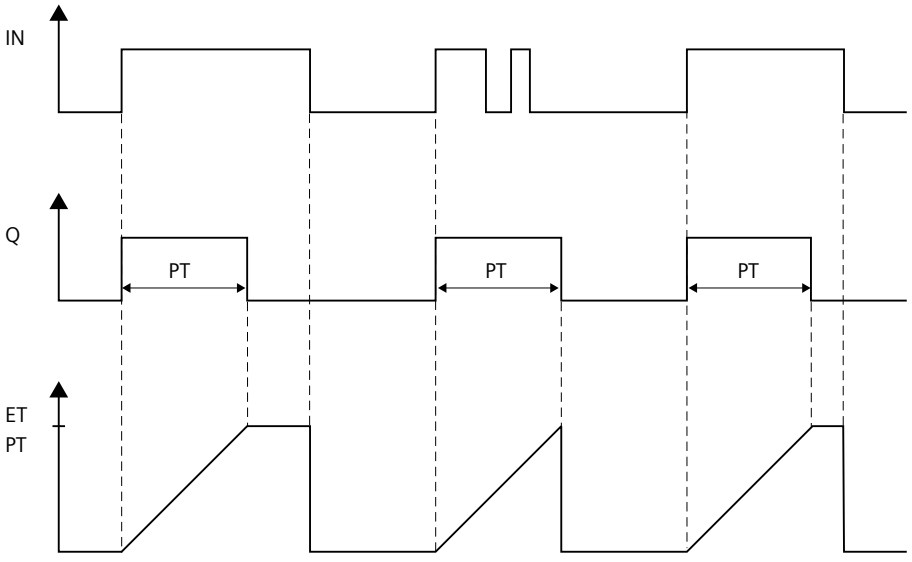
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate pulse":

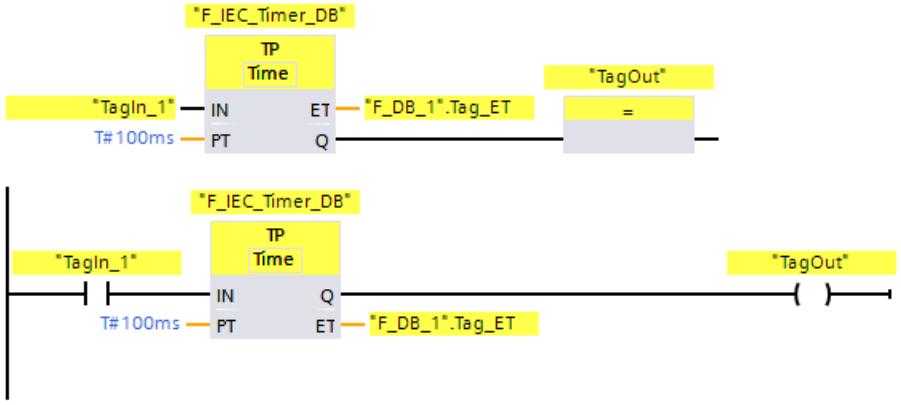


Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



If the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate pulse" instruction is started and the period assigned at input PT (100 ms) runs, regardless of the further course of operand "TagIn_1".

Operand "TagOut" at output Q has signal state "1" as long as the period is running. Operand ""F_DB_1".Tag_ET" contains the current time value.

13.6.2 TON: Generate on-delay (STEP 7 Safety V21)

Description

You use the "Generate on-delay" instruction to delay the setting of output Q by the assigned period PT. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. When period PT has expired, output Q is set to signal state "1". Output Q remains set as long as the start input is set to "1". When the signal state at the start input changes from "1" to "0", output Q is reset. The time function is restarted when a new positive signal edge is detected at the start input.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. Output ET is reset, as soon as the signal state at input IN changes to "0".

Every call of the "Generate on-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate on-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate on-delay" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TON instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the output ET is reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the on-delay, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of on-delay; must be positive.
Q	Output	BOOL	Output that is set after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

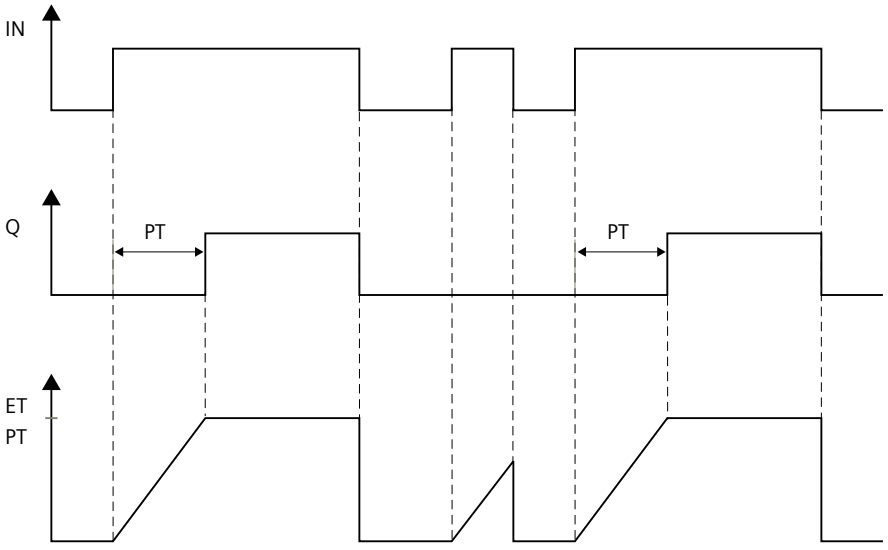
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate on-delay":

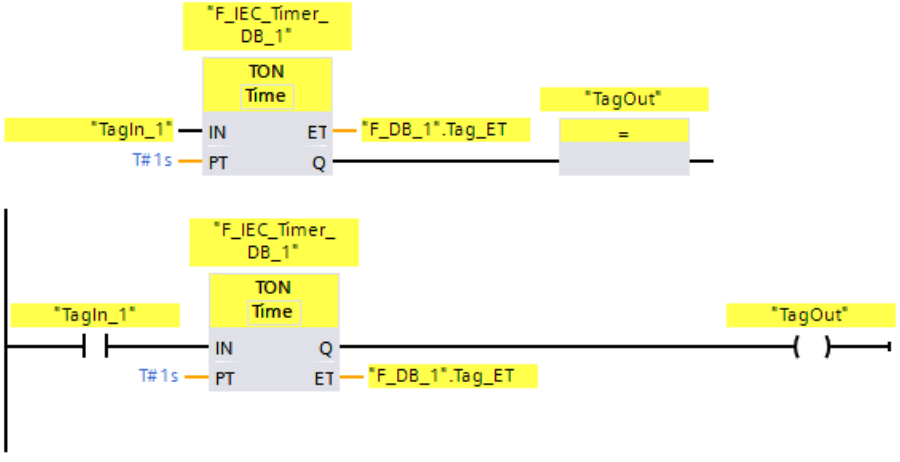


Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



When the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate on-delay" instruction is started and the period assigned at input PT (1 s) runs.

Operand "TagOut" at output Q feeds signal state "1" when the period has elapsed and remains set as long as operand "TagIn_1" still feeds signal state "1". Operand ""F_DB_1".Tag_ET" contains the current time value.

13.6.3 TOF: Generate off-delay (STEP 7 Safety V21)

Description

You use the "Generate off-delay" instruction to delay the resetting of output Q by the assigned period PT. Output Q is set if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. When the signal state at input IN changes back to "0", the programmed period PT starts. Output Q remains set as long as period PT runs. After period PT expires, output Q is reset. If the signal state at input IN changes to "1" before period PT has expired, then the time is reset. The signal state at output Q remains at "1".

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. After time PT has elapsed, output ET remains at its current value until input IN changes back to "1". If input IN changes to "1" before time PT has expired, the output ET is reset to value T#0.

Every call of the "Generate off-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is in inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate off-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate off-delay" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TOF instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the off-delay, another falling signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of off delay; must be positive.
Q	Output	BOOL	Output that is reset after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

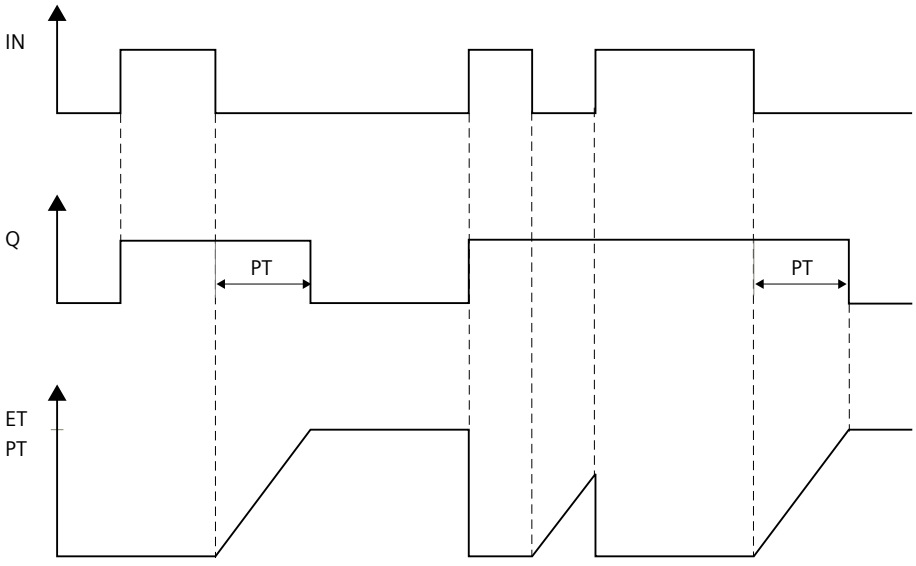
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate off-delay":

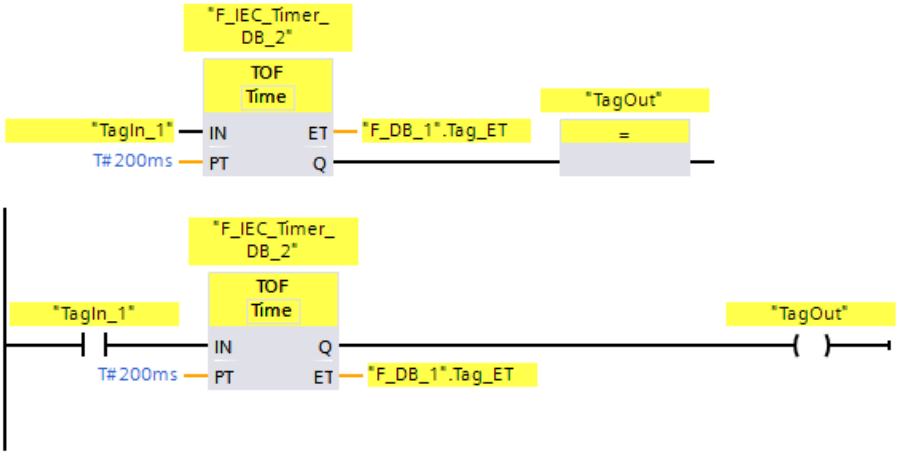


Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

The following example shows how the instruction works:



If the signal state of operand "TagIn_1" changes from "0" to "1", the signal state of operand"TagOut" at output Q is set to "1".

If the signal state of operand "TagIn_1" changes back to "0", the period assigned at input PT (200 ms) runs.

The "TagOut" operand at output Q is set back to "0" when the period expires. Operand ""F_DB_1".Tag_ET" contains the current time value.

13.7 Counter operations

13.7.1 CTU: Count up (STEP 7 Safety V21)

Description

You can use the "Count up" instruction to increment the value at output CV. When the signal state at the CU input changes from "0" to "1" (positive signal edge), the instruction is executed and the current count at the CV output increases by one. The count value is increased on each detection of a positive signal edge until it reaches the high limit of the data type specified at the CV output. When the high limit is reached, the signal state at the CU input no longer affects the instruction.

The counter status can be queried at output Q. The signal state at output Q is determined by parameter PV. When the current count value is greater than or equal to the value of parameter PV, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is reset to zero when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at input CU has no effect on the instruction.

Every call of the "Count up" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as

a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Counter input
R	Input	BOOL	Reset input
PV	Input	INT	Value for which output Q is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

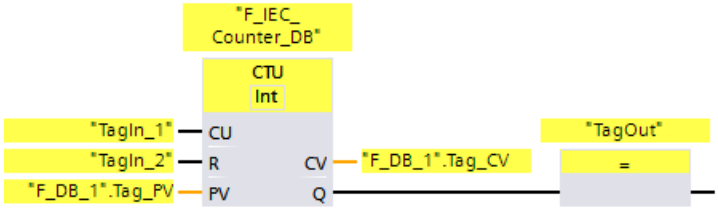
o This version is no longer supported.

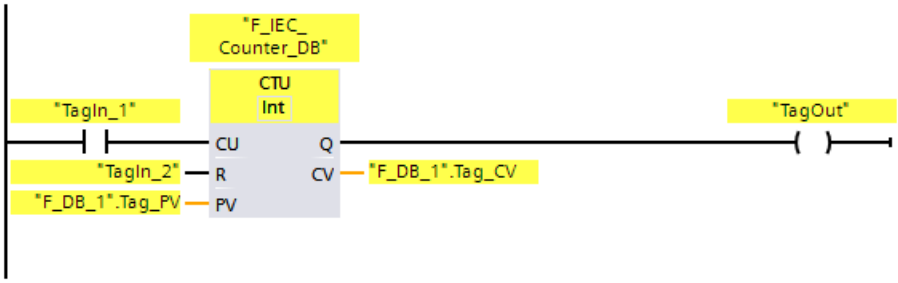
When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:





When the signal state of the "CU" input changes from "0" to "1", the "Count up" instruction is executed and the current count of the "CV" output increases by one. The count value is increased on every additional positive signal edge until the high limit of the specified data type (32767) is reached.

The value at the PV parameter is applied as the limit for determining the "TagOut" operands at the Q output. Output "Q" returns the signal state "1" as long as the current count is greater than or equal to the value of operand "PV". In all other cases, the "Q" output has the signal state "0".

13.7.2 CTD: Count down (STEP 7 Safety V21)

Description

You can use the "Count down" instruction to decrement the value at output CV. When the signal state at input CD changes from "0" to "1" (positive signal edge), the instruction is executed and the current count value at output CV is decreased by one. The count value is decreased on each detection of a positive signal edge until it reaches the low limit of the specified data type. When the low limit is reached, the signal state at input CD no longer affects the instruction.

The counter status can be queried at output Q. When the current count value is less than or equal to zero, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is set to the value of parameter "PV" when the signal state at input LD changes to "1". As long as signal state "1" exists at input LD, the signal state at input CD has no effect on the instruction.

Every call of the "Count down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count down" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CD	Input	BOOL	Counter input
LD	Input	BOOL	Load input
PV	Input	INT	Value at the output CV when LD = 1 is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

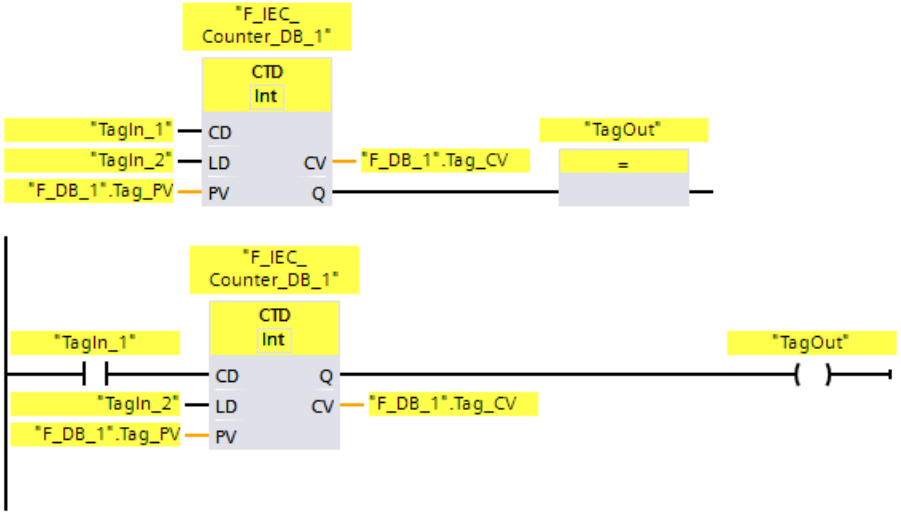
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



When the signal state of the "CD" input changes from "0" to "1", the "Count down" instruction is executed and the current count at "CV" output decreases by one. The count value is

decreased on each additional positive signal edge until the low limit of the specified data type (-32768) is reached.

Output "Q" returns the signal state "1" as long as the current count is less than or equal to zero. In all other cases, output "Q" has signal state "0".

13.7.3 CTUD: Count up and down (STEP 7 Safety V21)

Description

You can use the "Count up and down" instruction to increment and decrement the count value at output CV. If the signal state at the CU input changes from "0" to "1" (positive signal edge), the current count at the CV output increases by one. If the signal state at input CD changes from "0" to "1" (positive signal edge), the count value at output CV is decreased by one. If a positive signal edge is present at inputs CU and CD in one program cycle, the current count value at output CV remains unchanged.

The count value can be increased until it reaches the high limit of the data type specified at output CV. When the high limit is reached, the count value is no longer incremented on a positive signal edge. When the low limit of the specified data type is reached, the count value is no longer decreased.

When the signal state at input LD changes to "1", the count value at output CV is set to the value of parameter PV. As long as signal state "1" exists at input LD, the signal state at inputs CU and CD has no effect on the instruction.

The count value is set to zero, when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at inputs CU, CD, and LD has no effect on the "Count up and down" instruction.

The status of the up counter can be queried at output QU. When the current count value is greater than or equal to the value of parameter PV, output QU delivers signal state "1". In all other cases, the signal state at output QU is "0".

The status of the down counter can be queried at output QD. When the current count value is lesser than or equal to zero, output QD delivers signal state "1". In all other cases, the signal state at output QD is "0".

Every call of the "Count up and down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up and down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up and down" instruction when the F-system is started up.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Count up input
CD	Input	BOOL	Count down input

Parameter	Declaration	Data type	Description
R	Input	BOOL	Reset input
LD	Input	BOOL	Load input
PV	Input	INT	Value at which the output QU is set / to which the output CV is set when LD = 1
QU	Output	BOOL	Status of up counter
QD	Output	BOOL	Status of down counter
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

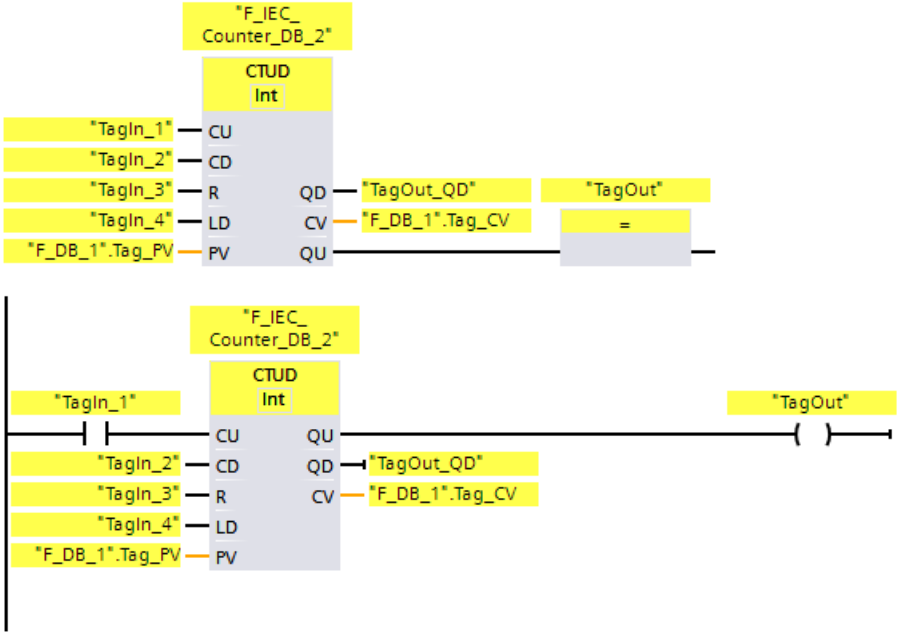
o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



When the signal state at the "CU" input or at the "CD" input changes from "0" to "1" (positive signal edge), the "Count up and down" instruction is executed. When a positive signal edge is present at the "CU" input, the current count of the "CV" output increases by one. When a positive signal edge is present at the "CD" input, the current count at the "CV" output decreases by one. The count value is increased on each positive signal edge at the CU input until it reaches the high limit of 32767. The count value is decreased on each positive signal edge at the CD input until it reaches the low limit of -32768.

Output "QU" returns the signal state "1" as long as the current count is greater than or equal to the value at the "PV" input. In all other cases, output "QU" has signal state "0".

Output "QD" returns the signal state "1" as long as the current count is less than or equal to zero. In all other cases, output "QD" has signal state "0".

13.8 Comparator operations

13.8.1 CMP ==: Equal (STEP 7 Safety V21)

Description

You can use the "Equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

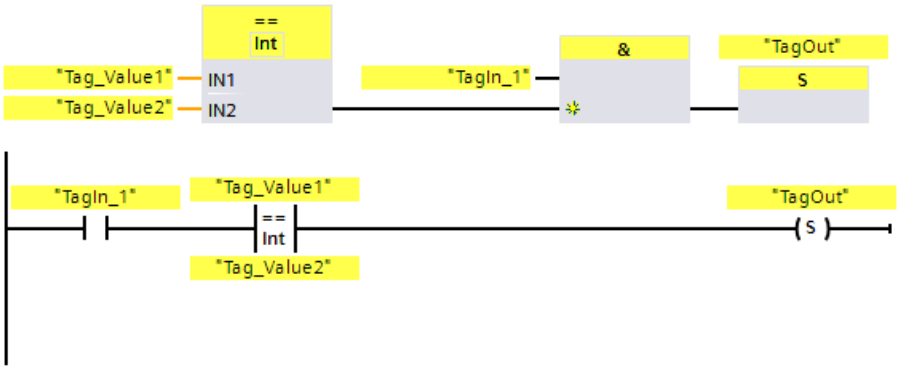
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" = "Tag_Value2").

13.8.2 CMP <>: Not equal (STEP 7 Safety V21)

Description

You can use the "Not equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is not equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

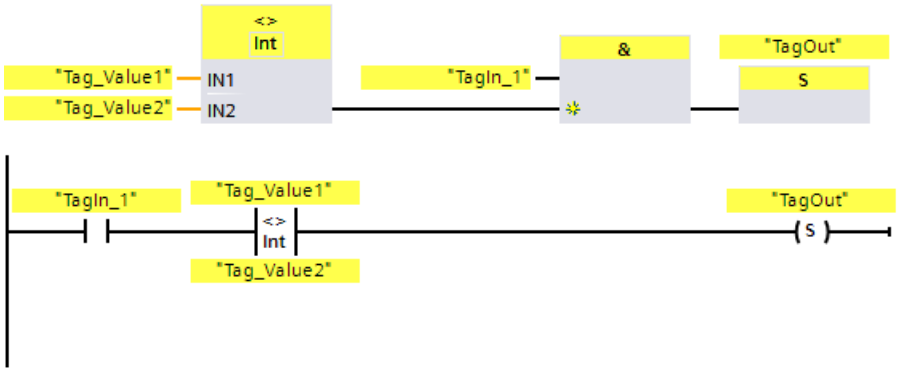
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <> "Tag_Value2").

13.8.3 CMP >=: Greater or equal (STEP 7 Safety V21)

Description

You can use the "Greater or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

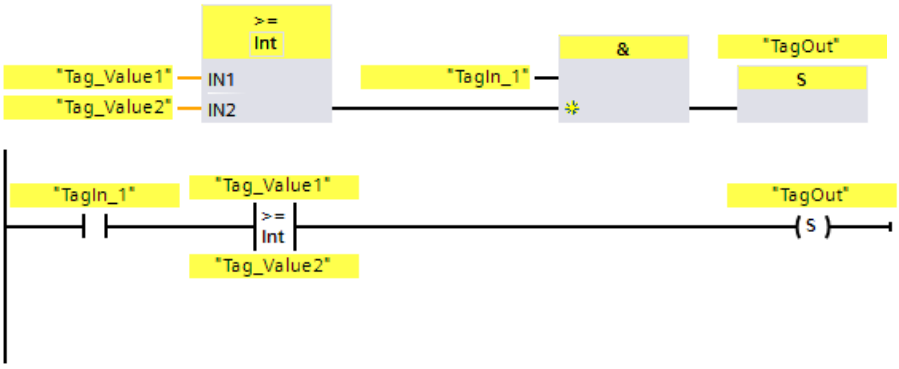
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" >= "Tag_Value2").

13.8.4 CMP <=: Less or equal (STEP 7 Safety V21)

Description

You can use the "Less or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

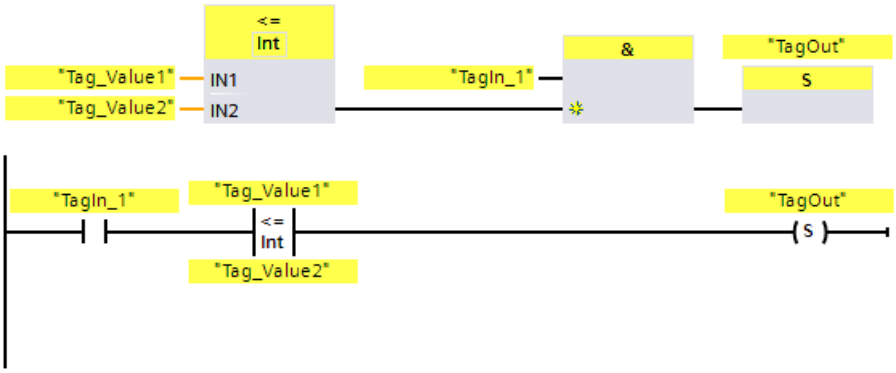
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <= "Tag_Value2").

13.8.5 CMP >: Greater than (STEP 7 Safety V21)

Description

You can use the "Greater than" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

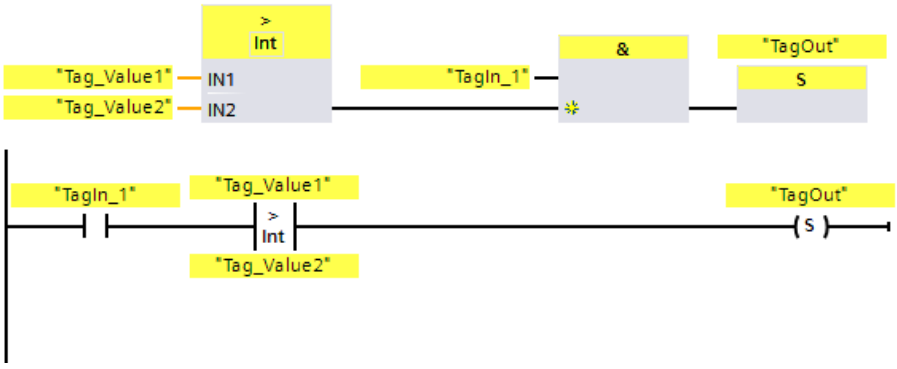
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" > "Tag_Value2").

13.8.6 CMP <: Less than (STEP 7 Safety V21)

Description

You can use the "Less than" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

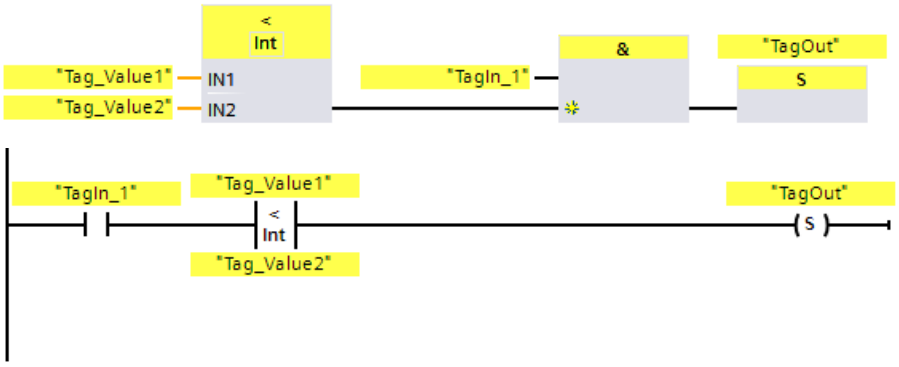
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" < "Tag_Value2").

13.9 Math functions

13.9.1 ADD: Add (STEP 7 Safety V21)

Description

You can use the "Add" instruction to add the value at input IN1 and the value at input IN2 and query the sum at the OUT output (OUT = IN1 + IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

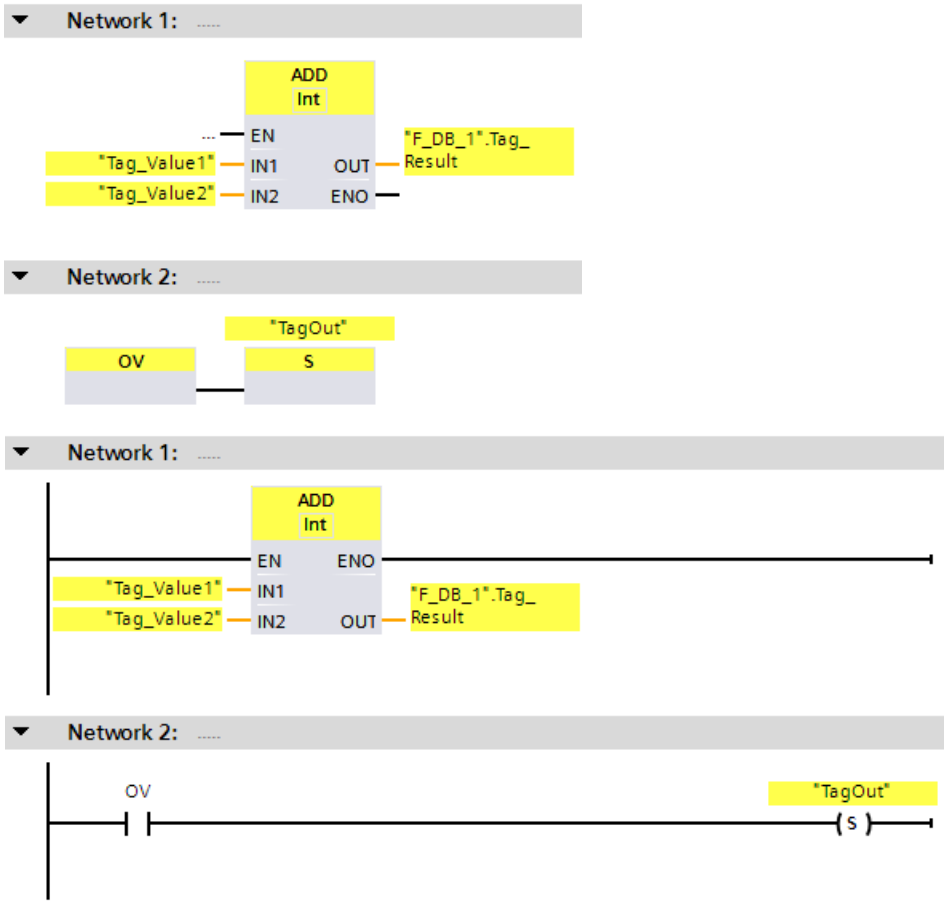
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	First addend
IN2	Input	INT, DINT	Second addend
OUT	Output	INT, DINT	Total

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:



The "Add" instruction is always executed regardless of the signal state at enable input EN.

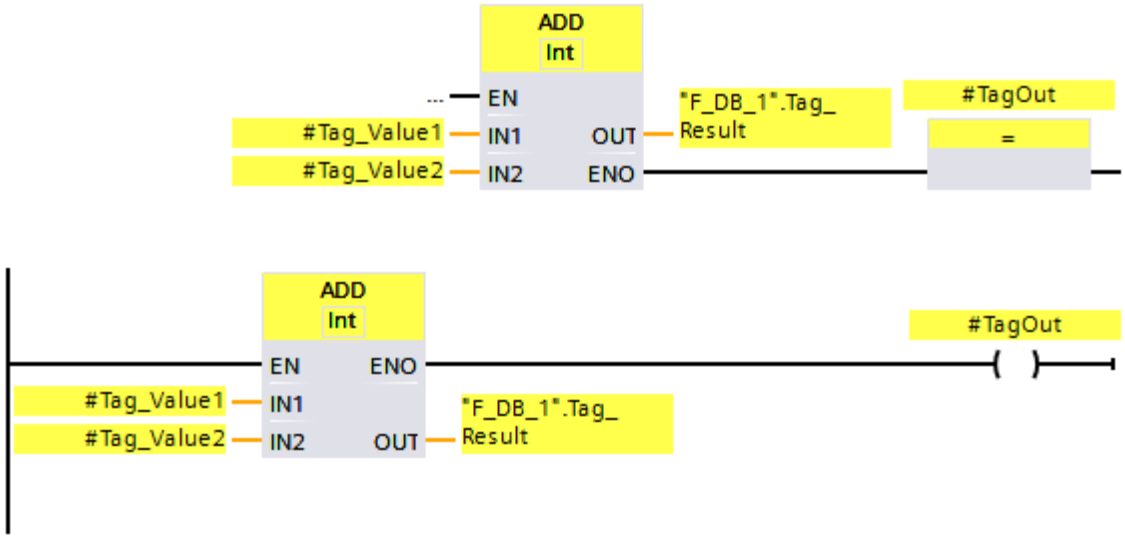
The value of the "Tag_Value1" operand is added to value of the "Tag_Value2" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If needed, you can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

When an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:



The "Add" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is added to value of the "#Tag_Value2" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Add" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

If needed, you can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 596)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 597)

13.9.2 SUB: Subtract (STEP 7 Safety V21)

Description

You can use the "Subtract" instruction to subtract the value at input IN2 from the value at input IN1 and query the difference at the OUT output (OUT = IN1 − IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

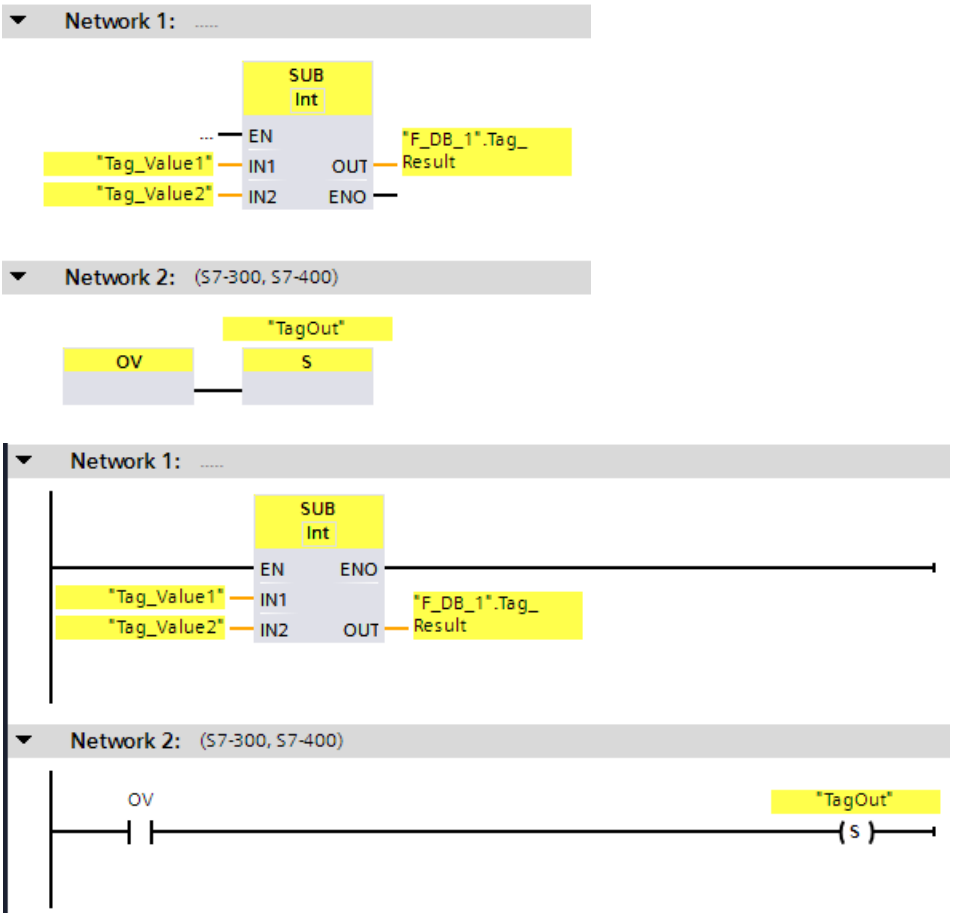
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Minuend
IN2	Input	INT, DINT	Subtrahend
OUT	Output	INT, DINT	Difference

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:



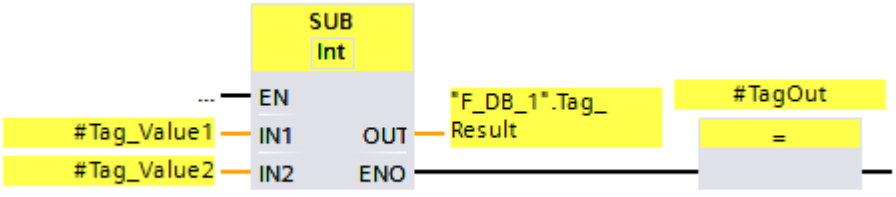
The "Subtract" instruction is always executed regardless of the signal state at enable input EN.

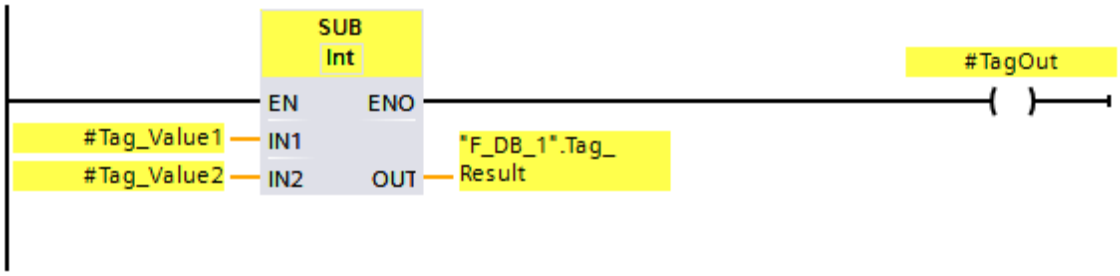
The value of the "Tag_Value2" operand is subtracted from the value of the "Tag_Value1" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Subtract" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:





The "Subtract" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value2" operand is subtracted from the value of the "#Tag_Value1" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Subtract" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 596)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 597)

13.9.3 MUL: Multiply (STEP 7 Safety V21)

Description

You can use the "Multiply" instruction to multiply the value at input IN1 by the value at input IN2 and query the product at output OUT (OUT = IN1 × IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

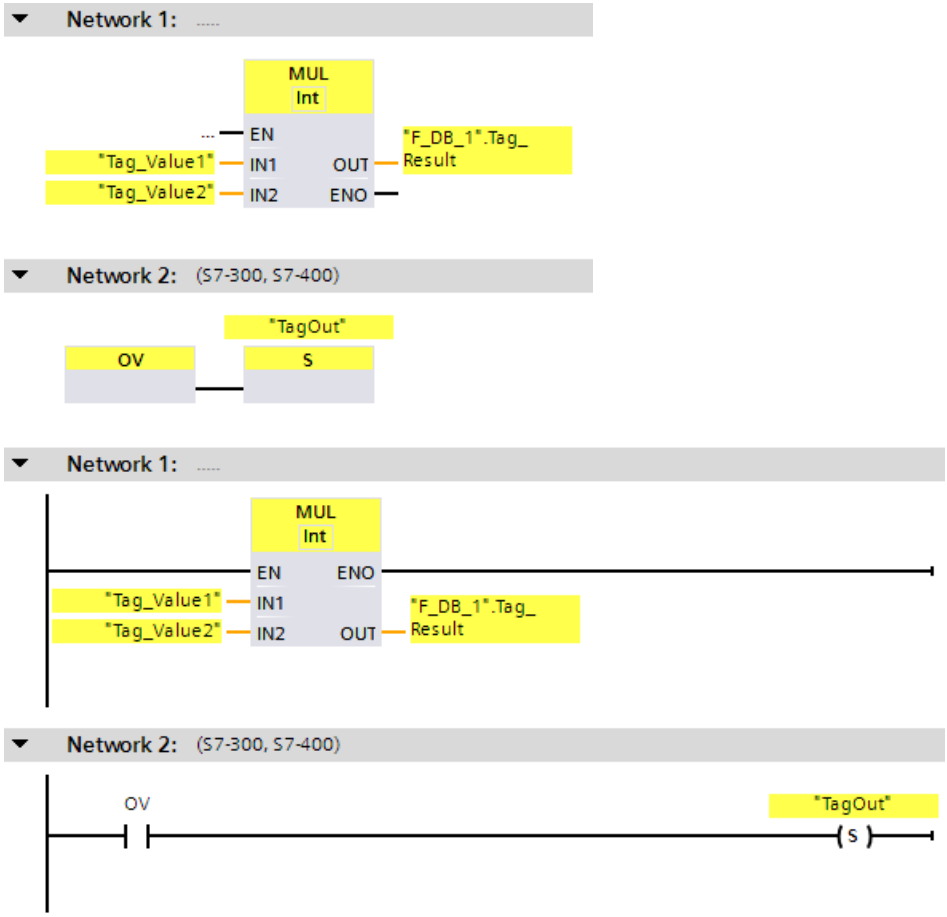
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Multiplier
IN2	Input	INT, DINT	Multiplicand
OUT	Output	INT, DINT	Product

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

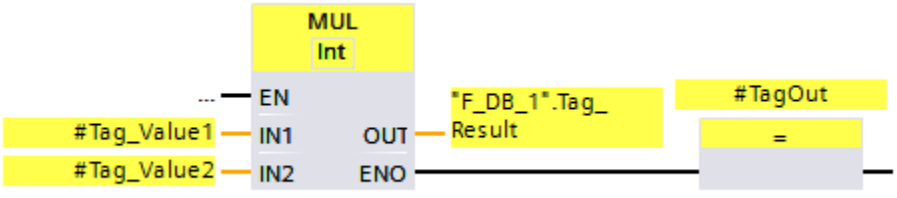


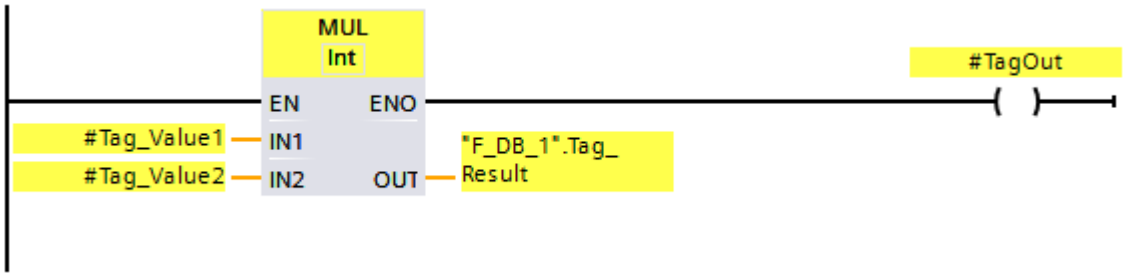
The "Multiply" instruction is always executed regardless of the signal state at enable input EN. The value of the "Tag_Value1" operand is multiplied by the value of the "Tag_Value2" operand. The result of the multiplication is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Multiply" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:





The "Multiply" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is multiplied by the value of the "#Tag_Value2" operand. The result of the multiplication is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Multiply" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 596)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 597)

13.9.4 DIV: Divide (STEP 7 Safety V21)

Description

You can use the "Divide" instruction to divide the value at input IN1 by the value at input IN2 and query the quotient at the OUT output (OUT = IN1 / IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

NOTE

S7-300/400, S7-1200/1500 (enable output ENO connected):

If the divisor (input IN2) of a DIV instruction = 0, the quotient of the division (result of division at output OUT) = 0. The result reacts like the corresponding instruction in a standard block. The F-CPU does *not* go to STOP mode.

S7-1200/1500 (enable output ENO not connected):

If the divisor (input IN2) of a DIV instruction = 0, the F-CPU goes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU. We recommend that you rule out a divisor (input IN2) = 0 when creating the program.

Parameters

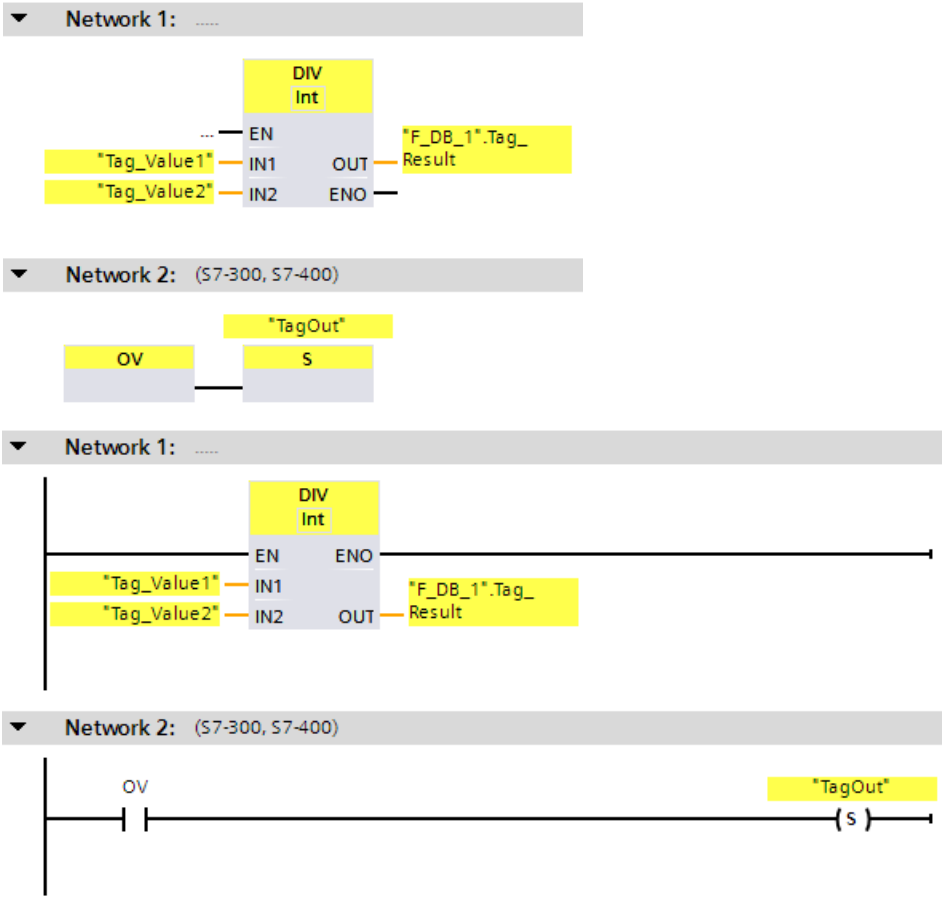
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Dividend
IN2	Input	INT, DINT	Divisor
OUT	Output	INT, DINT	Quotient

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:



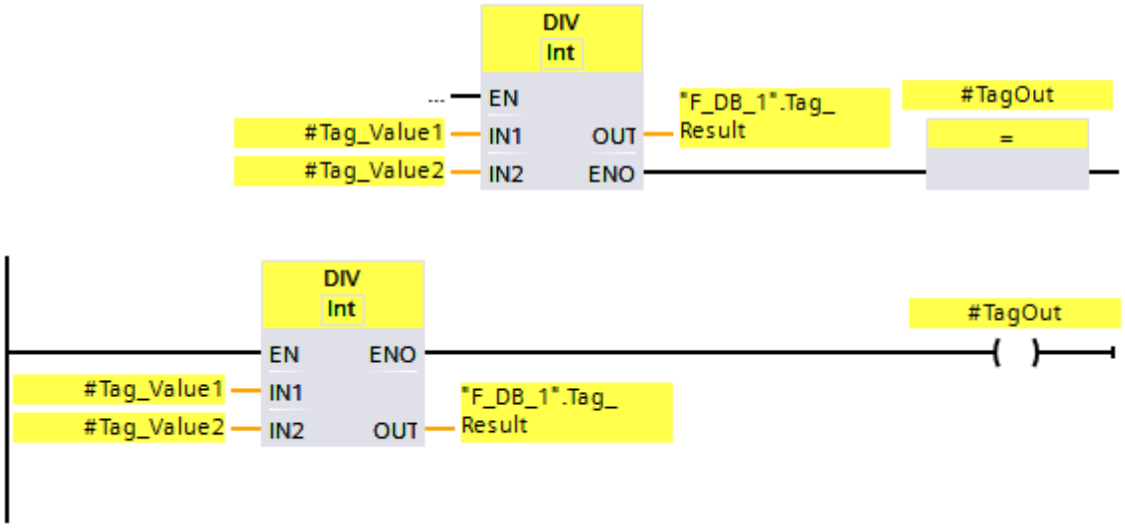
The "Divide" instruction is always execute regardless of the signal state at enable input EN.

The value of the "Tag_Value1" operand is divided by the value of the "Tag_Value2" operand. The result of the division is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Divide" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:



The "Divide" instruction is always execute regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is divided by the value of the "#Tag_Value2" operand. The result of the division is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Divide" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 596)
---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 597)

13.9.5 NEG: Create twos complement (STEP 7 Safety V21)

Description

You can use the "Create twos complement" instruction to change the sign of the value at input IN input and query the result at output OUT. If there is a positive value at input IN, for example, the negative equivalent of this value is sent to output OUT.

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

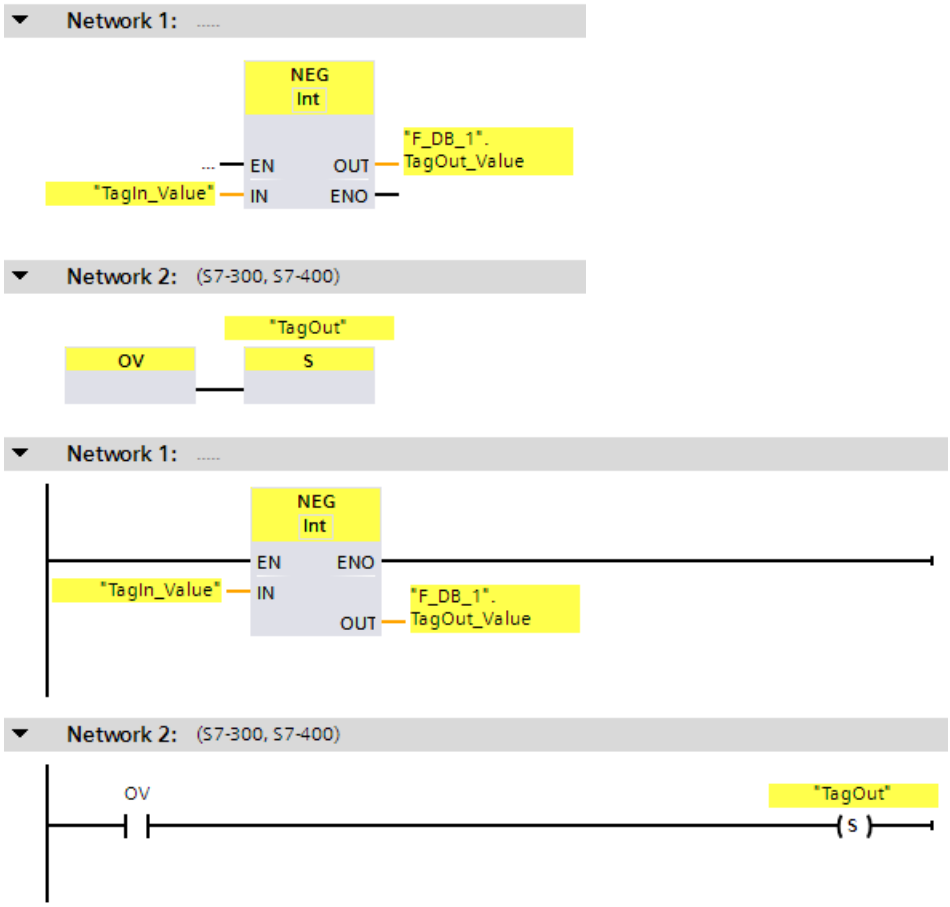
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN	Input	INT, DINT	Input value
OUT	Output	INT, DINT	Twos complement of the input value

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:



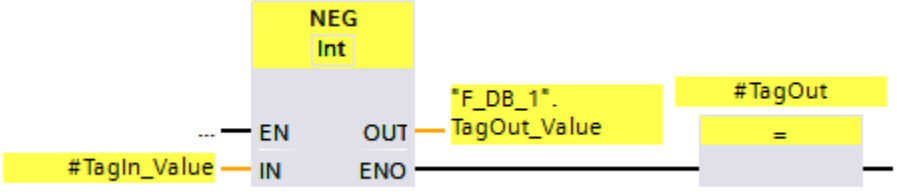
The "Create two's complement" instruction is always executed regardless of the signal state at enable input EN.

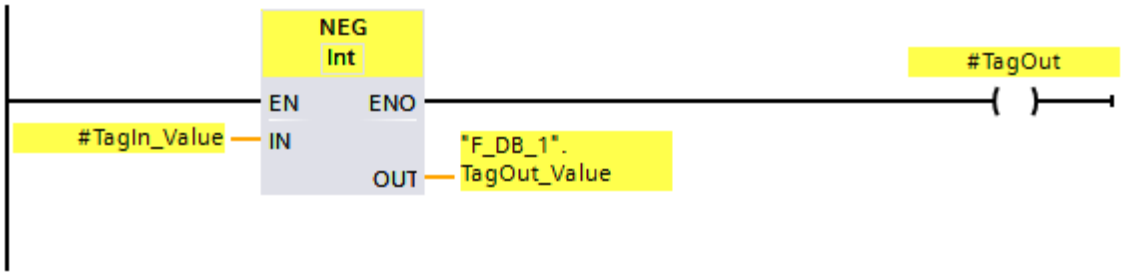
The sign of the "TagIn_Value" operand is changed and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When an overflow occurs during execution of the "Create two's complement" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:





The "Create two's complement" instruction is always executed regardless of the signal state at enable input EN.

The sign of the "#TagIn_Value" operand is changed and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Create two's complement" instruction, the ENO enable output has the signal state "1" and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 596)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 597)

13.9.6 ABS: Form absolute value (STEP 7 Safety V21) (S7-1200, S7-1500)

Description

You use the "Form absolute value" instruction to calculate the absolute amount of the value which is specified at the input "IN". The result of the instruction is output at the OUT output and can be queried there.

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

Parameters

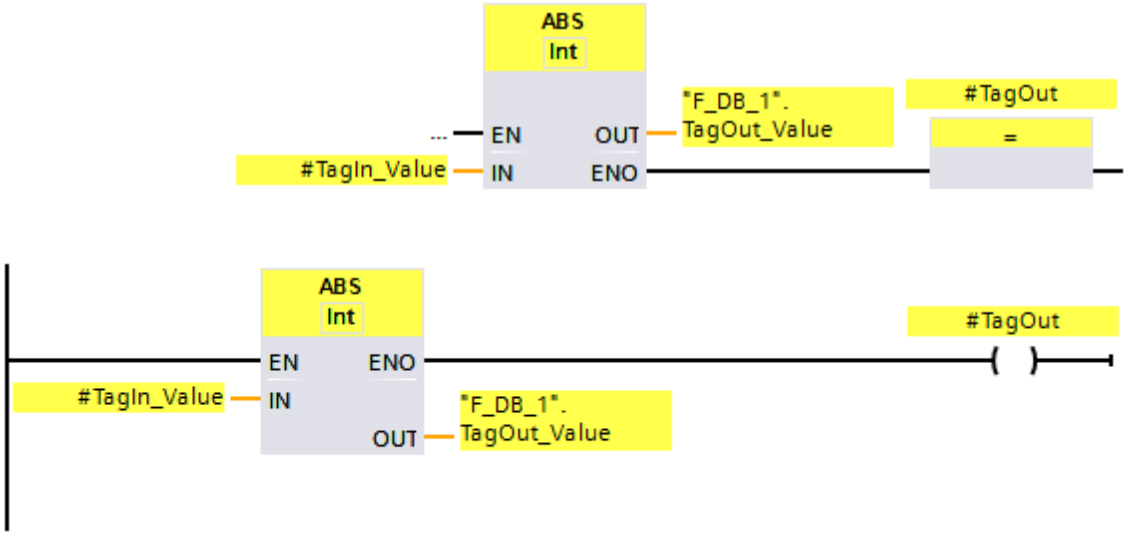
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN	Input	INT, DINT	Input value
OUT	Output	INT, DINT	Absolute value of the input value

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



The instruction "Form absolute value"is always executed regardless of the signal state at enable input "EN".

The absolute amount of the value at the "TagIn_Value" operand is calculated and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Form absolute value" instruction, the enable output ENO has the signal state "1" and the "#TagOut" operand is set.

13.10 Move operations

13.10.1 MOVE: Move value (STEP 7 Safety V21)

Description

You can use the "Move value" instruction to transfer the content of the operand at input IN to the operand at output OUT1.

Only operands with identical operand width and identical data structure can be specified for input IN and output OUT1.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

(S7-1200, S7-1500) In the basic state, the instruction box contains an output (OUT1). The number of outputs can be expanded. The inserted outputs are numbered in ascending order on the box. During execution, the content of the operand at the IN input is transferred to all available outputs. The instruction box cannot be expanded if operands with F-compliant PLC data types (UDT) are transferred.

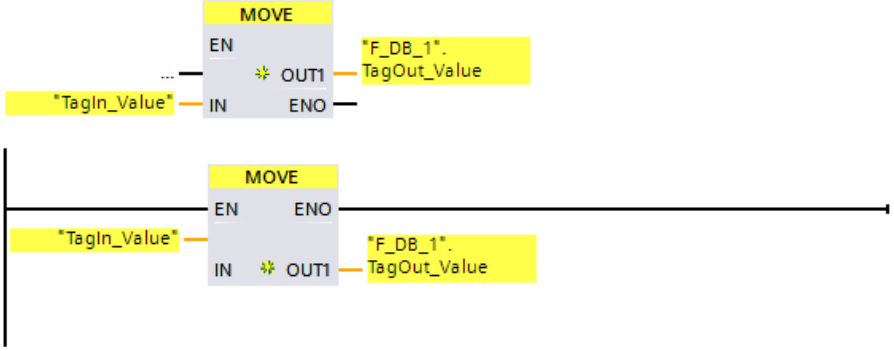
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT, WORD, (S7-300, S7-400) DWORD, TIME, F-compliant PLC data type (UDT)	Source value
OUT1	Output	INT, DINT, WORD, (S7-300, S7-400) DWORD, TIME, F-compliant PLC data type (UDT)	Destination address

Example

The following example shows how the instruction works:



The instruction is always executed regardless of the signal state at enable input "EN". The instruction copies the content of operand "TagIn_Value" to operand ""F_DB_1".TagOut_Value".

13.10.2 RD_ARRAY_I: Read value from INT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500)

Description

You use the "Read value from INT F-array" instruction to read an element from the array at the ARRAY input, which refers to the index at the INDEX input, and write its value at the OUT output. If an error occurs while accessing the array during runtime, this is displayed at the output ERROR.

The array must be created in an F-DB and can contain only one dimension. The elements of the ARRAY must be data type INT. The following applies for the array limits in contrast:

- The low limit must be 0.
- The high limit can be 10000 maximum.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ARRAY	Input	VARIANT	Array from which is read
INDEX	Input	DINT	Element in the array which is read. The specification may be a constant or a tag.
OUT	Output	INT	Value which is read and output.
ERROR	Output	BOOL	Error information The parameter ERROR is set if an error occurs during the processing of the instruction.

ARRAY parameter

In addition to the direct connection with an array within a fail-safe global DB, this input can also be interconnected with an INOUT of data type ARRAY[*] of INT. This enables the decoupling of data and program logic in order, for example, to create a library function without any connection existing to a dedicated data block.

ERROR parameter

The table below shows the meaning of the value of the ERROR parameter:

Value	Description
FALSE	No error
TRUE	Value at the INDEX parameter is outside the limit value of the ARRAY.

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x	x[1]	

[1] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

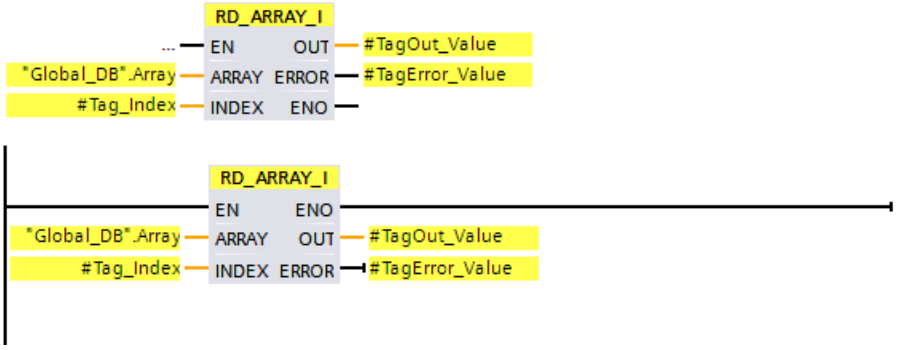
Reaction to errors

If the value at the INDEX input is outside the array limits, the output ERROR = 1 is set, and the array value of the element with index = 0 is output at OUT output, regardless of the value passed at the INDEX input.

Therefore, set the value of the element with index = 0 as a fail-safe substitute value.

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
ARRAY	"Global_DB".Array	The "Global_DB".Array operand is an ARRAY of data type Array[0..10] of INT
INDEX	#Tag_Index	2
OUT	#TagOut_Value	Value of the element at the location array[2]
ERROR	#TagError_Value	False

The instruction "Read value from INT F-array" is always executed regardless of the signal state at enable input "EN".

The content of the 2nd element of the operand "Global_DB.Array" is output at the "#TagOut_Value" output.

13.10.3 RD_ARRAY_DI: Read value from DINT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500)

Description

You use the "Read value from DINT F-array" instruction to read an element from the array at the ARRAY input, which refers to the index at the INDEX input, and write its value at the OUT output. If an error occurs while accessing the array during runtime, this is displayed at the output ERROR.

The array must be created in an F-DB and can contain only one dimension. The elements of the array must be of the DINT data type. The following applies for the array limits in contrast:

- The low limit must be 0.
- The high limit can be 10000 maximum.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ARRAY	Input	VARIANT	Array from which is read
INDEX	Input	DINT	Element in the array which is read. The specification may be a constant or a tag.
OUT	Output	DINT	Value which is read and output.
ERROR	Output	BOOL	Error information The parameter ERROR is set if an error occurs during the processing of the instruction.

ARRAY parameter

In addition to the direct connection with an array within a fail-safe global DB, this input can also be interconnected with an INOUT of data type ARRAY[*] of DINT. This enables the decoupling of data and program logic in order, for example, to create a library function without any connection existing to a dedicated data block.

ERROR parameter

The table below shows the meaning of the value of the ERROR parameter:

Value	Description
FALSE	No error
TRUE	Value at the INDEX parameter is outside the limit value of the ARRAY.

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x	x[1]	

[1] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

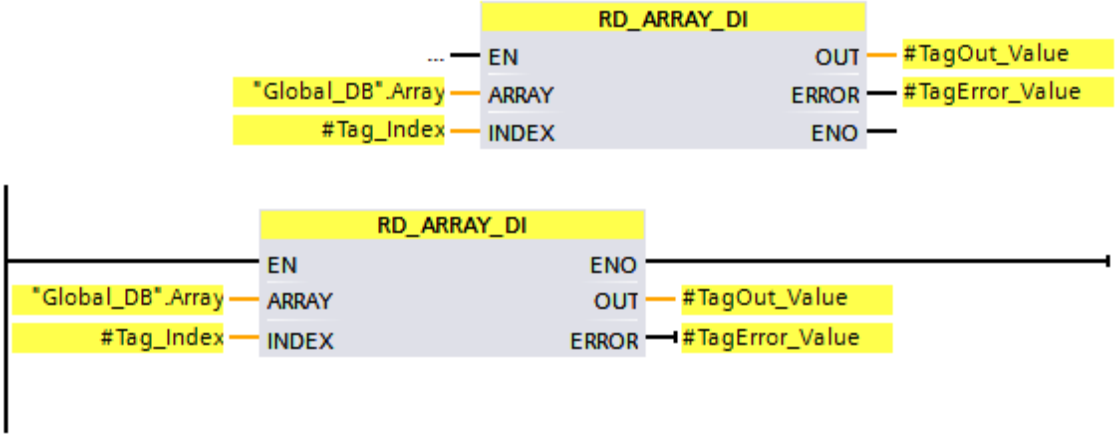
Reaction to errors

If the value at the INDEX input is outside the array limits, the output ERROR = 1 is set, and the array value of the element with index = 0 is output at OUT output, regardless of the value passed at the INDEX input.

Therefore, set the value of the element with index = 0 as a fail-safe substitute value.

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
ARRAY	"Global_DB".Array	The operand "Global_DB".Array is an ARRAY of data type Array[0..10] of DINT
INDEX	#Tag_Index	2
OUT	#TagOut_Value	Value of the element at the location array[2]
ERROR	#TagError_Value	False

The instruction "Read value from DINT F-array" is always executed regardless of the signal state at enable input "EN".

The content of the 2nd element of the operand "Global_DB.Array" is output at the "#TagOut_Value" output.

13.10.4 WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction writes the value specified in input IN to the tag addressed by INI_ADDR and OFFSET in an F-DB.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB to which the value at input IN is to be written is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

As shown in the following example, the INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT	Value to be written to the F-DB
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

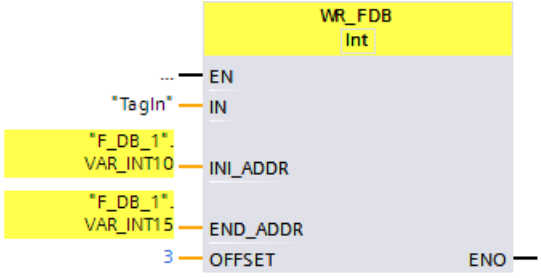
Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFS

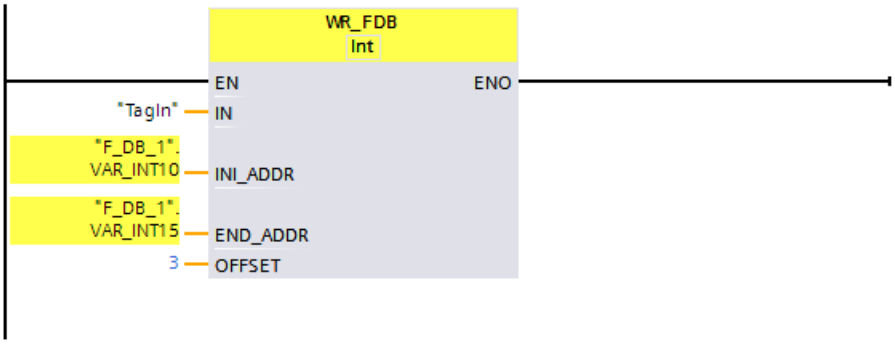
Name	Data type	Initial value	Comment
Static			
VAR_BOOL10	BOOL	false	
VAR_BOOL11	BOOL	false	
VAR_BOOL12	BOOL	false	
VAR_BOOL13	BOOL	false	
VAR_TIME10	TIME	T#0MS	
VAR_TIME11	TIME	T#0MS	

Name	Data type	Initial value	Comment
VAR_INT10	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT10 Example 1
VAR_INT11	INT	0	
VAR_INT12	INT	0	
VAR_INT13	INT	0	<- OFFSET = 3
VAR_INT14	INT	0	
VAR_INT15	INT	0	<- END_ADDR = "F-DB_1".VAR_INT15
VAR_BOOL20	BOOL	false	
VAR_BOOL21	BOOL	false	
VAR_BOOL22	BOOL	false	
VAR_BOOL23	BOOL	false	
VAR_INT20	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT20 Example 2
VAR_INT21	INT	0	
VAR_INT22	INT	0	
VAR_INT23	INT	0	<- END_ADDR = "F-DB_1".VAR_INT23
VAR_INT30	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT30 Example 3
VAR_INT31	INT	0	<- OFFSET = 1
VAR_INT32	INT	0	
VAR_INT33	INT	0	
VAR_INT34	INT	0	<- END_ADDR = "F-DB".VAR_INT34
VAR_TIME20	TIME	T#0MS	
VAR_DINT10	DINT	0	<- INI_ADDR = "F-DB_1".VAR_DINT10 Example 4
VAR_DINT11	DINT	0	
VAR_DINT12	DINT	0	<- OFFSET = 2
VAR_DINT13	DINT	0	<- END_ADDR = "F-DB_1".VAR_DINT13

Example

The following example shows how the instruction works:





13.10.5 RD_FDB: Read value indirectly from an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction reads the tag addressed via INI_ADDR and OFFSET in an F-DB and provides it at output OUT.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB from which the tag is to be read is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

The INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted. Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFSET are contained in WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 563).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

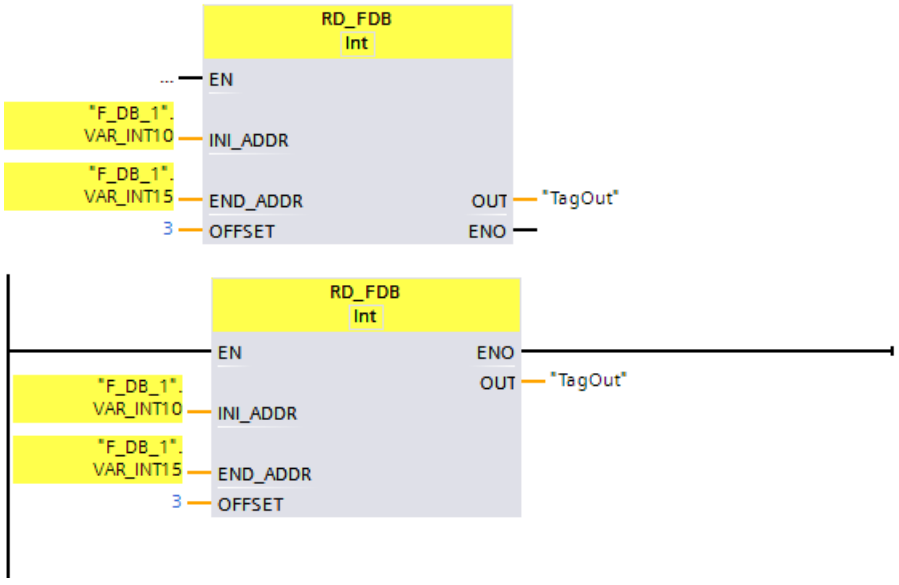
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset
OUT	Output	INT, DINT	Value to be read from the F-DB

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:



13.11 Conversion operations

13.11.1 CONVERT: Convert value (STEP 7 Safety V21)

Description

The "Convert value" instruction reads the content of parameter IN and converts it according to the data types selected in the instruction box. The converted value is output at the OUT output .

Enable input "EN" cannot be connected. The instruction is therefore always executed (regardless of the signal state at the "EN" enable input). The connection of the "ENO" enable output is only possible and required when converting from the "DINT" to the "INT" data type.

NOTE

When converting from "DINT" to the "INT" data type, you need to connect the ENO enable output and thereby programming overflow detection.
Note the following:

- If the value at the input is outside the INT range, ENO returns 0.
- The result of the instruction reacts like the analogous instruction in a standard block.

Parameters

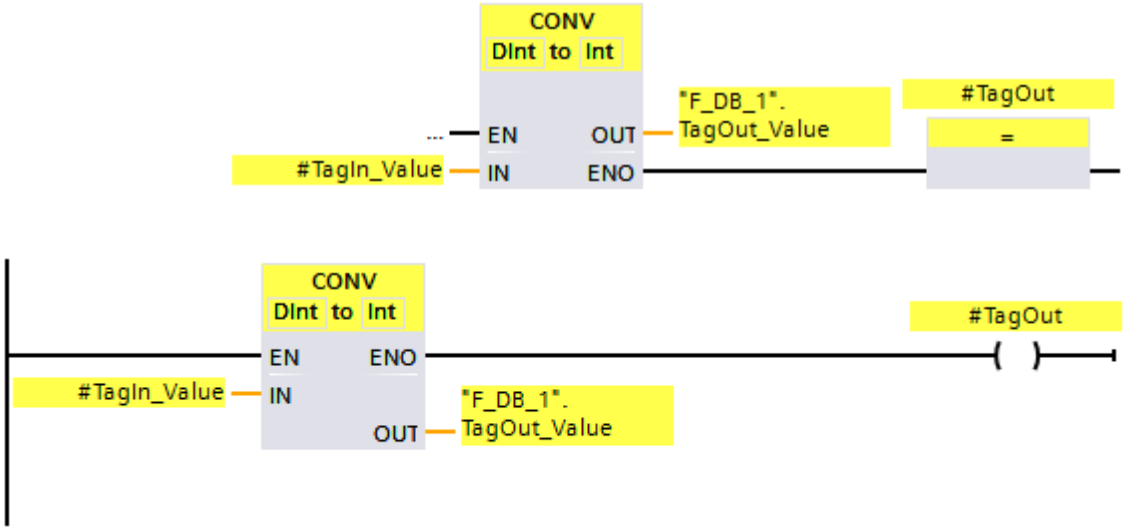
The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	Enable output
IN	Input	INT, DINT	Value to be converted.
OUT	Output	INT, DINT	Result of the conversion

You can select the data types of the instruction in the "<???>" drop-down lists of the instruction box. The supported conversions are from "INT to DINT" and "DINT to INT".

Example

The following example shows how the "Convert value "DINT to INT"" instruction for S7-1200/1500 F-CPUs works:



The instruction is always executed regardless of the signal state at enable input EN.

The value of the "TagIn_Value" operand is converted to an integer (16-bit) and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Convert value "DINT to INT"" instruction, the ENO enable output has the signal state "1" and the "TagOut" operand is set.

You can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

13.11.2 BO_W: Convert 16 data elements of data type BOOL to a data element of data type WORD (STEP 7 Safety V21)

Description

This instruction converts the 16 values of data type BOOL at inputs IN0 to IN15 to a value of data type WORD, which is made available at output OUT. The conversion takes place as follows: The i-th bit of the WORD value is set to 0 (or 1), if the value at input INi = 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN0	Input	BOOL	Bit 0 of WORD value
IN1	Input	BOOL	Bit 1 of WORD value
...			...
IN15	Input	BOOL	Bit 15 of WORD value
OUT	Output	WORD	WORD value consisting of IN0 to IN15

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

1 supported as of firmware V4.2

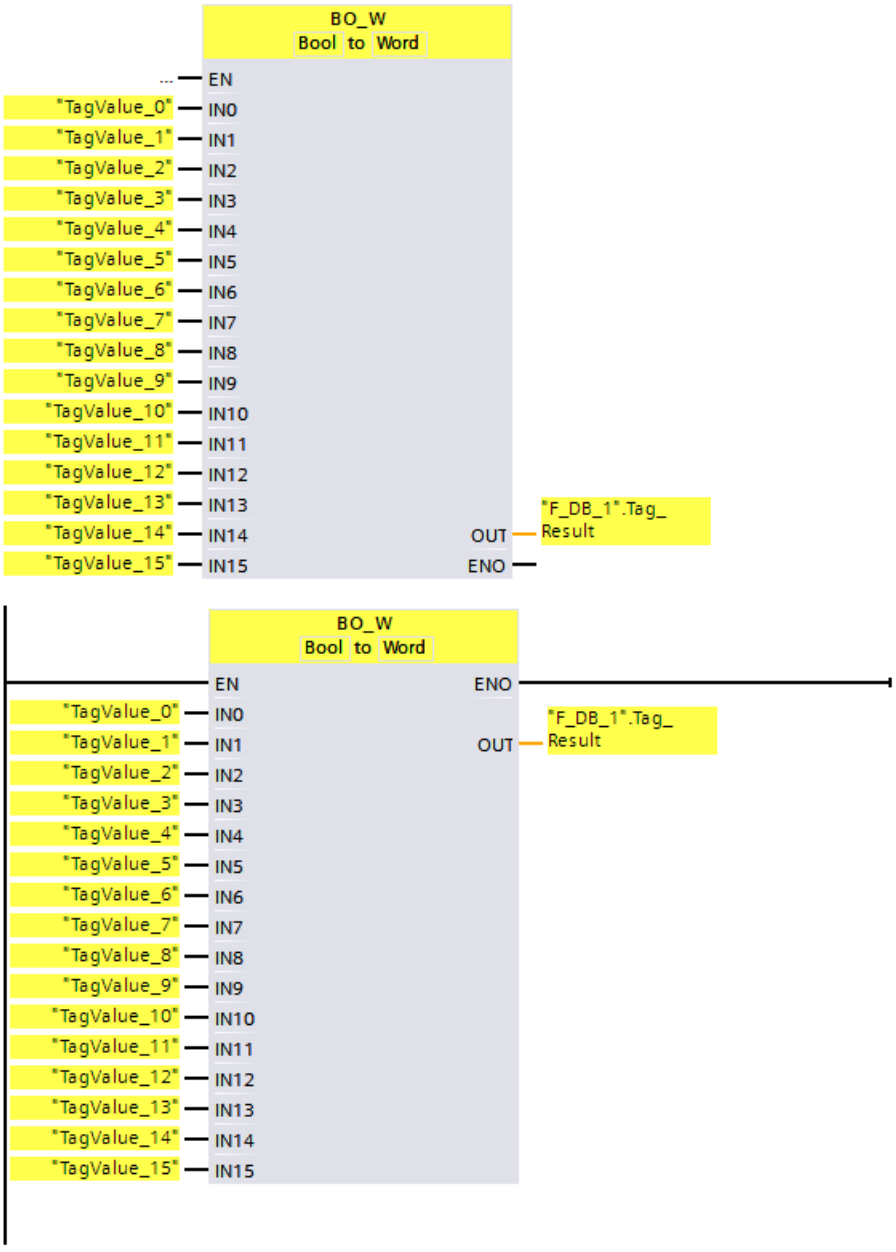
2 supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN0	TagValue_0	FALSE
IN1	TagValue_1	FALSE
...		...
IN13	TagValue_13	FALSE

Parameter	Operand	Value
IN14	TagValue_14	TRUE
IN15	TagValue_15	TRUE
OUT	"F_DB_1".Result	W#16#C000

The values of operands "TagValue_0" to "TagValue_15" are combined into a value of the data type WORD and assigned to operand ""F_DB_1".TagResult".

13.11.3 W_BO: Convert a data element of data type WORD to 16 data elements of data type BOOL (STEP 7 Safety V21)

Description

This instruction converts the value of data type WORD at input IN to 16 values of data type BOOL, which are provided at outputs OUT0 to OUT15. The conversion takes place as follows: Output OUTi is set to 0 (or 1), if the i-th bit of the WORD value is 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	WORD value
OUT0	Output	BOOL	Bit 0 of WORD value
OUT1	Output	BOOL	Bit 1 of WORD value
...			...
OUT15	Output	BOOL	Bit 15 of WORD value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

1 supported as of firmware V4.2

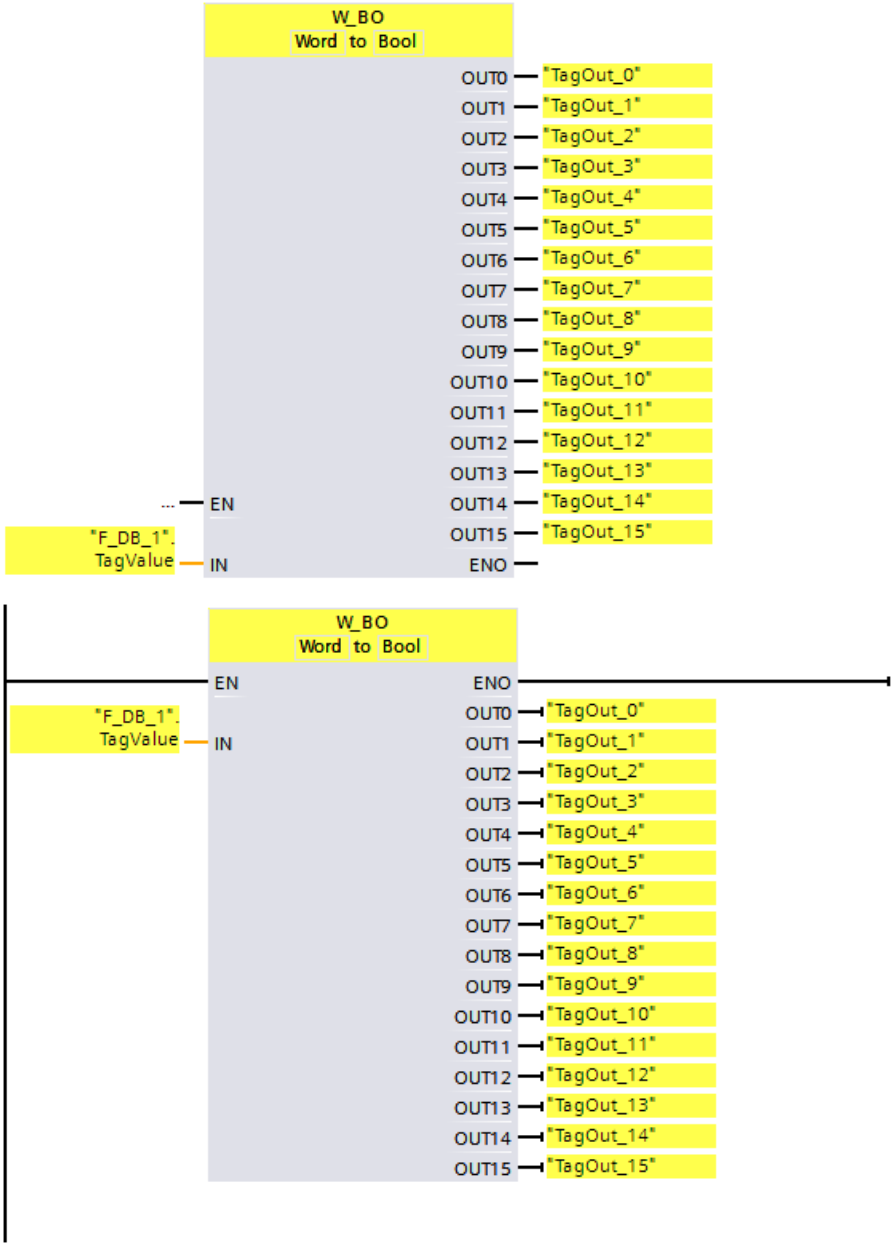
2 supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagValue	W#16#C000
OUT0	TagOUT_0	FALSE

Parameter	Operand	Value
OUT1	TagOUT_1	FALSE
...		...
OUT13	TagOUT_13	FALSE
OUT14	TagOUT_14	TRUE
OUT15	TagOUT_15	TRUE

The value of operand ""F_DB_1".TagValue" of data type WORD is converted to the 16 values "TagOUT_0" to "TagOUT_15" of data type BOOL.

13.11.4 SCALE: Scale (STEP 7 Safety V21)

Description

This instruction scales the value at input IN in physical units between the low limit value at input LO_LIM and the high limit value at input HI_LIM. It is assumed that the value at input IN is between 0 and 27648. The scaling result is provided at output OUT.

The instruction uses the following equation:

OUT = [IN × (HI_LIM – LO_LIM)] / 27648 + LO_LIM

As long as the value at input IN is greater than 27648, output OUT is linked to HI_LIM and OUT_HI is set to 1.

As long as the value at input IN is less than 0, output OUT is linked to LO_LIM and OUT_LO is set to 1.

For inverse scaling, you must assign LO_LIM > HI_LIM. With inverse scaling, the output value at output OUT decreases while the input value at input IN increases.

Every call of the "Scale value" instruction must be assigned a data area in which the instruction data is stored. In addition, when the instruction is inserted in the program, the "Call options" dialog is automatically opened, where you can create a data block (single instance) (e.g., SCALE_DB_1) or a multi-instance (e.g., SCALE_Instance_1) for the "Scale value" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Input value to be scaled in physical units
HI_LIM	Input	INT	High limit value of value range of OUT
LO_LIM	Input	INT	Low limit value of value range of OUT
OUT	Output	INT	Result of scaling
OUT_HI	Output	BOOL	1 = Input value > 27648: OUT = HI_LIM
OUT_LO	Output	BOOL	1 = Input value < 0: OUT = LO_LIM

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Behavior in the event of overflow or underflow of analog values and fail-safe value output

NOTE

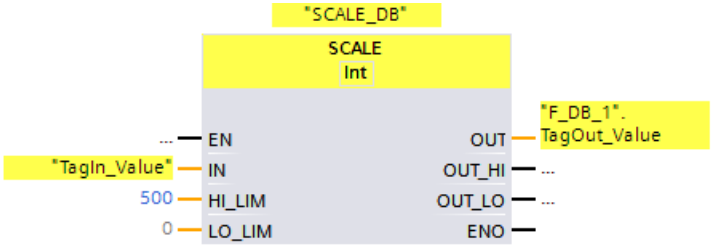
If inputs from the PII of an SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4 ... 20 mA HART are used as input values, note that the F-system detects an overflow or underflow of a channel of this F-SM as an F-I/O fault or channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

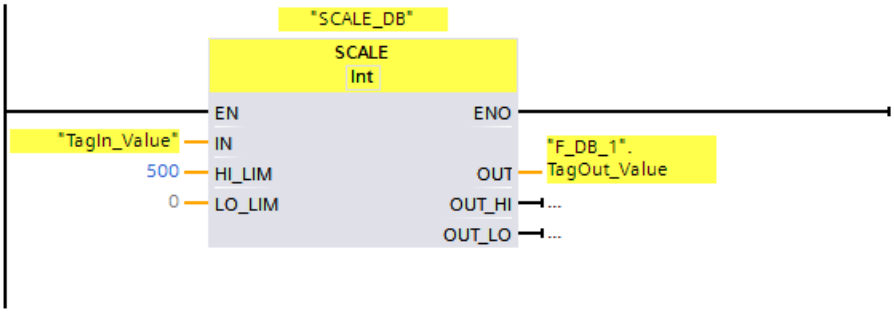
If other fail-safe values should be output in this case, you need to evaluate the QBAD signal of the associated F-I/O or QBAD_I_xx signal / value status of the corresponding channel.

If the value in the PII of the F-SM is within the overrange or underrange, but is > 27648 or < 0, you can likewise branch to the output of an individual fail-safe value by evaluating outputs OUT_HI and OUT_LO, respectively.

Example

The following example shows how the instruction works:





When operand "TagIn_Value" = 20000, the result for ""F_DB_1".TagOut_Value" is 361.

13.11.5 SCALE_D: Scale to data type DINT (STEP 7 Safety V21) (S7-1200, S7-1500)

Description

This instruction scales the value at input IN in physical units between the low limit value at input LO_LIM and the high limit value at input HI_LIM. It is assumed that the value at input IN is between 0 and 27648. The scaling result is provided at output OUT.

The instruction uses the following equation:

OUT = [IN × (HI_LIM – LO_LIM)] / 27648 + LO_LIM

As long as the value at input IN is greater than 27648, output OUT is linked to HI_LIM and OUT_HI is set to 1.

As long as the value at input IN is less than 0, output OUT is linked to LO_LIM and OUT_LO is set to 1.

For inverse scaling, you must assign LO_LIM > HI_LIM. With inverse scaling, the output value at output OUT decreases while the input value at input IN increases.

Every call of the "Scale value to data type DINT" instruction must be assigned a data area in which the instruction data is stored. In addition, when the instruction is inserted in the program, the "Call options" dialog is automatically opened, where you can create a data block (single instance) (e.g., SCALE_D_DB_1) or a multi-instance (e.g., SCALE_D_Instance_1) for the "Scale value to data type DINT" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Input value to be scaled in physical units
HI_LIM	Input	DINT	High limit value of value range of OUT
LO_LIM	Input	DINT	Low limit value of value range of OUT
OUT	Output	DINT	Result of scaling
OUT_HI	Output	BOOL	1 = Input value > 27648: OUT = HI_LIM
OUT_LO	Output	BOOL	1 = Input value < 0: OUT = LO_LIM

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
2.0	—	x[1]	x	x[2]	

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Behavior in the event of overflow or underflow of analog values and fail-safe value output

NOTE

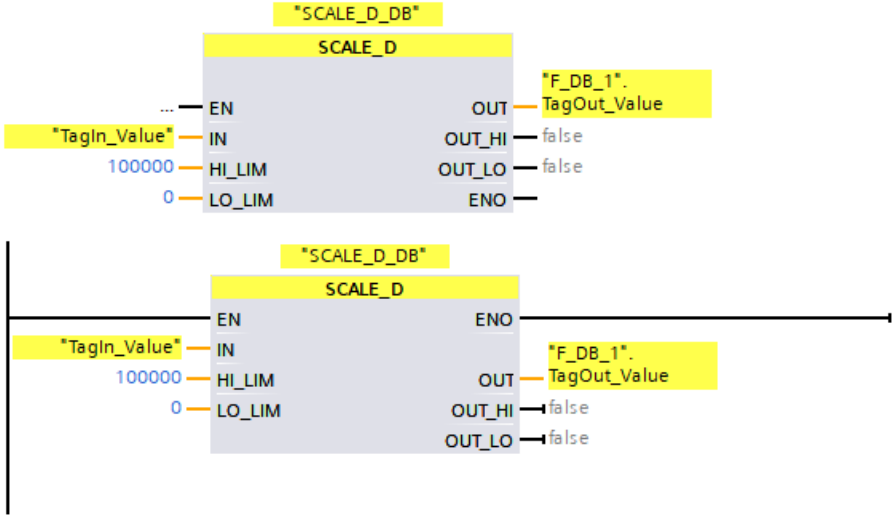
If inputs from the PII of an SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4 ... 20 mA HART are used as input values, note that the F-system detects an overflow or underflow of a channel of this F-SM as an F-I/O fault or channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If other fail-safe values should be output in this case, you need to evaluate the QBAD signal of the associated F-I/O or QBAD_I_xx signal / value status of the corresponding channel.

If the value in the PII of the F-SM is within the overrange or underrange, but is > 27648 or < 0, you can likewise branch to the output of an individual fail-safe value by evaluating outputs OUT_HI and OUT_LO, respectively.

Example

The following example shows how the instruction works:



When the operand "TagIn_Value" = 20000, the result for ""F_DB_1".TagOut_Value" is 72337.

13.12 Program control operations

13.12.1 JMP: Jump if RLO = 1 (STEP 7 Safety V21)

Description

You can use the "Jump if RLO = 1" instruction to interrupt the linear execution of the program and resume it in another network. The destination network must be identified by a jump label (Page 580) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "1" or the input is not connected, the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "0", the program continues executing in the next network.

NOTE

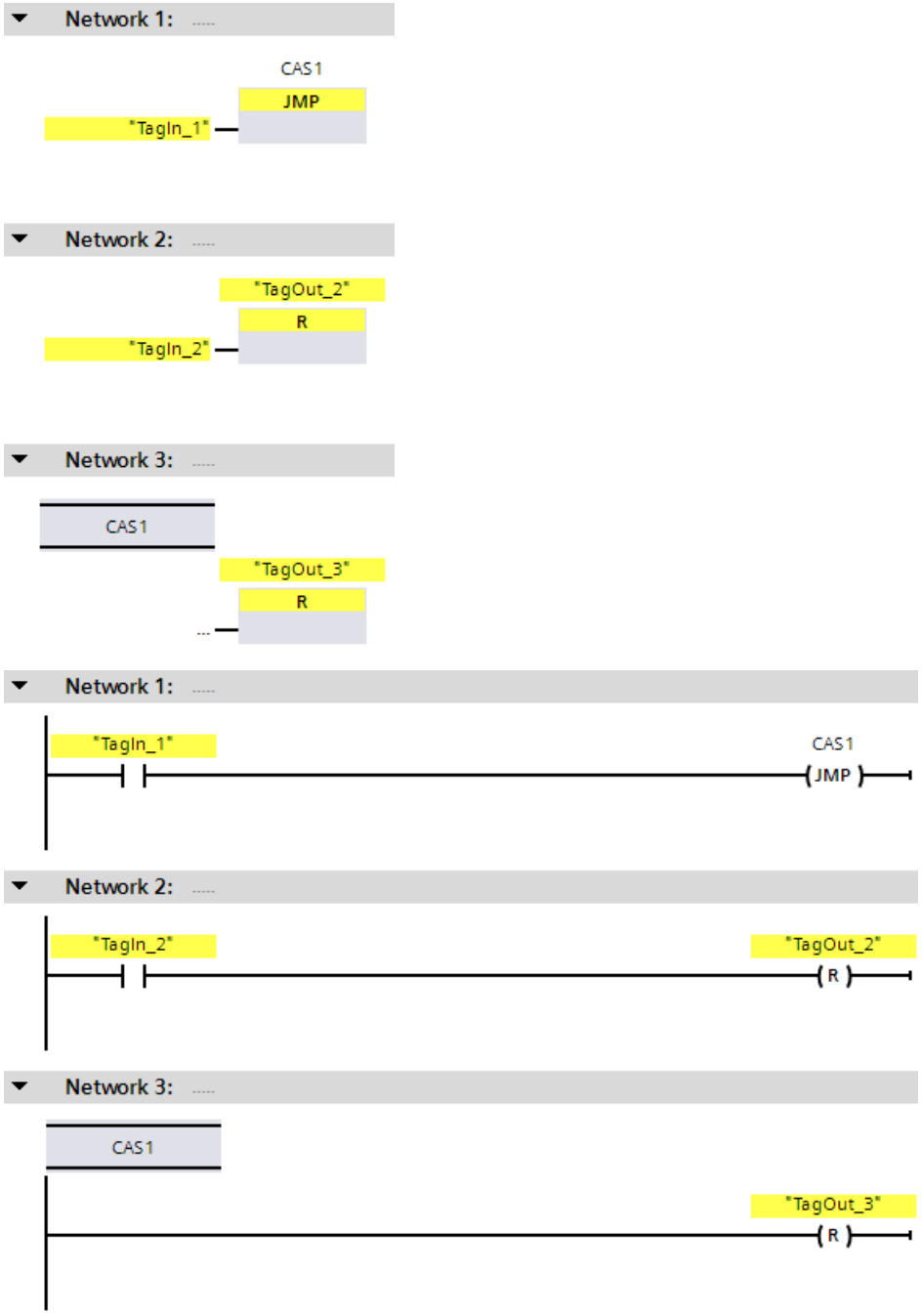
(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

NOTE

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:



When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.12.2 JMPN: Jump if RLO = 0 (STEP 7 Safety V21)

Description

You can use the "Jump if RLO = 0" instruction to interrupt the linear execution of the program and resume it in another network, when the result of logic operation at the input of the instruction is "0". The destination network must be identified by a jump label (Page 580) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "0", the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "1", the program continues executing in the next network.

NOTE

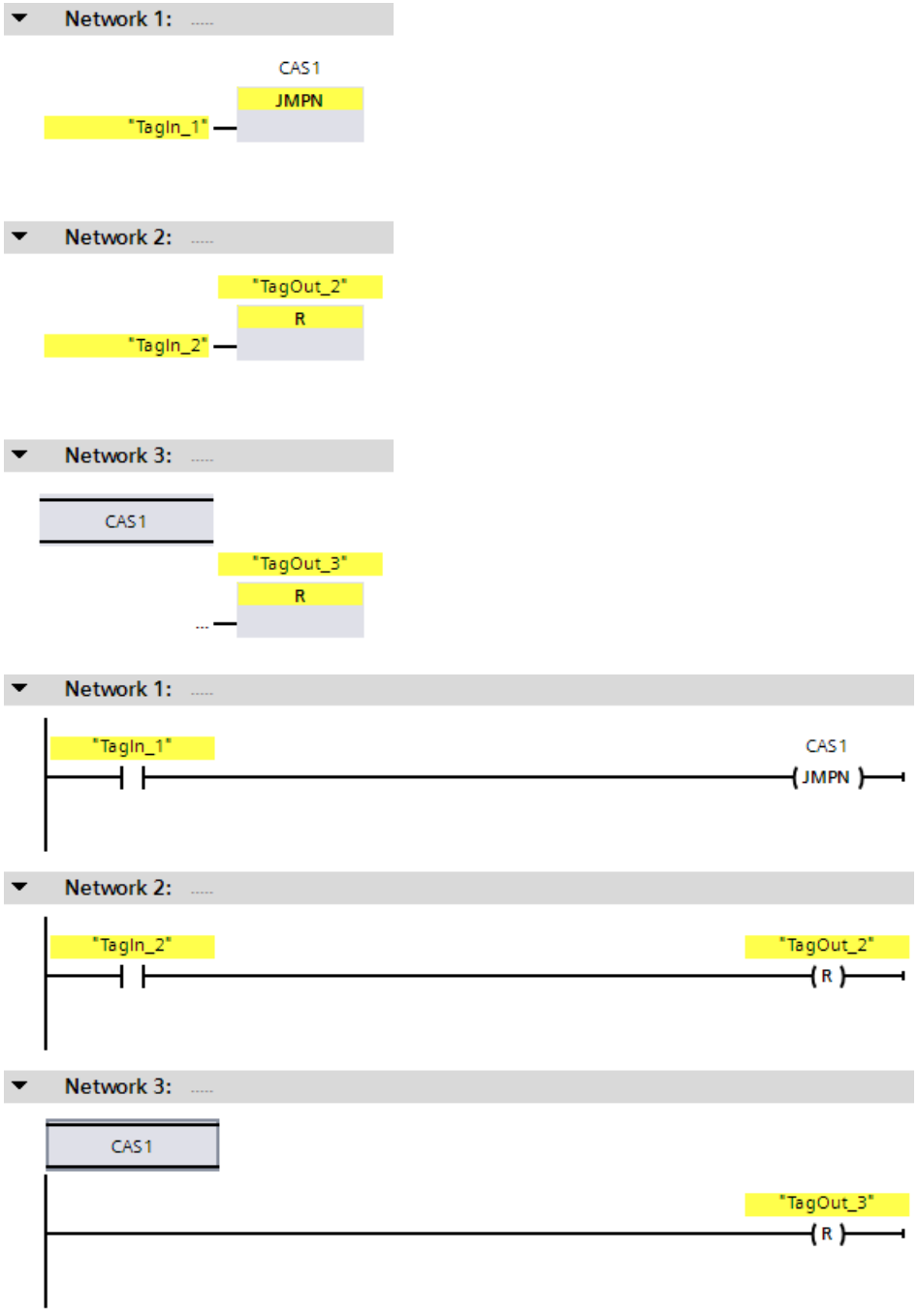
(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

NOTE

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:



When operand "TagIn_1" has signal state "0", the "Jump if RLO = 0" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.12.3 LABEL: Jump label (STEP 7 Safety V21)

Description

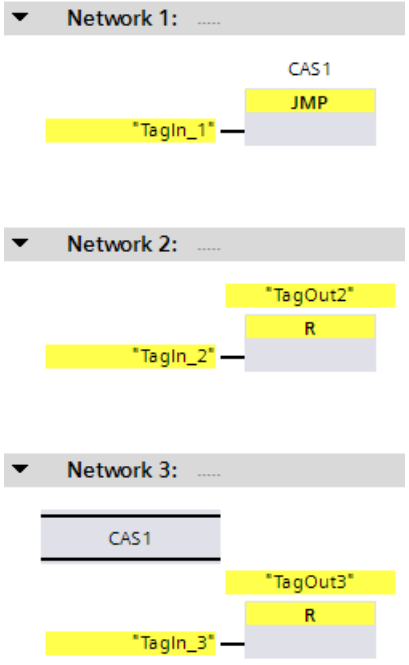
You can use a jump label to specify a destination network, in which the program execution should resume after a jump.

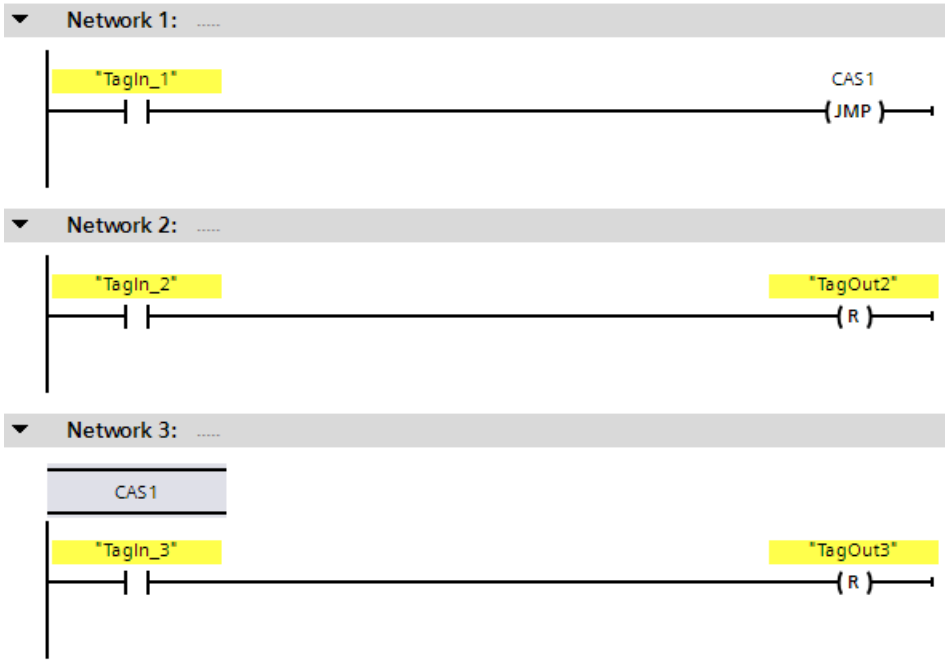
The jump label and the instruction in which the jump label is specified must be located in the same block. The name of a jump label can only be assigned once in a block.

Only one jump label can be placed in a network. To each jump label can be jumped from several locations.

Example

The following example shows how the instruction works:





When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V21) (Page 576)
JMPN: Jump if RLO = 0 (STEP 7 Safety V21) (Page 578)
RET: Return (STEP 7 Safety V21) (Page 581)

13.12.4 RET: Return (STEP 7 Safety V21)

Description

You can use the "Return" instruction to stop the processing of a block.

If the result of logic operation (RLO) at the input of the "Return" instruction is "1" or the box input of the S7-1200/1500 F-CPUs is not connected in FBD, program execution is terminated in the currently called block and continued in the calling block (for example, in the main safety block) after the call function. If the RLO at the input of the "Return" instruction is "0", the instruction is not executed. Program execution continues in the next network of the called block.

Influencing the status of the call function (ENO) is irrelevant, because the enable output "ENO" cannot be connected.

NOTE

(S7-300, S7-400) You may not program a RET instruction in the main safety block.

Example

The following example shows how the instruction works:



When the "TagIn" operand delivers signal state "1", the "Return" instruction is executed. Program execution is terminated in the called block and continues in the calling block.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V21) (Page 576)
JMPN: Jump if RLO = 0 (STEP 7 Safety V21) (Page 578)
LABEL: Jump label (STEP 7 Safety V21) (Page 580)

13.12.5 OPN: Open global data block (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Open global data block" instruction to open a data block. The number of the data block is transferred to the DB register. Subsequent DB commands access the relevant blocks depending on the register contents.

NOTE

Note when using the "Open global data block" instruction that the content of the DB register can be changed after calls of F-FB/F-FC and "fully qualified DB accesses", such that there is no guarantee that the last data block you opened with "Open global data block" is still open. You should therefore use the following method for addressing data to avoid errors when accessing data of the DB register:

- Use symbolic addressing.
- Use only fully qualified DB accesses.

If you still want to use the "Open global data block" operation, you must ensure that the DB register is restored by repeating the "Open global data block" instruction following calls of F-FB/F-FC and "fully qualified DB accesses." Otherwise, a malfunction could result.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Data block>	Input	BLOCK_DB	Data block that is opened

"Fully qualified DB access"

The initial access to data of a data block in an F-FB/F-FC must always be a "fully qualified DB access," or it must be preceded by the "Open global data block" instruction. This also applies to the initial access to data of a data block after a jump label.

An example of "fully qualified DB access" and "non-fully qualified DB access" is provided in Restrictions in the programming languages FBD/LAD (Page 116).

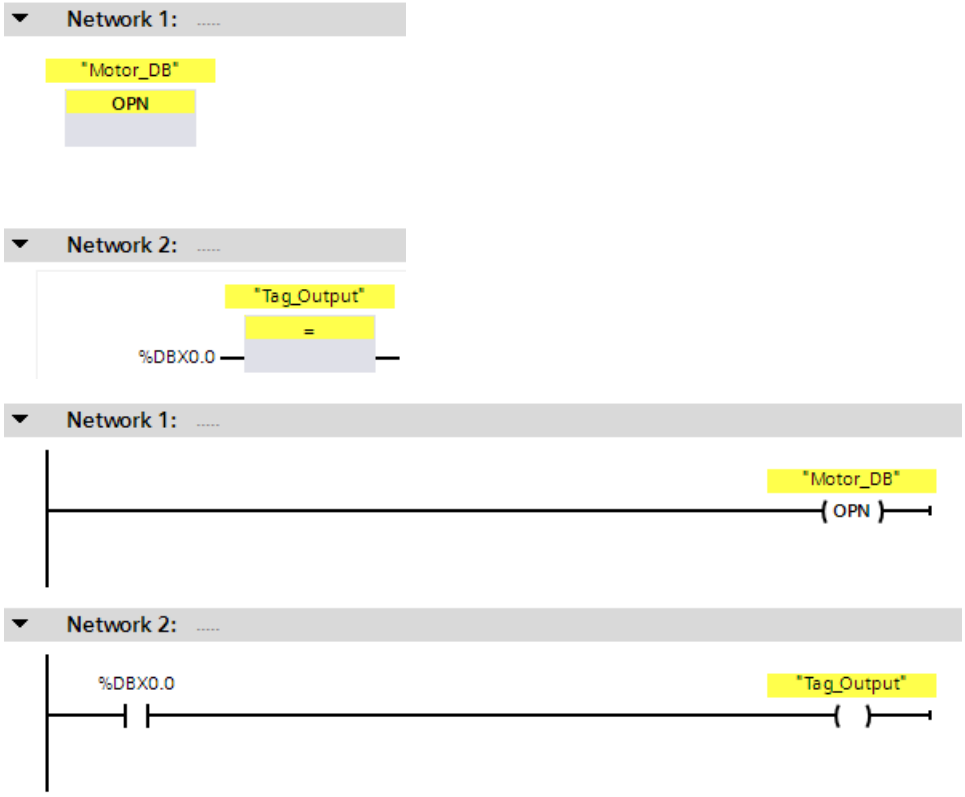
Access to instance DBs

You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

Example

The following example shows how the instruction works:



The "Motor_DB" data block is called in network 1. The number of the data block is transferred to the DB register. The "DBX0.0" operand is queried in network 2. The signal state of the "DBX0.0" operand is assigned to the "Tag_Output" operand.

13.13 Word logic operations

13.13.1 AND: AND logic operation (STEP 7 Safety V21)

Description

You can use the "AND logic operation" instruction to combine the value at input IN1 to the value at input IN2 bit-by-bit by AND logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ANDed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified values.

The result bit has signal state "1" only when both of the bits in the logic operation also have signal state "1". If one of the two bits of the logic operation has signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

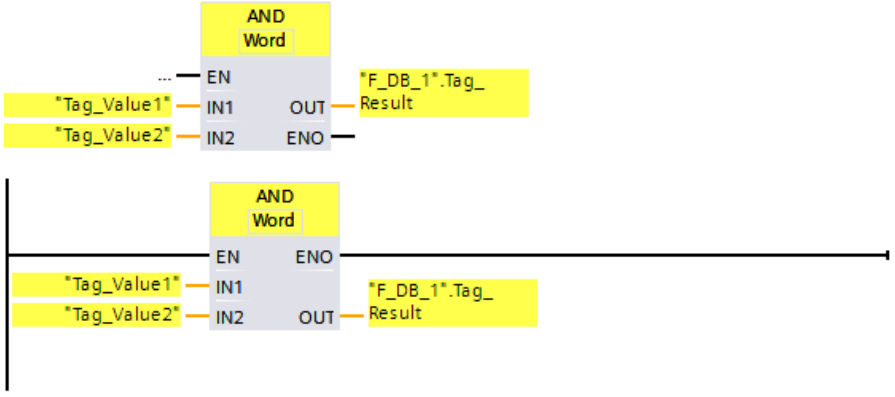
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"F_DB_1"."Tag_Result" = 00000000 00000101

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ANDed. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.13.2 OR: OR logic operation (STEP 7 Safety V21)

Description

You can use the "OR logic operation" instruction to connect the value at input IN1 input to the value at input IN2 bit-by-bit by OR logic and query the result at output OR.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ORed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all bits of the specified tags.

The result bit has signal state "1" when at least one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

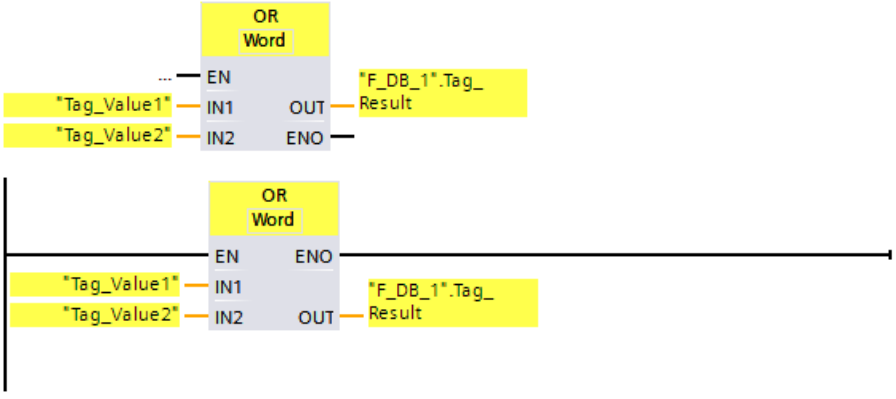
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"F_DB_1"."Tag_Result" = 01010101 01011111

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ORed. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.13.3 XOR: EXCLUSIVE OR logic operation (STEP 7 Safety V21)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to combine the value at input IN1 and the value at input IN2 bit-by-bit by EXCLUSIVE OR logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 input and bit 0 of the value at input IN2 are logically combined by EXCLUSIVE OR. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified value.

The result bit has signal state "1" when one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "1" or "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

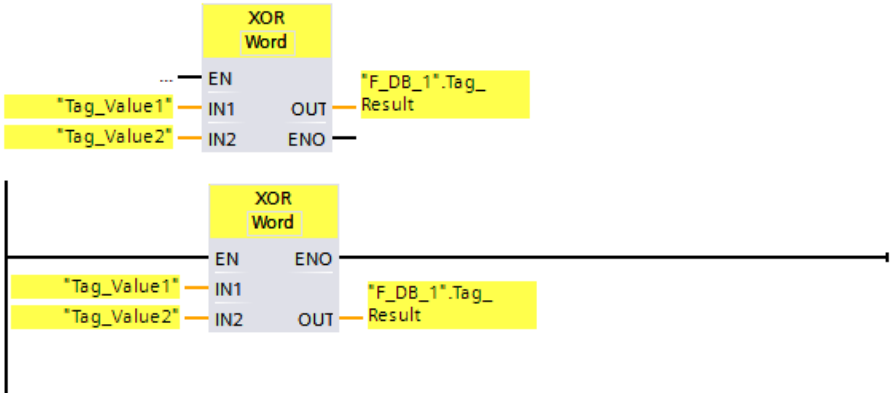
Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:



IN1	"Tag_Value1" = 01010101 01010101
IN2	"Tag_Value2" = 00000000 00001111
OUT	"F_DB_1"."Tag_Result" = 01010101 01011010

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are logically combined by EXCLUSIVE OR. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.14 Shift and rotate

13.14.1 SHR: Shift right (STEP 7 Safety V21)

Description

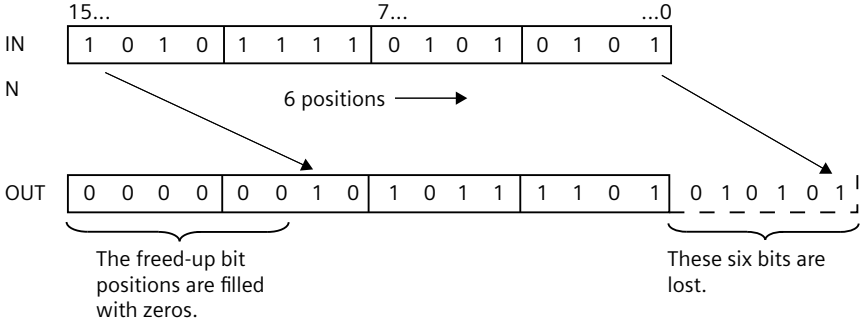
Use the "Shift right" instruction to shift the content of the operand at input IN bit-by-bit to the right and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the right by the available number of bit positions.

The bit locations that are freed up in the left area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the right:



Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

S7-300/400:
Only the low-byte is evaluated from input N.
S7-1200/1500:
If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

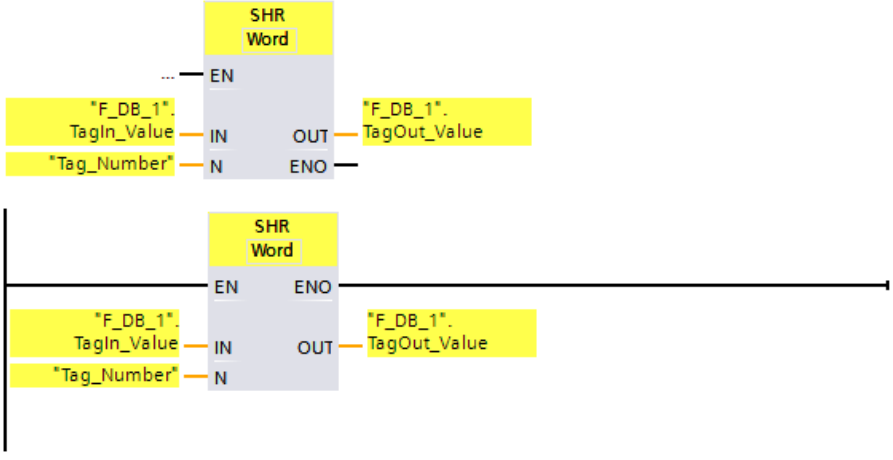
[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagIn_Value	0011 1111 1010 1111
N	Tag_Number	3
OUT	"F_DB_1".TagOut_Value	0000 0111 1111 0101

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand ""F_DB_1".TagIn_Value" is moved three bit positions to the right. The result is output at output ""F_DB_1".TagOut_Value".

13.14.2 SHL: Shift left (STEP 7 Safety V21)

Description

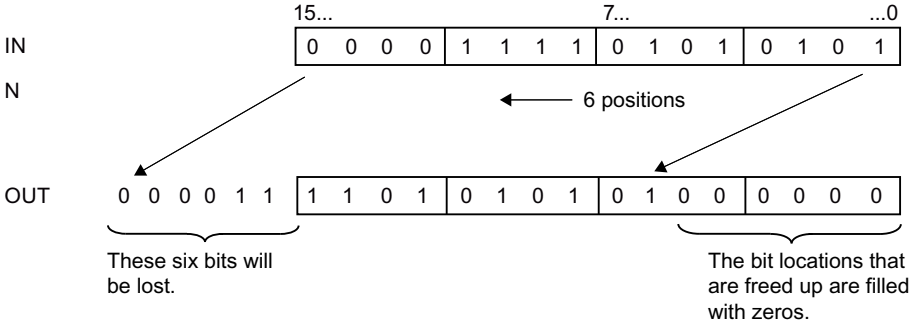
Use the "Shift left" instruction to shift the content of the operand at input IN bit-by-bit to the left and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the left by the available number of bit positions.

The bit positions that are freed up in the right area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the left:



Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

S7-300/400:
Only the low-byte is evaluated from input N.
S7-1200/1500:
If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

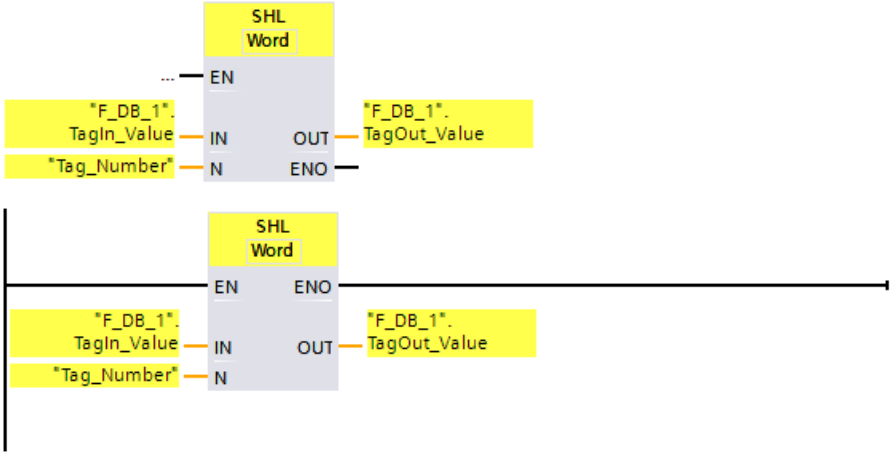
[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:



The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagIn_Value	0011 1111 1010 1111
N	Tag_Number	4
OUT	"F_DB_1".TagOut_Value	1111 1010 1111 0000

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand ""F_DB_1".TagIn_Value" is moved four bit positions to the left. The result is output at output ""F_DB_1".TagOut_Value".

13.15 Operating

13.15.1 ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21)

Description (S7-300, S7-400)

This instruction enables fail-safe acknowledgment from an operator control and monitoring system. It allows, for example, reintegration of F-I/O to be controlled from the operator control and monitoring system. Acknowledgment takes place in two steps:

- InOut IN changes to a value of 6 for exactly one cycle
- InOut IN changes to a value of 9 within a minute for exactly one cycle

Once InOut IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value of 9 after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if InOut IN has not changed to the value 9 within one minute or the change occurred before one second has elapsed, then InOut IN is reset to 0, and both steps listed above must be repeated.

During the time in which InOut IN must change from 6 to the value 9, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

NOTE

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.
If this is not observed, the behavior described under "Description" is no longer ensured.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.
The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

⚠ WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.
You can supply InOut IN with a separate memory word or DBW of a DB of the standard user program supply for each call of the ACK_OP instruction.

NOTE

The configuration of your operator control and monitoring system does not have any effect on the Collective F-Signature.

Description (S7-1200, S7-1500)

This instruction enables fail-safe acknowledgment from an operator control and monitoring system. It allows, for example, reintegration of F-I/O to be controlled from the operator control and monitoring system. Acknowledgment takes place in two steps:

- InOut IN changes to a value of 6 for exactly one cycle
- InOut IN changes to the value at the ACK_ID input within a minute for exactly one cycle

Once InOut IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value at the ACK_ID input after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if InOut IN has not changed to the value at the ACK_ID input within one minute or the change occurred before one second has elapsed, then iInOut IN is reset to 0, and both steps listed above must be repeated.

During the time in which InOut IN must change from 6 to the value at the ACK_ID input, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

NOTE

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.
If this is not observed, the behavior described under "Description" is no longer ensured.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.
The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

⚠ WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.
Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access to the ACK_ID tag in the associated instance DB is not permitted!

Alternative 2:

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.
You must supply InOut IN with a separate memory word or DBW of a DB of the standard user program for each call of the ACK_OP instruction.

NOTE

The supply of the IN iInOut of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the Collective F-Signature, the Collective F-SW-Signature or the signature of the block that calls the ACK_OP instruction. Changes to the supply of the IN InOut or to the configuration of your operator control and monitoring system therefore do not result in a changed Collective F-Signature/Collective F-SW-Signature/signature of the calling block.

Parameters (S7-300, S7-400)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	InOut	INT	Input variable from operator control and monitoring system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Parameters (S7-1200, S7-1500)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_ID	Input	INT	Identifier of the acknowledgment (9 to 30000)
IN	InOut	INT	Input variable from operator control and monitoring system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0 for S7-300/400 F-CPUs. The input ACK_ID must also be taken into consideration for S7-1200/1500 F-CPUs.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 444)" for more on this.

Example

An example how the instruction is used is available under Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 184).

See also

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 189)

13.16 Additional instructions

13.16.1 LAD

13.16.1.1 ---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" instruction functions like a normally open contact. If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

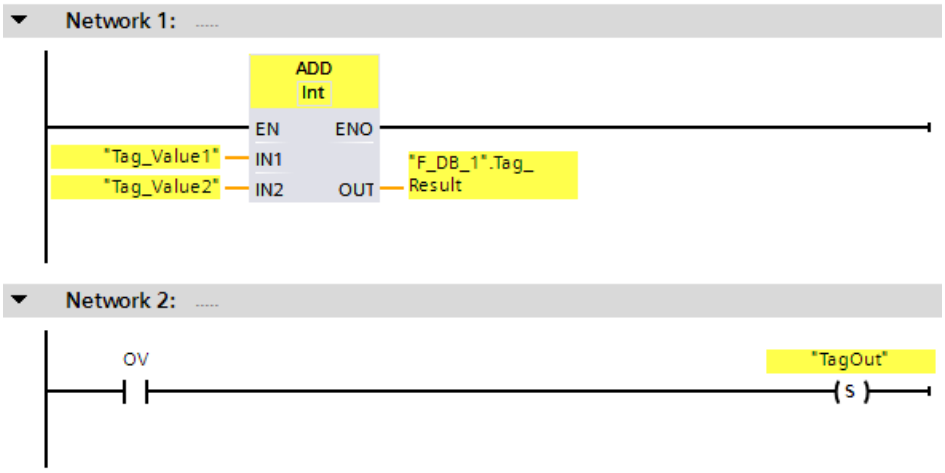
The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:



The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.16.1.2 ---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get negated status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed. This instruction is only available in LAD.

The "Get negated status bit OV" instruction functions like a normally closed contact. If the query is satisfied, the instruction has signal state "0". If the query is not satisfied, the instruction has signal state "1".

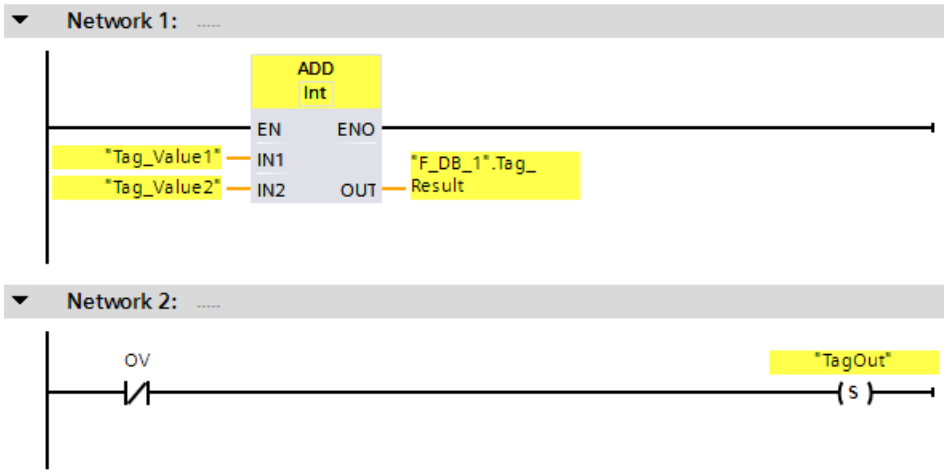
The "Get negated status bit OV" evaluation must be inserted in the network following the instruction that influences the OV. This network must not contain any jump labels.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get negated status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:



The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow does *not* occur during execution of the "Add" instruction, the status bit OV is reset to "0". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.16.2 FBD

13.16.2.1 OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

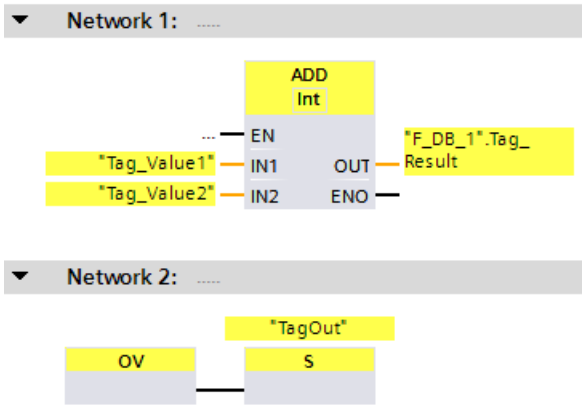
You can program a query of status bit OV for "0" with the "Invert RLO" instruction.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:



The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.17 Communication

13.17.1 PROFIBUS/PROFINET

13.17.1.1 SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21)

Introduction

You use the SENDDP and RCVDP instructions for fail-safe sending and receiving of data using:

- Safety-related master-master communication
- Safety-related master-master communication for S7 Distributed Safety
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for S7 Distributed Safety
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication

Description

The SENDDP instruction sends 16 data elements of data type BOOL and 2 data elements of data type INT or one data element of the data type DINT (S7-1200, S7-1500) in a fail-safe manner to another F-CPU via PROFIBUS DP/PROFINET IO. The data can be received there by the related RCVDP instruction.

Every call of this instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g. RCVDP_DB_1) for these instructions. Once it is created, the new data block can be found in the "STEP 7 Safety" folder in the project tree under "Program blocks > System blocks". For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

With the SENDDP instruction, the data to be sent (for example, outputs of other F-blocks/instructions) are available at input SD_BO_xx or SD_I_xx or SD_DI_00 as alternative.

With the RCVDP instruction, the data received are available at outputs RD_BO_xx and RD_I_xx or RD_DI_00 as alternative for additional processing by other F-blocks/instructions.

(S7-1200, S7-1500) At the DINTMODE input of the SENDDP instruction you specify if the data at the inputs SD_I_00 and SD_I_01 or the data at the input SD_DI_00 is sent.

The operating mode of the F-CPU with the SENDDP instruction is provided at output SENDMODE. If the F-CPU with the SENDDP instruction is in disabled safety mode, output SENDMODE = 1.

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define the communication relationship between a SENDDP instruction in one F-CPU and a RCVDP instruction in the other F-CPU by specifying an F-communication ID at the DP_DP_ID inputs of the SENDDP and RCVDP instructions. Associated SENDDP and RCVDP instructions are assigned the same value for DP_DP_ID.

⚠ WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only

specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

NOTE

Within a safety program, you must assign a different start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) for every call of the SENDDP and RCVDP instructions at input LADDR.

A separate instance DB must be used for each call of the SENDDP and RCVDP instructions. You must not declare and call these instructions as multi-instances.

(S7-300, S7-400) The inputs of the RCVDP and RCVS7 instructions may not have preceding logic operations (for example "AND logic operation").

The inputs of the RCVDP instruction cannot be initialized using fully qualified DB accesses with outputs of a RCVDP or RCVS7 instruction called in an upstream network.

(S7-1200, S7-1500) The RD_D_00 output must not be evaluated for DINTMODE = 0; the RD_I_xx outputs of the RCVDP instruction must not be evaluated for DINTMODE = 1.

(S7-1200, S7-1500) The outputs of the SENDDP and RCVDP instructions must not be supplied with tags from the standard user program. Exception: RET_DPRD, RET_DPWR and DIAG outputs.

Fully qualified access to DP_DP_ID and LADDR is not possible in the safety program.

You cannot use an actual parameter for an output of an RCVDP instruction, if it is already being used for an input of the same or another RCVDP or RCVS7 instruction.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

NOTE

You are not permitted to insert any SENDDP/RCVDP instructions between a JMP or JMPN instruction and the associated jump destination (jump label).

You cannot insert a RET instruction prior to a SENDDP instruction.

SENDDP parameter

The following table shows the parameters of the SENDDP instruction:

Parameter	Declaration	Data type	Description
SD_BO_00	Input	BOOL	Send data BOOL 00
...			...
SD_BO_15	Input	BOOL	Send data BOOL 15
SD_I_00	Input	INT	Send data INT 00
SD_I_01	Input	INT	Send data INT 01
SD_DI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Send data DINT 00
DINTMODE	Input	DINT	(S7-1200, S7-1500) (hidden) 0=SD_I_00 u. SD_I_01 are sent 1=SD_DI_00 is sent

Parameter	Declaration	Data type	Description
DP_DP_ID	Input	INT	F-communication ID between SENDDP and RCVDP
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 615))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=RCVDP outputs fail-safe values
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other")).
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other")).
DIAG	Output	BYTE	Non-fail safe service information

RCVDP parameter:

The following table shows the parameters of the RCVDP instruction:

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	1=Acknowledgment for reintegration of send data following communication error
SUBBO_00	Input	BOOL	Fail-safe value for receive data BOOL 00
...			...
SUBBO_15	Input	BOOL	Fail-safe value for receive data BOOL 15
SUBI_00	Input	INT	Fail-safe value for receive data INT 00
SUBI_01	Input	INT	Fail-safe value for receive data INT 01
SUBDI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Fail-safe value for receive data DINT 00
DP_DP_ID	Input	INT	F-communication ID between SENDDP and RCVDP
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 615))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication

Parameter	Declaration	Data type	Description
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required
SENDMODE	Output	BOOL	1=F-CPU with SENDDP instruction in disabled safety mode
RD_BO_00	Output	BOOL	Receive data BOOL 00
...			...
RD_BO_15	Output	BOOL	Receive data BOOL 15
RD_I_00	Output	INT	Receive data INT 00
RD_I_01	Output	INT	Receive data INT 01
RD_DI_00	Output	DINT	(S7-1200, S7-1500) (hidden) Receive data DINT 00
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other")).
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other")).
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.4	x	—	—	x	
1.3	x	—	—	o	S7-300/400: These versions have identical functions to version 1.0. S7-1200/1500: Instead of 2 data of data type INT, one data of data type DINT can be sent/received as alternative. Otherwise functionally identical to version 1.0.
1.5	x	x	—	x	
2.0	x	x[1]	—	x[2]	

o This version is no longer supported.

1 supported as of firmware V4.2

2 supported as of firmware V2.0

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
3.0	x	x[1]	—	x[2]	S7-300/400: This version has identical functions to version 2.0. S7-1200/1500: • The DP_DP_ID input can also be supplied with tags of a global F-DB. In case of DP_DP_ID = 0 no connection is established. • Supports the data status byte of the PN/PN coupler as of firmware V4.0 • Supports the simulation of the communication in S7-PLCISM operation • Use for communication with S7-1200/1500 CPUs is not recommended Otherwise functionally identical to version 2.0
3.1	x	x[1]	x	x[2]	S7-300/400: This version has identical functions to version 3.0. S7-1200/1500: • This version has identical functions to version 3.0. If the communication partner also uses a version > V3.0, a communication protocol with improved safety features becomes active. Upgrading to version V3.1 is recommended before new acceptance of an existing system. • Incompatible with S7-300/400 F-CPUs.

o This version is no longer supported.

1 supported as of firmware V4.2

2 supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

Check if all communication partners of this F-CPU with SENDDP/RCVDP are S7-1200/1500 F-CPUs. In this case, use version 3.1. Otherwise, only version 3.0 or lower is possible.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Placement

You must insert the RCVDP instruction *either* at the start of the main safety block *or* (for S7-1200/1500 F-CPUs) in an F-FB/F-FC called directly at the start of the main safety block. No other instructions can be located before in the main safety block and no other instructions can be located before or afterwards in the F-FB/F-FC.

You need to insert the SENDDP instruction *either* at the end of the main safety block *or* (with S7-1200/1500 F-CPUs) in an F-FB/F-FC called directly at the end of the main safety block. No other instructions can be located afterwards in the main safety block and no other instructions can be located before or afterwards in the F-FB/F-FC.

Startup behavior

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDDP and RCVDP instructions). During this time, the receiver (RCVDP instruction) outputs the fail-safe values present at its inputs SUBBO_xx and SUBI_xx or alternatively SUBDI_00.

The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON. The SENDMODE output has default setting "0" and is not updated as long as output SUBS_ON = 1.

As of version V3.0 of the SENDDP and RCVDP instructions, communication is only established when DP_DP_ID <> 0.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires or for S7-1200/1500 F-CPUs as of V3.0 due to a change of DP_DP_ID to 0 after establishment of communication, the outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVDP instruction) then outputs the fail-safe values assigned at its inputs SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs. Output SENDMODE is not updated while output SUBS_ON = 1.

The send data of the SENDDP instruction present at inputs SD_BO_xx and SD_I_xx, SD_DI_00 as alternative, are only output again when communication errors are no longer detected (ACK_REQ = 1) and you acknowledge (Page 184) the RCVDP instruction with a positive edge at input ACK_REI.

Communication errors also occur if the values of the DP_DP_IDs between associated SENDDP and RCVDP are temporarily different on a change of the values of variable DP_DP_IDs after communication establishment.

⚠ WARNING

A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted.* *(S011)*

* If variable F-communication IDs are used, the communication partner of the SENDDP or RCVDP instructions can be changed during running operation. The resultant communication errors may only be acknowledged with an automatically generated signal at the ACK_REI input under the following conditions:

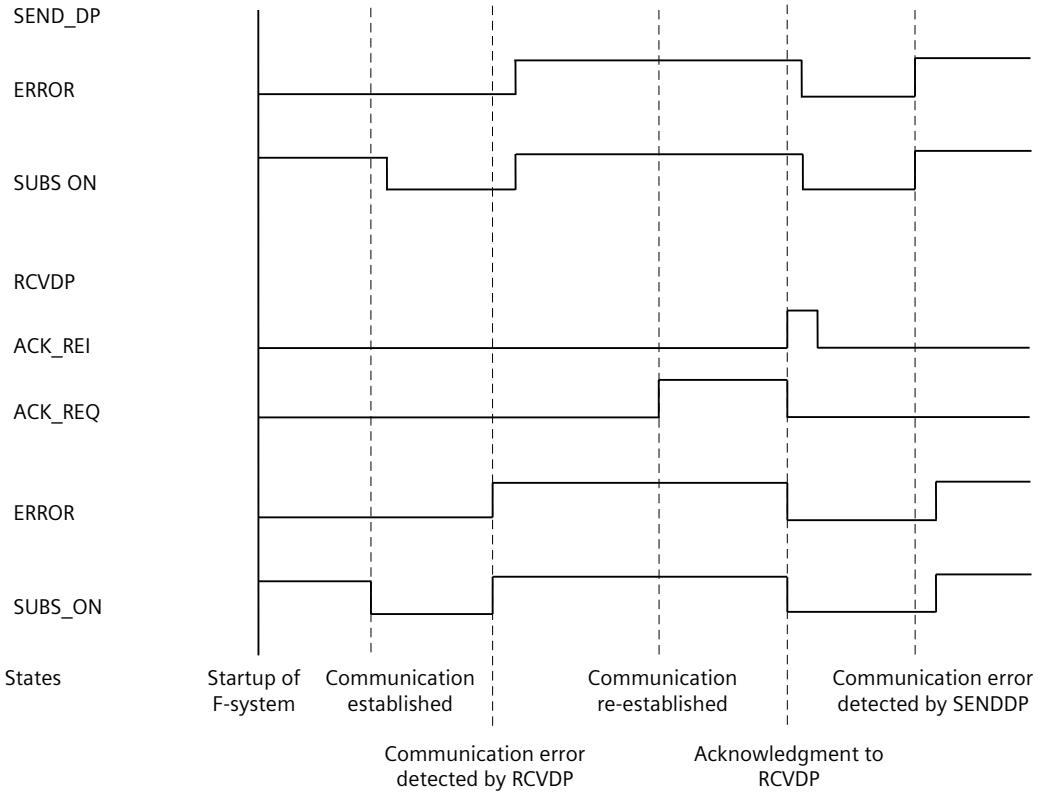
- The safety program reliably forms a signal "Communication partner change is in progress" with the RCVDP instruction on the basis of the process state.
- The signal "Communication partner change is in progress" is only formed if there is no communication error.
- While the signal "Communication partner change is in progress" is active, no evaluation of the received process values is carried out at the RCVDP instruction.
- Automatic acknowledgment takes place only if the "Communication partner change is in progress" signal is present.
- From a safety standpoint automatic reintegration is permitted for the relevant process.

Note that output ERROR (1=communication error) for a communication error will not be set unless communication between the connection partners (SENDDP and RCVDP instructions) has been previously established. If communication cannot be established after startup of the

sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDDP and the RCVDP instructions, and the bus connection. You also obtain information on possible error causes by evaluating outputs DIAG, RET_DPRD and RETDP_WR.

In general, always evaluate RET_DPRD and RETDP_WR, since it is possible that only one of the two outputs will contain error information.

Timing diagrams SENDDP/RCVDP



Output DIAG

In addition, non-fail-safe information about the communication states that occurred is provided at output DIAG of the SENDDP and RCVDP instructions for service purposes.

You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0-6 remain saved until you acknowledge the RCVDP instruction at the ACK_REI input.

Structure of DIAG of the SENDDP/RCVDP instruction

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Invalid DP_DP_ID	The DP_DP_ID is 0.	Check the DP_DP_ID of SENDDP or RCVDP.
Bit 4	Timeout of SENDDP/RCVDP detected	The standard user program overwrites transfer areas of SENDDP and RCVDP.	Check the standard user program for write access to the transfer areas of SENDDP and RCVDP. Also take indirect accesses into account.
		DP_DP_ID of SENDDP and RCVDP different.	Check the DP_DP_ID of SENDDP and RCVDP.
		For variable F-communication IDs the values are changed at the DP_DP_ID input.	When the DP_DP_ID of SENDDP and RCVD is consistent again, perform an acknowledgment at the ACK_REI input.
		Interference in bus connection to partner F-CPU.	Check the bus connection and ensure that there are no external sources of interference.
		The values at the TIMEOUT input are different for SENDDP and RCVDP.	Configure identical values at the TIMEOUT input of SENDDP and RCVDP.
		Monitoring time setting for F-CPU and partner F-CPU is too low.	Check the parameterized monitoring time TIMEOUT at SENDDP and RCVDP of both CPUs. Set a higher value if necessary. Recompile the safety program.
		Configuration of the DP/DP coupler or PN/PN coupler is invalid.	Check the configuration of the DP/DP coupler or of the PN/PN coupler.
		Data validity indicator "DIA" of the DP/DP coupler is "ON".	Set the data validity indicator "DIA" at the DIL switch of the DP/DP coupler to "OFF".
		Parameter "Data validity indicator DIA" of the PN/PN coupler is activated.	Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler.
		Parameter "Activate data status" of the PN/PN coupler (as of V4.0) is activated.	Deactivate the "Activate data status" parameter in the properties for the PN/PN coupler (as of V4.0) or S7-1200/1500: Use Version V3.0 of the SENDDP and RCVDP instructions.
		Internal fault of DP/DP coupler or PN/PN coupler	Replace the DP/DP coupler or PN/PN coupler
		CP in STOP mode, or internal fault in CP	Switch the CP to RUN. Check the diagnostics buffer of the CP. If necessary, replace the CP.
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	Switch the F-CPUs to RUN. Check the diagnostics buffer of the F-CPUs. If necessary, replace the F-CPUs.
Bit 5	Sequence number error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 6	CRC-error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 7	Communication protocol with improved safety features is not active.	Communication partner uses an instruction version < V3.1	Upgrade the communication partner to an instruction version > V3.0 at the next opportunity.

See also

Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication) (Page 236)
Communication with S7 Distributed Safety via DP/DP coupler (master-master communication) (Page 237)
Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 196)
Safety-related IO controller-IO controller communication (Page 199)
Safety-related master-master communication (Page 206)
Safety-related IO controller-I-device communication (Page 214)
Safety-related master-I-slave communication (Page 219)
Safety-related IO controller-I-slave communication (Page 230)

13.17.2 S7 communication

13.17.2.1 SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Introduction

You use the SENDS7 and RCVS7 instructions for fail-safe sending and receiving of data using S7 connections.

NOTE
In *STEP 7 Safety Advanced*, S7 connections are generally permitted over Industrial Ethernet only.
Safety-related communication via S7 connections is possible from and to F-CPUs with PROFINET interface or S7-400 F-CPUs with PROFINET-capable CPs. See also Safety-related communication via S7 connections (Page 230).

Description

The SENDS7 instruction sends the send data contained in an F-communication DB to the F-communication DB of the associated RCVS7 instruction of another F-CPU in a fail-safe manner using an S7 connection.

Every call of this instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SENDS7_DB_1) or a multi-instance (e.g., SENDS7_Instance_1) for this instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Information on the F-communication DB is contained in "Programming safety-related communication via S7 connections (Page 232)".

An F-communication DB is an F-DB for safety-related CPU-CPU communication with special properties. You must specify the numbers of the F-communication DBs at inputs SEND_DB and RCV_DB of instructions SENDS7 and RCVS7.

The operating mode of the F-CPU with the SENDS7 instruction is provided at output SENDMODE of the RCVS7 instruction. If the F-CPU with the SENDS7 instruction is in disabled safety mode, then output SENDMODE = 1.

To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND with "0" (default = "1"). In this case, send data is no longer sent to the F-communication DB of the associated RCVS7 instruction, and the receiver provides fail-safe values for this period of time (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.

You must specify the local ID - from the perspective of the F-CPU - of the S7 connection (from the connection table in the network view) at input ID of the SENDS7 instruction (see also Configuring (Page 33)).

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define a communication relationship between an SENDS7 instruction in one F-CPU and a communication relationship between an RCVS7 instruction and the other F-CPU by assigning an odd number at input R_ID (of the SENDS7 and RCVS7 instructions). Associated SENDS7 and RCVS7 instructions receive the same value for R_ID.

⚠ WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.
You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

NOTE

A separate instance DB must be used for each call of the SENDS7 and RCVS7 instructions within a safety program. You must not declare and call these instructions as multi-instances.
The inputs of the RCVS7 instruction cannot be initialized with outputs (using fully qualified DB accesses) of a RCVS7 or RCVDP instruction called in an upstream network.
You cannot use an actual parameter for an output of an RCVS7 instruction, if it is already being used for an input of the same or another RCVS7 or RCVDP instruction.
The F-CPU can go to STOP if this is not observed. A diagnostics event is entered in the diagnostics buffer of the F-CPU.

NOTE

You must not program any SENDS7/RCVS7 instruction between a JMP or JMPN instruction and the associated destination network of the JMP or JMPN instruction.
You cannot program a RET instruction prior to a SENDS7 instruction.

SENDS7 parameter

The following table shows the parameters of the SENDS7 instruction:

Parameter	Declaration	Data type	Description
SEND_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 615))
EN_SEND	Input	BOOL	1= Send enable
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for a F-communication ID between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Receiving block outputs fail-safe values
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail-safe service information

RCVS7 parameter

The following table shows the parameters of the RCVS7 instruction.

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	Acknowledgment for reintegration of send data after communication error
RCV_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 615))
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for a F-communication ID between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required
SENDMODE	Output	BOOL	1=F-CPU with the SENDS7 instruction in disabled safety mode

Parameter	Declaration	Data type	Description
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail-safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1500	Function
1.0	x	—	
1.1	x	—	This version has identical functions to version 1.0. It also supports later versions of internally called instructions.
1.2	x	—	This version has identical functions to version 1.0/1.1. It also supports later versions of internally called instructions.

When a new F-CPU is created with *STEP 7 Safety Advanced*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Placement

You must insert the RCVS7 instruction at the start of the main safety block. No other instructions may be located before it in the main safety block.

You must insert the SENDS7 instruction at the end of the main safety block. No other instructions may be located after it in the main safety block.

Startup behavior

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDS7 and RCVS7 instructions). The receiver (RCVS7 instruction) provides fail-safe values for this time period (initial values in its F-communication DB).

The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON. The SENDMODE output (RCVS7 instruction) has default setting "0" and is not updated as long as output SUBS_ON = 1.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires, outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVS7 instruction) then provides fail-safe values (initial values in its F-communication DB). Output SENDMODE is not updated while output SUBS_ON = 1.

The send data present in the F-communication DB (SENDS7 instruction) are not output before the communication error is no longer detected (ACK_REQ = 1) and you acknowledge (Page 184) with a positive edge at input ACK_REI of the RCVS7 instruction.

WARNING

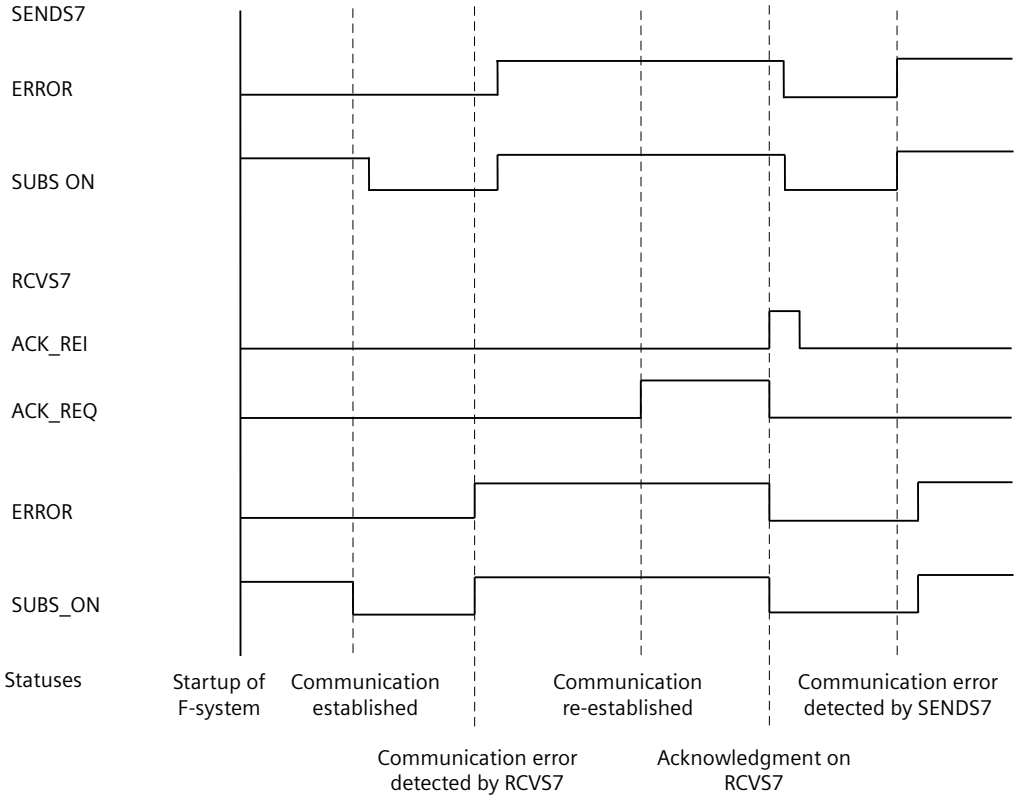
A user acknowledgment (Page 184) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

Note that output ERROR (1=communication error) will be set for the first time on a communication error if communication has already been established between the connection partners (SENDS7 and RCVS7 instructions). If communication cannot be established after startup of the sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions, and the bus connection. You can also receive information on possible error causes by evaluating the STAT_RCV and STAT_SND outputs.

In general, always evaluate STAT_RCV and STAT_SND, since it is possible that only one of the two outputs will contain error information.

If one of the DIAG bits is set at output DIAG, also check whether the length and structure of the associated F-communication DB on both the sending and receiving ends match.

Timing diagrams SENDS7 and RCVS7



Output DIAG

Non-fail-safe information on the type of communication errors that have occurred is made available at output DIAG for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you acknowledge them at input ACK_REI of the associated RCVS7 instruction.

Structure of DIAG

Bit no.	Assignment of SENDS7 and RCVS7	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Timeout detected by SENDS7 and RCVS7	Fault in bus connection to partner F-CPU	Check bus connection and ensure that no external fault sources are present.

Bit no.	Assignment of SENDS7 and RCVS7	Possible error causes	Remedies
Bit 4	Timeout detected by SENDS7 and RCVS7	Monitoring time setting for F-CPU and partner F-CPU is too low	Check assigned monitoring time TIMEOUT for SENDS7 and RCVS7 of both F-CPUs. If possible, set a higher value. Recompile safety program
		CPs in STOP mode, or internal fault in CPs	• Switch CPs to RUN mode • Check diagnostic buffer of CPs • Replace CPs, if necessary
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	• Switch F-CPUs to RUN mode • Check diagnostic buffer of F-CPUs • Replace F-CPUs, if necessary
		Communication was shut down with EN_SEND = 0.	Enable communication again at the associated SENDS7 with EN_SEND = 1
		S7 connection has changed, the IP address of the CP has changed, for example	Recompile the safety programs and download them to the F-CPUs
Bit 5	Sequence number error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 6	CRC-error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 7	RCVS7: Communication cannot be established	Configuration of the safety-related CPU-CPU communication is incorrect, parameter assignment of the SENDS7 and RCVS7 instructions is incorrect See also description for Bit 4	Check configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions is incorrect See also description for Bit 4
	SENDS7: Reserved	—	—

Monitoring and response times

A

Introduction

In the following, you will learn:

- Which F-specific monitoring times you must configure
- Which rules must be followed when specifying monitoring times
- Where you enter the F-specific monitoring times
- Which rules must be followed with regard to the maximum response time of a safety function

Support for calculations

An Excel file is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831) to support you in the approximative calculation of the runtimes of the F-runtime groups, the F-specific minimum monitoring times and the maximum response times for your F-system.

Additional information

The monitoring and response times for the standard part are calculated in SIMATIC Safety in exactly the same way as for standard S7-300, S7-400, S7-1200 and S7-1500 automation systems and are not addressed here. For a description of this calculation, refer to the *hardware manuals for the CPUs*. For redundant S7-1500HF systems, also observe the system manual "Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)".

A.1 Configuring monitoring times

Monitoring times to be configured

You must configure the following monitoring times:

Monitoring...	Setting...	Parameter	See
F-cycle time or cycle time warning limit of the F-runtime groups that contain the Safety program	in *Safety Administration Editor*: • Dialog for definition of an F-runtime group	Maximum cycle time of the F-runtime group	• Procedure for defining an F-runtime group (S7-300, S7-400) (Page 130) • Procedure for defining an F-runtime group (S7-1200, S7-1500) (Page 134)
of the safety-related communication between F-CPU and F-I/O via PROFIsafe (PROFIsafe monitoring time)	In the *hardware and network editor*: • Centrally when configuring the F-CPU; properties of the F-CPU; or • when configuring the F-I/O; properties of the F-I/O	F-monitoring time F_WD_TIME	• Configuring an F-CPU (Page 39) • Configuring F-I/O (Page 51) • Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 37)
Communication via SENDDP/RCVDP or SENDS7/RCVS7 instructions:	At the TIMEOUT input of the instructions: • SENDDP; RCVDP; SENDS7; RCVS7	TIMEOUT	• Communication (Page 599)
(S7-1500) Communication via OPC UA Safety	After adding a SafetyProvider to a SafetyProvider list of a client interface (Page 315) in the properties of the SafetyConsumer in the editor for client interfaces (Page 319)	SafetyConsumer-Timeout	• Safety Parameter Interface (SPI) of the SafetyConsumer (Page 288)
(S7-1200, S7-1500) Communication with Flexible F-Link	in Safety Administration Editor: • "Flexible F-Link" area	F-monitoring time of F-communication	• "Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 94) • F-runtime group communication (S7-1200, S7-1500) (Page 141) • Communication with Flexible F-Link (S7-1200, S7-1500) (Page 338)

(S7-300, S7-400) You do not have to configure the monitoring time for safety-related communication between F-runtime groups.

Rules for configuring monitoring times

When configuring monitoring times, you must take into account the availability as well as the safety of the F-system as follows:

- Availability: Sufficiently large monitoring times must be selected so that time monitoring is not exceeded in an error-free scenario.
- Safety: Sufficiently small monitoring times must be selected so that the process safety time of the process is not exceeded.

⚠ WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

General procedure for configuring monitoring times

Use the following procedure for configuring monitoring times:

1. Configure the standard system.
   Refer to the applicable *hardware manuals* and *Help on STEP 7* for the necessary information.
2. Configure the specific monitoring times of the F-System with respect to availability. You use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) to calculate the approximate minimum monitoring time.

   NOTE
   To avoid a triggering of the time monitoring in the special operating and system states of the redundant S7-1500HF system in case of error-free operation, higher minimum monitoring times are required for a redundant S7-1500HF system with regard to availability. This is taken into account accordingly in the Excel file for the response time calculation.

3. Use the Excel file for response time calculation to calculate the maximum response time and then verify that the process safety time of the process is not exceeded. If necessary, you must reduce the specific monitoring times of the F-System.

See also

Redundant System S7-1500R/H
(https://support.industry.siemens.com/cs/ww/en/view/109754833)

A.1.1 Minimum monitoring time for the F-runtime group cycle time

Parameter "Maximum cycle time of the F-runtime group"

You configure the monitoring time for the F-runtime group cycle time in the *Safety Administration Editor* in the work area for definition of the F-runtime group (Page 129).

To prevent F-runtime group cycle time monitoring from being triggered when there are no pending faults and causing the F-CPU to go to STOP, you must set the maximum cycle time of the F-runtime group high enough.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) to determine the minimum monitoring time for the F-runtime group cycle time. Note also the comments in the Excel file.

For S7-1200/1500 F-CPUs, you can also use the tags TCYC_CURR (Page 149) and TCYC_LONG (Page 149) to determine the current and longest cycle time of the F-runtime group that occurred since the last STOP-RUN transition for dimensioning.

A.1.2 Minimum monitoring time of the F-I/O access

Parameter "F-monitoring time"

You have two options for configuring the monitoring time of safety-related communication between the F-CPU and F-I/O:

- Centrally in the *hardware and network editor* during parameter assignment of the F-CPU (Page 39); in the properties of the F-CPU, or
- During parameter assignment of the F-I/O (Page 51) in the *hardware and network editor*; in the properties of the F-I/O

NOTE

Note that in a redundant S7-1500HF system and use of an IO device that does not support system redundancy S2, there is an interruption of PROFINET communication with this device when the primary CPU fails and thus a communication error in the F-I/Os of this IO device, which requires reintegration of the F-I/Os (see section "After communication errors (Page 169)").
For IO devices with system redundancy S2, the redundant S7-1500HF system switches to the backup CPU without interruption if the primary CPU fails. During the primary backup switchover, the fail-safe outputs remain active.

"F-monitoring time" = PROFIsafe monitoring time T_{PSTO}

The specified PROFIsafe monitoring time T_{PSTO} must be high enough to prevent tripping the F-cycle time monitoring when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) available for SIMATIC Safety to calculate the minimum monitoring time for safety-related communication between the F-CPU and F-I/O.

Note also the comments in the Excel file.

Check to determine whether configured PROFIsafe monitoring time is too short

NOTE

During commissioning of the F-system, you can perform a check while safety mode is active to determine whether the configured PROFIsafe monitoring time is too short.

This check of the PROFIsafe monitoring time is useful if you want to ensure that the configured monitoring time exceeds the minimum monitoring time by a sufficient amount. In this way, you can avoid the possible occurrence of sporadic monitoring time errors.

Procedure:

1. Insert an F-I/O (one that will not be needed later for system operation).
2. Assign a shorter monitoring time for this F-I/O than for the F-I/O of the system.
3. If the additional F-I/O fails and the "Monitoring time for safety message frame exceeded" diagnostic is signaled, you have fallen below the minimum possible PROFIsafe monitoring time.
4. Increase the monitoring time for the added F-I/O just to the point where it no longer fails. This monitoring time corresponds approximately to the minimum possible monitoring time.

Conditions:

The F-I/O to be inserted additionally and the F-I/O whose PROFIsafe monitoring time is to be checked must have the following properties in common:

- They must be inserted in the same rack
- They must be nodes in the same subnet

Tip:

It may be useful to leave the additional F-I/O in place for systems that will be modified or expanded during operation after commissioning. This F-I/O will then provide an early warning in the event of changes in the time behavior, enabling you to avoid a process shutdown triggered by the F-I/O in the process.

In a redundant S7-1500HF system, the check as to whether the configured PROFIsafe monitoring time is too short should be carried out in all operating and system states, because the response times there also depend on the respective operating and system state.

A.1.3 Minimum monitoring time for communication via the SENDDP/RCVDP or SENDS7/RCVS7 instructions

TIMEOUT Input at SENDDP and RCVDP or SENDS7 and RCVS7

The time monitoring is performed in the SENDDP and RCVDP (Page 599) or SENDS7 and RCVS7 (Page 608) instructions of the communication partners. You must assign the time monitoring with identical monitoring time for both instructions at the TIMEOUT input.

You must specify a monitoring time TIMEOUT that is large enough so that monitoring is not initiated when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for TIMEOUT.

Note also the comments in the Excel file.

A.1.4 Minimum monitoring time of communication with OPC UA Safety

"SafetyConsumerTimeout" SAPI parameter

For communication with OPC UA Safety, specify the F-monitoring time for this safety-related communication after adding a SafetyProvider to a SafetyProvider list of a client interface (Page 321) in the properties of the SafetyConsumer in the editor for client interfaces (Page 315).

You must specify a monitoring time that is high enough so that SafetyConsumerTimeout is not triggered when no error has occurred.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for SafetyConsumerTimeout.

Note also the comments in the Excel file.

A.1.5 Minimum monitoring time for communication with Flexible F-Link

"F-monitoring time" parameter in the settings for Flexible F-Link

For communication with Flexible F-Link, you specify the F-monitoring time for the safety-related communication when establishing safety-related communication (Page 94).

You must specify a monitoring time that is large enough so that F-monitoring is not initiated when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for the F-monitoring time.

Note also the comments in the Excel file.

A.1.6 Monitoring Time for Safety-Related Communication between F-Runtime Groups

Monitoring time for safety-related communication between F-runtime groups (S7-300, S7-400)

The monitoring time for safety-related communication between F-runtime groups with Flexible F-Link is determined automatically from the values of the "Maximum cycle time of F-runtime group" (work area for Definition of the F-runtime group (Page 129) in the *Safety Administration Editor*).

Monitoring time = (maximum cycle time of the 1st F-runtime group) + (maximum cycle time of the 2nd F-runtime group)

Monitoring time for safety-related communication between F-runtime groups (S7-1200, S7-1500)

You can calculate the monitoring time for safety-related communication between F-runtime groups from the values for the "Maximum cycle time of the F-runtime group" (area for Definition of the F-runtime group (Page 129) in the *Safety Administration Editor*), if you place the default user program for the F-runtime group communication into pre-/postprocessing (Page 85).

Monitoring time = (Maximum cycle time of the 1st F-runtime group) + (Maximum cycle time of the 2nd F-runtime group).

A.2 Response Times of Safety Functions

Definition of response time

The response time is the time from detection of an input signal until the linked output signal changes.

Fluctuation range

The actual response time lies between a minimum response time and maximum response time. You must always take the maximum response time into account in your system configuration.

Also note the comments in the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831).

NOTE

In a redundant S7-1500HF system, the current operating and system state influences the actual response time.

Rules for maximum response time of a safety function

The maximum response time of a safety function must be shorter than the process safety time of the process.

Definition for process safety time of a process

The process safety time of a process is the time interval between the occurrence of an error, within which the process can be left on its own without causing injury to operating personnel or damage to the environment, and the point in time the response is completed.

The controlling F-system can perform any control during the process safety time, this includes incorrectly or not at all. The process safety time of a process depends on the process type and must be determined on a case-by-case basis.

Procedure for response time calculation

The Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) is available for calculating the maximum response time of a safety function.

Use the Excel file to calculate the approximate maximum response time of the safety function and then check that the process safety time of the process is not exceeded.

If necessary, you must reduce the specific monitoring times of the F-system (see Minimum monitoring time of the F-I/O access (Page 618)).

⚠ WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.
Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.
Examples:

- Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
- The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the collective F-signature.
If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 616)).
The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the collective F-SW-signature.
When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

⚠ WARNING

You may only use the Excel file for response time calculation or for timeout calculation when using Flexible F-Link communication, if you have observed the following rules with regard to the standard instructions for consistent transfer of data:
CPU-CPU communication (Page 338)
You must call the standard instruction for consistent sending of data and acknowledgment in the post-processing of the F-runtime group (Page 85). With the standard instructions for receiving data and acknowledgments consistently, you must differentiate whether or not the standard communication connection is deterministic. For deterministic connections (such as DPRD_DAT / DPWR_DAT), you need to call the standard instruction in the pre-processing of the F-runtime group (Page 85). If the connection is non-deterministic (e.g. S7 connection, TCP connections), you must call the standard instruction in a cyclic interrupt OB. This cyclic interrupt OB must be called at shorter intervals than the F-runtime group. A ratio of 1:5 is recommended for this.
F-runtime group communication (Page 141)
You have to call up the standard instruction UMOVE_BLK for transferring the data to be sent in the postprocessing of the sending F-runtime group. You have to call the standard instruction UMOVE_BLK for transferring the acknowledgment to be sent in the postprocessing of the receiving F-runtime group. *(S089)*

⚠ WARNING

You may only use the Excel file for response time calculation or for timeout calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) when using OPC UA Safety communication, if you have observed the following rules with regard to the standard instruction OPC_UA_MethodCall:
You must call up the standard instruction OPC_UA_METHODCALL to receive the data in the pre-processing of the F-runtime group (Page 85) and to send the request in the post-processing of the F-runtime group (Page 85). The REQ input of the instruction must be supplied with a positive signal edge during preprocessing. You can use the F-OPC-UA-Consumer-Com-FB provided by the system for this. *(S112)*

Checklist

B

Life cycle of fail-safe automation systems

The following table contains a checklist summarizing all activities in the life cycle of a fail-safe SIMATIC Safety system, including requirements and rules that must be observed for each activity.

Checklist

Legend:

- Stand-alone section references refer to this documentation.
- *"F-SMs manual"* refers to the Automation System S7-300, ET 200M Distributed I/O System, Fail-Safe Signal Modules manual (https://support.industry.siemens.com/cs/ww/en/view/19026151)
- *"F-Modules manual"* refers to the ET 200S Distributed I/O System, Fail-Safe Modules manual (https://support.industry.siemens.com/cs/ww/en/view/27235629)
- *"ET 200eco manual"* refers to the ET 200eco Distributed I/O Station, Fail-Safe I/O Module manual (https://support.industry.siemens.com/cs/ww/en/view19033850)
- *"ET 200eco PN manual"* refers to the ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 equipment manual (https://support.industry.siemens.com/cs/ww/en/view/109765611)
- *"ET 200pro manual"* refers to the ET 200pro Distributed I/O System, Fail-Safe I/O Module manual (https://support.industry.siemens.com/cs/ww/en/view22098524)
- *"ET 200iSP manual"* refers to the ET 200iSP Distributed I/O Device, Fail-Safe Modules manual (https://support.industry.siemens.com/cs/ww/en/view/47357221)
- *"ET 200SP manual"* refers to the ET 200SP system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
- *"ET 200SP HA manual"* refers to the ET 200SP HA system manual (https://support.industry.siemens.com/cs/ww/en/view/109817158)
- *"ET 200AL manual"* refers to the ET 200AL system manual (https://support.industry.siemens.com/cs/ww/en/view/89254965)
- *"ET 200MP manual"* refers to the S7-1500/ET 200MP Distributed I/O system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792)
- *"S7-1500R/H manual"* refers to the S7-1500R/H system manual (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- *"SIMATIC Drive Controller manual"* refers to the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665)
- *"ET 200SP Modules manual"* refers to the equipment manuals for F-Modules of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/14059/man)
- *"ET 200SP HA Modules manual"* refers to the equipment manuals for F-Modules of the ET 200SP HA Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/28940/man)

- *"ET 200MP Modules manual"* refers to the equipment manuals for F-Modules of the ET 200MP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/29727/man)
- *"ET 200AL Module manual"* refers to the equipment manual for the F-Module of the ET 200AL Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/109798489)

Phase	Note the following	Reference	Check
Planning			
Requirement: "Safety requirements specification" available for the intended application	Process-dependent	—	
Specification of system architecture	Process-dependent	—	
Assignment of functions and subfunctions to system components	Process-dependent	under Product Overview (Page 22)	
Selection of sensors and actuators	Requirements for actuators	*F-SMs Manual*, section 6.5; *F-Modules Manual*, section 4.5; *ET 200eco Manual*, section 5.5 *ET 200eco PN Manual*, section 5.2; *ET 200pro Manual*, section 4.4 *ET 200iSP Manual*, section 4.5 *ET 200SP Manual*, section 6.2.2 *ET 200SP HA Manual*, sec. 9 *ET 200MP Manual*, section 6.2.2	
Specification of required safety properties for individual components	IEC 61508:2010	—	
Configuration			
Installing license	Requirement for installation	under Installing/uninstalling the STEP 7 Safety Advanced V21 license (Page 29)	
Selection of S7 components	Descriptions of configuration	under Product Overview (Page 22); *F-SMs Manual*, section 3; *F-Modules Manual*, section 3; *ET 200eco Manual*, section 3 *ET 200eco PN Manual*, section 4; *ET 200pro Manual*, section 2 *ET 200iSP Manual*, section 3 *ET 200SP Manual*, section 4 *ET 200SP HA Manual*, sec. 4 *ET 200AL Manual*, section 3 *ET 200MP Manual*, section 4 *S7-1500R/H Manual*, section 4 *HB SIMATIC Drive Controller*, section 4	
Configuration of hardware	• Description of F-systems • Verification of utilized hardware components based on Annex 1 of Report in the Certificate	under Configuring (Page 33); Annex 1 of Report on the Certificate	

Phase	Note the following	Reference	Check
Configuration of F-CPU	• Protection level, "Write protection for F-blocks" (S7-300, S7-400) • Protection level, at least "Full access" (S7-1200, S7-1500) • Password • F-capability enabled • Definition/setting of F-specific parameters • Cycle time for the F-runtime group in which the safety program is to be executed, defined in accordance with the requirements and safety regulations - same as with standard system	under Configuring an F-CPU (Page 39); *Standard-S7-300 Manual;* *Standard-S7-400 Manual;* *Standard-S7-1200 Manual;* *Standard-S7-1500 Manual;* under Monitoring and response times (Page 615)	
Configuration of F-I/O	• Settings for safety mode • Setting of passivation type • Configuring monitoring times • Defining sensor evaluation • Defining diagnostic behavior • Special F-parameters • Assigning names • Unique PROFIsafe address	under Configuring F-I/O (Page 51) orPeculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 37) under Monitoring and response times (Page 615); *F-SMs Manual*, sections 3, 9, 10; *F-Modules Manual*, sections 2.4, 7; *ET 200eco Manual*, sections 3, 8; *ET 200eco PN Manual*, section 6; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200SP HA Modules manual,* sec. 9 *ET 200MP Modules Manual*, section 4 *ET 200AL Module Manual*, section 4	
Programming			
Defining program design and structure	• Follow warnings and notes on programming	under Overview of Programming (Page 108), Program structure of the safety program (S7-300, S7-400) (Page 108), Program structure of the safety program (S7-1200, S7-1500) (Page 110); Programming startup protection (Page 150);	
Creating the F-runtime groups	• Assignment of F-FB or F-FC as main safety block to the calling block (S7-300, S7-400) or F-OB (S7-1200, S7-1500) • Setting maximum cycle time for the F-runtime group in accordance with requirements (dependent on process and safety regulations) • Creating DB for F-runtime group communication • (S7-300, S7-400) Call of main safety blocks directly in OBs (e.g. OB 35), FBs, or FCs • (S7-1200, S7-1500) Call of the main safety block from the F-OB	under Defining F-Runtime Groups (Page 129) under Monitoring and response times (Page 615)	

Phase	Note the following	Reference	Check
Creating/inserting the F-blocks	• Generating, editing, and saving F-FBs, F-FCs, and F-DBs in accordance with the requirements of the program structure • Description: – F-I/O access – Passivation and reintegration of F-I/O – Inserting F-blocks from global libraries – Safety-related CPU-CPU communication – Communication with the standard user program	under Creating F-blocks (Page 145) under Addressing F-I/O (Page 151) under Implementation of user acknowledgment (Page 184) under Reuse of F-blocks (Page 147) under Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 196) and Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 241) under Data exchange between standard user program and safety program (Page 192)	
Compiling the safety program	—	under Compiling the safety program (Page 344)	
Implementing safety program call (S7-300, S7-400)	Check whether the main safety block is called directly in OBs (e.g., OB 35), FBs, or FCs.	under Defining F-Runtime Groups (Page 129)	
Installation			
Hardware configuration	Description of • Installation • Wiring	under Overview of Configuration (Page 33); AUTOHOTSPOT; *F-SMs Manual*, sections 5, 6; *F-Modules Manual*, sections 3, 4; *ET 200eco Manual*, sections 3, 4; *ET 200eco PN Manual*, sections 4, 5; *ET 200pro Manual*, Sections 2, 3; *ET 200iSP Manual*, sections 3 and 4; *ET 200SP Manual*, sections 5 and 6 *ET 200SP HA Manual*, sec. 5, 6 *ET 200AL Manual*, sections 4, 5 *ET 200MP Manual*, sections 5 and 6 *S7-1500R/H Manual*, sections 5, 6 *HB SIMATIC Drive Controller*, section 5, 6	
Commissioning, Testing			
Switching on	Description of commissioning – same as in standard	*Standard-S7-300 Manual;* *Standard-S7-400 Manual;* *Standard-S7-1200 Manual;* *Standard-S7-1500 Manual;* *Standard-S7-1500 Software Controller Manual;* *S7-1500R/H Module Manual* *HB SIMATIC Drive Controller Manual*	
Downloading safety program and standard user program	Description • Downloading • Program identification • Comparing safety programs	under Downloading project data (Page 345) under Comparing Safety Programs (Page 380)	
Testing the safety program	• Description of disabling of safety mode • Procedures for changing safety program data	under Downloading project data (Page 345); Testing the safety program (Page 390); Disabling safety mode (Page 386)	
Changing the safety program	Description • Disabling safety mode • Changing the safety program	under Changing the safety program in RUN mode (S7-300, S7-400) (Page 397), Safety program in RUN mode (S7-1200, S7-1500) (Page 399), Disabling safety mode (Page 386), Deleting the safety program (Page 128)	
Testing the safety-related parameters	Description of configuration	under Creating a safety summary (Page 382); *F-SMs Manual*, sections 4, 9, 10; *F-Modules Manual*, sections 2.4, 7;	

Phase	Note the following	Reference	Check
		ET 200eco Manual, sections 3, 8; *ET 200eco Manual*, section 6; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200SP HA Modules manual*, sec. 5 *ET 200MP Modules Manual*, section 4 *ET 200AL Module Manual*, section 4	
System acceptance			
Acceptance	• Description and notes on acceptance • Printouts	under System acceptance (Page 407)	
Operation, maintenance			
General operation	Notes on operation	under Notes on Safety Mode of the Safety Program (Page 435)	
Access protection	—	under Access protection (Page 96)	
Diagnostics	Responses to faults and events	under Guide to Diagnostics (Page 441)	
Replacement of software and hardware components	Description • Module replacement • Update of operating systems of F-CPU – same as in standard • Update of SW components Notes • Operating system update of IMs	under Replacing Software and Hardware Components (Page 437); Addressing F-I/O (Page 151); Help on *STEP 7*	
Uninstalling the license, Disassembly	• Notes for uninstalling the license • Notes for disassembling modules	under Installing/uninstalling the STEP 7 Safety Advanced V21 license (Page 29), Replacing Software and Hardware Components (Page 437)	

Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500)

C

If the F-BaseID with the value "Delayed transfer" (0x7C6) has been configured, you must generate an active F-BaseID in runtime and assign it to the F-CPU and the F-I/O. The following instructions are available to you for this purpose.

- BASEID_GEN
- BASEID_DATA
- BASEID_CODING
- BASEID_HOST

The instructions are made available in the "Extended instructions" area under "Safety-Extensions".

These instructions are not fail-safe instructions and can only be placed in a standard block. They may only be used in the case "Delayed transfer of the F-BaseID".

In the case "Delayed transfer of the F-BaseID", the F-BaseID is generated once by these instructions on the first startup of the F-CPU, saved in the F-CPU and assigned to the F-I/Os. After the F-CPU starts up again, the F-BaseID previously saved in the F-CPU is applied again and forwarded to the F-I/O.

NOTE

The F-I/Os of PROFIsafe address type 3 remain passivated until the logic for assignment of the F-BaseID is complete.

NOTE

You can find the BaseIDAssign application example on the Internet. It presents a possible interconnection of the above-named instructions for the delayed transfer of the F-BaseID.

NOTE

The BASEID_GEN instruction is only supported for S7-1500 HF-CPUs as of firmware V4.2.

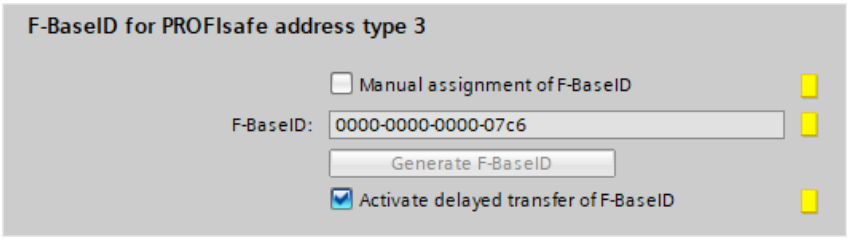
Configuring delayed transfer of the F-BaseID

For delayed transfer of the F-BaseID, configure the F-CPUs and the F-I/Os with the "Activate delayed transfer of F-BaseID" option enabled in accordance with the PROFIsafe specification.

Proceed as follows:

1. For the F-I/Os of PROFIsafe address type 3, configure (Page 68) the F-BaseID with the value 0 and with the intended F-source and F-destination addresses.
2. Download (Page 345) the project data to the F-CPU.
3. Assign (Page 70) the PROFIsafe addresses with SIMATIC Safety.
4. Create the user program.

5. In the F-CPU parameters (Page 39), enable the "Activate delayed transfer of the F-BaseID" option. The F-BaseID changes to 0x7C6.



6. In the standard program, program the logic for assigning the F-BaseID with BASEID_GEN, BASEID_DATA, BASEID_CODING and BASEID_HOST.
7. Download (Page 345) the project data to the F-CPU.
8. Switch the F-CPU to RUN. The F-BaseID is assigned.

⚠ WARNING

During assignment of the F-BaseID by means of the BASEID_CODING instruction, only the F-modules to which the F-BaseID is to be assigned should be accessible. Therefore, temporarily isolate the network in which the F-CPU and the assigned F-modules are located. *(S119)*

As an alternative to the BASEID_CODING instruction, you can use the instruction PROFIsafeAddrAssign (https://support.industry.siemens.com/cs/ww/en/view/109748466) (as of Version 3.0). With this instruction, you can additionally assign the F-destination and F-source addresses. Steps 1 to 3 are omitted in this case.

⚠ WARNING

Note that when the PROFIsafeAddrAssign instruction with F-I/Os of PROFIsafe address type 3 is being used, you must always confirm the correctness of the assignment using suitable measures. This applies even if you only changed the F-BaseID, because all parts of the PROFIsafe address are assigned at the same time in this case. In addition, you must prevent an unintended execution of the PROFIsafeAddrAssign instruction. You can find details on this in the named application example. *(S118)*

Order when programming the instructions for F-BaseID

In order to set the F-BaseID at runtime, you must interconnect the following instructions from the standard library under "Safety Extensions" in a cyclic standard user program:

- BASEID_GEN
- BASEID_DATA
- BASEID_CODING
- BASEID_HOST

NOTE

The instructions BASEID_GEN, BASEID_DATA, BASEID_CODING and BASEID_HOST are processed asynchronously. You must interconnect these instructions in such a way that they are processed sequentially in the above-named order.

C.1 Safety Extensions

C.1.1 BASEID_GEN

Description

At a positive edge at input REQ, the BASEID_GEN instruction generates the F-BaseID once and provides it at output BASEID.

If the F-CPU already has a set F-BaseID, this F-BaseID is provided at output BASEID.

Parameters

The following table shows the parameters of the BASEID_GEN instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_GEN.
HW_IDENTIFIER_IM	Input	HW_IO	The HW identifier of the executing F-CPU.
BASEID	Output	LINT	The read or generated F-BaseID.
CALCULATED	Output	BOOL	CALCULATED = 1: The output F-BaseID was generated.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: Generation of the F-BaseID is active.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

NOTE

If you want to regenerate the F-BaseID but the parameter of the F-CPU no longer has the value 0x7C6, you must first reset this to 0x7C6 using the BASEID_Host instruction.

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_GEN reads the F-BaseID from the parameters of the F-CPU or, if F-BaseID = 0x7C6 was read, generates a new F-BaseID.

[1] Supported as of firmware V4.1 (for S7-1500 HF-CPUs only as of V4.2) or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x8001	Error in the generation of the F-BaseID

C.1.2 BASEID_DATA

Description

The instruction BASEID_DATA calculates the F-BaseID CRC according to the PROFIsafe specification and writes the F-BaseID with the calculated F-BaseID CRC to the data record of the F-module specified at input HW_WRITE_RECORD_NR. To calculate the F-BaseID CRC, the F_Par_CRC is read from the data record of the F-module specified at the HW_READ_RECORD_NR input.

Parameters

The following table shows the parameters of the BASEID_DATA instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_DATA.
BASEID	Input	LINT	The F-BaseID to be written.
HW_IDENTIFIER_MODULE	Input	HW_IO	The HW identifier of the F-module.
HW_READ_RECORD_NR	Input	DINT	Data record number of the F-module for reading the F_Par_CRC (needed to calculate the F-BaseID CRC).
HW_WRITE_RECORD_NR	Input	DINT	Data record number of the F-module for writing the F-BaseID.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

NOTE
The inputs HW_READ_RECORD_NR (128) and HW_WRITE_RECORD_NR (130) are preassigned with the usual data record numbers for F-modules by SIEMENS.

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_DATA writes the F-BaseID to the data record of an F-module

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x8001	Error during generation of the F-BaseID CRC
0x0050	The F-BaseID is in the reserved range.

C.1.3 BASEID_CODING

Description

The instruction BASEID_CODING writes the F-BaseID to the electronic coding element of the F-module specified at input HW_IDENTIFIER_MODULE. If the values in the data record and the electronic coding element do not match, an inconsistency occurs and the F-module is passivated until the values match.

NOTE

Using the BASEID_CODING instruction, the F-BaseID in the electronic coding element can only be overwritten if it still has the value 0.
Otherwise, the firmware prevents the writing of the new F-BaseID and the existing value in the electronic coding element is retained. To be able to change an F-BaseID, a project with F-BaseID with value 0 must therefore first be loaded and an assignment made via TIA Portal. "Delayed transfer" must then be parameterized again in the project and this project must be loaded. Now the F-BaseID can be set at the electronic coding element again with the BASEID_CODING instruction.

NOTE

As an alternative to using the BASEID_CODING instruction, the F-BaseID can also be assigned together with the PROFIsafe addresses. For this you can use the instruction PROFIsafeAddrAssign (https://support.industry.siemens.com/cs/ww/en/view/109748466) (as of Version 3.0) available on the Internet.

⚠ WARNING

Note that when the PROFIsafeAddrAssign instruction with F-I/Os of PROFIsafe address type 3 is being used, you must always confirm the correctness of the assignment using suitable measures. This applies even if you only changed the F-BaseID, because all parts of the PROFIsafe address are assigned at the same time in this case. In addition, you must prevent an unintended execution of the PROFIsafeAddrAssign instruction. You can find details on this in the named application example. *(S118)*

⚠ WARNING

During assignment of the F-BaseID by means of the BASEID_CODING instruction, only the F-modules to which the F-BaseID is to be assigned should be accessible. Therefore, temporarily isolate the network in which the F-CPU and the assigned F-modules are located. *(S119)*

Parameters

The following table shows the parameters of the BASEID_CODING instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_CODING.
BASEID	Input	LINT	The F-BaseID to be written.
HW_IDENTIFIER_MODULE	Input	HW_IO	The HW identifier of the F-module.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_CODING writes the F-BaseID to the electronic coding element of an F-module.

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x0050	The F-BaseID is in the reserved range.

C.1.4 BASEID_HOST

Description

The instruction BASEID_HOST writes the specified F-BaseID to the parameters of the executing F-CPU.

Parameters

The following table shows the parameters of the BASEID_HOST instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_HOST.
BASEID	Input	LINT	The F-BaseID to be written.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_HOST writes the F-BaseID to the parameters of the F-CPU.

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x0050	The F-BaseID is in the reserved range.

SIEMENS
SIMATIC
S7-1200/S7-1500
F-CPUs
Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.
For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://www.siemens.com/cert.

Content

Introduction
This Product Information contains important information on the F-CPUs specified in the section "Scope of validity". The Product Information is part of the product supplied. The information in this Product Information should be considered more up-to-date than other documentation if uncertainties arise.

Scope of validity
The statements in this Product Information apply to the F-CPUs listed below:

S7-1200 F-CPUs	
S7-1200 F-CPUs G1	**S7-1200 F-CPUs G2**
• CPU 1212FC DC/DC/DC • CPU 1212FC DC/DC/Rly • CPU 1214FC DC/DC/DC • CPU 1214FC DC/DC/Rly • CPU 1215FC DC/DC/DC • CPU 1215FC DC/DC/Rly	• CPU 1212FC DC/DC/DC • CPU 1212FC DC/DC/Rly • CPU 1214FC DC/DC/DC • CPU 1214FC DC/DC/Rly

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S7-1500 F-CPUs		
• CPU 1511(T)F-1 PN • CPU 1511VF-1 PN • CPU 1513F-1 PN • CPU 1515(T)F-2 PN • CPU 1516TF-3 PN • CPU 1516(T)F-3 PN/DP • CPU 1517(T)F-3 PN • CPU 1517(T)F-3 PN/DP • CPU 1517VF-1 PN • CPU 1518(T)F-3 PN • CPU 1518(T)F-4 PN/DP (MFP/ODK) • CPU 1518HF-4 PN	• CPU 1510SP F-1 PN • CPU 1512SP F-1 PN • CPU 1514SP (T)F-2 PN • CPU 1513proF-2 PN • CPU 1516proF-2 PN	S7-1500 F-Software Controller • CPU 1505SP (T)F • CPU 1507S F • CPU 1508S (T)F

Areas of application

Main areas of application of the S7-1200/1500 F-CPUs are personal and machine safety and burner controls. In addition to the safety program, you can also program standard applications.

You can operate the S7-1200/1500 F-CPUs in safety or standard mode. In standard mode, S7-1200/1500 F-CPUs behave like standard S7-1200/1500 CPUs.

For S7-1500 F-CPUs, an installed license for *STEP 7 Safety* is required for safety mode. Without an installed license for *STEP 7 Safety*, you can use the S7-1500 F-CPUs in standard mode.

An installed license for *STEP 7 Safety* is not required for S7-1200 F-CPUs for safety mode.

Additional information on using the S7-1200/1500 F-CPUs in safety mode is available in the programming and operating manual "SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)".

Information on using the S7-1200 F-CPUs in standard mode is available in the relevant system manuals for the S7-1200 standard CPUs at the following links:

- CPUs 121x G1 (https://support.industry.siemens.com/cs/ww/en/view/109772940)
- CPUs 121x G2 (https://support.industry.siemens.com/cs/ww/en/ps/30069/man)

Additional information on using the S7-1500 F-CPUs in standard mode is available in the relevant manuals for the S7-1500 and the standard-T-CPUs S7-1500 at the following links:

- CPUs 151x (http://support.automation.siemens.com/WW/view/en/67295862/133300)
- CPU 1518HF-4 PN (https://support.industry.siemens.com/cs/ww/en/view/109784207)
- CPUs 151xT (https://support.industry.siemens.com/cs/ww/en/ps/22057/man)
- CPUs 151xSP (http://support.automation.siemens.com/WW/view/en/90466439/133300)
- CPU 151xpro-2 PN (https://support.industry.siemens.com/cs/ww/en/ps/13906/man)
- CPU 151xV-1 PN (https://support.industry.siemens.com/cs/ww/en/view/109996319)
- S7-1500 Software Controller (https://support.industry.siemens.com/cs/ww/en/ps/13911/man)

You can find the latest firmware for the relevant F-CPU by searching for downloads with the respective article number in the Industry Online Support (https://support.industry.siemens.com).

NOTE

Observe any application-specific requirements, for example on mains buffering for power supplies/power packs.

PFD_{avg} and PFH values for F-CPUs
Below are the probability of failure on demand values (PFD_{avg}, PFH values) for the above-named F-CPUs with a mission time of 20 years and an MTTR of 100 hours:

Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]
< 2E-05	< 1E-09 up to an operational altitude of 3 000 m or < 2E-09 at an operating altitude greater than 3 000 m up to 5 000 m

S7-1200/1500 F-CPUs for permissible ambient temperature and max. permissible installation height and work memory as compared to the standard CPUs

CPU	Article number	Ambient temperature		Installation altitude		Work memory (Std.-/F-CPU)
		Temperature range [°C]	From revision level	Max. altitude [m]	From revision level	
S7-1200 F G1						
CPU 1212FC DC/DC/DC	6ES7212-1AF40-0XB0	0 to +55	FS 05	5 000	FS 10	100 KB/150 KB
CPU 1212FC DC/DC/RLY	6ES7212-1HF40-0XB0	0 to +55	FS 05	2 000	FS 05	100 KB/150 KB
CPU 1214FC DC/DC/DC	6ES7214-1AF40-0XB0	0 to +55	FS 01	5 000	FS 10	150 KB/200 KB
CPU 1214FC DC/DC/RLY	6ES7214-1HF40-0XB0	0 to +55	FS 01	2 000	FS 01	150 KB/200 KB
CPU 1215FC DC/DC/DC	6ES7215-1AF40-0XB0	0 to +55	FS 01	5 000	FS 10	200 KB/250 KB
CPU 1215FC DC/DC/RLY	6ES7215-1HF40-0XB0	0 to +55	FS 01	2 000	FS 01	200 KB/250 KB
S7-1200 F G2						
CPU 1212FC DC/DC/DC	6ES7212-1AF50-0XB0	0 to +55	FS 01	5 000	FS 01	150 KB/200 KB
CPU 1212FC DC/DC/RLY	6ES7212-1HF50-0XB0	0 to +55	FS 01	2 000	FS 01	150 KB/200 KB
CPU 1214FC DC/DC/DC	6ES7214-1AF50-0XB0	0 to +55	FS 01	5 000	FS 01	250 KB/300 KB
CPU 1214FC DC/DC/RLY	6ES7214-1HF50-0XB0	0 to +55	FS 01	2 000	FS 01	250 KB/300 KB
S7-1500 F						
CPU 1510SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 01	5 000	FS 03	100 KB/150 KB
CPU 1510SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000	FS 01	200 KB/300 KB
CPU 1512SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 01	5 000	FS 03	200 KB/300 KB
CPU 1512SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000	FS 01	400 KB/600 KB
CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000	FS 01	600 KB/900 KB
CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000	FS 01	900 KB/900 KB
CPU 1511F-1 PN	6ES7511-1FK01-0AB0	0 to +60	FS 01	5 000	FS 03	150 KB/225 KB
CPU 1511F-1 PN	6ES7511-1FK02-0AB0	-25 to +60	FS 01	5 000	FS 01	150 KB/225 KB
CPU 1511F-1 PN	6ES7511-1FL03-0AB0	-30 to +60	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1511TF-1 PN	6ES7511-1UK01-0AB0	0 to +60	FS 03	5 000	FS 03	225 KB/225 KB
CPU 1511TF-1 PN	6ES7511-1UL03-0AB0	-30 to +60	FS 01	5 000	FS 01	450 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FL01-0AB0	0 to +60	FS 01	5 000	FS 03	300 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FL02-0AB0	-25 to +60	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FM03-0AB0	-30 to +60	FS 01	5 000	FS 01	600 KB/900 KB

* with condensation

CPU	Article number	Ambient temperature		Installation altitude		Work memory (Std.-/F-CPU)
		Temperature range [°C]	From revision level	Max. altitude [m]	From revision level	
CPU 1515F-2 PN	6ES7515-2FM01-0AB0	0 to +60	FS 01	5 000	FS 03	500 KB/750 KB
CPU 1515F-2 PN	6ES7515-2FM02-0AB0	-25 to +60	FS 01	5 000	FS 01	500 KB/750 KB
CPU 1515F-2 PN	6ES7515-2FN03-0AB0	-30 to +60	FS 01	5 000	FS 01	1 MB/1.5 MB
CPU 1515TF-2 PN	6ES7515-2UM01-0AB0	0 to +60	FS 03	5 000	FS 03	750 KB/750 KB
CPU 1515TF-2 PN	6ES7515-2UN03-0AB0	-30 to +60	FS 01	5 000	FS 01	1.5 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FN01-0AB0	0 to +60	FS 01	5 000	FS 03	1 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FN02-0AB0	-25 to +60	FS 01	5 000	FS 01	1 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FP03-0AB0	-30 to +60	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1513proF-2 PN*	6ES7513-2GL00-0AB0	-25 to +55	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1516proF-2 PN*	6ES7516-2GN00-0AB0	-25 to +55	FS 01	5 000	FS 02	1 MB/1.5 MB
CPU 1513proF-2 PN*	6ES7513-2GM03-0AB0	-25 to +55	FS 01	5 000	FS 01	600 KB/900 KB
CPU 1516proF-2 PN*	6ES7516-2GP03-0AB0	-25 to +55	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1516TF-3 PN/DP	6ES7516-3UN00-0AB0	0 to +60	FS 05	5 000	FS 05	3 MB/3 MB
CPU 1516TF-3 PN	6ES7 516-3UP10-0AB0	0 to +60	FS 01	5 000	FS 01	3 MB/3 MB
CPU 1517F-3 PN/DP	6ES7517-3FP00-0AB0	0 to +60	FS 01	5 000	FS 05	2 MB/3 MB
CPU 1517F-3 PN/DP	6ES7517-3FP01-0AB0	0 to +60	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1517F-3 PN	6ES7 517-3FQ10-0AB0	0 to +60	FS 01	5 000	FS 01	4 MB/6 MB
CPU 1517TF-3 PN/DP	6ES7517-3UP00-0AB0	0 to +60	FS 04	5 000	FS 05	3 MB/3 MB
CPU 1517TF-3 PN	6ES7 517-3UQ10-0AB0	0 to +60	FS 01	5 000	FS 01	6 MB/6 MB
CPU 1518F-4 PN/DP	6ES7518-4FP00-0AB0	0 to +60	FS 01	5 000	FS 05	6 MB/9 MB
CPU 1518F-3 PN	6ES7 518-3FT10-0AB0	0 to +60	FS 01	5 000	FS 01	12 MB/18 MB
CPU 1518F-4 PN/DP ODK	6ES7518-4FP00-3AB0	0 to +60	FS 04	5 000	FS 05	6 MB/9 MB
CPU 1518F-4 PN/DP MFP	6ES7518-4FX00-1AB0	0 to +60	FS 01	5 000	FS 01	6 MB/9 MB
CPU 1518HF-4 PN	6ES7518-4JP00-0AB0	0 to +60	FS 01	5 000	FS 01	-- /9 MB
CPU 1518HF-4 PN	6ES7 518-4JT10-0AB0	0 to +60	FS 01	5 000	FS 01	-- /18 MB
CPU 1518TF-4 PN/DP	6ES7518-4UP00-0AB0	0 to +60	FS 10	5 000	FS 10	9 MB/9 MB
CPU 1518TF-3 PN	6ES7 518-3UT10-0AB0	0 to +60	FS 01	5 000	FS 01	18 MB/18 MB

* with condensation

NOTE

Operation of an (F-)CPU is permitted only up to 100% of the indicated CPU work memory in the TIA Portal.

Restrictions on the maximum specified ambient air temperature with reference to the installation altitude

Installation altitude	Derating factor for ambient air temperature [1]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 m	0.7

[1] The basic value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Pay attention to the mounting position of the respective module in the technical data. Based on the IEC 61131-2 standard.
- Ensure that the power supply units used are also adequate for altitudes > 2 000 m.
- The displays of the S7-1500 CPUs are designed for an altitude of ≤ 3 000 m. If used at > 3 000 m, in rare cases, there can be problems in the representation of the CPU display; however, these do not have an effect on the functional safety of the F-CPU.
- The "Safety-oriented tripping of standard modules" function, as described on the SIEMENS Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/39198632) pages, is only approved up to max. 2 000 m.

Effects on the availability

The higher cosmic radiation present during operation at altitudes above 2 000 m will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases, this can result in a transition of the F-CPU into the safe state. However, the functional safety of the F-CPU is fully retained.

Currently valid markings and approvals

NOTE

Information on the components of the S7-1200/S7-1500

The currently valid markings and approvals are printed on the components of the S7-1500.

The F-CPUs are certified for use in safety mode up to 3 000 m or 5 000 m. All other markings and approvals are currently based on a height of up to 2 000 m.

Shipping and storage conditions

The S7-1200/S7-1500 fulfills the requirements according to IEC 61131-2 with regard to the shipping and storage conditions. The following information applies to modules shipped or stored in their original packaging.

Type of condition	Permissible range
Air pressure	from 1 140 to 540 hPa (corresponds to an altitude of -1 000 m to 5 000 m)

Equipment manual for CPU 1517F-3 PN/DP (6ES7517-3FP01-0AB0)

You can find the technical specifications in the equipment manual for the CPU 1517-3 PN/DP (6ES7517-3AP00-0AB0) (https://support.industry.siemens.com/cs/ww/en/view/90471765).

The following values differ with the CPU 1517F-3 PN/DP (6ES7517-3FP01-0AB0):

- Current consumption (nominal value) is 1.7 A
- The current consumption (max.) and inrush current (max.) amounts to 2.2 A
- I^2t is 0.5 A^2s
- The power loss is 29 W

Overview of the behavior of the F-CPUs regarding communication network disconnectors according to IEC 61784-3-3 (PROFIsafe standard)

F-CPU	Network disconnector according to IEC 61784-3-3	Remark
S7-1200 G1	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1212FC DC/DC/DC CPU 1212FC DC/DC/Rly		
CPU 1214FC DC/DC/DC CPU 1214FC DC/DC/Rly		
CPU 1215FC DC/DC/DC CPU 1215FC DC/DC/Rly		
S7-1200 G2	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1212FC DC/DC/DC CPU 1212FC DC/DC/Rly		
CPU 1214FC DC/DC/DC CPU 1214FC DC/DC/Rly		

[1] Absolute network disconnector between socket A and B:

a) If A and B belong to different local Ethernet interfaces (for example, X1 and X2) and no bridging is implemented at communication level 2 for these interfaces.

a) If either A or B are part of a local Ethernet interface and the other is part of a backplane bus module with an Ethernet interface (CP, CM), and no bridging is implemented at communication level 2 for these interfaces.

[2] No network disconnector between socket A and B:

a) If A and B belong to the same local Ethernet interface (for example, X1).

b) If A and B both belong to a backplane bus module (CP, CM).

[3] As of firmware V3.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[4] As of firmware V3.1, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[5] As of firmware V4.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[6] With firmware higher than V40.0.0 with configured CP1625-2 (in TIA Portal and Resource Configurator), the F-CPU is only a network disconnector between the two interfaces of the CP1625-2 if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

S7-1500	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1511(T)F-1 PN		
CPU 1513F-1 PN		
CPU 1510SP F-1 PN		
CPU 1512SP F-1 PN		
CPU 1514SP (T)F-2 PN [3]	• Network disconnection between Ethernet X1 and X2. • Network disconnection between Ethernet X1 and CP/CM on the backplane bus. • Network disconnection between Ethernet X2 and CP/CM on the backplane bus.	
CPU 1515(T)F-2 PN [3]		
CPU 1516F-3 PN/DP [3]		
CPU 1516TF-3 PN/DP		
CPU 1517(T)F-3 PN/DP		
CPU 1513proF-2 PN [4]		
CPU 1516proF-2 PN [4]		
CPU 1516TF-3 PN [5] CPU 1517(T)F-3 PN [5] CPU 1518(T)F-3 PN [5] CPU 1518(T)F-4 PN/DP (ODK) CPU 1518HF-4 PN [5]	• Network disconnection between Ethernet X1, X2 and X3. • Network disconnection between Ethernet X1 and CP/CM on the backplane bus. • Network disconnection between Ethernet X2 and CP/CM on the backplane bus. • Network disconnection between Ethernet X3 and CP/CM on the backplane bus.	
CPU 1511VF-1 PN CPU 1517VF-1 PN	**No**	-
CPU 1518F-4 PN/DP MFP		
CPU 1505SP (T)F	• With Open Controller CPU 1515SP PC1 and PC2: **No** • With Open Controller CPU 1515SP PC3: Network disconnection between Ethernet X1 and X10.	See [1] and [2]
CPU 1507S F [6]	• With firmware lower than V40.0.0: **No** • With firmware V40.0.0: Network disconnection between local Ethernet interface X2 and CP. Note: There is no network disconnection between multiple local Ethernet interfaces and between multiple Ethernet interfaces on a CP. • With firmware higher than V40.0.0: Network separation between local and external Ethernet interfaces, between different external Ethernet interfaces and between the two interfaces of the CP1625-2.	
CPU 1508S (T)F [6]		

1 Absolute network disconnector between socket A and B:

a) If A and B belong to different local Ethernet interfaces (for example, X1 and X2) and no bridging is implemented at communication level 2 for these interfaces.

a) If either A or B are part of a local Ethernet interface and the other is part of a backplane bus module with an Ethernet interface (CP, CM), and no bridging is implemented at communication level 2 for these interfaces.

2 No network disconnector between socket A and B:

a) If A and B belong to the same local Ethernet interface (for example, X1).

b) If A and B both belong to a backplane bus module (CP, CM).

3 As of firmware V3.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

4 As of firmware V3.1, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

5 As of firmware V4.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

6 With firmware higher than V40.0.0 with configured CP1625-2 (in TIA Portal and Resource Configurator), the F-CPU is only a network disconnector between the two interfaces of the CP1625-2 if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

Even when using a communication network disconnector according to IEC 61784-3-3 (PROFIsafe standard), you must still ensure that the individual isolated networks are not connected by other standard components. See also this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).
Standard CPUs are generally not network disconnectors according to IEC 61784-3-3 (PROFIsafe standard).

Support of PROFIsafe V2 for PROFINET IO
Interfaces that support PROFINET IO also support PROFIsafe V2.

Support of PROFIsafe V2.4 for PROFIBUS DP
Interfaces that support PROFIBUS DP also support PROFIsafe V2.4 but not PROFIsafe V2.6.

Restriction with "CREAT_DB" and "DELETE_DB" instructions
F-DBs can neither be created nor deleted.

Restriction with "READ_DBL" and "WRIT_DBL" instructions
The destination address must not point to an F-DB.

Restrictions when configuring the retentive behavior of data blocks
The configuration of the retentive behavior of data blocks is not supported for F-DBs. This means that the actual values of the F-DBs will not be retentive in the event of POWER OFF/POWER ON and restart (STOP-RUN) of the F-CPU. The F-DBs retain the initial values from the load memory.
The "Retain" check box is grayed-out for all tags in F-DBs.

Configuration control (option handling) on an S7-1200 F-CPU G1
Configuration control (option handling) on an S7-1200 F-CPU G1 is possible with central modules subject to the following limitation:

- The fail-safe S7-1200 G1 modules cannot be swapped and must also always be physically inserted into their configured slot.

Position the fail-safe S7-1200 G1 modules directly next to the F-CPU. Position the standard modules on the right next to the fail-safe S7-1200 G1 modules.

Fail-safe runtime rights when using the user management (UMAC)
When using the user management (UMAC), you can assign the following fail-safe runtime rights:

- "Full access incl. fail-safe access" for use in the TIA Portal
- "Change parameter of the F-System (F-Admin)" for use in the web server environment

Procedure for loading a configuration for firmware < V2.0 for S7-1500 F-CPUs
If you have loaded an S7-1500 F-CPU with a configuration for firmware as of V2.0 with configured protection level "Full access incl. fail-safe (no protection)" and you now want to load a configuration for firmware <= V1.8 to this F-CPU, you must observe the following:
When the configuration with firmware <= V1.8 is loaded to the F-CPU, you will be prompted to enter the password and the entered password will be identified as invalid.
As a remedy, format the SIMATIC Memory Card as described in the online help for STEP 7 under "Formatting an S7-1500 memory card". You can then load the configuration for firmware <= V1.8 to the F-CPU.

Procedure for loading a configuration for firmware V4.1 S7-1200 F-CPUs G1
If you have loaded an S7-1200 F-CPU G1 with a configuration for firmware as of V4.5 with configured protection level "Full access incl. fail-safe (no protection)" and you now want to load a configuration for firmware 4.1 to this F-CPU, you must observe the following:
When the configuration with firmware V4.1 is loaded onto the F-CPU, you are prompted to enter the password and the entered password will be identified as invalid.
As a remedy, format the SIMATIC Memory Card if you are working with an external load memory (SIMATIC Memory Card). If you are working with the internal load memory, proceed as you would for a lost password. You can then load the configuration for firmware V4.1 to the F-CPU.

Migrating or upgrading to TIA Portal V17 or higher
When migrating or upgrading to TIA Portal V17 or higher and current firmware (S7-1500F V2.9/S7-1200F G1 V4.5), we recommend that you create a new backup file.
If the existing backup file is still used, an access authorization for the F-CPU may be required when restoring the software and hardware configuration of the F-CPU.

Use of isochronous mode interrupt (F-)OBs
The number of isochronous mode interrupt (F-)OBs depends on the F-CPU used. You can obtain information in the technical specification of the F-CPU.
If the sum of the isochronous mode interrupt OBs and the isochronous mode interrupt F-OBs exceeds the number specified in the technical specifications of the F-CPU, it is no longer possible to load the standard user program in RUN.

Supplement to syslog messages for F-CPUs
For F-CPUs S7-1500/S7-1200 G2 as of V4.1, at the event "SE_USER_PROGRAM_CHANGED" the collective F signature is entered in the syslog message. If the change is rejected, the previous collective F signature is entered.
For more information about the "Syslog messages" function, see:

- SIMATIC S7-1500/ET 200MP Automation System system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792) in the section "Syslog messages"
- Syslog messages product information (https://support.industry.siemens.com/cs/ww/en/view/109823696)

F-diagnostic messages with an S7-1500 HF CPU

NOTE
On a redundant system S7-1500HF, F-diagnostic messages are entered duplicated on both HF-CPUs (primary and backup CPU).
If one of the two HF CPUs is not available (e.g. STOP, POWER OFF, etc.), then the F-diagnostics is simply entered on the accessible HF CPU only. When the redundant HF-CPU returns, the diagnostics is duplicated again.

Download in Multiuser Commissioning mode

NOTE
When downloading in the Multiuser Commissioning mode, the serial number is read exclusively from the server project and compared to the linked F-CPU.
In the same manner the transferred serial number of the linked F-CPU is written back solely to the server project. The serial number from the local session is not used.

TIA Portal with CFC
STEP 7 Safety and F-CPUs with active F-functionality are not supported. You can use either CFC or the F-capability on an F-CPU.

Resetting a (T)F-CPU to factory settings

If you want to reset a (T)F-CPU online to factory settings including formatting of the SIMATIC Memory Card and are logged in with the password for "Full access (no protection)", the message "The device could not be reset" may be displayed.
Follow these steps:

1. Go to "Online und diagnostics".
2. Format the SIMATIC Memory Card under "Functions" with "Format memory card".
3. Enter the password for "Full access incl. fail-safe (no protection)".

Alternatively, follow these steps:

1. Go to the "Online" menu command. Select "Delete access rights".
2. Go to "Online und diagnostics".
3. Under "Functions", go to "Reset to factory settings".
4. Select "Format memory card".
5. Click on "Reset PLC".
6. Enter the password for "Full access incl. fail-safe (no protection)".

Requirements for power supplies in the event of voltage interruption

NOTE

To ensure adherence to IEC 61131-2 and NAMUR Recommendation NE 21, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirements in your product standards (e.g. 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).
These requirements, of course, also apply to power packs/power supply units not constructed using ET 200SP or S7-300-/400-/1500 technology.

Display (for S7-1500 F-CPUs with display)

S7-1500 F-CPUs with display show you the following in the "Overview" menu under "Fail-safe":

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled.
- Remaining runtime in deactivated safety mode (for F-CPUs FW V4.0 or higher)
- F-BaseID (for F-CPUs FW 4.1 or higher)
- Information on the F-runtime groups
  - Name of F-runtime group
  - F-runtime groups signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime
  - For F-CPUs from FW V3.0 to <V4.0 (valid from CPU 1511SP F-1 PN to CPU 1516F-3 PN/DP), "Remaining runtime in deactivated safety mode" is also displayed here.

The following is displayed for each F-I/O under "Fail-safe parameters":

- F-parameter signature (with addresses)
- safety mode (for F-CPUs with FW <V4.0)
- F-monitoring time
- F-source address
- F-destination address

The following additional menu command is displayed in the "Settings" menu under "Protection":

- Enable/disable F-password

Write access to F-blocks is not permitted.

NOTE

Controlling fail-safe inputs/outputs can result set the F-CPU to STOP.

NOTE

With the display firmware V2.5, the display is not refreshed and cannot be operated for a few minutes after loading program changes. Afterwards, the display restarts.

NOTE

In the case of a redundant S7-1500HF system, the display of the "Last fail-safe change" in the display and web server is only synchronized in the RUN-Redundant mode.

Web server/Web API

The F-CPUs S7-1200/1500 show you the following on the previous web pages (except S7-1200 G2) or the system web pages (except S7-1200 G1) of the web server and via the Web API:

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled. (Not supported by Web API).
- Remaining runtime in deactivated safety mode (not on the existing web pages)
- F-BaseID (not on the existing web pages)
- Information on the F-runtime groups
  - Name of F-runtime group
  - Remaining runtime in deactivated safety mode (only on existing web pages; in the case of Web API, the smaller of the two F-runtime groups is always returned.)
  - F-runtime groups signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime

The following is displayed for each F-I/O on the "Module Information" web page in the "Fail-safe" tab:

- F-parameter signature (with addresses)
- Safety mode (only on existing web pages; not supported by Web API).
- F-monitoring time
- F-source address
- F-destination address

Write access to F-blocks is not permitted.

NOTE

Controlling fail-safe inputs/outputs can result set the F-CPU to STOP.

The new system web pages on the F-CPUs S7-1200G2/S7-1500 only show information on the safety-related project data from FW V4.1 onwards.

To use a program card as external load memory with an S7-1200F G2, the following warning must be observed, contrary to the information in the "SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)" programming and operating manual:

⚠ WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 F-CPU G2:

1. Check whether **the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup when the card slot is empty.**
   If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as an external load memory), step 3 is skipped (except with FW V4.1.x) and you can skip step 5.
2. Insert the program card into the F-CPU.
   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. **After the restart, the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 5 can be skipped.
   Use one of the following variants to evaluate the program card:
   – Turn the F-CPU off and back on.
   – Remove and insert the program card.
   – Execute the "Memory reset" (MRES) function.
4. After the restart, the program card is evaluated. The F-CPU then enters the startup mode (RUN or STOP) that was set up for the F-CPU (variant 1 of step 3) or remains in STOP (variant 2 or 3 of step 3 or if step 3 was skipped because the internal load memory was empty).
5. Perform a program identification. *(S106)*

Application UI with API (for F-CPUs S7-1500V)

S7-1500V F-CPUs as of V2.1 show you the following in the menu "PLC" under "Failsafe" (the language of the S7-1500V UI is English):

- Safety mode activated/deactivated ("Safety mode")
- Collective F signature ("F-Signature")
- Last fail-safe change ("Last modification")
- Redundancy of the available Virtual Timeservices ("Virt. Timeservice redundant")
- ID of the last active Virtual Timeservice ("Last active Virt. Timeservice")

NOTE

The "Last modification" parameter in the UI or API of the S7-1500VF corresponds with the PLC time. Note that the PLC time in the virtualized environment does generally not correspond with the IE(V)D time. If you use the "Cyclic Retentive Backup" functionality, note that "Last modification" will be overwritten with the current timestamp when restoring the S7-1500VF.

NOTE

The "Virt. Timeservice redundant" parameter is returned in STOP of the S7-1500VF in the API as the Boolean value "false" and displayed in the WebUI as "-".

The following points relate to the S7-1500 F Virtual Controller

Information on the type tests

Edge-enabled devices are approved for use with the S7-1500 F Virtual Controller. With STEP 7 Safety, these are fail-safe even in the case of elevated electromagnetic interference. Special type tests for functional safety are therefore not required for these devices – unlike for F-I/O. With regard to availability, however, you must observe the application-specific requirements, especially the standards for burner control.

The following points relate to the S7-1500 F-Software Controller

The S7-1500 F Software Controller is a fail-safe software CPU that is used on the following devices and is also only approved for these devices:

S7-1500 F-Software Controller	Device as of V30.0 and below V40.0	Device with V40.0	Device as of V40.1
CPU 1505SP F	• CPU 1515SP PC(2)[1]	• CPU 1515SP PC(3)[1]	• CPU 1515SP PC(3)[1]
CPU 1505SP TF	• CPU 1515SP PC(2)[1]	---	• CPU 1515SP PC(3)[1]
CPU 1507S F	• IPC 427E[2] and IPC 477E[2] • IPC 627E[2], IPC 647E[2] and IPC 677E[2] • IPC 847E[2] • IPC 227G and IPC 277G[3] • IPC BX-39A[2] and IPC PX-39A (PRO)[2]	• IPC BX-59A[1]	• IPC BX-39A[1] • IPC BX-59A[1]
CPU 1508S F	• IPC 427E[2] and IPC 477E[2] • IPC 627E[2], IPC 647E[2] and IPC 677E[2] • IPC 847E[2] • IPC BX-39A[2] and IPC PX-39A (PRO)[2]	• IPC BX-59A[1]	• IPC BX-39A[1] • IPC BX-59A[1]
CPU 1508S TF	• IPC 627E[3] and IPC 677E[3]	---	• IPC BX-59A[1]

1 These devices support Fast Commissioning mode.

2 Can be used even without NVRAM memory, but Fast Commissioning mode is then not supported. If NVRAM is present and assigned to the SW Controller via the Resource Configurator Tool, then Fast Commissioning mode is supported.

3 Can be used even without NVRAM memory. Fast Commissioning mode is not supported.

The devices specified in the table above react in a fail-safe manner when the S7-1500 F-Software Controller and *STEP 7 Safety* are used, even in the case of elevated electromagnetic interference. Special type tests for functional safety are therefore not required for these devices – unlike for F-I/O. With regard to availability, however, you must observe the application-specific requirements, especially the standards for burner control.

The yellow adhesive label with the TÜV SÜD test mark for functional safety included in the scope of delivery is exclusively intended for use in connection with S7-1500 F-Software Controllers (not included in the download version of the product package). You can use the adhesive label to mark the hardware on which the S7-1500 F-Software Controller is installed. You must remove the adhesive label when you uninstall the S7-1500 F-Software Controller.

Backup and restore

Backup and restoration of project data is not supported.

NOTE

The Windows user "Everyone" is not taken into consideration if it is in the "Failsafe Operators" Windows user group.

TPM functionality

The TPM functionality cannot be used for S7-1500 F-Software Controllers because it could result in a STOP.

Using EWF or UWF and the EWF or UWF Manager

You cannot select EWF or UWF and the EWF or UWF Manager for the CPU volume.

Other particularities

NOTE

The NVRAM must inserted in an IPC before installation of an S7-1500 F Software Controller. If the NVRAM is inserted subsequently, the S7-1500 F Software Controller must be uninstalled and then reinstalled.

NOTE

No NVRAM is required for the operation of an S7-1500 F Software Controller as of firmware V40.0.

NOTE

If you want to start the import of the configuration file of an S7-1500 F Software Controller, the user performing the import must be in the "Failsafe Operators" (Windows) or "failsafe_operators" (Linux) user group.

NOTE

The lock symbol is only set in the panel if you have set up a standard password.

NOTE

For an S7-1500 F Software Controller on an IPC 627E, IPC 647E, IPC 677E or IPC 847E, you must use at least the BIOS version V25.02.10.

NOTE

The CPU clock must not be changed in RUN because this would result in a STOP. You can prevent this by disabling the energy-saving function.

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SIMATIC
Industrial software
PFDavg and PFH values according to IEC 61508:2010 for components with use in SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
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PFDavg and PFH values according to IEC 61508:2010 for components with use in SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems

This product information contains **important information on the F-systems SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems**. The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

PFD_{avg} and PFH values

The following tables contain the PFD_{avg} and PFH values for individual components with use in SIMATIC Safety (S), Distributed Safety (D), PCS neo Safety (N) and S7 F/FH Systems (F) with a repair time of 100 hours, an operational altitude of up to 2 000 m above sea level and, unless marked otherwise, an ambient temperature of 60 °C.

S7-1200/1500 F-CPUs	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
For all **S7-1200/1500 F-CPUs**	< 2E-05	< 1E-09 up to an operational altitude[1] of 3 000 m or < 2E-09 at an operational altitude[1] greater than 3 000 m up to 5 000 m	20 years	x	-	-	-

[1] Information on which F-CPU supports an operational altitude > 2 000 m can be found in the F-CPU Product Information (https://support.industry.siemens.com/cs/ww/en/view/109478599).

S7-300/400 F-CPUs	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
IM 151-7 F-CPU	6ES7151-7FA21-0-AB0	< 1.5E-05 < 3E-05	< 3.5E-10 < 3.5E-10	10 years 20 years	x	x	-	-
IM 151-8F PN/DP CPU	6ES7151-8FB01-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
IM 154-8F PN/DP CPU	6ES7154-8FB01-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
IM 154-8FX PN/DP CPU	6ES7154-8FX00-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 315F-2 DP	6ES7315-6FF04-0-AB0	< 2E-05 < 4E-05	< 5E-10 < 5E-10	10 years 20 years	x	x	-	-
CPU 315F-2 PN/DP	6ES7315-2FJ14-0A-B0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300/400 F-CPUs	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
CPU 317F-2 DP	6ES7317-6FF04-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 317F-2 PN/DP	6ES7317-2FK14-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 317TF-3 PN/DP	6ES7317-7UL10-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	-	x	-	-
CPU 319F-3 PN/DP	6ES7318-3FL01-0-AB0	< 1E-04 < 2E-04	< 3E-09 < 3E-09	10 years 20 years	x	x	-	-
CPU 414F-3 PN/DP	6ES7414-3FM06-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
	6ES7414-3FM07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 416F-2	6ES7416-2FN05-0-AB0	< 4.76E-05 < 9.52E-05	< 1.09E-09 < 1.09E-09	10 years 20 years	x	x	-	-
	6ES7416-2FP07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 416F-3 PN/DP	6ES7416-3FS06-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
	6ES7416-3FS07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 410-5H	6ES7410-5HX08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	x	x
		< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	x	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	x	x
CPU 410E	6ES7410-5HM08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 410SIS	6ES7410-5FM08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 412-5H PN/DP	6ES7412-5HK06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300/400 F-CPUs	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
CPU 414-5H PN/DP	6ES7414-5HM06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 416-5H PN/DP	6ES7416-5HS06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 417-5H PN/DP	6ES7417-5HT06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
WinAC RTX F based controller		< 1E-04	< 3E-09	10 years	x	x	-	-

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300 F-CPUs	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
For all F-CPUs	< 2E-04	< 3E-09 at an operational altitude[1] greater than 2 000 m up to 5 000 m	20 years	x	-	-	-

[1] Information on which F-CPU supports an operational altitude > 2 000 m can be found in the S7-300 Product Information: Use of (F-)CPUs at altitudes > 2,000 m (https://support.industry.siemens.com/cs/ww/en/view/109763261).

Safety-related communication	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
	< 1E-05[1]	< 1E-09[1]	20 years	x	x	x	x

1 **Note on S7-300/400 F-CPUs:**

The PFD_{avg} value is valid under the assumption that a maximum of 25 F-modules are involved in a safety function. If more than 25 F-modules are used, you need to add 3.5E-7 per F-modules for this safety function.

The PFH value is valid under the assumption that a maximum of 100 F-modules are involved in a safety function. If more than 100 F-modules are used, you need to add a 4E-12 1/h for each F-modules for this safety function.

S7-1200 F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
SM 1226 F-DI 16 x 24 VDC	6ES7226-6BA32-0-XB0	SIL 2: < 5E-04 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-10	20 years	x	-	-	-
SM 1226 F-DQ 4 x 24 VDC	6ES7226-6DA32-0-XB0	SIL 3: < 1E-05	SIL 3: < 4E-09	20 years	x	-	-	-
SM 1226 F-DQ 2 x Relay	6ES7226-6RA32-0-XB0	SIL 3: < 1E-05	SIL 3: < 4E-09	20 years	x	-	-	-

ET 200SP F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0-CA1	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	x[1]
F-AI 4xU 0..10V HF	6ES7136-6AB00-0-CA1	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	-
F-DI 8x24VDC HF	6ES7136-6BA00-0-CA0	SIL 3: < 2E-05	SIL 3: < 1E-09	20 years	x	x	-	x[1]
F-DI 8x24VDC HF	6ES7136-6BA01-0-CA0	SIL 3: < 2E-05	SIL 3: < 1E-09	20 years	x	x[4]	-	x[4]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0-CA0	SIL 2: < 2E-04[3] SIL 3: < 2E-05	SIL 2: < 1E-08[3] SIL 3: < 1E-09	20 years	x	x[2]	-	x[1]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB01-0-CA0	SIL 2: < 2E-04[5] SIL 3: < 2E-05	SIL 2: < 1E-08[5] SIL 3: < 1E-09	20 years	x	x[6]	-	x[6]
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0-CA0	SIL 3: < 6E-05	SIL 3: < 2E-09	20 years	x	x	-	x[1]
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0-BC0	SIL 2: < 2E-04[3] SIL 3: < 2E-05	SIL 2: < 1E-08[3] SIL 3: < 1E-09	20 years	x	x[2]	-	x[1]

1 Supports S2 redundancy with S7-400 H-CPUs

2 As of firmware version V2.0.0 can be used with GSD and S7-FCT

3 With deactivated dark test as of firmware version V2.0.0. A signal change is necessary at least once a year.

4 As spare part for 6ES7136-6BA00-0CA0

5 With deactivated dark test. A signal change is necessary at least once a year.

6 As a replacement part for 6ES7136-6DB00-0CA0

ET 200SP F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-RQ 1x24VDC/24..230VAC/5A	6ES7136-6RA00-0BF0	SIL 2: < 1E-04 With function test 1x per year	SIL 2: < 1E-08 With function test 1x per year	20 years	x	x	-	x[1]
		SIL 3: < 1E-05 With function test 1x per month	SIL 3: < 6E-09 With function test 1x per month	20 years	x	x	-	x[1]
F-TM Count 1x1Vpp sin/cos HF	6ES7136-6CB00-0CA0	SIL 1: < 2E-03 Signal monitoring deactivated SIL 3: < 3E-05	SIL 1: < 3E-08 Signal monitoring deactivated SIL 3: < 1E-09	20 years	x	-	-	-

1 Supports S2 redundancy with S7-400 H-CPUs

2 As of firmware version V2.0.0 can be used with GSD and S7-FCT

3 With deactivated dark test as of firmware version V2.0.0. A signal change is necessary at least once a year.

4 As spare part for 6ES7136-6BA00-0CA0

5 With deactivated dark test. A signal change is necessary at least once a year.

6 As a replacement part for 6ES7136-6DB00-0CA0

ET 200SP HA F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 16x24VDC HA	6DL1136-6BA00-0PH1	SIL 3: < 3E-05[1] SIL 3: < 2E-05[2]	SIL 3: < 2E-09[1] SIL 3: < 1E-09[2]	20 years	-	-	x	x
F-DQ 10x24VDC/2A PP HA	6DL1136-6DA00-0PH1	SIL 3: < 7E-05[1] SIL 3: < 5E-05[2]	SIL 3: < 2E-09[1] SIL 3: < 1E-09[2]	20 years	-	-	x	x
F-AI 8xI 2-/4-wire HART HA	6DL1136-6AA00-0PH1	SIL 3: < 2.7E-04 (< 9E-05 for 1oo2 voting in the F-CPU)[1] SIL 3: < 9E-05 (< 3E-05 for 1oo2 voting in the F-CPU)[2]	SIL 3: < 4E-09 (< 1E-09 for 1oo2 voting in the F-CPU)[1] SIL 3: < 1E-09 (< 1E-09 for 1oo2 voting in the F-CPU)[2]	20 years	-	-	x	x
F-DI 16xNAMUR HA	6DL1136-6TH00-0PH1	SIL 3: < 4.00E-05[1] SIL 3: < 2.00E-05[2]	SIL 3: < 1.00E-09[1] SIL 3: < 1.00E-09[2]	20 years	-	-	-	x

1 With use up to max. 70 °C.

2 With use up to max. 40 °C.

ET 200MP F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 16x24VDC	6ES7526-1BH00-0-AB0	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	-
F-DQ 8x24VDC/2A PPM	6ES7526-2BF00-0-AB0	SIL 3: < 6E-05	SIL 3: < 2E-09	20 years	x	-	-	-
F-AI 8xI 0(4)..20 mA	6ES7536-1MF00-0-AB0	SIL 3: < 4E-05	SIL 3: < 1E-09	20 years	x	-	-	-

ET 200eco PN F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12	6ES7146-6FF00-0-AB0	1-channel input: SIL 2: < 6E-04 2-channel input: SIL 3: < 1E-05 Output channel: SIL 3: < 2E-05	1-channel input: SIL 2: < 1E-08 2-channel input: SIL 3: < 2E-10 Output channel: SIL 3: < 7E-09	20 years	x	x[1]	-	x[1]
4x F-DI + 2x F-DQ + 4x DIQ + CM IO-Link M12L	6ES7146-6FF00-0-BB0[2]	F-DI SIL 2: < 8E-05 SIL 3: < 7E-05 F-DQ SIL 2< 3E-04 SIL 3< 8E-05	F-DI SIL 2: < 1E-09 SIL 3: < 6E-10 F-DQ SIL 2: < 5E-09 SIL 3: < 4E-09	20 years	x	x	-	x

1 Can be used with GSD and S7-FCT

2 Can be used up to 5 000 m above sea level

ET 200AL F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
ET 200AL F-DI 4+F-DQ 2x24VDC/2A, 4xM12	6ES7146-5FF00-0-BA0	1-channel input: SIL 2: < 1E-03 2-channel input: SIL 3: < 1E-05 Output channel: SIL 2: < 1E-03[1] SIL 3: < 2E-05	1-channel input: SIL 2: < 1E-08 2-channel input: SIL 3: < 1E-09 Output channel: SIL 2: < 1E-07[1] SIL 3: < 1E-08	20 years	x	-	-	-

[1] With deactivated dark test

S7-300/ET 200M F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
SM 326; DI 24 x DC24V	6ES7326-1BK02-0-AB0	SIL 2: < 8E-04 (alternative: SIL 2: < 1E-05 + 3.5E-05 per input) SIL 3: < 2E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; DI 8 x NAMUR	6ES7326-1RF01-0-AB0	SIL 2: < 1E-03 (alternative: SIL 2: < 2E-05 + 1.3E-04 per input) SIL 3: < 3E-05	SIL 2: < 2E-08 SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; F-DO 10 x DC 24V/2A PP	6ES7326-2BF10-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; DO 8 x DC 24V/2A PM	6ES7326-2BF41-0-AB0	SIL 3: < 1E-05	SIL 3: < 3E-09	20 years	x	x	-	x
SM 336; F-AI 6 x 0/4...20mA HART	6ES7336-4GE00-0-AB0	1-channel: SIL 3: < 1E-04 2-channel: SIL 3: < 1E-05	1-channel: SIL 3: < 1E-08 2-channel: SIL 3: < 1E-09	20 years	x	x	-	x

Fail-safe I/O S7-300/ET 200M F-MTA	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
6-Channel F Analog Input HART MTA	6ES7650-1AH62-5-XX0	Channel: SIL 3: 6.17E-05	Channel: SIL 3: 1.90E-09	10 years	x	x	-	x
		Channel: SIL 3: 1.45E-04		20 years				
12/24-Channel, 24 VDC F Discrete Input MTA	6ES7650-1AK11-7-XX0	Channel: SIL 2: 0 SIL 3: 0	Channel: SIL 2: 0 SIL 3: 0	20 years	x	x	-	x
10-Channel, 24 VDC F Discrete Output MTA	6ES7650-1AL11-6-XX0	Channel: SIL 3: 0	Channel: SIL 3: 0	20 years	x	x	-	x
Failsafe 10-Channel, 24-150 VDC/120-230VAC Relay Output MTA	6ES7650-1AM31-6-XX0	Channel: SIL 2: 2.53E-02	Channel: SIL 2: 5.77E-07	10 years	x	x	-	x
		Channel: SIL 2: 5.06E-02		20 years				

ET 200S F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
4/8 F-DI DC24V PROFIsafe	6ES7138-4FA05-0-AB0	SIL 2: < 1E-03 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
4 F-DO DC24V/2A PROFIsafe	6ES7138-4FB04-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
4 F-DI/3 F-DO DC24V PROFIsafe	6ES7138-4FC01-0-AB0	SIL 2: < 1E-03	SIL 2: < 1E-08	20 years	x	x	-	x
PM-E F pm DC24V PROFIsafe	6ES7138-4CF03-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
PM-E F pp DC24V PROFIsafe	6ES7138-4CF42-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
PM-D F DC24V PROFIsafe	3RK1903-3BA02	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x

With a mission time of 20 years, the following values apply to the 1 F-RO DC24V/AC24..230V/5A 6ES7138-4FR00-0AA0:

Load according to IEC 60947-5-1 DC13/AC1-5	Current	Average max. permitted switching cycles	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	S	D	N	F
DC13	I <= 5 A	1 time per day	< 4E-05	< 1E-09	x	x	-	x
		3 times per day	< 1.2E-04	< 2E-09	x	x	-	x
	I <= 2.5 A	1 time per day	< 3E-05	< 1E-09	x	x	-	x
		3 times per day	< 8E-05	< 1E-09	x	x	-	x
	I <= 1.25 A	1 time per day	< 2E-05	< 1E-09	x	x	-	x
		3 times per day	< 5E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 8E-09	x	x	-	x
AC15	I <= 3 A	1 time per day	< 2E-05	< 1E-09	x	x	-	x
		3 times per day	< 5E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 7E-09	x	x	-	x
	I <= 1.5 A	1 time per day	< 1E-05	< 1E-09	x	x	-	x
		3 times per day	< 3E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 4E-09	x	x	-	x

Within the range of validity of the machinery directive or IEC 62061:2021, SIL3/Cat.4/PLe requires the readback of process states and at least monthly signal change.

F-I/O ET 200pro	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
8/16 F-DI DC24V PROFIsafe	6ES7148-4FA00-0-AB0	SIL 2: < 1E-03 SIL 3: < 2E-05	SIL 2: < 2E-08 SIL 3: < 1E-09	20 years	x	x	-	x
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe	6ES7148-4FC00-0-AB0	SIL 2: < 1E-03 SIL 3: < 2E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
F-Switch PROFIsafe	6ES7148-4FS00-0-AB0	SIL 2: < 1E-03 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x

F-I/O ET 200eco	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
4/8 F-DI DC24V PROFIsafe	6ES7148-3FA00-0-XB0	SIL 2: < 8E-04 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x

F-I/O ET 200iSP	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
EM138 8 F-DI Ex NAMUR	6ES7138-7FN00-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	x	x
EM138 4 F-DO Ex 17,4V/40mA	6ES7138-7FD00-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	x	x
EM138 4 F-AI Ex HART	6ES7138-7FA00-0-AB0	1-channel: SIL 3: < 1E-04 2-channel: SIL 3: < 1E-05	1-channel: SIL 3: < 1E-08 2-channel: SIL 3: < 1E-09	20 years	x	x	x	x

Fail-safe GSD based DP standard slaves Fail-safe GSD based IO devices Fail-safe PA field devices Fail-safe HMI devices	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
Fail-safe GSD based DP standard slaves: See technical specifications for fail-safe GSD based DP standard slave							
Fail-safe GSD based IO devices: See technical specifications for fail-safe GSD based IO device							
Fail-safe PA field devices: See technical specifications for fail-safe PA field device							
Fail-safe HMI devices: See technical specifications on the fail-safe HMI device							
Other fail-safe devices: See technical specifications on the fail-safe device							

Determine the contribution of the F-system to the PFD_{avg} and PFH values

The contribution of the fail-safe system to the PFD_{avg} and PFH values of a safety function is determined by adding the PFD_{avg}- and PFH values of the F-CPUs and F-I/Os involved.

The contribution of the safety-oriented communication is added to this. Note that several F-systems can be involved in a safety function.

You determine the PFD_{avg} and PFH values of a safety function by adding the contribution of the fail-safe system to the contribution of the encoders and actuators involved in the safety function.

Calculation example

A safety function is implemented with a SIMATIC Safety F-system. The F-CPU and fail-safe modules listed in the following table are involved in the safety function.

20 years was selected as the mission time. The fail-safe modules are in safety mode for SIL3/Cat.4/PLe. Operation is in high demand mode:

F-CPU, F-modules and safety-related communication involved in the safety function	Quantity	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]
F-CPU S7-1500	1	1E-09
F-DQ 8x24VDC/2A PPM 6ES7526-2BF00-0AB0	1	2E-09
F-DI 16x24VDC 6ES7526-1BH00-0AB0	2	2 x 1E-09
Safety-related communication		1E-09
Total		**6E-09**

SIEMENS

SIMATIC

ET200SP Safety engineering with AS-Interface in the SIMATIC ET 200SP, including typical circuit diagram

Function Manual

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Commissioning and operation 5

Appendix 6

08/2020

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Legal information

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1.1 Legal information

Using the application examples

The application examples illustrate automation task solutions with the interaction of several components in the form of text, graphics and/or software blocks. The application examples are a free-of-charge service provided by Siemens AG and/or a subsidiary company of Siemens AG ("Siemens"). They are not binding and do not claim to be complete or functional with regard to configuration or equipment. The application examples do not represent customer-specific solutions, but rather, only provide help for typical tasks. You are responsible for the proper and safe operation of products in compliance with the applicable regulations. You must check the function of the associated application example and adapt it specifically to your system.

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed here (https://www.siemens.com/industrialsecurity).

About this documentation 2

2.1 Additional documentation

This documentation and the associated sample files are available free of charge in the Internet (http://support.automation.siemens.com/WW/view/en/109769506) for downloading.

2.2 Purpose of the documentation

This documentation provides the introduction to communication via the AS-Interface and AS-i Safety, and uses a typical circuit diagram to show how safety functions can be implemented with AS-i in the ET 200SP distributed I/O system.

Further information on the topic of AS-i can be found in the AS-i System Manual (https://support.automation.siemens.com/WW/view/de/51579885) and on the Internet (https://www.siemens.com/as-interface).

2.3 Target group

This documentation contains information for the following target groups:

- Decision makers
- Technologists
- Configuration engineers
- Commissioning engineers

2.4 Required knowledge

A general knowledge of the following areas is needed to understand this documentation:

- Low-voltage controls and distribution
- Digital circuit logic
- Automation technology
- AS-Interface
- Safety engineering
- SIMATIC STEP 7 or TIA Portal

Introduction 3

3.1 AS-Interface

3.1.1 AS-Interface basics

AS-Interface is an industrial fieldbus system and international standard in accordance with IEC/EN 62026-2.

AS-Interface (in short: AS-i) stands for "Actuator Sensor Interface". It was developed to connect numerous individual sensors and actuators in a system to the PLC as simply as possible:

- Straightforward bus system with space-saving slave modules directly in the field
- Data transmission and power supply over a single unshielded 2-wire flat cable
- Extremely fast installation and integrated fast connection system (insulation piercing method)
- Real-time capable system response time
- Economically attractive replacement for elaborate cable harnesses

AS-Interface transmits standard signals and safe signals, e.g. for safety doors or emergency stop buttons, together on one AS-i cable.

With safety-related sensors in particular, the savings potential can be fully exploited because the dual cabling for two-channel safety sensors is only necessary up to the safe AS-i input module.

For safety sensors with integrated AS-i interface, the sensor cables and their protected routing are completely eliminated.

The safe AS-i signals are transmitted directly to a safe PLC, where they can be further processed.

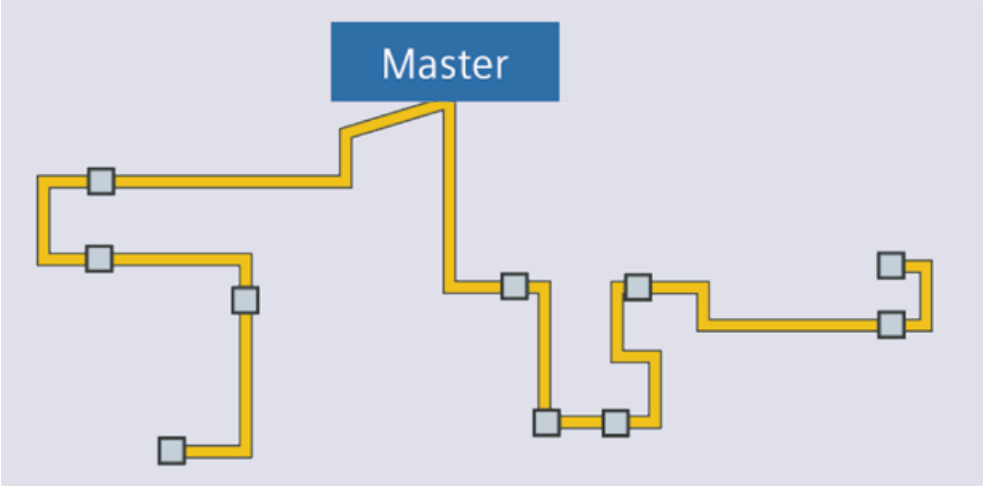
Siemens AS-i masters and Siemens AS-i modules are integrated in SIMATIC STEP 7, and can be inserted into the configuration at the click of a mouse.

- Familiar work environment since the procedure for the AS-Interface network configuration with Siemens AS-i modules is the same as for other SIMATIC components.
- Problem-free data management and documentation because the configuration of the Siemens AS-i master and the associated AS-i network along with all other SIMATIC controller components is stored in one STEP 7 project.
- In the STEP 7 program, the AS-i signals are accessed in the same way as by other I/O modules.
- Safe AS-i signals are easily forwarded to the F-CPU or SINUMERIK via the Siemens F-CM AS-i Safety ST module, without external PC programs or additional file management.

3.1.2 Network structure

Linear, star, and tree topologies are supported by the AS-Interface, making assembly practical with hardly any restrictions.

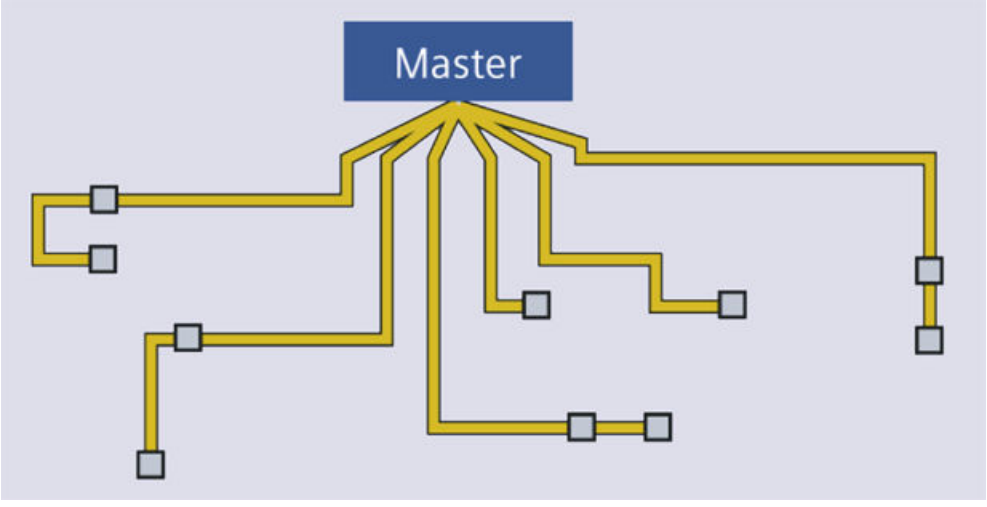
Linear structure



Nodes

All devices are connected to a continuous cable.

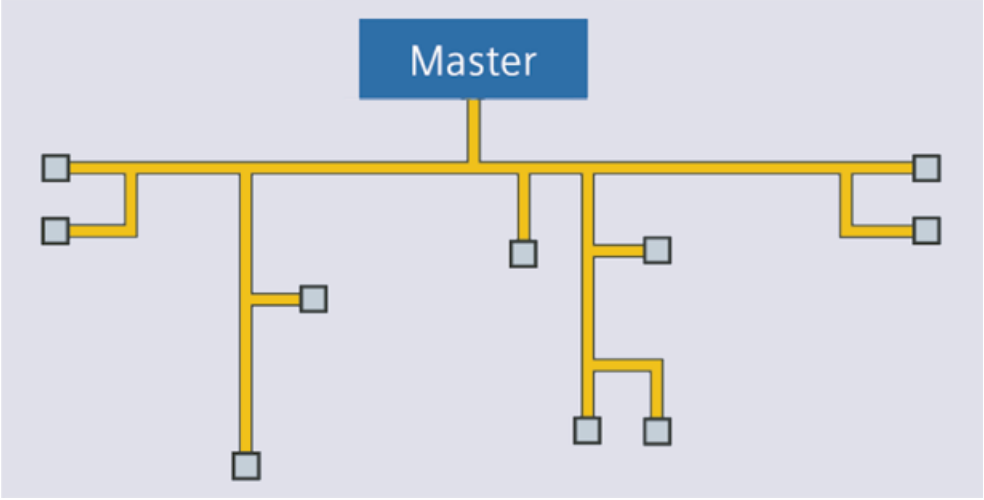
Star structure



Nodes

The nodes are connected to one another in a star-shaped structure.

Tree topology



Nodes

The tree topology is similar to the star topology, but with any number of branches.

3.1.3 Creating an AS-Interface network

An AS-i network always comprises a master, an AS-i power supply unit, and the AS-i slaves. AS-i is a single master system, i.e. a master module collects the data from multiple AS-i slaves and transfers it to the process image of the PLC. From the perspective of the PLC CPU, the AS-i master acts like an I/O module with numerous inputs and outputs.

AS-i master and AS-i slaves are connected to one another via an AS-i cable. The AS-i master and the AS-i slaves are positioned freely on the cable.

The AS-i cable has only two wires: ASI+ and ASI–. The AS-i master and all AS-i slaves only have to be connected to these two wires. Slaves in the IP65 version are easily connected to the AS-i flat cable.

To supply power to the AS-i network, an AS-i power supply unit can be connected to the AS-i cable at any position.

The AS-i power supply unit contains a data decoupling circuit that enables the AS-i communication signals and the direct voltage to supply the modules and sensors to run on the same AS-i cable. Parallel connection of two AS-i power supply units is not permissible. This is in order to maintain the function of the data decoupling.

In an AS-i network with repeaters, a new segment is inserted downstream of each repeater; each repeater requires a separate AS-i power supply unit.

The AS-Interface is designed as a single-master system with cyclic polling.

An AS-i network always contains only one master, which queries the data of all the nodes at regular, defined intervals.

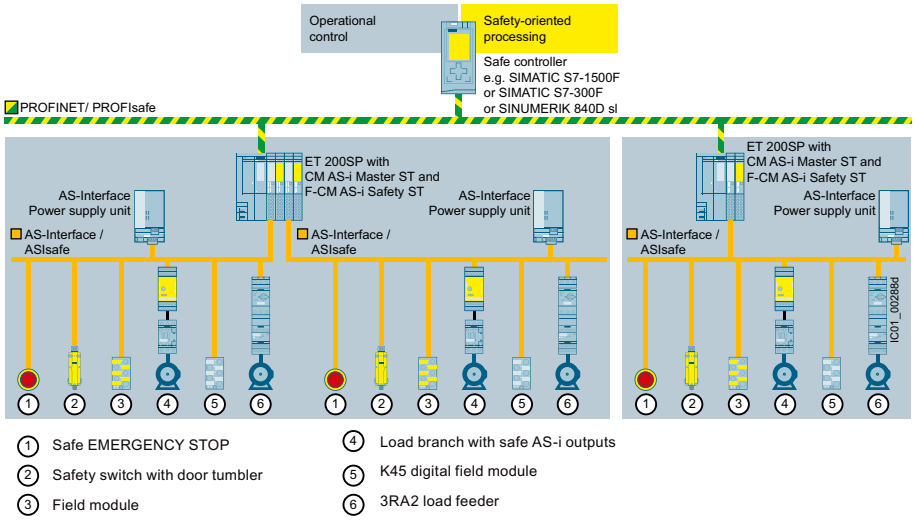


Figure 2-4 AS-Interface configuration with AS-i Master modules in the ET 200SP

3.1.4 Number of nodes

An AS-i network contains a maximum of 62 slaves with unique AS-i addresses. The AS-i master can manage 31 different addresses for the data exchange, whereby it can subdivide and reference each address as an A address or B address.

Slaves with standard addressing can be set to an address in the range 1 ... 31.

Slaves with extended addressing have address numbers followed by A or B. They are set to an address in the range 1A ... 31A or 1B ... 31B (often referred to as A/B slaves for short).

All slaves, whether with standard or extended addressing, are operated together on one AS-i network. The AS-i master automatically manages the addresses.

Backup AS-i slaves always use standard addressing. Slaves with standard addressing or extended addressing can be used for acknowledgment and other non-safety-related signals.

3.1.5 Network extension

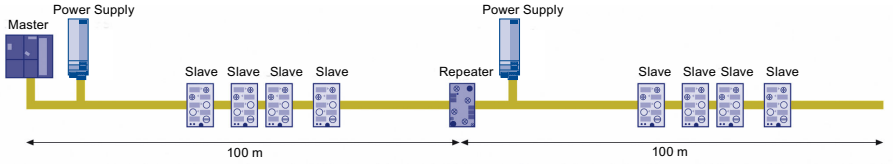


Figure 2-5 Network extension – previously a maximum of 100 m per segment

An AS-i line can be up to 100 m long without additional components. Repeaters can be used to increase the maximum possible cable length. Two repeaters can be connected in series, which can extend the network to 300 m as a linear structure. A separate AS-i power supply unit must be provided in each new segment.

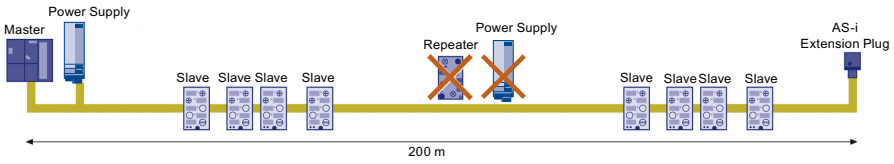


Figure 2-6 Network extension - now with AS-i extension plug, max. 200 m per segment

An extension plug can be used to double the length of an AS-i line to 200 m. Repeaters cannot be connected in series when they are used in conjunction with AS-i extension plugs. A maximum distance of 400 m between the master and slave and a total cable extension of 600 m can be achieved by using 2 repeaters and one extension plug per segment (master in the middle of the network). Repeaters can be connected in parallel in a star configuration, each with up to 200 m long segments.

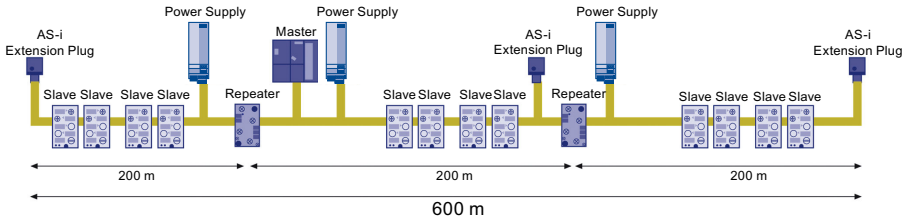


Figure 2-7 The maximum network extension with an AS-i extension plug is 200 m per segment, with only one repeater connected in series between master and any slave.

3.1.6 AS-i Safety

AS-i Safety enables safety-related components – such as EMERGENCY-STOP devices, protective door switches or safety light arrays – to be integrated in an AS-Interface network. The safety-related slaves are fully compatible with the familiar AS-Interface components (masters, slaves, power supplies, repeaters, etc.) in accordance with IEC 62026-2 and are operated in conjunction with them on the yellow AS-Interface cable.

The transmission method for safety-related signals is approved for applications up to PL e according to EN ISO 13849-1 and up to SIL 3 according to EN 62061.

As usual, nodes on the AS-Interface bus are controlled in operation by the standard program of the higher-level SIMATIC (F) CPU or by a SINUMERIK controller.

In order to implement safe functions, the information from the safe and standard nodes must be combined logically, and additional parameters set. The configuration of the safety functions depends on which safety solution is being used:

In conjunction with the modular safe AS-i master, which is formed by combining the CM AS-i Master ST and F-CM AS-i Safety ST modules in an ET 200SP station, all safety functions and combinations are configured via STEP 7 and processed in the controller (F-CPU) by the fail-safe program.

The AS-i communication modules in the ET 200SP facilitate the use of an AS-Interface under fail-safe SIMATIC or SINUMERIK controllers.

Tasks are allocated as follows:

- Acquisition of safety-related signals is via safe input slaves on the AS-Interface bus. Further signals can be detected through F-DI modules of the SIMATIC.
- Evaluation and processing of signals is via the fail-safe SIMATIC or SINUMERIK controller
- Reaction via safe output modules on the AS-Interface bus or via F-DQ modules of the SIMATIC

Simple combination of the CM AS-i Master ST and F-CM AS-i Safety ST modules in one ET 200SP station results in a powerful, safety-related router between PROFINET (or PROFIBUS) and PROFIsafe and AS-Interface, which can be expanded further in a modular fashion with further I/O modules of the ET 200SP.

In this way, it is possible to create expansion versions for almost all cases. Besides the single AS-i master, double, triple or generally multiple masters can also be realized with or without fail-safe functionality.

NOTE

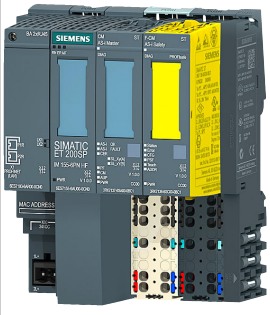
The SIRIUS 3RK3 modular safety system, MSS for short, with connection to AS-Interface can be used for a safety application without a fail-safe controller (F-CPU). This system is not covered in this documentation. Further information can be found on the Internet (http://www.siemens.de/sirius-mss).

AS-i Safety is also referred to as ASIsafe.

3.2 AS-i Safety product overview

This section provides an overview of ASIsafe components as well as the accessories available to help you assemble, install, and use these components. The tables contain images of the products and their features.

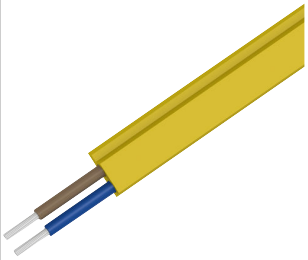
AS-i safety components

Product	Features
F-CM AS-i Safety ST and CM AS-i Master ST 	Expansion of a standard AS-Interface network to include safety-related communication through an F-CM AS-i Safety ST fail-safe communication module. The F-CM AS-i Safety ST module has no AS-i master functionality. A CM AS-i Master ST module is required for operation of the AS-i network. • Gateway between PROFIsafe and ASIsafe, without master functionality • Expands a standard AS-i network to include safety-related communication (ASIsafe) • Monitoring of up to 31 safety-related input slaves • Control of up to 16 safety-related AS-i output slaves or switch-off groups • Power supplied from the AS-i voltage • Various interconnection types (1oo1 and 1oo2) may be used • A parameterizable input delay from 0 ms to 150 ms can be assigned to each channel • Startup test can be activated for each channel • Discrepancy monitoring can be configured for each channel • Sequential monitoring can be set for each channel • Channel-wise passivation

	• Test for 0 signal before reintegration • 8 LED displays for status and error diagnostics
Safe modules  K45F K20F SlimLine Compact	Easy integration of safe signals, both in the control cabinet and in the field • IP65 / IP67 or IP20 degree of protection • Compact dimensions from a width of 17.5 mm • Inputs: – Two single-channel inputs / one two-channel input – Four single-channel inputs / two two-channel inputs • Standard position switch or magnetically operated switch can be connected • Versions also available with two standard outputs
3SU1 EMERGENCY STOP command devices 	Simple, direct connection of tried-and-tested command devices to ASIsafe • Enclosure with IP65 / IP67 degree of protection • EMERGENCY STOP directly on AS-Interface via integrated modules • Metal or plastic version • Any combination of pushbuttons, indicator lights, and toggle switches can be controlled with just one cable • AS-i F adapter in IP20 degree of protection
3SF1 position switches Position switches With tumbler 	Conventional wiring of safety functions no longer required • IP65 degree of protection • Direct connection of position switches to AS-i • Available with separate actuator or tumbler • Encased in plastic or metal

System components and accessories

Function / product	Properties
Power supply units and data decoupling 	The AS-i power supply unit allows the simultaneous transmission of data and power on the same two-wire line. Alternatively, a combination of a standard power supply unit and AS-i data decoupling can be used. • Various levels (3 A, 5 A, 8 A etc.) • Ground fault detection included • AS-i power supply unit (30 V) with integrated data decoupling • 30 V power supply units without data decoupling • AS-i data decoupling modules

Addressing unit for commissioning 	Simple address assignment to the slaves with wiring test during commissioning • Addressing of all nodes in the AS-Interface network (standard and A/B slaves) • Readout of the slave profile (IO, ID, ID2) and ID1 code • Adjusting the slave parameters for commissioning • Measurement of the AS-Interface voltage • Enables direct setting of outputs and reading in of inputs in a slave • Readout of the code table of safe input slaves • Saving of complete plant configurations
Analyzer for maintenance and service 	Quality assessment of an AS-Interface network with report printout and frame recording for on-site and remote diagnostics • Checks quality and proper functioning of AS-Interface installation • Transfers data to a PC/PG via an RS 232 interface • Software-based evaluation • Automatic generation of test reports • Advanced trigger functions for accurate analysis • Bundle error display for support of preventive diagnostics • Process data can be monitored online
Cable 	Rapid replacement and connection to AS-Interface thanks to piercing technology • Trapezoidal profile prevents reverse polarity • Cables for various application conditions made of correspondingly optimized material
Range extension Extension plug  Repeater 	Lower infrastructure costs, more possibilities of use and greater freedom for plant planning • Extension of an AS-i segment to a max. of 200 m with extension plug (without additional power supply unit) • Extension by one bus segment with AS-i Repeater Maximum combined extension increases to 600 m or more (with parallel connection of repeaters)

Compact distributor  **M12 branches** 	Quick and easy distribution and branching to the AS-i shaped cable • Simple distribution/connection of AS-i shaped cable with high degree of protection • Branching from AS-i and U_{aux} to round cable • Connection of slaves with M12 bus connection • M12 branch with direct M12 socket or M12 round cable available • Easy to use
Overvoltage protection 	Protection against overvoltage on AS-i • Special module: Overvoltage protection

NOTE

Ground fault detection is integrated into the CM AS-i Master ST, AS-i power supply units and the data decoupling unit

Circuit diagram example

4

4.1 Knowledge required

The following application example shows how conventional safety functions, such as emergency stop shutdown and protective door monitoring in the ET 200SP system can be configured and programmed with AS-Interface via the TIA Portal.

Knowledge required

The following knowledge and skills are required:

- Fundamentals of functional safety
- Fundamentals of AS-Interface
- Fundamentals in STEP 7 programming

4.2 Operating principle

4.2.1 Overview

Protective doors are frequently used to fence off danger zones. These are monitored for position and, if necessary, the area from which the hazard emanates is switched off. If the machine continues to present a hazard even after switching off, access can be prevented for this period by a tumbler. An emergency stop command device is additionally monitored for shutting down the machine in an emergency. CM AS-i Master and F-CM AS-i Safety are used to connect to the fail-safe controller.

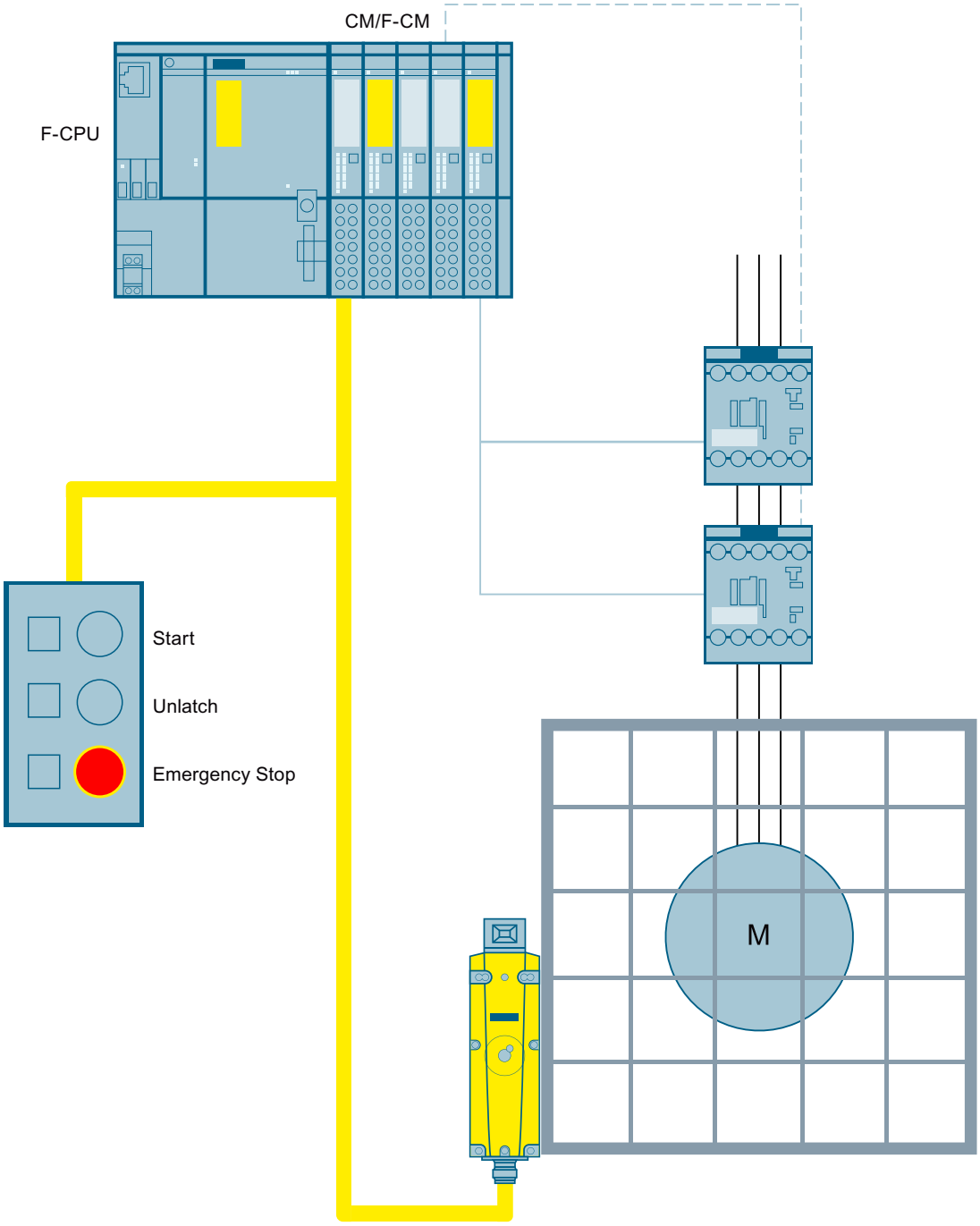


Figure 2-8 Circuit diagram example

The fail-safe controller monitors the emergency stop command device and the safety switch on two channels. Both devices have an integrated AS-i slave and are thereby connected to the AS-Interface. The two signals are transmitted to the fail-safe controller using the combination of CM AS-i Master and F-CM AS-i Safety (ET 200SP station modules).

The protective door position is monitored by a safety switch. In addition, the door is locked by means of a tumbler integrated in the safety switch. When the command to release the door is issued by means of a toggle switch, safety switch-off of the power contactors takes place via the fail-safe controller. On expiry of a set time, the tumbler is unlocked and access to the machine is enabled.

After the door has been closed and locked again, and the feedback circuit of the power contactors is closed, the Start button can be used to switch on again. When the emergency stop command device is actuated, the fail-safe controller also switches off the power contactors in a safety-related way. If the emergency stop command device is reset and the feedback circuit is closed, the Start button can be used to switch on again. Start pushbuttons and toggle switches are also read in via the AS-Interface.

The "Stopping in an emergency" safety function is designed up to SIL 3 or PL e.

The "Protective door monitoring" safety function is designed up to SIL 2 or PL d.

Safety function	Description	Requirement
SF1	If the emergency stop command device is actuated, the machine is shut down safely.	SIL 3 or PL e
SF2	If the protective door is opened, the machine is shut down safely.	SIL 2 or PL d

NOTE

Non-safety-related tumbler via integrated standard output of 3SF1324-1S.21-1BA4: The protective door tumbler is not a safety function (non-safety-related control of the solenoid). It can be used to safeguard the production process.
If during the risk assessment a safety level for the tumbler was defined in addition to the protective door monitoring, it is then possible to use a mechanical safety position switch with tumbler 3SE53 without an integrated AS-i slave. This means that control of the tumbler solenoids can take place via a fail-safe digital output on the F-PLC, for example.

NOTE

Taking account of fault exclusions, the use of only one safety switch with or without tumbler is permissible up to SIL 2 or PL d. Further information is contained in the PDF under the following link "concerning the use of safety switches up to SIL 2 or PL d (http://support.automation.siemens.com/WW/view/de/35443942)".

4.2.2 Emergency stop

The emergency stop command device is a component that is widely used to protect people, equipment and the environment against possible hazards, and to initiate stopping in an emergency. Equipment, functional aspects and design guidelines for emergency stop are listed in EN ISO 13850. The EN 60204-1 standard must also be observed.

The emergency stop command device with its two positive opening contacts is monitored by the F-CPU. If the emergency stop is actuated, the F-CPU switches the downstream actuators off via safe outputs in accordance with Stop Category 0 as per EN 60204-1. Before restarting or acknowledging the emergency stop shutdown, a check is made as to whether the contacts of the emergency stop command device have been closed and the feedback circuit of the downstream actuators is closed.

To connect the two normally closed contacts of the emergency stop command device to the AS-i bus, an AS-i interface module with two safe inputs (3SU1401-2EE60-6AA0) is installed in the enclosures of the command devices.

NOTE

Emergency stop is not a way of reducing the risk. "Emergency stop" is a supplementary safety function. (When "emergency stop" is operated, the motor must be shut down).

4.2.3 Monitoring the position of the protective door and tumbler function

The position of the protective door is monitored by a SIRIUS 3SF1 position switch. The position switch detects the position of the protective door by a separate actuator. This moves into the position switch when the protective door closes.

The SIRIUS 3SF1 position switch also contains an integrated tumbler which can keep the protective door closed during operation and thus prevent entry into the danger zone. An actuator mounted on the protective door moves into the positively-driven position switch with tumbler. The SIRIUS 3SF1 position switch with tumbler used here has a spring-actuated lock. This means that door is held shut in the de-energized state and the door is unlocked by applying a voltage.

Operating principle: If the door is closed and no voltage is applied, a locking mechanism moves into the separate actuator, which prevents the door from being opened. If a voltage is applied, the locking mechanism is drawn out of the separate actuator by a solenoid, which unlocks the tumbler.

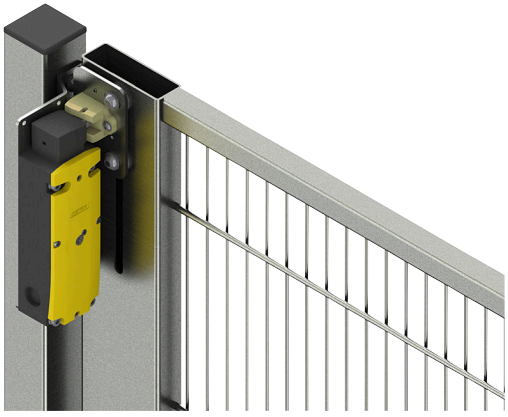


Figure 2-9 Position switch with tumbler

The SIRIUS 3SF1 position switches are equipped with mechanical protection against incorrect locking. This ensures that the door or locking mechanism can only be locked if the door is closed.

The SIRIUS 3SF1 position switch has an integrated AS-i slave, in contrast to the 3SE5 standard position switch.

Two contacts are evaluated internally in order to reach the required (SIL 2 or PL d) safety level. If one of the contacts is defective, opening of the protective door is still detected by the second contact. Failure of a contact is detected by a discrepancy monitor, which prevents a renewed switch on until the fault has been rectified.

There are basically three different combinations for forwarding the contacts of the AS-i position switch with tumbler as ASIsafe channel 1 and 2 to the controller for evaluation:

3SF13 version	ASIsafe channel 1	ASIsafe channel 2
3SF13 ... 1BA1	1st normally closed contact of actuator	Normally closed contact of solenoid
3SF13 ... 1BA3	1st normally closed contact of actuator	2nd normally closed contact of actuator
3SF13 ... 1BA4	1st and 2nd normally closed contacts of actuator	Normally closed contact of solenoid

Version 3SF13 ... 1BA3

In the 1BA3 version, both ASIsafe channels are supplied with a normally closed actuator contact. The signaling contact of the solenoid for the tumbler is not taken into account. This means that the user program cannot be used to evaluate whether the door is actually locked (diagnostics not possible). The 1BA3 version must be parameterized in the TIA Portal as 1oo2 (equivalent). The discrepancy time must be adapted to the conditions where the position switch is installed. The default setting of the discrepancy time (500 ms) is normally suitable for this position switch.

Version 3SF13 ... 1BA1

In contrast to the 1BA3 version, the signaling contact (normally closed contact) of the solenoid is evaluated as the second ASIsafe channel in the 1BA1 version. This means that the user program can be used to evaluate whether the door is actually locked (diagnostics possible). However this means that the two ASIsafe channels run asynchronously, resulting in the following requirement on the machine operator:
Each time unlocking the door is requested, the door also has to be opened. In the parameter assignment of the position switch, a 1oo2 evaluation (equivalent) must be set with the "Discrepancy time unlimited" option, whereby the F-CM AS-i Safety module expects a zero crossing of both ASIsafe channels before reclosing becomes possible. Therefore, in the case of a door release request without subsequent door opening, the F-CPU would prevent a hot restart of the machine.

Version 3SF13 ... 1BA4

In the 1BA4 version, for the first ASIsafe channel both normally closed contacts of the actuator are already linked in the switch and automatically evaluated for discrepancy. Therefore, for this version it must be ensured that the discrepancy analysis is deactivated (1oo1 evaluation) in the configuration of the AS-i slave in the TIA Portal. The signaling contact (normally closed contact) of the solenoid is evaluated as the second ASIsafe channel. This means that the user program can be used to evaluate whether the door is actually locked (diagnostics possible). The 1BA4 version of the 3SF1 position switch thus offers the advantage that with a door release request the door does not then have to be opened immediately. Nevertheless, malfunctioning of the tumbler solenoid can still be diagnosed by evaluating the signaling contact.

For this reason, a 1BA4 version of the 3SF1 position switch is used in the application example described here.

See the figure below:

- 1st normally closed contact of actuator (state: door closed): 11 / 12
- 2nd normally closed contact of actuator (state: door closed): 21 / 22
- Normally closed contact / signaling contact of the solenoid (state: tumbler active): 41 / 42
- Control of the solenoid (state: door release inactive): E1 / E2

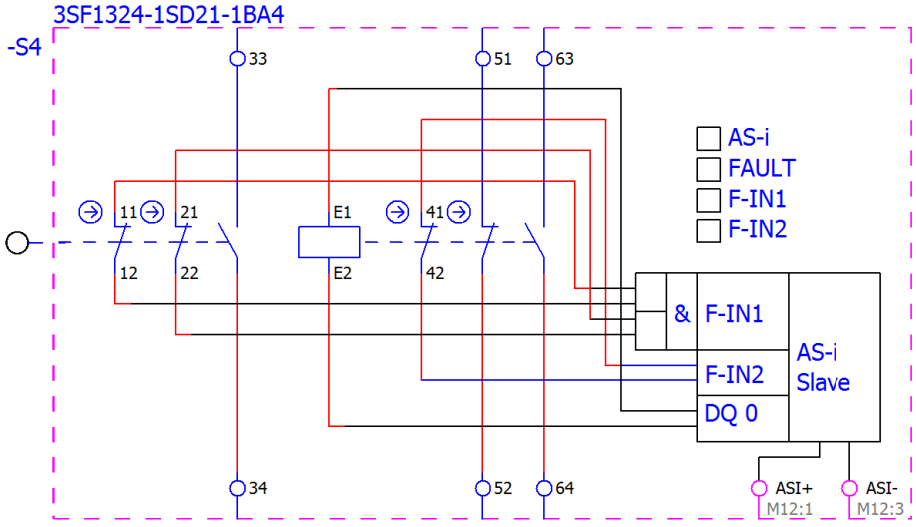


Figure 2-10 3SF1324-1SD21-1BA4 internal circuit diagram

4.2.4 Control and monitoring of the actuator

In order to achieve PL e according to ISO 13849-1 or SIL 3 according to IEC 62061, the shutdown of the machine is designed redundantly. Here, two SIRIUS 3RT2 contactors are used and their correct functioning is monitored by the failsafe controller (feedback circuit monitoring) through their auxiliary contacts (mirror contacts). The mirror contacts can be read by a standard input module.

If one of the two contactors welds, the second contactor can continue to ensure a safe shutdown. The welding of a contact is detected by the feedback circuit monitoring at the next signal change, and a new switch on is prevented until the fault is rectified.

4.3 Hardware and software components

4.3.1 Validity

This application example is valid for:

- All SIMATIC F controllers
- STEP 7 Professional as from V 15

4.3.2 Components used

The application was created with the following components.

Hardware components

Component	Quantity	Article No.	Note
Power supply	1	6EP1333-2BA20	SITOP PSU100S 24 V/5 A
Fail-safe S7-CPU	1	6ES7512-1SK01-0AB0	CPU 1512SP F-1 PN ET 200SP including server module
PROFINET bus adapter	1	6ES7193-6AR00-0AA0	Bus adapter 2 x RJ45 plug sockets
SIMATIC Memory Card	1	6ES7954-8LC02-0AA0	SMC 4 MB
AS-Interface communication module	1	3RK7137-6SA00-0BC1	CM AS-i Master
AS-Interface safety communication module	1	3RK7136-6SC00-0BC1	F-CM AS-i Safety
Digital input module	1	6ES7131-6BF00-0CA0	DI 8X24VDC HF
Fail-safe digital output module	1	6ES7136-6DB00-0CA0	F-DQ 4X24VDC/2A PM HF
Base unit	1	6ES7193-6BP20-0DC0	Light base unit 20 mm, type C0 (new load group)
Base unit	1	6ES7193-6BP20-0BC1	Dark base unit 20 mm, type C1 (jumpered to the left)
Base unit	1	6ES7193-6BP00-0DA0	Light base unit 15 mm, type A0 (new load group)
Base unit	1	6ES7193-6BP00-0BA0	Dark base unit 15 mm, type A0 (jumpered to the left)
3SU AS-Interface enclosure	1	CIN 20180516133320114162	EMERGENCY STOP mushroom pushbutton Illuminated push-button, toggle switch
Safety position switch	1	3SF1324-1SD21-1BA4	With tumbler and auxiliary release
Power contactor	2	3RT2015-1BB42	S00 AC-3 7A
AS-i power supply unit	1	3RX9501-0BA00	IN: 120 V ... 230 V AC, OUT: 3 A AS-i
AS-i cable	1	3RX9010-0AA00	100 m roll, rubber

Software components

Component	Quantity	Article No.	Note
STEP 7 Professional	1	6ES7810-5CC12-0YA5	V 15.1
STEP 7 Safety Advanced	1	6ES7833-1FA15-0YA5	V 15.1

4.3.3 Example of wiring

The wiring example is available for download in the Internet (http://support.automation.siemens.com/WW/view/en/109769506) as a PDF and EPLAN macro.

4.3.4 Sample data and projects

The following table contains all the files and projects used in this example.

Component	Note
E-Stop_SIL3_Protective_door_tumbler_SIL2_AS-i.zap15_1	TIA Portal project
Wiring_E-Stop_SIL3_Protective_door_tumbler_SIL2_AS-i.emp	EPLAN macro
E-Stop_SIL3_Protective_door_tumbler_SIL2_AS-i_de.set	SET file

4.4 TIA Portal configuration

4.4.1 TIA Portal engineering

The supplied TIA Portal project contains the example configuration. The most important settings for reuse in one's own project are shown in this section.

NOTICE
Loss of safety function The settings shown below contribute toward meeting the required safety. Changes to the settings may lead to a loss of the safety function.

In the following, the hardware configuration of the ET 200SP F-CPU is performed with I/O and the AS-i slaves.

After a new CPU 1512SP F-1 PN has been created in the project, the ET 200SP station is configured. In addition to the CM AS-i Master ST and F-CM AS-i Safety ST ET 200SP modules, a fail-safe digital output module and a standard digital input module are needed for this typical circuit diagram. The order numbers are to be taken from the table "Components used" (Section 4.3.2 (Page 23)).

4.4.2 Configuration of the ET 200SP modules CM AS-i Master ST and F-CM AS-i Safety ST

NOTE

Configuration of the CM AS-i Master ST
A detailed guide to configuring CM AS-i Master ST is available in the "Configuration" Section of the "AS-Interface Master CM AS-i Master ST (https://support.industry.siemens.com/cs/ww/view/71756485)" Manual.

Configuration of the F-CM Safety ST
A detailed guide to configuring the F-CM Safety ST is available in the "Configuration" Section of the "ET 200SP Failsafe Module F-CM AS-i Safety ST (https://support.industry.siemens.com/cs/ww/view/90265988)" Manual.

Programming the safety program in SIMATIC STEP 7 Safety Advanced
Programming of the safety program in SIMATIC STEP 7 Safety Advanced is described in detail in the "SIMATIC Industry Software SIMATIC Safety - Configuration and Programming (https://support.industry.siemens.com/cs/ww/de/view/54110126)" Manual.

CM AS-i Master ST and F-CM AS-i Safety ST can also be configured under SIMATIC S7 Distributed Safety in STEP 7 classic. Here the comfort functions and diagnostics may be restricted in comparison to TIA Portal STEP 7 (Safety Advanced).

4.4.3 Configuring ET 200SP System

In this example, an ET 200SP F-CPU is configured

with TIA Portal V15.1. In other versions, the representation may be slightly different; it then applies analogously.

The steps shown apply correspondingly if an ET 200SP station is used with an interface module (e.g. IM 155-6 PN ST) on a SIMATIC F-CPU (e.g. CPU 1515F-2PN). Alternatively to the SIMATIC F-CPU, a fail-safe SINUMERIK controller can be used. The safety program is always executed in the safe controller.

Configure the CM AS-i Master ST and F-CM AS-i Safety ST modules in the ET 200SP station.

Procedure:

1. Open your STEP 7-project in the TIA Portal.
2. Add your ET 200SP station from the hardware catalog.
3. Switch to the device view of the ET 200SP station.
4. Select the CM AS-i Master ST module from the ET 200SP folder in the "Hardware catalog" window.

   Communication module > AS-Interface > CM AS-i Master ST > 3RK7137-6SA00-0BC1. Ensure that the selected version is the same as that of your device, otherwise update the FW.
5. Drag & drop the selected AS-i Master to the next free slot of your ET 200SP station. The CM AS-i Master ST module is plugged into a light base unit.
6. Select the F-CM AS-i Safety ST module from the ET 200SP folder in the "Hardware catalog" window: Communication module > AS-Interface > F-CM AS-i Safety ST > 3RK7136-6SC00-0BC1. Ensure that the selected version is the same as that of your device, otherwise update the FW.

7. Drag & drop the selected F-CM AS-i Safety ST module directly to the right of the AS-i Master in your ET 200SP station. Select a dark base unit for the F-CM AS-i Safety ST module.
8. Open the Properties window of the CM AS-i Master ST and switch to the AS-Interface tab in the "General" area. Create a new AS-i network by clicking the "Add new subnet" button.

Result:

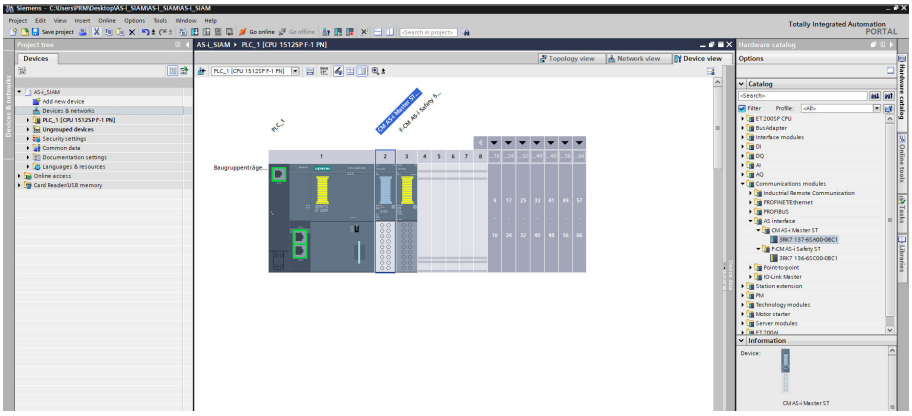


Figure 2-11 Adding the two AS-i modules to the ET 200SP station

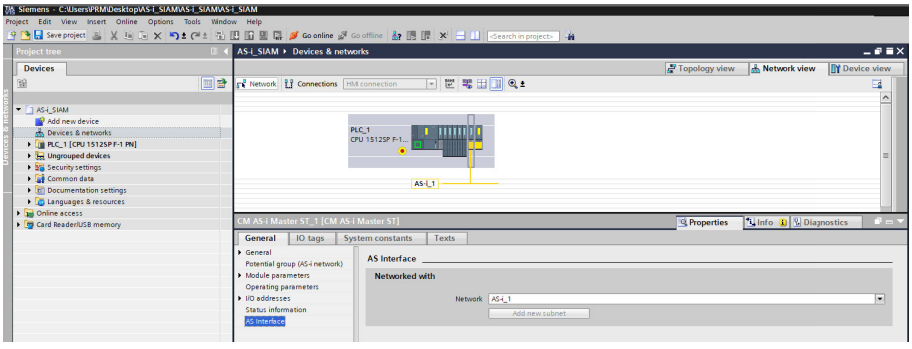


Figure 2-12 Creating a new AS-i network

9. Insert the F-DQ 4x24VDC/2A PM HF module on the right of the F-CM module, and activate its 1st channel in its "DQ parameters".

10. Insert the DI 8x24VDC HF module and a server module on the right of the F-DQ module.

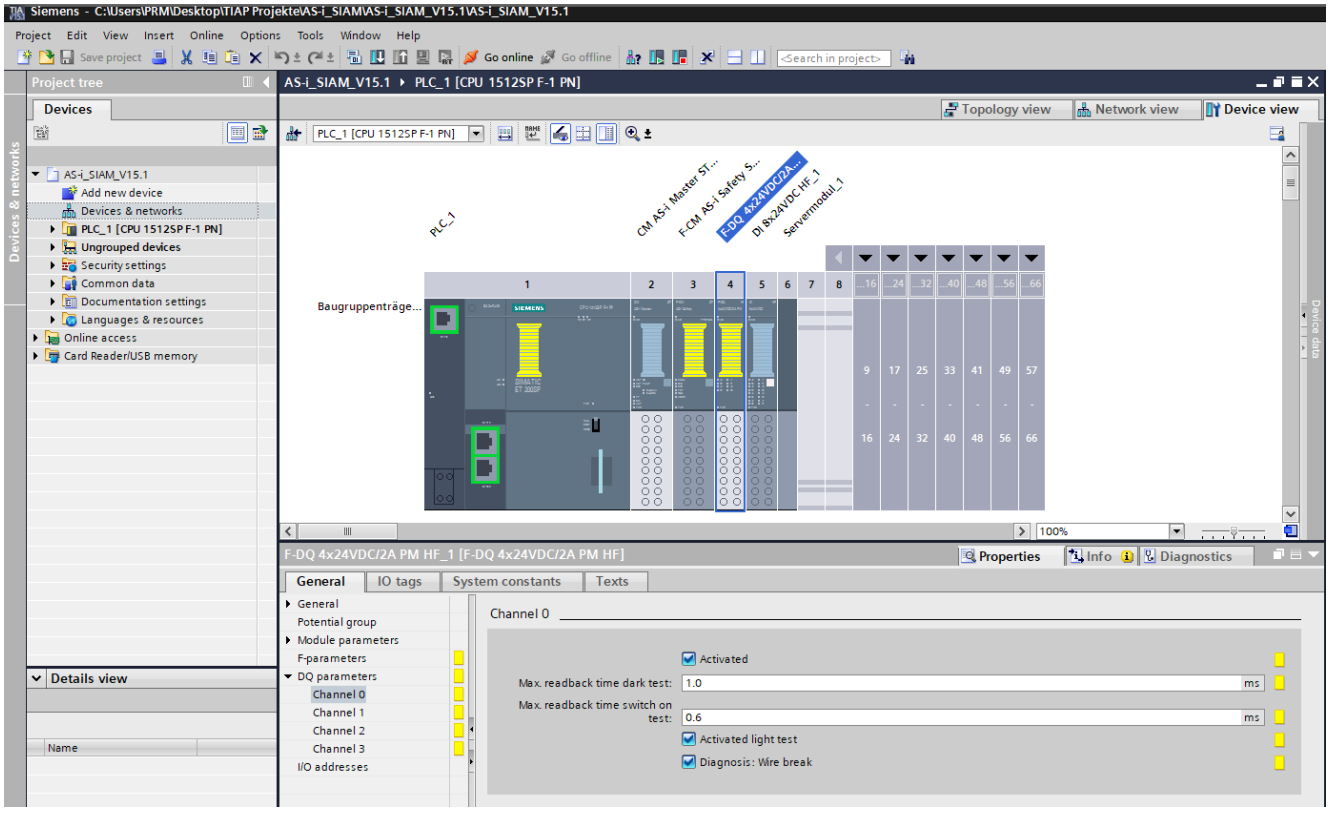


Figure 2-13 Complete configuration of the ET 200SP station

NOTE
The setting of the correct base units (light or dark) must be observed for all four modules.

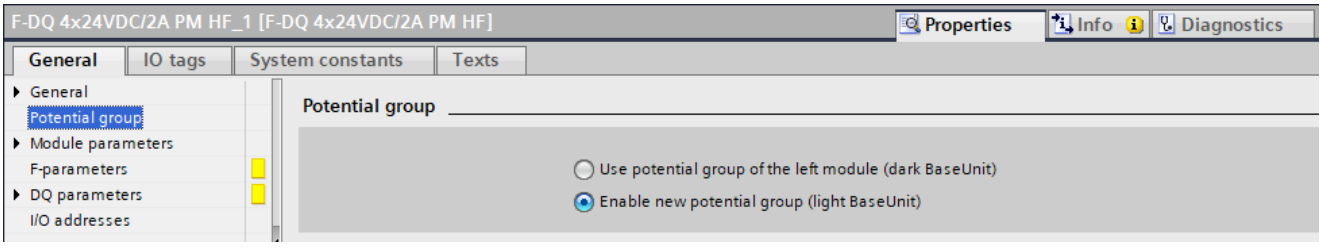


Figure 2-14 Selecting the correct base unit

4.4.4 Adding AS-i slaves

Configure an AS-i slave in the AS-i subnet.

In the following example, an emergency stop command device is connected to an ASIsafe F adapter. Other AS-i (ASIsafe) slaves can be correspondingly configured.

Procedure:

1. Open the Network view of your project.
2. Select the ASIsafe F adapter in the "Hardware catalog" window from the folder: Field devices > AS-Interface > Command and signaling devices > F adapter > ASIsafe F-ADAP, 2 F-DI > 3SU1400-4AA0
3. Drag & drop the selected AS-i slave into the empty space below your ET 200SP station.
4. Connect the emergency stop command device to the AS-i network created in Chapter 4.4.3 by moving the port (yellow square) of the F adapter with drag & drop to the port of the CM AS-i Master ST. Connecting the AS-i slave to the AS-i network automatically assigns the next free AS-i address. If required, the address can be changed in the Properties window of the AS-i slave.

Result:

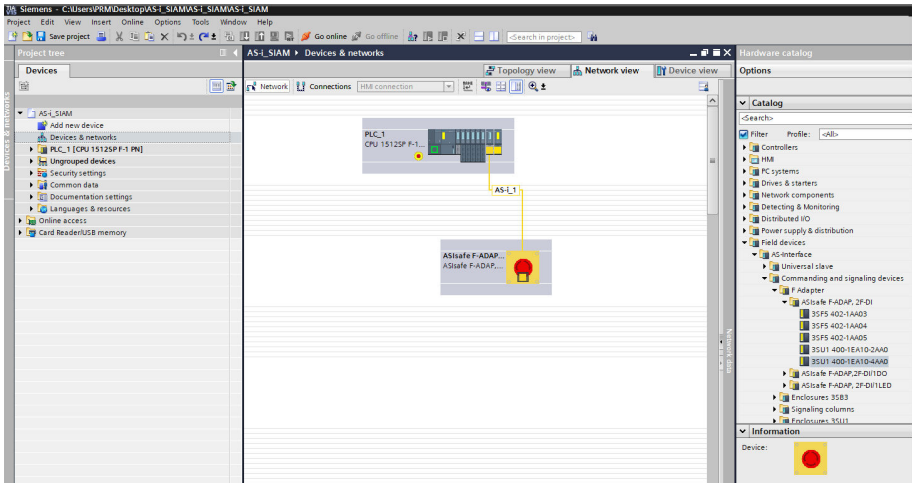


Figure 2-15 Adding and connecting an AS-i slave

5. Perform the steps listed above for two further AS-i slaves:

- ASIsafe position switch with tumbler (Field devices > AS-Interface > Detecting devices > Position switches > Operation with tumbler > ASIsafe POS-SWITCH-LOCK)

- AS-i 3SU1 (Field devices > AS-Interface > Command and signaling devices > 3SU1 enclosure > AS-i 3SU1, 4DI/3DO, AB)

Tip: Display the AS-i addresses on the slaves by activating the "Show addresses" function (symbol with eye in the menu bar of the network view, above the empty area).

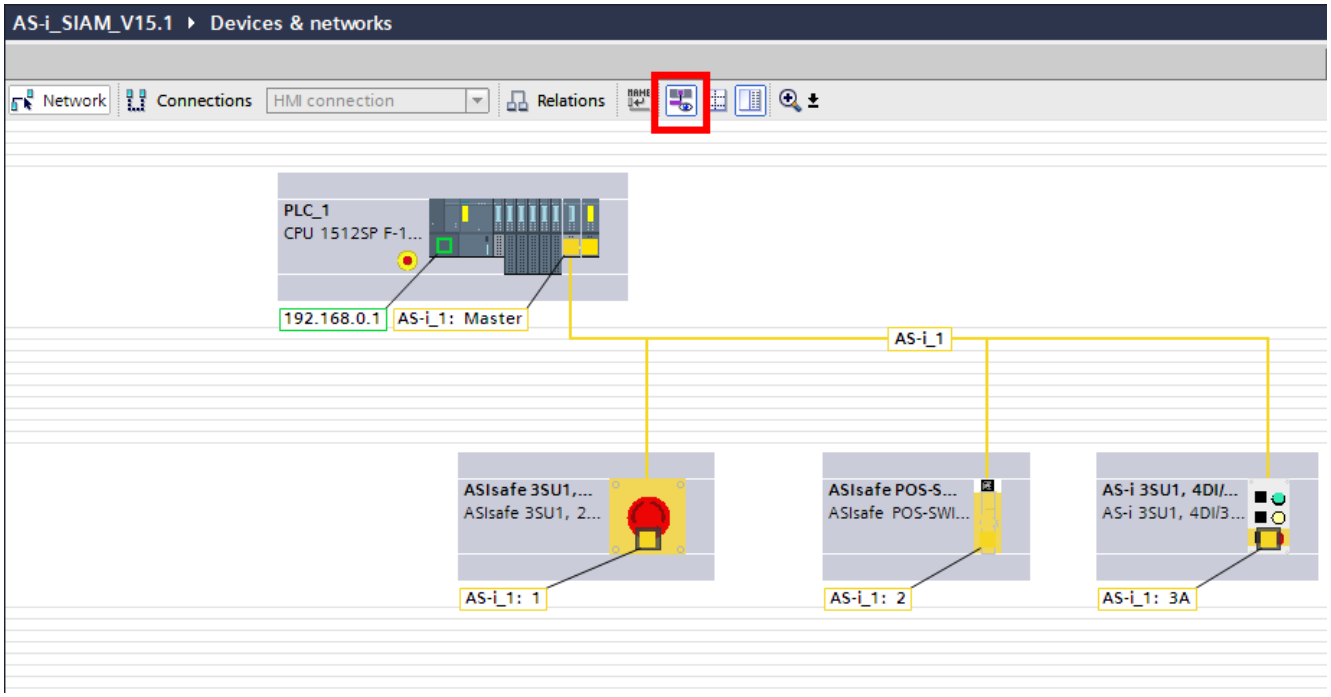


Figure 2-16 Display addresses

4.4.5 Setting F parameters

To set the F parameters, open the "General" dialog box of the F-CM AS-i Safety ST in the device view of the ET 200SP station.

Settings made in the "F parameter" tab affect the fail-safe communication of the module with the F-CPU.

The individual parameters are explained briefly below. Further information may be found in the "SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/de/54110126)" Manual.

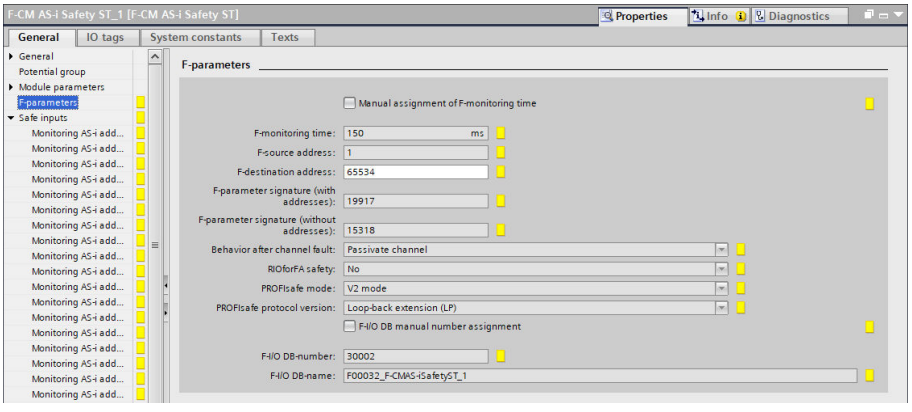


Figure 2-17 Parameters of the F-CM AS-i Safety ST

The **F monitoring time [ms]** is the PROFIsafe monitoring time for the safety-related communication between F-CPU and F I/O. If the F-I/O does not receive a valid safety message frame from the F-CPU within the parameterizable monitoring time, the F module passivates with a "communication error". The F monitoring time can assigned manually or on a module-specific basis (check "Manual assignment of monitoring time") or be assigned centrally in the F parameters of the CPU for all I/O modules.

Via the **F source address**, the F-I/O module F-CM AS-i Safety ST is uniquely assigned to an F-CPU with the corresponding F source address. The F-source address must be unique throughout the network.

The **F destination address** is the PROFIsafe address and uniquely identifies source (F-CPU) and destination (F module). The PROFIsafe addresses must be unique across stations and the network. To prevent incorrect parameter assignment, the F destination address is assigned automatically. When changing the F destination address manually, its station-wide uniqueness is checked automatically, but not its network-wide uniqueness. This has to be ensured by the user him/herself.

Behavior after channel faults: In the event of a channel fault, the F-CM AS-i Safety ST F-I/O module only ever passivates the faulty channel(s).

In this example, the default settings are accepted for the F parameters of the F-CM AS-i Safety ST module.

4.4.6 Configuring safe AS-i slave monitoring

To change the safe I/O addresses and AS-i slave parameters, open the Properties dialog box of the F-CM AS-i Safety ST in the device view of the ET 200SP station.

Under the "Safe inputs" tab there is an entry for each AS-i address in the range 1 ... 31. Initially, all addresses for safe evaluation are deactivated. Select the tab for monitoring AS-i address 1, and activate the "Activate input monitoring" option.

The individual module parameters are explained briefly below.

Tip: Clicking the green arrow to the right of the "Name" field to switch directly between the F parameter dialog window of F-CM AS-i Safety ST and the fail-safe AS-i slave.

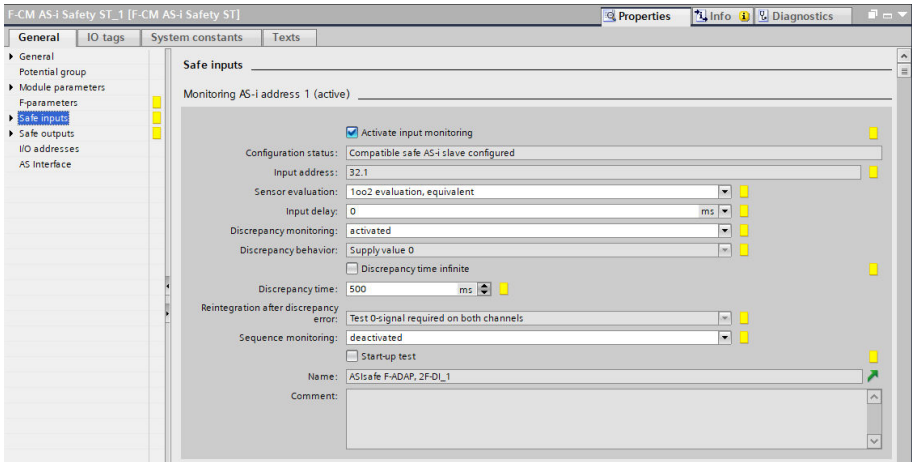


Figure 2-18 Setting the safe input monitoring of the F-CM AS-i Safety ST

By activating the **input monitoring**, you can enable the corresponding AS-i slave as an input channel for signal processing in the safety program. The AS-i address must be assigned to a safe AS-i input slave.

The **configuration status** provides information about whether a safe AS-i slave is configured at this AS-i address ("Compatible safe AS-i slave configured"). Free AS-i addresses or those occupied by a non-safe AS-i slave can also be configured (configuration status: "AS-i slave missing"). The safe AS-i slaves can be inserted later.

Input address: The input bit address of the input channel for the signal processing in the safety program is shown here. It is calculated automatically from the start of the inputs entered in the "Addresses" tab.

Encoder evaluation: Two options are available here.

For the **1oo1 evaluation** , the encoder is present once and connected to a single channel on the first input of the safe AS-i slave. To achieve this, jumper the second input of the AS-i slave. Instead of the jumper, you can also connect another single-channel sensor to the second input. Only when both inputs supply an ON signal does the F-CM AS-i Safety ST module transfer the "1" value to the safety program (the two inputs are ANDed). A discrepancy analysis is not performed in the 1oo1 evaluation.

In the **1oo2 evaluation, equivalent** both inputs of the safe AS-i slave are occupied, either by a 2-channel encoder or by two single-channel encoders. The two single-channel sensors then belong together functionally as a pair, e.g. two position switches of one door monitoring. The input signals are compared internally for equivalence. A discrepancy analysis is possible in the 1oo2 evaluation equivalent.

To suppress coupled-in interference or brief switching pulses, you can set an **input delay** for each AS-i slave.

For fail-safe inputs, the **discrepancy monitoring** for equivalence is used to infer errors from the time characteristic of two signals with the same functionality. If different levels for two associated input signals are detected after the input delay time has expired, the discrepancy analysis is started. A check is made to determine if the difference has disappeared after expiration of an assignable time period, the so-called **discrepancy time**. If not, there is a discrepancy error. Before reclosing, the signal value 0 must be present at both inputs.

The **discrepancy behavior** determines the value that is made available to the safety program in the F-CPU during the discrepancy, i.e. while the discrepancy time is running. This parameter is permanently set to "Provide 0 value".

Reintegration after discrepancy error: This parameter is permanently set to "Test 0 signal necessary on both channels". A discrepancy error is not considered to be rectified until an "OFF" signal is present again at both input channels. Reintegration of the PROFIsafe channel is then possible.

The **sequence monitoring** monitors the sequence of the signals of the channel pair when there is a signal change OFF >>> ON at the inputs of the safe AS-i slave.

If the **Startup test** parameter is activated, the value transferred to the safety program is kept at the substitute value "0" until the connected sensor has been correctly actuated at least once.

You can specify the start address of the process image in the "I/O addresses" tab of the Properties dialog box of the F-CM AS-i Safety ST. Which actual bit in the safety program is accessed, for example for a safe input slave, can be found in the "Input address" described above.

The "I/O addresses" tab also appears in the Properties dialog box of the AS-i slaves. Taking the example of the AS-i F adapter, a distinction is made between "Digital I/O" and "Safe inputs". Under "Digital I/O", the data area of the communication is set with the AS-i master. This area in the user program can be accessed e.g. for diagnostic purposes. Under "Safe inputs", the same input bit as under the AS-i address in the Properties dialog box of the F-CM AS-i Safety (see "Input address") is present. As described above, this bit is accessed in the safety program.

Emergency stop and pushbutton and toggle switch are in an enclosure together with the two necessary AS-i slaves (a safety slave and a standard slave). The two installed slaves are configured separately in the TIA Portal.

The safe monitoring of the position switch is then configured as follows. The explanation of the individual parameters can be found in Section 4.4.5 (Page 29). A 1oo1 evaluation is selected to monitor the position switch because the switch used (version 3SF13 ... 1BA4) is already monitored for discrepancy (see Section 4.2.3 (Page 20)).

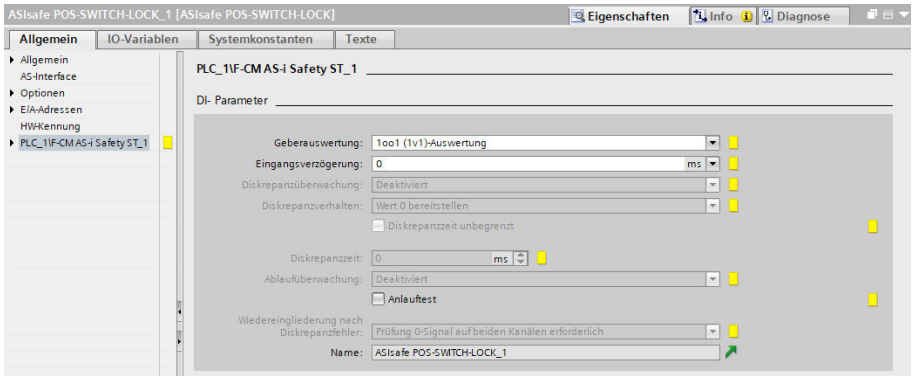


Figure 2-19 Configuration of the position switch

The position signal of the position switch is transferred to the safety program as a safe input bit. The address of the safe input is shown in the following figure (I32.1 in this example).

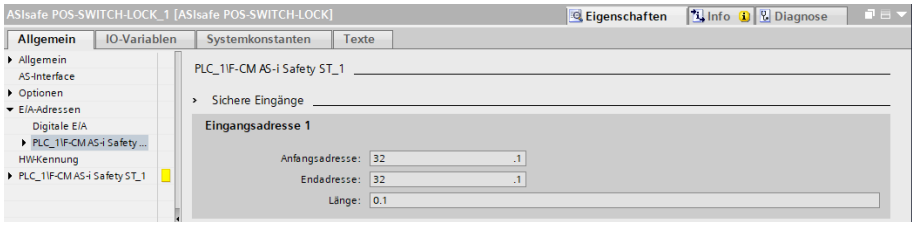


Figure 2-20 Address for reading out the position of the position switch

The solenoid for releasing the door tumbler is controlled via a standard output of the AS-i slave installed in the position switch (output bit 0, see "Digital I/O"; Q0.0 in this example).

The read back signal (normally closed contact) of the solenoid is the second fail-safe channel of the AS-i slave (see Section 4.2.3 (Page 20), 1BA4 version). Since it is directly processed to a fail-safe digital input bit (in this example I32.1, see below) with the first fail-safe channel in the F-CM AS-i Safety ST module, the read-back signal of the solenoid is accessed via the associated standard input bit of the AS-i slave installed in the position switch (input bit 0, see "Digital I/O"; in this example I0.0).

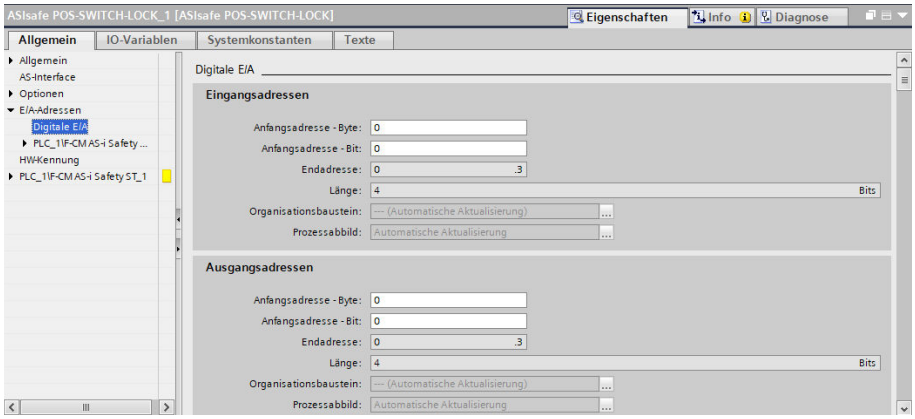


Figure 2-21 Address for controlling the solenoid

The safe monitoring of the emergency stop command device is then configured as follows.

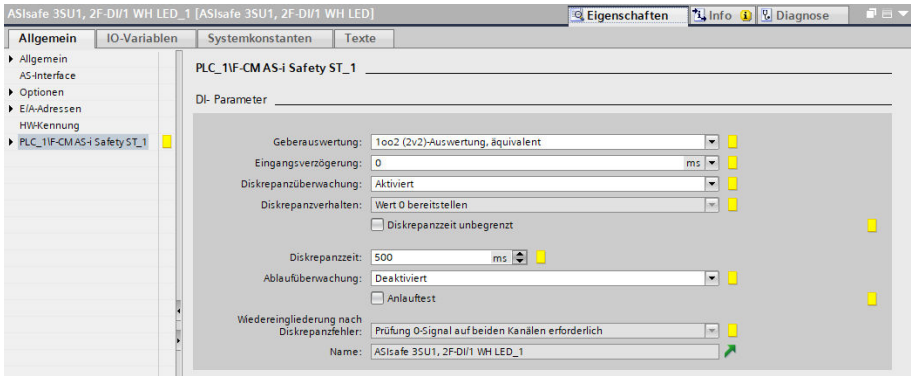


Figure 2-22 Configuration of the emergency stop command device

Finally, the F-DQ module is configured to control the redundant contactors. Here again, the F parameters remain unchanged (default setting). The setting of the safe monitoring can be taken from the following figure.

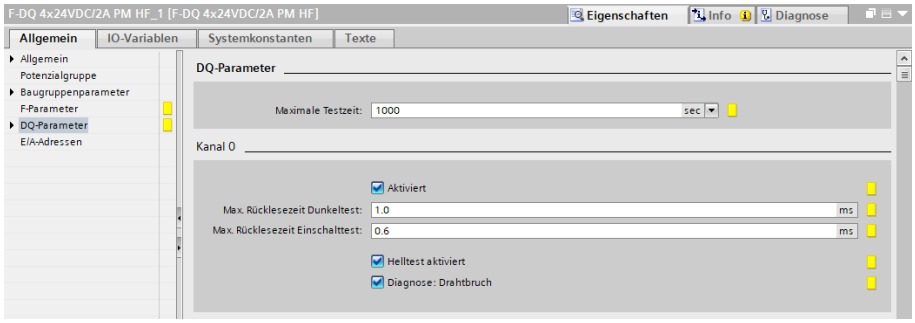


Figure 2-23 Configuration of the F-DQ module

NOTE

Unused channels, such as channels 1 to 3 of the F-DQ module, should be deactivated for reasons of clarity and improved performance. For this purpose, the check is removed from "Activated" for the corresponding channels. For the F-CM AS-i Safety ST module, the user must activate the input channels required for the configured AS-i slaves.

4.4.7 Minimum number of slaves for AS-i Safety applications

In a normal application, an AS-i network contains more than 5 AS-i slaves.

However, only 3 AS-i slaves are used for this example. In this case, the specifications in EN 60262-2 (AS-i specification) for the minimum cycle time and minimum number of slaves for AS-i Safety applications must be observed.

In an AS-i network with at least 5 different slave addresses in the numerical part of the address, each safety component functions as intended. "In the numerical part of the address" means that two slaves with the addresses 5A and 5B are counted here as 1 address, whereas two slaves with the addresses 10A and 11B are counted as 2 addresses. For the count, it is irrelevant whether or not these are safety slaves.

With less than 5 slave addresses, only restricted plant availability is possible, i.e. instead of an "ON" signal in the safety transmission report, it is possible to switch back to the "OFF" safe state, since the affected safety component cannot execute the report for the "ON" signal quickly enough in the short bus cycle time. An "OFF" signal remains of course in the safe state "OFF".

The TIA Portal outputs a corresponding warning message on compilation if not enough slaves have been configured as AS-i slaves in the TIA project.

An AS-i Safety network usually still functions with fewer slaves. However, to avoid an unwanted shutdown, the rules in the standard should be observed. The F-CM AS-i Safety module offers a simple solution for this, without installing additional slaves.

Open the Properties dialog of the F-CM AS-i Safety, and navigate to the "Safe outputs" tab. Select the vector group 0, and set the option "Activate output control". The F-CM AS-i Safety module now generates an AS-i address internally. At the same time, an associated virtual module (AS-i Safe Out Ctrl) is configured on the AS-i subnet, so that the AS-i master is instructed to accept the additional AS-i address into the cyclic operation.

Repeat this step four more times, so that a total of 5 additional AS-i addresses are activated in the F-CM AS-i module. These act as a "base load" in the AS-i network, irrespective of the number of other AS-i modules in the AS-i network.

If your AS-i network has enough modules, you can correspondingly deactivate the output control in the vector groups of the F-CM AS-i Safety.

When a vector group is activated, additional safe output bits are made available. Do not interconnect these safe output bits in the safety program if the vector group is only used to increase the number of slaves.

You can use the vector groups of the F-CM AS-i Safety and the associated safe output bits as required to control safe AS-i output modules in the AS-i network (see e.g. Art. No. 3RK1405-1SG15-0AA2). In this case, you use the safe output bits in the safety logic of the safety program in a similar way as for F-DQ modules of the ET 200SP. This Function Manual does not include a detailed example for this application.

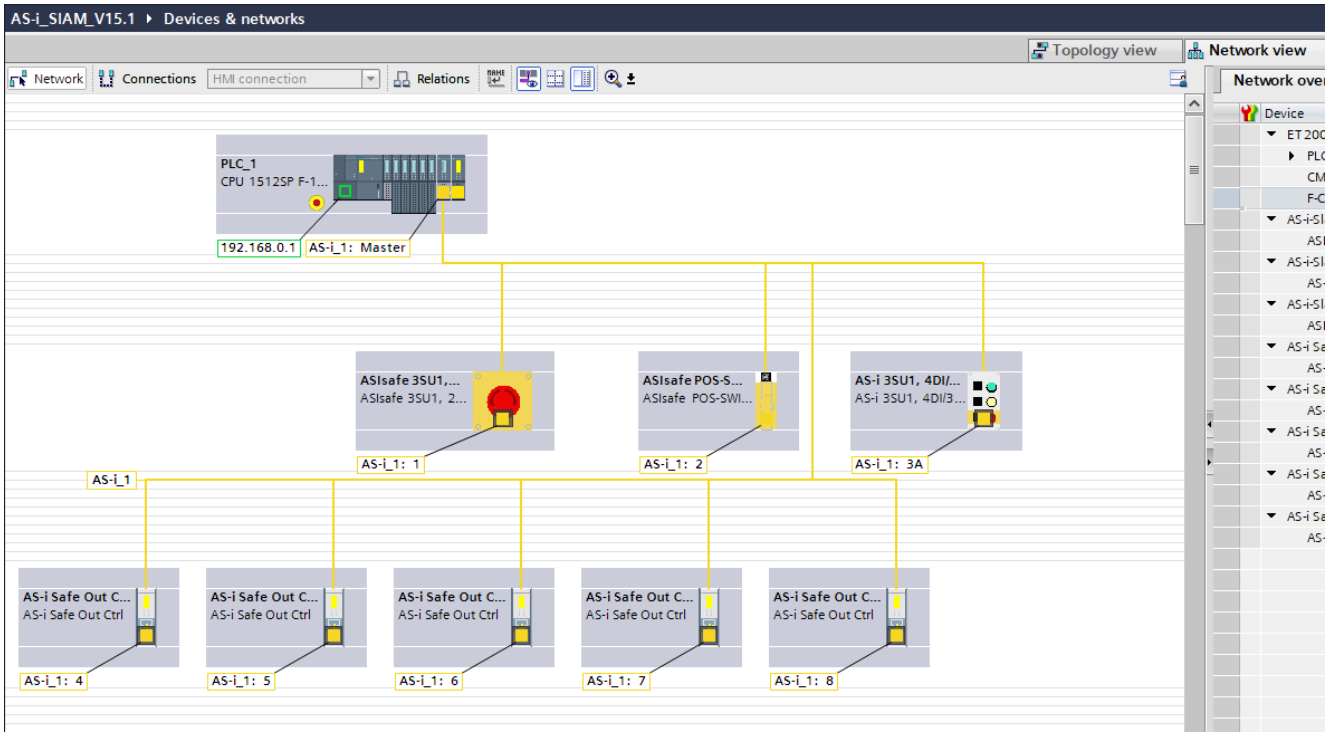


Figure 2-24 Hardware configuration with virtual slaves

4.4.8 Assigning fail-safe addresses to ET 200SP

After setting the F parameters of the F-CM AS-i Safety ST module, the PROFIsafe-/F destination address still has to be assigned to the extended module (real hardware).

Fail-safe ET 200SP modules do not have DIP switches with which you can assign the unique F destination address (= PROFIsafe address) to each module. Instead, assign the PROFIsafe address directly from STEP 7. F destination addresses are assigned in the hardware configuration for the F module. An assignment is necessary when a system is commissioned for the first time, for example. The F destination address can only be assigned if the PROFINET device name is also assigned.

Open the shortcut menu of the F-CM AS-i Safety ST (right click on the F-CM AS-i Safety module) and select "Assign F destination address". In the dialog which then appears, identify the F-CM AS-i Safety ST module, and then assign the PROFIsafe address.

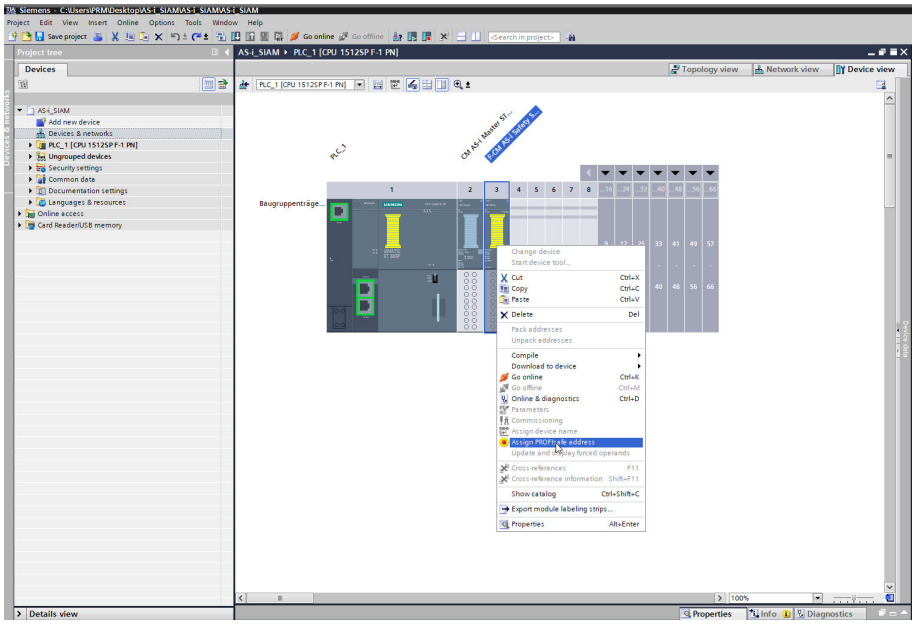


Figure 2-25 Assigning the PROFIsafe address

Repeat the described procedure for assigning the fail-safe address for the F-DQ module.

4.4.9 Teaching ASIsafe code sequences

To perform safety-related communication, each safe AS-i input slave sends a code sequence over the AS-i bus. To prevent a mix-up of AS-i input slaves on the AS-i bus, each AS-i input slave sends a different code sequence. The code sequences are permanently stored in the AS-i input slave.

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus.

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component. Two methods of accepting code sequences are available:

Transfer the code sequences via STEP 7 online access:

Open the F-CM AS-i Safety ST shortcut menu and select "Online & Diagnostics". Change to the "Functions > ASIsafe code sequences" tab. The "Teach ASIsafe code sequences" dialog contains an overview of the code sequences of the existing safety-related AS-i slaves. Start the acceptance of the code sequences read on the AS-i bus into the memory of the F-CM AS-i Safety ST module in this dialog. To do so, click the "Transfer taught code sequences" button.

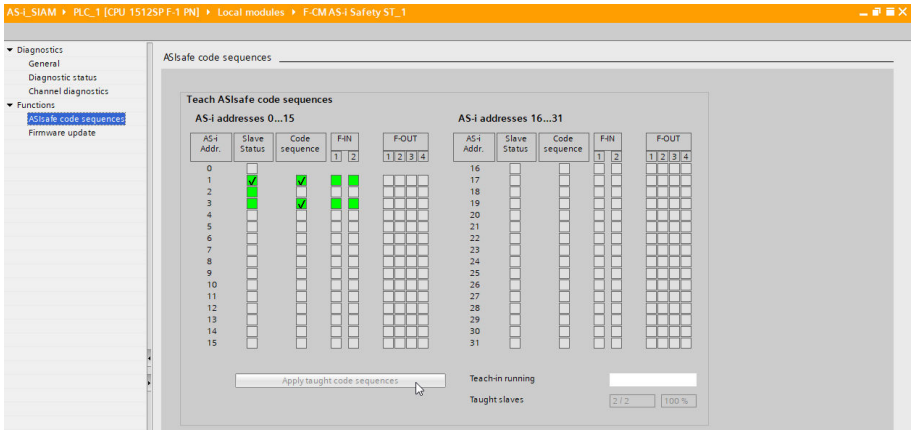


Figure 2-26 Accepting code sequences

Transfer the code sequences with the "TEACH" button:

As an alternative, the "TEACH" button can be used to provide an easy way of transferring taught code sequences. The "TEACH" button can be used, for example, to transfer code sequences of modules replaced during operation. However, it is also suitable for initial commissioning.

The "TEACH" pushbutton is connected to the terminals "TEACH1" and "TEACH2" (terminals 1 and 2) of the base unit of the F-CM AS-i Safety ST module.

Press the "TEACH" button for at least 3 s. This action causes all currently taught code sequences that are unique and consistent to be transferred to the non-volatile memory. Next, the input data of the safe AS-i input slaves is evaluated, allowing reintegration in the safety program.

Further information on the topic of code sequences can be found in the "T 200SP fail-safe module F-CM AS-i Safety ST (https://support.industry.siemens.com/cs/ww/de/view/90265988)" Manual in the "Code sequences" section.

4.5 TIA Portal programming

In this typical circuit diagram, the focus is on the safety-related switching of the machine. Therefore, operational switching is not taken into account, and no standard user program is programmed. In this example, the user must implement the operational switching – adapted to the conditions of the machine – in their program with the aid of the "operativeOn" variable in the DB "DataToSafety" via the FB "StartStop".

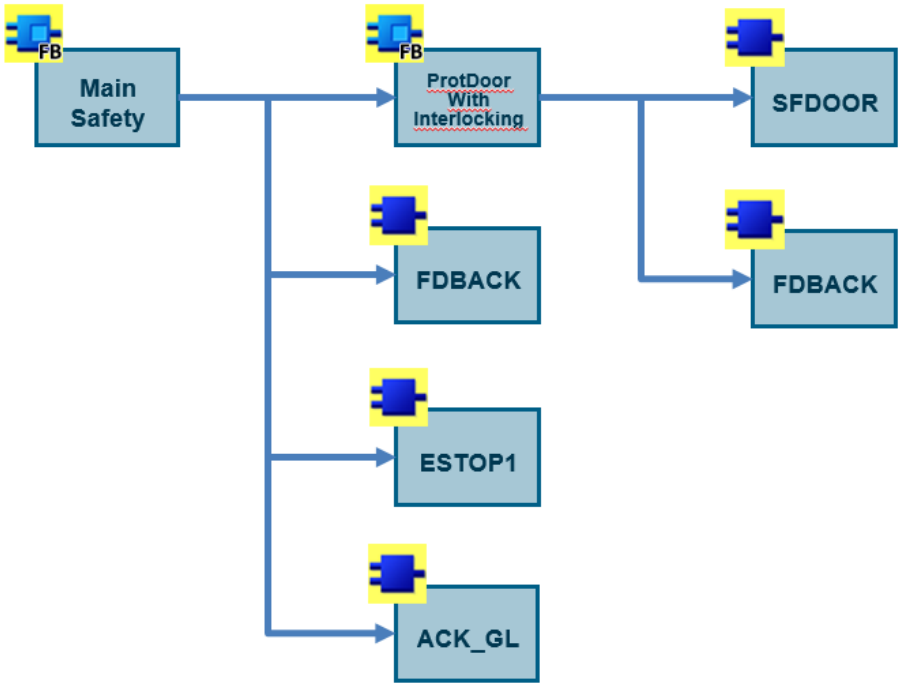


Figure 2-27 Safety program

The MainSafety function block is called cyclically by an F-runtime group. This contains all other safety-related program parts.

Reintegration of passivated channels

The ACK_GL instruction in STEP 7 Safety is used for this purpose. It generates an acknowledgment for the simultaneous reintegration of all F-I/O or channels of the F I/O of an F runtime group after communication faults or F I/O / channel faults.



Figure 2-28 Call ACK_GL

Examples of events that lead to passivation:

- Wire break in an F-DQ module
- Fault on a AS-i safety slave, e.g. slave failure or discrepancy fault at the safety inputs

NOTE

If a fault occurs in the hardware (e.g. wire break detected), depending on the fault it may take several seconds before the module detects the rectification of the fault. The acknowledgment does not have an effect until after this.

Data exchange between standard user program and safety program

In the event of inadequate programming, data corruption resulting in a CPU/ system stop may occur in the communication between standard user program and safety program (see (https://support.industry.siemens.com/cs/document/19183712/what-should-you-do-if-the-f-cpu-goes-into-stop-mode-and-the-message-data-corruption-in-the-safety-program-appears-in-the-diagnostics-buffer-?dti=0&lc=en-WW)).

Therefore two global data blocks should be used to exchange data between the standard user program and the safety program.

- DataToSafety
- DataFromSafety

The values in the DataToSafety data block are written by the standard user program and read by the safety program. The values in the DataFromSafety data block are written by the safety program and read by the standard user program. Since this example does not contain a standard user program, these two global data blocks were not included. They should be added by the user of this example.

NOTE

Further information on the data exchange between standard user program and safety program can be found in the "SIMATIC Safety - Configuring and Programming" Manual. (https://support.industry.siemens.com/cs/ww/en/view/54110126)

Commissioning and operation

5

5.1 Commissioning

5.1.1 Preparation

1. Download the "E-Stop_SIL3_Protective_door_tumbler_SIL2_AS-i.zap15_1" project file. Link: . (http://support.automation.siemens.com/WW/view/en/109769506)
2. Save the file in any folder on your computer.
3. Set the IP address of the PG/PC so that the PG/PC is in the same subnet as the CPU.
4. Connect the PG/PC to the Ethernet interface of the CPU 1512SP F-1 PN using an Ethernet cable.

The following IP address has been used for this application example:

CPU S7-1512SP F-1 PN

IP address: 192.168.0.1

Subnet mask: 255.255.255.0

5.1.2 Load S7 project into the CPU

1. Open "TIA Portal V15.1".
2. Switch to the project view.
3. Click "Project > Dearchive" in the menu bar of the TIA Portal.
4. Click "Browse" and dearchive the project.
5. Set the CPU 1512SP-1 F-1 PN to STOP.
6. Right mouse click in the project topology on "PLC_1 [CPU1512SP F-1 PN] and then on "Load into device > Hardware and software (changes only)".
7. In the open window, select the desired interface and click "Start search".
8. Select the CPU on the basis of the MAC address, and the click "Load".

NOTE

The IP address and the device name are automatically assigned when the project is loaded into the CPU.

9. Confirm the dialog by clicking "Load".
10. Click "Finished" when the loading process has finished.

5.1.3 Assigning PROFIsafe addresses

For safe communication between the F-CPU and the fail-safe modules (F-CM AS-i Safety and F-DQ), the correct PROFIsafe addresses must be assigned to the modules. To do this, follow the steps in Section 4.4.8. (Page 35)

NOTE

Since the PROFIsafe address is stored in the electronic coding element of the ET 200SP slot, this step is only necessary if a PROFIsafe address is missing, or if a different one was assigned.

Now set the CPU 1512SP F-1 PN to RUN.

NOTE

All red LEDs of the fail-safe modules should go out after the PROFIsafe addresses have been assigned. If this is not the case, there may be a fault in the wiring.

Apart from that, the ASIsafe code sequences still have to be read. The procedure for loading the code tables is described in Section 4.4.9 (Page 36) "Teach ASIsafe code sequences".

5.2 Using the application

Starting a machine

No.	Action	Note
1	Close the protective door.	
2	Move the toggle switch into the position that locks the protective door.	The voltage in the solenoid is switched off and the locking mechanism moves into the actuator. The protective door is locked.
3	Unlock the emergency stop button.	
4	Press the start pushbutton.	After the emergency stop button has been unlocked, acknowledgment is required. The machine starts.

Unlock and open the protective door

No.	Action	Note
1	Move the toggle switch into the position that unlocks the protective door.	The machine switches off and runs down.
2	Wait for the parameterized delay time before unlocking the protective door.	In this example: 5 seconds After the time has expired, the solenoid is supplied with power, and moves the locking mechanism out of the actuator. The protective door is unlocked.
4	Open the protective door.	

Acknowledging other faults in the safety function

If another fault occurs in the safety function, the machine is immediately switched off and a restart is prevented. Proceed as follows to acknowledge the fault.

Possible faults that are acknowledged in this way include:

- Cross circuit between the two emergency stop channels.
- External voltage on the fail-safe outputs
- Withdrawing a fail-safe module
- Contact welding of a contactor

No.	Action	Note
1	Check the LEDs on the fail-safe modules. If one red LED illuminates, a fault in the hardware has been detected. Search for the fault by means of the online diagnostics in the TIA Portal.	
2	If all LEDs are green, the safety program has detected a fault. Look at the variable table to find the fault.	The #fault and #ackReg variables of the ProtDoorWithInterlocking block instructions can help with the search.
3	Eliminate the fault.	
4	Close the protective door.	
5	Unlock the emergency stop button.	
6	Move the toggle switch to lock the protective door.	The voltage in the solenoid is switched off and the locking mechanism moves into the actuator.
7	Press the start pushbutton.	Passivated channels of the fail-safe modules are re-integrated. Faults detected by the safety program are acknowledged. The machine starts.

5.3 Evaluating the safety function

An evaluation is made according to both EN ISO 13849-1 and EN 62061 with the Safety Evaluation Tool (SET) (http://siemens.de/safety-evaluation-tool).

The result of the evaluation - the SET file (http://support.automation.siemens.com/WW/view/en/109769506)- is added to the SIOS entry of this document.

Appendix 6

6.1 Service and Support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round-the-clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs and application examples – all information is accessible with just a few mouse clicks here (https://support.industry.siemens.com).

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- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the Service Catalog (https://support.industry.siemens.com/cs/sc).

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" (https://support.industry.siemens.com/cs/ww/de/sc/2067) app. The app is available for Apple iOS, Android and Windows Phone.

6.2 Links and literature

No.	Topic
\1\	Siemens Industry Online Support (https://support.industry.siemens.com)
\2\	Link (http://support.automation.siemens.com/WW/view/en/109769506) to the entry page of the application example
\3\	Project file (http://support.automation.siemens.com/WW/view/en/109769506)

6.3 Version history

Version	Date	Change
V1.0	09/2019	First edition
V2.0	08/2020	Correction: Non-safety-related tumbler via integrated standard output of 3SF1324-1S.21-1BA4

SIEMENS

SIMATIC

Industrial Software SIMATIC S7-FCT V4.0 - Fail-safe Configuration Tool

Configuration Manual

Introduction 1

Installing SIMATIC S7-FCT 2

SIMATIC S7-FCT procedure 3

Calculating F_iPar_CRC for an F-I/O 4

Assigning the PROFIsafe addresses to the F-I/Os 5

06/2024
A5E39732236-AD

Preface

Conventions

Please also observe the notes identified as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which particular attention should be paid.

Incorporation in the information landscape

System Manuals and Equipment Manuals of the respective F-I/Os describe the hardware of the F-I/Os, including configuration, wiring, parameter assignment, diagnostics and technical specifications.

Online help for SIMATIC S7-FCT

You can easily open this manual from the SIMATIC S7-FCT by placing the focus on a SIMATIC S7-FCT dialog or SIMATIC S7-FCT window and pressing "F1".

Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.
You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.
Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)

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Introduction

1

SIMATIC S7-FCT enables you to calculate the F_iPar_CRC and to assign the PROFIsafe address for selected F-I/Os from Siemens, which you integrate into your engineering system via a PROFINET GSD file.

SIMATIC S7-FCT fulfills the function of a CPD tool according to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO".

Approved F-I/Os and hardware configurations

WARNING

You may use SIMATIC S7-FCT only for F-I/Os that have been approved for the version of SIMATIC S7-FCT you are using.
You can find a list of the F-I/Os and hardware configurations approved for SIMATIC S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

NOTE

- The "Shared Device" function is not supported.
- Redundant interface modules are not supported.

Installing SIMATIC S7-FCT

2

Requirements

SIMATIC S7-FCT can be operated under the following operating systems:

- Windows Server 2019 (version 1809) Standard (full installation)
- Windows Server 2022 Standard (full installation)
- Windows 10 Home Version 22H2 (OS Build 19045)
- Windows 10 Pro Version 22H2 (OS Build 19045)
- Windows 10 Enterprise Version 22H2 (OS Build 19045) in General Availability Channel
- Windows 10 Enterprise 21H2/ 2021 LTSC (OS Build 19044) (Test for IPC)
- Windows 10 Enterprise 1809/ 2019 LTSC (OS Build 17763) (Test for IPC)
- Windows 10 Enterprise 1607/ 2016 LTSC (OS Build 14393) (Test for IPC) Anniversary Update
- Windows 11 Home Version 23H2 (OS Build 22631)
- Windows 11 Home Version 22H2 (OS Build 22621)
- Windows 11 Pro Version 23H2 (OS Build 22631)
- Windows 11 Pro Version 23H2 (OS Build 22631)
- Windows 11 Enterprise 23H2(OS Build 22631)
- Windows 11 Enterprise 22H2(OS Build 22621)

Requirements for your engineering system:

- So that you can call the functions of SIMATIC S7-FCT in your engineering system, your engineering system must support CPD system integration.

Installing SIMATIC S7-FCT

1. Call the SIMATIC_S7_FCT_V4.EXE program.
2. Follow the setup program instructions.

NOTE

If you want to install SIMATIC S7-FCT over an existing version older than V4.0, you must uninstall the existing version first. Then start the SIMATIC_S7_FCT_V4.EXE program and follow the installation instructions. For existing versions starting from V4.0, the setup routine offers a modification/upgrade to the newer version.

2.1 Uninstalling

Uninstall the SIMATIC S7-FCT in the usual way on your operating system, for example, using Add-Remove Program.

SIMATIC S7-FCT procedure

3

Requirement

The device must be integrated into your engineering system as PROFINET GSD file.

Procedure

The device is configured in the usual way according to the engineering system used. The following steps are an example of what is required:

1. Install the PROFINET GSD file in your engineering system.
2. Configure an F-CPU and the GSD device, connect the F-CPU and the device via PROFINET.
3. Configure the F-I/Os.
4. Paramaterize all parameters of the F-CPU and the F-I/Os according to the manufacturer's specifications.
5. Start SIMATIC S7-FCT from your engineering system for calculation of F_iPar_CRC.
6. In your engineering system, copy the value for F_iParCRC (Page 11) calculated by SIMATIC S7-FCT into the PROFIsafe parameter "F_iPar_CRC" of the F-I/O.
7. In your engineering system, download the hardware configuration to the F-CPU.

   Depending on your engineering system, you may need to compile the hardware configuration before loading.
8. Start SIMATIC S7-FCT for the assignment of the PROFIsafe address (Page 13).

NOTE

If you have problems connecting to the interface module when assigning the PROFIsafe address, deactivate the Internet protocol version 6 (TCP/IPv6) for the network adapter you are using.

3.1 Registering the TCI Communication Server for 64-bit version

To assign the PROFIsafe address, SIMATIC S7-FCT communicates with the engineering system via the standardized TCI interface with the TCI Communication Server. The TCI Communication Server must be available in the 64-bit version.

Registering the TCI Communication Server for 64-bit version

If the TCI Communication Server does not already exist as a 64-bit version, a dialog prompts you to register the TCI Communication Server for calling with 64-bit applications when you start SIMATIC S7-FCT from your engineering system the first time.

Start the registration with a double-click on the automatically created file "Register_S7-FCT.reg". The dialog shows you the path to the file.

It is recommended to manually undo the registration when uninstalling SIMATIC S7-FCT. Start the removal of the registration with a double-click on the file "UnRegister_S7-FCT.reg". The path to the file corresponds to that from the registration dialog.

NOTE

If the rights granted to you by your system administrator do not permit you to write to the hard disk and/or registry, the system administrator must ensure that the TCI Communication Server is registered prior to installation of S7-FCT.

Procedure for the system administrator:
Besides the installation file there is a PowerShell script (/Tools/RegisterTciCommunicationServers.ps1) you can use to register the TCI Communication Server. You can also find this script in the installed folder after finishing the setup.
The script requires the COM ProgId of the TCI Communication Server of the target engineering system. Already provided in the script are the TCI Communication Server COM ProgIds of several current Siemens TIA Portal versions, the SIMATIC Manager (STEP 7 V5.6) and several selected third-party engineering systems. You must add the COM ProgId of the TCI Communication Server of the target engineering system there. You must execute the script **after** installation of the target engineering system.
The ProgId of the TCI Communication Server is named by the target engineering system, or you read it from the TPF file Tpf0.xml, which you can find under <user>/AppData/Local/Temp, possibly in a subdirectory "TCI", after starting S7-FCT. Note, however, that the TPF file Tpf0.xml is deleted again when you close SIMATIC S7-FCT.
You will find the ProgId of the target engineering system under the tag <General />, e.g. CommServer-ProgID="Tci.SimaticCommunicationServerV19".

Calculating F_iPar_CRC for an F-I/O

4

Introduction

This dialog allows you to calculate the value of F_iPar_CRC from the safety-related fail-safe iParameters of an F-I/O.

Requirement

The following requirements must be met:

- The PROFINET GSD file is installed in your engineering system.
- The F-I/O is configured and parameterized in your engineering system.

Procedure

1. Open the "F_iPar_CRC calculation" dialog for the desired F-I/O. Proceed as described in the documentation of your engineering system. For example, via the shortcut menu of the F-I/O with "Start device tool > SIMATIC S7-FCT V4.0 > F_iPar_CRC calculation".

   NOTE

   If your engineering system does not offer the start of SIMATIC S7-FCT, check whether the F-I/O is supported by SIMATIC S7-FCT (https://support.industry.siemens.com/cs/ww/en/view/109762827). Try reinstalling SIMATIC S7-FCT. If SIMATIC S7-FCT is still not shown, contact the manufacturer of the engineering system.

   The fail-safe iParameters of the F-I/O are displayed in the dialog.
2. Check the fail-safe iParameters of the F-I/O.

   ⚠ WARNING

   Setting of the fail-safe iParameters
   You are responsible for the correct setting of the fail-safe iParameters.
   Before calculating the value of F_iPar_CRC, check the fail-safe iParameters displayed in the SIMATIC S7-FCT dialog and their values for consistency with all iParameters and their value settings displayed in your engineering system for the F-I/O.
   If you notice missing fail-safe iParameters or deviating values, you must abort the F_iPar_CRC calculation. Contact Siemens Industry Online Support.

3. Then click "Confirm iParameters".
   F_iPar_CRC is calculated for the values of the safety-related fail-safe iParameters.

   NOTE
   You need to close and restart SIMATIC S7-FCT after changing the safety-related iParameters in the engineering system. The changes in the safety-related iParameters for the calculation of F_iPar_CRC only take effect after a restart.

4. Copy the calculated value for F_iPar_CRC from one of the two fields (decimal or hexadecimal format) with the corresponding button.
5. Insert the calculated value for F_iPar_CRC in your engineering system as value for the "F_iPar_CRC" parameter of the F-I/O.
6. In your engineering system, download the hardware configuration to the F-CPU.
   Depending on your engineering system, you may need to compile the hardware configuration before loading.

Assigning the PROFIsafe addresses to the F-I/Os 5

5.1 Introduction

For F-I/Os from Siemens that do not have a DIP switch for setting the F-destination address, assign the PROFIsafe address (combination of F-source address and F-destination address) with SIMATIC S7-FCT.

In the following cases, reassignment of the PROFIsafe address is required:

- Changing the F-destination address or F-source address
- Replacement of the coding element

In the following cases, reassignment of the PROFIsafe address is not required:

- When you replace an F-I/O / BaseUnit and apply the original coding element
- Replacement of the interface module

Basic procedure

1. Configure and parameterize your F-I/Os, including the PROFIsafe address (combination of F-source address and F-destination address), with your engineering system. You calculate the value for F_iPar_CRC (Page 11) with SIMATIC S7-FCT.
2. Identify (Page 14) the F-I/Os to which you want to assign the parameterized PROFIsafe address.
3. Assign (Page 15) the PROFIsafe address to the F-I/Os.

⚠ WARNING

If you make changes in which the assignment of the input/output channels of the F-I/O and the inputs/outputs can change in the safety program, you need to test the following for the relevant F-I/Os, regardless of whether the PROFIsafe addresses change or not:

- Whether a signal at an input channel at the F-I/O arrives at the expected input in the safety program
- Whether the value of an output in the safety program arrives at the expected output channel of the F-I/O

Examples for such changes are:

- Adding F-I/Os
- Changing the input/output addresses of F-I/Os
- Changing the slot position of F-I/Os
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

5.2 Identifying F-I/Os

Requirement

The following requirements must be met:

- The F-CPU is configured and parameterized.
- The F-I/Os are configured and parameterized (Page 11) including correct values for F_iPar_CRC.
- The current hardware configuration has been saved and loaded and, depending on your engineering system, compiled before loading.
- The F-I/Os and, if necessary, the F-CPU can be reached online.

⚠ WARNING

Make sure that the latest hardware configuration has been downloaded to the F-CPU before the identification. By clicking the "Identification" button and then clicking on "Assign PROFIsafe address", you confirm the correctness of the PROFIsafe addresses for the F-I/Os.
Therefore, proceed carefully when confirming the F-I/Os by LED flashing or by checking the serial number of the interface module with F-I/Os.
To do this, you have to read and write down the serial number directly at the interface module. It is not permitted to read out the serial number via your engineering system.
A special rule applies for F-I/Os of the ET 200AL distributed I/O system. For these F-I/Os, only identification by LED flashing is permissible and only exactly one F-I/O at a time may be selected for assignment of the PROFIsafe address.

Procedure

Proceed as follows to identify the F-I/Os:

1. Open the "PROFIsafe address assignment" dialog for the desired F-I/Os / device. Proceed as described in the documentation of your engineering system. For example, via the shortcut menu of the F-I/O / device with "Start Device Tool > SIMATIC S7-FCT V4.0 > PROFIsafe address assignment".

NOTE

If you integrate an F-I/O of the ET 200AL distributed I/O system in a configuration of the ET 200SP distributed I/O system (mixed configuration ET 200AL/ET 200SP with ET-Connection), you need to open the dialog "PROFIsafe address assignment" for the F-I/Os / device of the respective distributed I/O systems separately.

NOTE

If your engineering system does not offer the start of SIMATIC S7-FCT, check whether the F-I/Os are supported by SIMATIC S7-FCT (https://support.industry.siemens.com/cs/ww/en/view/109762827). Try reinstalling SIMATIC S7-FCT. If SIMATIC S7-FCT is still not shown, contact the manufacturer of the engineering system.

2. Under "Assign PROFIsafe address via", select the method to be used for identifying the F-I/O.
   – "Identification by LED flashing"
     This is the default setting. The DIAG and STATUS LEDs of the F-I/Os to be identified flash upon identification.
   – "Identification by serial number"
     If you cannot see the F-I/Os directly, you can identify the F-I/Os by the previously noted serial number of the interface module.

     NOTE
     The displayed serial number may be amended with a year number compared to the serial number printed on the interface module. The serial numbers are still considered identical, however.

3. With identification by LED flashing, select all the F-I/Os to which you want to assign the PROFIsafe addresses in the "Assign" column.
   If you select the interface module in the "Assign" column, all F-I/Os of the station are selected.
4. If you have configured more F-I/Os for an ET 200MP device than are actually available, a dialog appears. In this dialog, enter the number of actually existing ET 200MP F-I/Os and confirm the dialog. If you have configured fewer ET 200MP F-I/Os than are actually available, an online-offline difference is shown and the assignment of the PROFIsafe address is not possible.
5. Click the "Identification" button. Check whether the DIAG and STATUS LEDs for the F-I/Os whose PROFIsafe addresses you want to assign are flashing green. If you identify using the serial number, compare the displayed serial number to the noted serial number of the interface module.

5.3 Assign PROFIsafe address

Introduction

After you have identified the F-I/Os, you can assign the PROFIsafe addresses to the F-I/Os.

Requirement

- The F-I/Os and, if necessary, the F-CPU can be reached online.
- The F-I/Os have been successfully identified.

Procedure

Follow these steps to assign the PROFIsafe addresses:

1. In the "Confirm" column, select all the F-I/Os to which you want to assign the PROFIsafe addresses.
2. Use the "Assign PROFIsafe address" button to assign the PROFIsafe addresses to the F-I/Os.
   You must confirm the "Confirm assignment" dialog within 60 seconds to assign the PROFIsafe addresses.

NOTE
Note that SIMATIC S7-FCT communicates directly with the interface module when assigning the PROFIsafe address. For this reason, it is not possible to protect this operation using the access protection of the host system.
Access protection to protect against unauthorized personnel is not required for the SIMATIC S7-FCT, as automatic start-up of the F-I/Os is not possible.

5.4 Changing the PROFIsafe address

Procedure

NOTE
Please note that the uniqueness of the PROFIsafe addresses (combination of F-source address and F-destination address) must be ensured even after changing the F-source address or F-destination address of the F-I/Os.

1. Change the F-source address or F-destination address in the hardware configuration.
2. Compile and download the hardware configuration to the F-CPU.
3. Proceed as described under Identifying F-I/Os (Page 14) and Assign PROFIsafe address (Page 15).

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SIMATIC
Industrial Software
Product Information on the SIMATIC S7-FCT V3.0 - Fail-safe Configuration Tool configuration manual

Product Information

Security information

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Content

The configuration manual "SIMATIC S7-FCT V3.0 – Fail-safe Configuration Tool" remains valid with Update 1 and includes version SIMATIC S7-FCT V3.0 Update 1.
In the "Installation" section, use file "SIMATIC_S7_FCT_V3_Update1.EXE" instead of file "SIMATIC_S7_FCT_V3.EXE".

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SIEMENS

SIMATIC
ET 200SP
Dependencies during configuration with GSD files for ET 200SP fail-safe modules

Product Information

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Introduction

Note the following dependencies for PROFINET IO during configuration of ET 200SP fail-safe modules per with GSD file.

NOTE

When using ET 200SP fail-safe modules with the GSD file on F-CPUs, note that the warnings, information and references contained in the F-module manuals are still valid for other manuals.

Also observe the specifications of the F-CPU.

An F-CPU is an F-capable IO controller that supports PROFIsafe.

Requirement

ET 200SP fail-safe modules can be used with the GSD file on the following interface modules:

- IM 155-6 PN ST as of V3.1
- IM 155-6 PN HF as of V3.1
- IM 155-6 PN/2 HF as of V4.2
- IM 155-6 PN/3 HF as of V4.2
- IM 155-6 PN HS as of V4.0
- IM 155-6 MF HF as of V5.0

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An S7-FCT is required to calculate the F_iParCRC and address the F-I/O.

NOTE

If the identification during the assignment of the PROFIsafe address does not succeed, e.g. the F module flashes continuously, the following corrective measures are possible:

- Pull/plug the F module.
- Repeat the assignment of the PROFIsafe address after approx. 2 minutes.
- Increase the PROFINET update time of the F-CPU and IM for the duration of the F-address assignment.

S7-FCT allows you to configure selected F-I/Os from SIEMENS in an engineering system from another manufacturer.
You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).
Observe the minimum requirements for the installation of the F-system to be used.

Table 1 Configuration software and requirements

Configuration software	Requirements	Information on installation
STEP 7 (TIA Portal) as of V15	S7-FCT as of V2.0	STEP 7 online help
STEP 7 as of V5.5 SP4 HF19		
STEP 7 as of V5.6 HF5 or higher		
STEP 7 as of V5.6 SP1 HF5		
Software of another manufacturer		Documentation of the manufacturer

We recommend that you use the latest HF.

NOTE

Observe the module-specific restrictions.

Dependencies F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.
When configuring with GSD file, only module-wide passivation is possible.
In TIA Portal, the "IO Tags" tab displays more tags than supported by the F module.

F-DQ 4x24VDC/2A PM HF (6ES7136-6DB01-0CA0) dependencies as of firmware version V1.0.0

The same dependencies apply to this F-module as to F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0).
In addition, channel-by-channel passivation is also possible due to the support of PROFIsafe V2.6MU1.
With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, the I/O module is only compliant with EN 54-2.

Dependencies for "Disable Dark Test (max. SIL2, CAT3, PLd)"
If you have enabled "Disable Dark Test (max. SIL2, CAT3, PLd)", "Disable Dark Test for 48 hours" and "Enable Dynamic Read Back" cannot be set.

Dependencies for "Disable Dark Test for 48 hours"
If you have enabled "Disable Dark Test for 48 hours", you must configure the "Max. readback time light test / dark test" parameter the same for all channels.
"Disable Dark Test (max. SIL2, CAT3, PLd)" and "Enable Dynamic Read Back" cannot be set.

Dependencies for "Enable Dynamic Read Back"
If you have enabled "Enable Dynamic Read Back", then "Disable Dark Test (max. SIL2, CAT3, PLd)" and "Disable Dark Test for 48 hours" cannot be set.
Limit the range of values of the "Max. readback time, dark test and switch-off test" parameter to between 0.6 ms and 20 ms.

Dependencies F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

General dependencies
The following applies to the "Input delay" parameter, depending on the sensor supply and activation of the short-circuit test:
"Input delay" < MIN ("Startup time of the sensor after a short-circuit test", "Time for the short-circuit test").
The "Startup time of the sensor after a short circuit test" must be configured to be at least 1% of the "Time for the short circuit test".
If a sensor supply is selected for a channel, this sensor supply must also be activated. You also need to disable unused encoder supplies.
Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.
When configuring with GSD file, only module-wide passivation is possible.

Dependencies for 1oo2 evaluation
Both channels must be activated.
The "Input delay" parameter must be identical for each pair. The "Input delay" parameter for the channel pair is determined as follows:
"Input delay" < MIN("Input delay" for channel n, "Input delay" for channel n+4).
The configured discrepancy time must be greater than the configured input delay.
Disable chatter monitoring for both channels.

Dependencies F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)

The same dependencies apply to this F-module as for F-DI 8x24VDC HF (6ES7136-6BA00-0CA0).
In addition, channel-by-channel passivation is also possible due to the support of PROFIsafe V2.6MU1.

Dependencies for safety mat evaluation (as of firmware version V2.0.0)
If you have configured a channel group as a safety mat evaluation, you must assign the sensor supplies to the digital inputs as follows:

- VS_0 to DI_0 and VS_4 to DI_4
- VS_1 to DI_1 and VS_5 to DI_5
- VS_2 to DI_2 and VS_6 to DI_6
- VS_3 to DI_3 and VS_7 to DI_7

The short-circuit test must be activated on both sensor supplies.
You must set the parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" to 4.2 ms.
Both channels must be activated.
You must set the parameter "Input delay" to the fixed value 1.6 ms for each channel of the channel pair.
Disable chatter monitoring for both channels.
The parameter "Channel failure acknowledge" must have the same value for both channels of the channel pair.

Dependencies for the "Counter" operating mode (as of firmware version V3.0.0)
Ensure that the value of the "High counting limit" parameter is higher than the value of the "Start value" parameter.
Ensure that the value of the "Start value" parameter is higher than the value of the "Low counting limit" parameter.
Configure the "Input delay" parameter for "Gate hardware control - Channel 1, 5" so that it is equal to the "Input delay" parameter of "Counter - Channel 0, 4".
Configure the "Input delay" parameter for "Direction hardware control - Channel 3, 7" so that it is equal to the "Input delay" parameter of "Counter - Channel 0, 4".

Dependencies for the "Standstill and overspeed monitoring" operating mode (as of firmware version V3.0.0)
Ensure that the value of the "Overspeed threshold" parameter is at least 2 greater than the value of the "Standstill threshold" parameter.
Configure the "Input delay" parameter for "Gate hardware control - Channel 1, 5" so that it is equal to the "Input delay" parameter of "Standstill and overspeed monitoring - Channel 0, 4".

NOTE

Note that the following parameters are connected to each other and influence each other:

- Overspeed threshold
- Standstill threshold
- Input delay
- Monitoring window duration [100 ms]

If one of these parameters is changed, you have to ensure by means of the following formula that the Overspeed threshold and Standstill threshold can be reached:

$$\text{Maximum reachable value} = \text{maximum frequency} * \frac{\text{Monitoring window duration [100 ms]}}{10}$$

The "Maximum reachable value" is the highest possible value that can be reached in a monitoring window.
The value of the "Overspeed threshold" parameter must be less than or equal to "Maximum reachable value" to ensure that the limit is reachable.
The value of the "Standstill threshold" parameter must be less than or equal to "Maximum reachable value" - 2.

The "Maximum frequency" tag is determined by the "Input delay" parameter:

- If the "Input delay" is 0.4 ms, the maximum frequency is 480 Hz.
- If the "Input delay" is 0.8 ms, the maximum frequency is 350 Hz.
- If the "Input delay" is 3.2 ms, the maximum frequency is 120 Hz.

The value of the "Monitoring window duration" parameter is set as a multiple of 100 ms.

Dependencies F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) as of firmware version V2.0.0

The same dependencies apply to this F-module as for the two F-modules with article numbers 6ES7136-6DB00-0CA0 and 6ES7136-6BA00-0CA0 described above.
In TIA Portal, the "IO Tags" tab displays more tags than supported by the F module.

Dependencies F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

If you have enabled "Disable Dark Test for 48 hours", you must configure the "Max. readback time light test / dark test" parameter the same for all channels.
Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.
When configuring with GSD file, only module-wide passivation is possible.

Dependencies F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

The F module has no F_iPar_CRC and no PROFIsafe address. You do not need to assign a PROFIsafe address to the F module. If you nevertheless assign a PROFIsafe address to the F module with S7-FCT, an error message is displayed.

Dependencies of F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1) as of firmware version V1.0.2

NOTE

If the F-module is not visible in the module selection after the installation of the GSDML, check whether your configuration software supports the GSDML specification V2.35 or higher.

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU.
In the module parameters, you can set the reintegration method a channel at a time. Manual or automatic reintegration is possible. When configuring with GSD file, only module-wide passivation is possible.
With configuration by GSD file, the F-module supports PROFIsafe V2.6MU1. An F-CPU is required which also supports a PROFIsafe V2.6MU1 or higher.

With "Evaluation of the sensors" with the setting "1oo1 evaluation (max. SIL3/Cat.3/PLd)"
The following parameters do not have any influence on the measured values and can be ignored.

- Standard value
- Discrepancy time
- Tolerance window % absolute
- Tolerance window % relative

With "Evaluation of the sensors" with the setting "1oo2 evaluation (max. SIL3/Cat.4/PLe)"
When switching from 1oo1 evaluation to 1oo2 evaluation, you have to activate the two corresponding channels.
The following parameters must have the same settings for the primary and secondary channel:

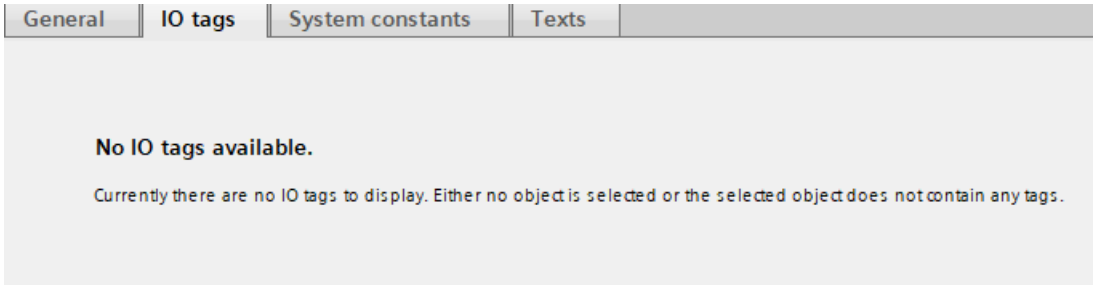
- Channel failure acknowledge
- Measuring range
- Diagnosis: Wire break
- Smoothing

NOTE

For the measuring range 0...20 mA, you have to activate the parameter "Diagnosis: Wire break".

NOTE

Ignore the following error message. This is a representation problem in the GSDML configuration. When you access the process data in your application, the IO variables are available.



Dependencies of F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

NOTE

If the F-module is not visible in the module selection after the installation of the GSDML, check whether your configuration software supports the GSDML specification V2.35 or higher.

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU.
In the module parameters, you can set the reintegration method a channel at a time. Manual or automatic reintegration is possible. When configuring with GSD file, only module-wide passivation is possible.
With configuration by GSD file, the F-module supports PROFIsafe V2.6MU1. An F-CPU is required which also supports a PROFIsafe V2.6MU1 or higher.

With "Evaluation of the sensors" with the setting "1oo1 evaluation (max. SIL2/Cat.3/PLd)"
The following parameters do not have any influence on the measured values and can be ignored:

- Standard value
- Discrepancy time
- Tolerance window % absolute
- Tolerance window % relative

With "Evaluation of the sensors" with the setting "1oo2 evaluation (max. SIL3/Cat.4/PLe)"
When switching from 1oo1 evaluation to 1oo2 evaluation, you have to activate the two corresponding channels.
The following parameters must have the same settings for the primary and secondary channel:

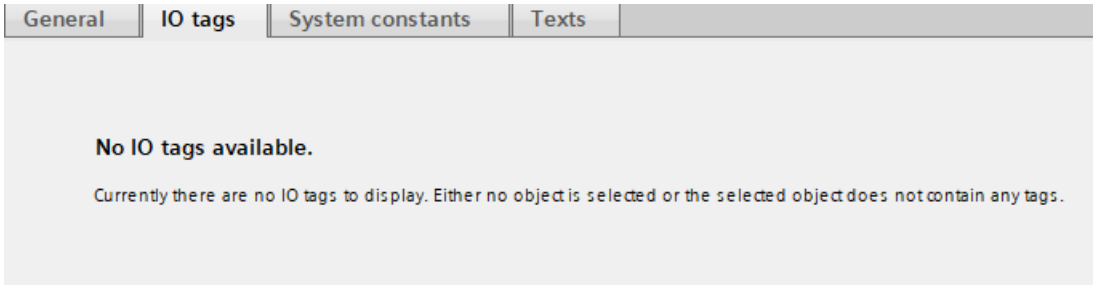
- Channel failure acknowledge
- Diagnosis: Wire break
- Smoothing

NOTE

If the above-mentioned condition is not met, a parameter assignment error occurs or the parameter assignment is refused.

NOTE

Ignore the following error message. This is a representation problem in the GSDML configuration. When you access the process data in your application, the IO variables are available.


General
IO tags
System constants
Texts
No IO tags available.
Currently there are no IO tags to display. Either no object is selected or the selected object does not contain any tags.

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SIMATIC
ET 200MP
Dependencies during configuration with GSD files for ET 200MP fail-safe modules
Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.
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For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://new.siemens.com/cert.

Introduction

Note the following dependencies when configuring ET 200MP fail-safe modules with a GSD file for PROFINET IO.

NOTE

When using ET 200MP fail-safe modules with the GSD file on F-CPUs, note that the warnings, notes and references to other manuals in the equipment manuals of the F-modules are still valid.

Also observe the specifications of the F-CPU.

An F-CPU is an F-capable IO controller that supports PROFIsafe.

Requirement

The described modules have the process data lengths listed in the table. Column 2 shows the net data length. Column 3 lists the process data lengths including a PROFIsafe driver of 5 bytes. Make sure that your F-CPU supports the process data lengths.

Module designation	Process data (input/output) in bytes	Process data incl. PROFIsafe driver data (input/output) in bytes
F-DI 16x24VDC	4/0	9/5
F-DQ 8x24VDC/2A PPM	1/1	6/6
F-AI 8xI 0(4)..20mA	18/1	23/6

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ET 200MP fail-safe modules can be used with the GSD file on the following interface modules:

- IM 155-5 PN ST as of V3.0
- IM 155-5 PN HF as of V3.0
- IM 155-5 PN BA as of V4.3
- IM 155-5 MF HF as of V5.0

An S7-FCT is required to calculate the F_iParCRC and address the F-I/Os (see table "Configuration software and requirements" under).

NOTE

If identification during assignment of the PROFIsafe address is unsuccessful, e.g. the F-module flashes continuously, the following corrective measures are possible:

- Pull/plug the F module.
- Repeat the assignment of the PROFIsafe address after approx. two minutes.
- Increase the PROFINET update time of F-CPU and IM for the duration of the F-address assignment.

S7-FCT allows you to use selected F-I/Os from SIEMENS in an engineering system of a third-party manufacturer.
You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).
Observe the minimum requirements for installation of the F-system to be used.

Table 1 Configuration software and requirements

Configuration software	Requirements	Information on installation
STEP 7 as of (TIA Portal) V15	S7-FCT as of V3.0 Update 1 When using S7-FCT submodules as of V4.0	STEP 7 online help
STEP 7 as of V5.5 SP4 HF19		
STEP 7 as of V5.6 HF5		
STEP 7 as of V5.6 SP1 HF5		
Software of another manufacturer		Documentation of the manufacturer

We recommend that you use the latest HF.

NOTE

Observe the module-specific restrictions.

Dependencies for F-DI 16x24VDC (6ES7526-1BH00-0AB0)

The fail-safe module F-DI 16x24VDC supports the configuration with PROFIsafe profile 2.4 and profile 2.6.1 respectively.
F-DI 16x24VDC V1.0, BP (Basic protocol, PROFIsafe protocol version V2.4)

- Module-wide passivation

F-DI 16x24VDC V1.0, XP (Extended protocol, PROFIsafe protocol version V2.6.1)

- Channel-specific passivation (RIOforFA-Safety)

Dependencies for F-DI 16x24VDC, BP

General dependencies

The following applies to the "Input delay" parameter, depending on the sensor supply and activation of the short-circuit test:
"Input delay" < MIN("Startup time of sensor after short-circuit test", "Time for short-circuit test").
The "Startup time of sensor after short-circuit test" must be configured to be at least 1% of "Time for short-circuit test".
If a sensor supply has been selected for a channel, this sensor supply must also be enabled. In addition, you must disable unused sensor supplies and the associated short-circuit tests.
Re-integration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F-module supports PROFIsafe V2.4 when configuring with a GSD file.

When configuring with a GSD file, only module-wide passivation is possible.

Dependencies for 1oo2 evaluation
Both channels must be activated.
The "Input delay" configuration must be identical for each pair. You determine the "Input delay" parameter for the channel pair as follows:
"Input delay" < MIN("Input delay" for channel n, "Input delay" for channel n+8).
The configured discrepancy time must be greater than the input delay.
Disable chatter monitoring for both channels.
The "Channel failure acknowledge" parameter must have the same value for both channels of the channel pair.
Differing configuration of the 1oo2 channel pairs results in a parameter error.
Channel groups 0..3, 4..7, 8..11 and 12..15 must be connected to the same sensor supply.

Dependencies for F-DI 16x24VDC, XP

General dependencies
The following applies to the "Input delay" parameter, depending on the sensor supply and activation of the short-circuit test:
"Input delay" < MIN("Startup time of sensor after short-circuit test", "Time for short-circuit test").
The "Startup time of sensor after short-circuit test" must be configured to be at least 1% of "Time for short-circuit test".
If a sensor supply has been selected for a channel, this sensor supply must also be enabled. In addition, you must disable unused sensor supplies and the associated short-circuit tests.
Re-integration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F-module supports PROFIsafe V2.6.1 when configuring with a GSD file.

Dependencies for 1oo2 evaluation
Both channels must be activated.
The "Input delay" configuration must be identical for each pair. You determine the "Input delay" parameter for the channel pair as follows:
"Input delay" < MIN("Input delay" for channel n, "Input delay" for channel n+8).
The configured discrepancy time must be greater than the input delay.
Disable chatter monitoring for both channels.
The "Channel failure acknowledge" parameter must have the same value for both channels of the channel pair.
Differing configuration of the 1oo2 channel pairs results in a parameter error.
Channel groups 0..3, 4..7, 8..11 and 12..15 must be connected to the same sensor supply.

Dependencies for F-DQ 8x24VDC/2A PPM (6ES7526-2BF00-0AB0)

The fail-safe module F-DQ 8x24VDC/2A PPM supports the configuration with PROFIsafe profile 2.4 and profile 2.6.1 respectively.
F-DQ 8x24VDC/2A PPM, BP (Basic protocol, PROFIsafe protocol version V2.4)
- Module-wide passivation

F-DQ 8x24VDC/2A PPM, XP (Extended protocol, PROFIsafe protocol version V2.6.1)
- Channel-specific passivation (RIOforFA-Safety)

Dependencies for F-DQ 8x24VDC/2A PPM, BP

Re-integration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F-module supports PROFIsafe V2.4 when configuring with a GSD file.
When configuring with a GSD file, only module-wide passivation is possible.
In TIA Portal, the "IO tags" tab displays more tags than supported by the F-module.
You can operate the module in two variants:
PP switching
The following parameters are affected:

- Max. readback time switch on test 0.8 to 5 ms
- Max. readback time dark test 0.8 to 400 ms
- The light test is always active in this operation case.

PM switching
You can configure each channel 0..7 independent of the other channels.

Dependencies in PP switching mode
You must not deactivate channel 0.
You must activate the light text for all activated channels.
You must not select the "Disable dark test for 48 hours" parameter for all activated channels.
The values of the "Max. readback time dark test" and "Max. readback time switch on test" parameters must be identical to the values for channel 0 for all activated channels.

Dependencies for F-DQ 8x24VDC/2A PPM, XP

General dependencies
Re-integration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F-module supports PROFIsafe V2.6.1 when configuring with a GSD file.
In TIA Portal, the "IO tags" tab displays more tags than supported by the F-module.
You can operate the module in two variants:
PP switching
The following parameters are affected:

- Max. readback time switch on test 0.8 to 5 ms
- Max. readback time dark test 0.8 to 400 ms
- The light test is always active in this operation case.

PM switching
You can configure each channel 0..7 independent of the other channels.

Dependencies in PP switching mode
You must not deactivate channel 0.
You must activate the light text for all activated channels.
You must not select the "Disable dark test for 48 hours" parameter for all activated channels.
The values of the "Max. readback time dark test" and "Max. readback time switch on test" parameters must be identical to the values for channel 0 for all activated channels.

Dependencies F-AI 8xI 0(4)..20mA (6ES7536-1MF00-0AB0)

The fail-safe module F-AI 8xI 0(4)..20mA supports the configuration with PROFIsafe profile 2.6.1.
F-AI 8xI 0(4)..20mA V1.0, XP (Extended protocol, PROFIsafe protocol version V2.6.1)

- Channel-specific passivation (RIOforFA-Safety)

F-AI 8xI 0(4)..20mA V2.0, XP (Extended protocol, PROFIsafe protocol version V2.6.1)

- Channel-specific passivation (RIOforFA-Safety)

F-AI 8xI 0(4)..20mA V2.0, XP, Submodules (Extended protocol, PROFIsafe protocol version V2.6.1)

- Channel-specific passivation (RIOforFA-Safety)

Dependencies F-AI 8xI 0(4)..20mA V1.0, XP

Re-integration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The fail-safe module supports PROFIsafe V2.6.1 when configuring with a GSD file.

With "Sensor evaluation" with the setting "1oo1 evaluation (max. SIL3/Cat.3/PLd)"
The following parameters do not have any influence on the measured values and can be ignored.

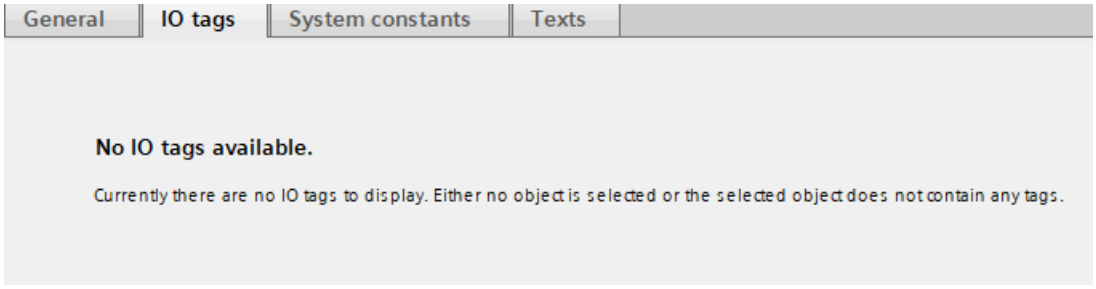
- Unit value
- Discrepancy time
- Tolerance window abs.
- Tolerance window rel.

Dependencies with "1oo2 evaluation (max. SIL3/Cat.4/PLe)"
When switching from 1oo1 evaluation to 1oo2 evaluation, you have to activate the two corresponding channels.
The following parameters must have the same settings for the primary and secondary channel:

- Channel failure acknowledge
- Measuring range
- Diagnosis: Wire break
- Smoothing

NOTE
For the measuring range 0 ... 20 mA, you have to activate the parameter "Diagnosis: Wire break".

NOTE
Ignore the following error message: This is a representation problem in the GSDML configuration. When you access the process data in your application, the IO variables are available.



Dependencies F-AI 8xI 0(4)..20mA V2.0, XP

The dependencies for "F-AI 8xI 0(4)..20mA V1.0, XP" apply as well as the dependencies described below.

Dependencies at the activation of HART communication
To activate the HART communication of a channel, follow these steps:

1. Set the "Measuring range" parameter to "4..20mA".
2. Set the "HART gate" parameter to "On" or "Switchable".
3. Activate the "HART function" parameter.

Dependencies F-AI 8xI 0(4)..20mA V2.0, XP, Submodules

The dependencies for "F-AI 8xI 0(4)..20mA V2.0, XP" apply as well as the dependencies described below.

Dependencies when using additional submodules

You can use MSI and HART variables at the same time in up to 3 additional submodules. For example, MSI ("F-AI 8xI 0(4)..20mA V2.0, XP, MSI") in the 1st additional submodule and HART variables in the 2nd and 3rd additional submodule. However, you can only use one type of HART variable submodule:

- "F-AI 8xI 0(4)..20mA V2.0, XP, 1 multiHART" or
- "F-AI 8xI 0(4)..20mA V2.0, XP, 4 HART" or
- "F-AI 8xI 0(4)..20mA V2.0, XP, 8 HART"

If you use the submodule "F-AI 8xI 0(4)..20mA V2.0, XP, 8 HART", all 8 variables that are set under "HART Mapping" are stored in the input address space of the submodule.
If you use the submodule "F-AI 8xI 0(4)..20mA V2.0, XP, 4 HART", the first 4 variables that are set under "HART Mapping" are stored in the input address space of the submodule.
If you use the submodule "F-AI 8xI 0(4)..20mA V2.0, XP, 1 multiHART", the variables set under "HART Mapping" are irrelevant.

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Configuring ET 200AL F-DI 4+F-DQ 2x24VDC/2A, 4xM12 (6ES7146-5FF00-0BA0) with a GSDML File

Product Information

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
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Introduction

Note the following dependencies for PROFINET IO during configuration of ET 200AL fail-safe modules with a GSDML file.

NOTE

When using ET 200AL fail-safe modules with a GSDML file on non-Siemens PROFIsafe masters, note that the warnings, information, and references contained in the F-module device manuals are still valid.
Please also observe the warnings, information, and references of the non-Siemens master.

Requirement

S7-FCT is required to calculate the F_iPar_CRC and perform PROFIsafe addressing for the F-I/O according to PROFIsafe address type 2.
You can find instructions and additional information for the SIMATIC S7-FCT V3.0 - Fail-safe Configuration Tool on the Internet (https://support.industry.siemens.com/cs/us/en/view/109763833).
You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

NOTE

If identification of the F-module does not succeed during the assignment of the PROFIsafe address (for example, the F-module's channel LEDs flash continuously), you can take the following corrective measures:

- Repeat the assignment of the PROFIsafe address after approximately 5 minutes.
- Power cycle the F-module and then repeat the assignment of the PROFIsafe address.
- Increase the PROFINET update time of F-host and IM for the duration of the PROFIsafe address assignment.

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S7-FCT, in conjunction with a GSDML file, allows you to configure selected F-I/Os from Siemens in versions of STEP 7 that do not natively support the F-I/O and in an engineering system from another manufacturer.

Configuration software	Support as of	Information on installation	Requirements
STEP 7 (TIA Portal) V17	or later	STEP 7 online help	S7-FCT V3.0 or later
STEP 7 (TIA Portal) V16	Upd1 or later		
STEP 7 (TIA Portal) V15.1	Upd5 or later		
STEP 7 (Classic) V5.7	or later	STEP 7 help	
STEP 7 (Classic) V5.6 SP2	HF2 or later		
STEP 7 (Classic) V5.5 SP4	HF19 or later		
Software of other manufacturer		Documentation of the manufacturer	

Configuring the ET 200AL F-DI 4+F-DQ 2x24VDC/2A, 4xM12 (6ES7 146-5FF00-0BA0) as of firmware version V1.0.0 or later

In TIA Portal, the "IO Tags" tab displays more tags than are supported by the F-module.

Configuring F-I/O module parameters using GSDML

You specify the properties of the F-I/O module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

1. Insert the IM 157-1 PN interface module. When using STEP 7, the interface module is found in the hardware catalog under "Other field devices->PROFINET IO->I/O->SIEMENS AG->ET 200AL".
2. Insert the F-I/O module. When using STEP 7, the F-I/O module is found in the hardware catalog under "Module->DIQ->F-DI 4+F-DQ 2x24VDC/2A, 4xM12". Select PROFIsafe V2.4 or PROFIsafe V2.6 based upon the specifications of your fail-safe controller. If you are using Siemens fail-safe controllers, select PROFIsafe V2.4 if you are using an S7-300 or S7-400 F-CPU or select PROFIsafe V2.6 if you are using an S7-1200 or S7-1500 F-CPU.
3. Access the F-I/O module's parameters in your programming package. To display the module's parameters in STEP 7, on the Device view or Device overview select the F-I/O module and select the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select "PROFIsafe" and the drop-down arrows for "Module parameters>I/O parameters" to see a subset of the properties of the "PROFIsafe" and "I/O parameters".
5. Set values for "PROFIsafe" or "I/O parameters" in the right side property fields.
6. Right click the F-I/O module name in the Device view and click "Start device tool ..." to launch S7-FCT.
   - Select "F_iPar_CRC calculation" and click Start.
   - If asked, choose and confirm the desired communication interface.
   - Examine the parameters, and if correct, press "Confirm i-parameters" to calculate the F_iPar_CRC.
   - If parameters are not correct, close out of S7-FCT and return to the module Properties dialog to correct the parameter settings.
   - Click the copy button next to the hexadecimal representation of the F_iPar_CRC (left value) to place this value on the clipboard.
   - Close out of S7-FCT.
7. In the "Properties" view on the "General" tab for the module, select "PROFIsafe" in the tree and paste the clipboard value into the F_iPar_CRC field.
8. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-I/O module.

Assigning PROFIsafe addresses for F-I/Os

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address of each F-module and the F-source address of the F-CPU in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-I/O module to which you want to assign the configured F-destination and F-source addresses. F-destination addresses are generally assigned with lower numbers (for example, less than 100) for GSDML configured devices.
3. Use "Assigning the PROFIsafe addresses to the F-I/Os" section in the instructions for the SIMATIC S7-FCT V3.0 - Fail-safe Configuration Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833) to assign the PROFIsafe address (F-destination address together with F-source address) to each F-module before you put it into operation. To launch the PROFIsafe-Address Assignment dialog:
   - Right click the F-I/O module name in the Device view and click "Start device tool ..." to launch S7-FCT.
   - Select "PROFIsafe address assignment" and click Start.
   - If asked, choose and confirm the desired communication interface.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Dependencies ET 200AL F-DI 4+F-DQ 2x24VDC/2A, 4xM12 (6ES7146-5FF00-0BA0) as of firmware version V1.0.0 or later

Dependencies for 1oo2 evaluation

In a 1oo2 channel configuration, you must set the following 1oo2 DI channel parameters to the same value:

- Activated check box
- Input filter
- Channel failure knowledge (PROFISAFE V2.6 only)
- Sensor supply

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Configuring ET 200eco PN Fail-Safe Modules with a GSDML File

Product Information

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).
Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Introduction

Note the following dependencies for PROFINET IO during configuration of ET 200eco PN fail-safe modules with a GSDML file.

NOTE

When using ET 200eco PN fail-safe modules with a GSDML file on non-Siemens PROFIsafe masters, note that the warnings, information, and references contained in the F-module device manuals are still valid.
Please also observe the warnings, information, and references of the non-Siemens master.

Requirement

S7-FCT is required to calculate the F_iPar_CRC and perform PROFIsafe addressing for the F-I/O according to PROFIsafe address type 2.
You can find instructions and additional information for the SIMATIC S7-FCT V3.0 - Fail-safe Configuration Tool on the Internet (https://support.industry.siemens.com/cs/us/en/view/109763833).
You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

NOTE

If identification of the F-module does not succeed during the assignment of the PROFIsafe address (for example, the F-module's channel LEDs flash continuously), you can take the following corrective measures:

- Repeat the assignment of the PROFIsafe address after approximately 5 minutes.
- Power cycle the F-module and then repeat the assignment of the PROFIsafe address.
- Increase the PROFINET update time of F-host and IM for the duration of the PROFIsafe address assignment.

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S7-FCT, in conjunction with a GSDML file, allows you to configure selected F-I/Os from Siemens in versions of STEP 7 that do not natively support the F-I/O and in an engineering system from another manufacturer.
S7-FCT also allows you to configure selected F-I/Os from Siemens that are not contained in the hardware catalog of supported Siemens configuration software.

Configuration software	Support as of	Information on installation	Requirements
STEP 7 (TIA Portal) V17	or later	STEP 7 online help	S7-FCT V2.0 or later
STEP 7 (TIA Portal) V16	Upd1 or later		
STEP 7 (TIA Portal) V15.1	Upd5 or later		
STEP 7 (Classic) V5.7	or later	STEP 7 help	
STEP 7 (Classic) V5.6 SP2	HF2 or later		
STEP 7 (Classic) V5.6 SP1	HF5 or later		
STEP 7 (Classic) V5.6	HF5 or later		
STEP 7 (Classic) V5.5 SP4	HF19 or later		
Software of other manufacturer		Documentation of the manufacturer	

Configuring the ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 (6ES7146-6FF00-0AB0) as of firmware version V1.0.0 or later

In TIA Portal, the "IO Tags" tab displays more tags than are supported by the F-module.

Configuring F-I/O module parameters using GSDML
You specify the properties of the F-I/O module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.
You set the parameters of the module as follows:

1. Insert the IM 157-1 PN interface module. When using STEP 7, the interface module is found in the hardware catalog under "Other field devices->PROFINET IO->I/O->SIEMENS AG->ET 200AL".
2. Insert the F-I/O module. When using STEP 7, the F-I/O module is found in the hardware catalog under "Module->DIQ->F-DI 4+F-DQ 2x24VDC/2A, 4xM12". Select PROFIsafe V2.4 or PROFIsafe V2.6 based upon the specifications of your fail-safe controller. If you are using Siemens fail-safe controllers, select PROFIsafe V2.4 if you are using an S7-300 or S7-400 F-CPU or select PROFIsafe V2.6 if you are using an S7-1200 or S7-1500 F-CPU.
3. Access the F-I/O module's parameters in your programming package. To display the module's parameters in STEP 7, on the Device view or Device overview select the F-I/O module and select the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select "PROFIsafe" and the drop-down arrows for "Module parameters>I/O parameters" to see a subset of the properties of the "PROFIsafe" and "I/O parameters".
5. Set values for "PROFIsafe" or "I/O parameters" in the right side property fields.
6. Right click the F-I/O module name in the Device view and click "Start device tool ..." to launch S7-FCT.
   - Select "F_iPar_CRC calculation" and click Start.
   - If asked, choose and confirm the desired communication interface.
   - Examine the parameters, and if correct, press "Confirm i-parameters" to calculate the F_iPar_CRC.
   - If parameters are not correct, close out of S7-FCT and return to the module Properties dialog to correct the parameter settings.
   - Click the copy button next to the hexadecimal representation of the F_iPar_CRC (left value) to place this value on the clipboard.
   - Close out of S7-FCT.
7. In the "Properties" view on the "General" tab for the module, select "PROFIsafe" in the tree and paste the clipboard value into the F_iPar_CRC field.
8. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-I/O module.

Assigning PROFIsafe addresses for F-I/Os

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address of each F-module and the F-source address of the F-CPU in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-I/O module to which you want to assign the configured F-destination and F-source addresses. F-destination addresses are generally assigned with lower numbers (for example, less than 100) for GSDML configured devices.
3. Use "Assigning the PROFIsafe addresses to the F-I/Os" section in the instructions for the SIMATIC S7-FCT V3.0 - Fail-safe Configuration Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833) to assign the PROFIsafe address (F-destination address together with F-source address) to each F-module before you put it into operation. To launch the PROFIsafe-Address Assignment dialog:
   - Right click the F-I/O module name in the Device view and click "Start device tool ..." to launch S7-FCT.
   - Select "PROFIsafe address assignment" and click Start.
   - If asked, choose and confirm the desired communication interface.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Dependencies ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 (6ES7146-6FF00-0AB0) as of firmware version V1.0.0 or later

Re-integration after a channel fault depends on the host used. You can find information on this in the documentation of the host.
In TIA Portal, the "IO Tags" tab displays more tags than supported by the F-module.

Dependencies for 1oo2 evaluation

In a 1oo2 channel configuration, you must set the following 1oo2 DI channel parameters to the same value:

- Activated check box
- Input filter
- Sensor supply

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Product Information on fail-safe modules with GSD configuration

Product Information

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.
In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.
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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Introduction

Observe the following notes and explanations for PROFINET IO during parameterization of fail-safe modules with GSD file in the PROFIsafe profile 2.4 (BP mode).

NOTE

When using fail-safe modules with the GSD file on an F-host, note that the warnings, information and references to other manuals contained in the F-module equipment manuals are still valid.
Please also observe the F-host specifications.

Implementation of the Device_Fault bit in BP (Basic Protocol) mode of the fail-safe modules

PROFIsafe 2.4 with automatic reintegration:
In this mode, the F-host is responsible for module-wide passivation in the event of a channel fault. This means that if an individual channel reports a fault, the F-host performs passivation of all channels within an F-module. Notification of the F-CPU about faults and the consequent reaction of the F-CPU takes place via PROFIsafe status and control bits.
Reintegration of an F-module with faults in this mode takes place automatically after all channel faults have been completely eliminated.
After all pending faults have been corrected, the F-module returns to the normal state and process values are updated cyclically again.

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PROFIsafe 2.4 with operator acknowledgment for reintegration:
This is the same mode as before, but the reintegration can only be completed after a pending operator acknowledgment signal is released by the F-host (i.e. operator acknowledgment is handled by the F-host).
From the operator's perspective, waiting for the operator acknowledgment signal is indicated by specific LED flashing (red-green). This means that, after pending faults of an affected channel have been eliminated, the value status is set to "good" and the LED flashing will show optically that the channel is ready to finish reintegration.
After all channel faults have been eliminated, the F-module checks whether operator acknowledgment from the F-host is pending by evaluating the PROFIsafe control bit **OA_Req**. As long as this control bit is set to "true", the channel shows "Waiting for reintegration" through flashing LEDs. In this state, note that the value status bits for the channels have already been set to "good" and the F-module is ready to function normally. For this reason, the received operator acknowledgment only affects the LED flashing.

Summary of failure and reintegration from the perspective of the F-module

1. Fault occurs and is detected.
2. Device_Fault is sent to the F-host.

NOTE

This can be viewed as an implicit request for an operator acknowledgment.

3. Channel fault is corrected, Device_Fault=0 is sent to the F-host and the F-module is reintegrated
4. Operator acknowledgment via the PROFIsafe control bit OA_Req is received by the F-host and the alternating flashing of the LEDs is switched off.

Restart
After all channel faults have been corrected (all I/O self-tests are completed successfully), the process values are automatically output or supplied again.

⚠ WARNING

Manual reintegration must be realized on the F-host side
You can find a description of suitable measures in the technical specification PROFISafe Version 2.6, Annex C, subsection *"C.1.4.2 Prevent unintentional restart by application measures"*.