SIEMENS

SIMATIC

S7-400
FM 451 positioning module

Operating Instructions

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Preface

Preface

Scope of this manual

The present manual contains the description of function module FM 451 applicable at the time the manual was published. We reserve the right to publish modifications of FM 451 functionality in a separate Product Information.

Content of this manual

This manual describes the hardware and software of the FM 451 positioning module.

It consists of the following:

- Basic information: Chapters "Product overview" to "Commissioning FM 451"
- Reference information: Chapters "Machine data and increments" to "Examples"
- Appendices: Chapters "Technical specifications", "Connection diagrams", and "Data blocks/ error lists"
- An index

Standards

The SIMATIC S7-400 product series fulfills the requirements and criteria of IEC 61131-2.

Recycling and disposal

The FM 451 is low in contaminants and can therefore be recycled. For ecologically compatible recycling and disposal of your old device, contact a certificated disposal service for electronic scrap.

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Product overview

1

1.1 FM 451 positioning module

Description of the FM 451

The FM 451 positioning module is used for controlled positioning with rapid traverse/creep speed drives in the S7-400 automation system. The module has 3 independent channels and, thus controls one rotary axis axis or one linear axis at a time. The module supports one incremental encoder or absolute encoder (SSI) for each channel.

You can operate several FM 451 positioning modules simultaneously. The module also supports combinations with other FM/CP modules. A typical application is the combination of the module with an FM 452 electronic cam controller.

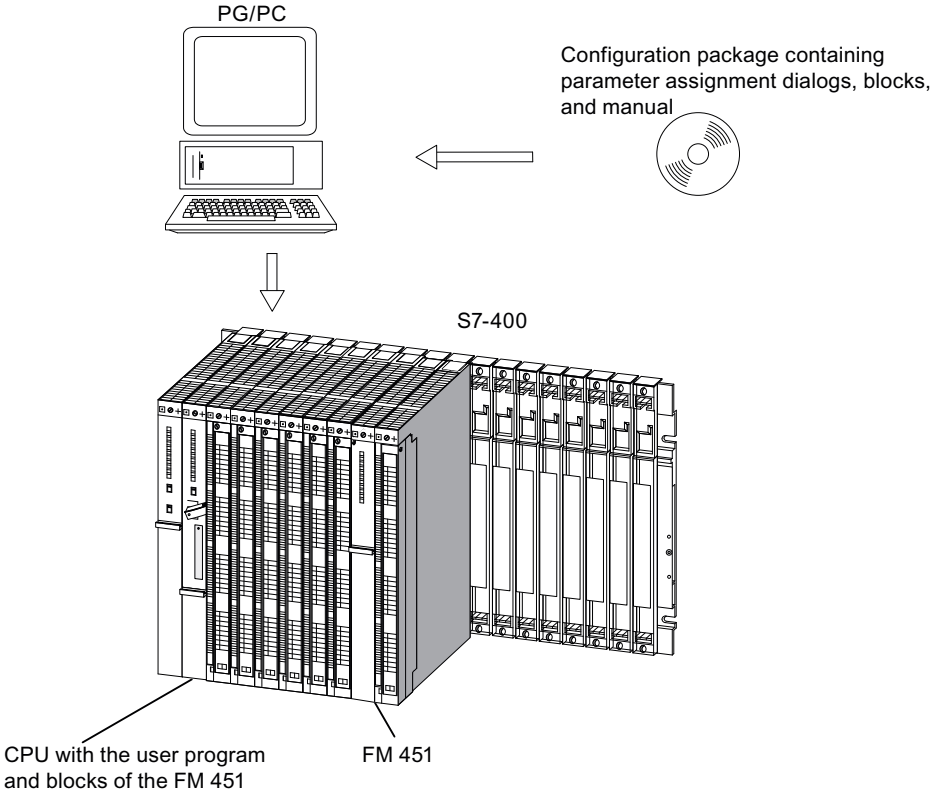


Figure 1-1 Configuration of a SIMATIC S7-400 with FM 451

1.2 Application areas of the positioning module

Overview

- Packaging machines
- Lifting and conveying equipment
- Woodworking machinery
  Example: Controlling delivery processes
  Various wooden parts are processed using a profiling machine. Various work processes and, with that, different cutting heads, are required to machine the wood. The various cutting heads are exchanged by means of a controlled positioning process.
- Paper making machines and printing machines
- Rubber and plastics processing machines
  Example: Simply handling processes
  The injection molded parts in an injection molding machine are removed from the work piece by means of a gripper arm. The gripper arm is controlled by the positioning module.
- Building materials industry
- Machine tools

1.3 Configuration of a controlled positioning with an FM 451

Control circuit

The following figure shows the components of a controlled positioning with rapid traverse/creep speed drives.

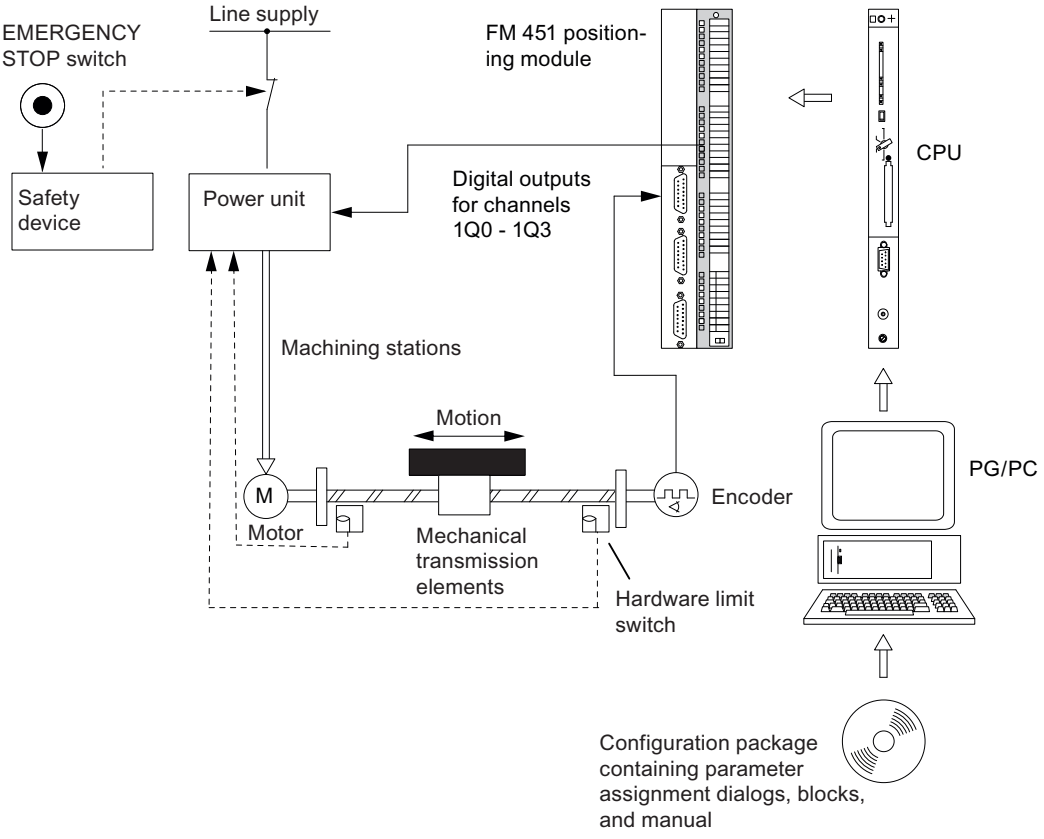


Figure 1-2 Controlled positioning

Power unit and safety system

The digital outputs of the FM 451 control the power unit (e.g., a protective circuit). The FM 451 has 4 control modes (see chapter "Machine data of the drive (Page 66)").

The power unit shuts off the motor if the safety system responds (EMERGENCY STOP switch or hardware limit switch).

Motor

The motor drives the axis, controlled by the power unit.

Encoder

The encoder returns position and direction data. Connectable encoders are:

- Incremental encoder with 5 V differential signal, symmetrical
- Incremental encoder with 24 V signal, asymmetrical
- SSI absolute encoder

FM 451 positioning module

The FM 451 can position up to 3 axes independently based on the rapid traverse/creep speed process.

The power section is controlled by the 4 digital outputs (see chapter "Machine data of the drive (Page 66)").

The FM 451 positioning module establishes the current actual position value of the axis from the encoder signals, which are proportional to the distance moved (see chapter "Machine data of the encoder (Page 73)" and chapter "Resolution (Page 80)").

The FM 451 provides the following operating modes and functions:

- "Jog" mode
  (see chapter "Configuring jog mode (Page 94)")
- "Reference point approach" mode:
  (see chapter "Configuring reference point approach mode (Page 98)")
- "Absolute/relative incremental approach" mode
  (see chapter "Configuring incremental approach mode (Page 104)")
- Set actual value / set actual value on-the-fly
  (see chapter "Configuring set actual value/set actual value on-the-fly/cancel set actual value (Page 110)")
- Zero offset
  (see chapter "Configuring zero offset (Page 112)")
- Set reference point
  (see chapter "Configuring set reference point (Page 115)")
- Length measurement/edge detection
  (see chapter "Configuring length measurement / edge detection (Page 117)")
- Loop approach
  (see chapter "Configuring loop approach (Page 119)")

CPU

The CPU executes the user program. The user program and the module exchange data and signals by means of function calls.

PG/PC

The PG/PC is used for

- Assigning parameters: You assign parameters for the FM 451 using the *parameter assignment dialogs* or the parameter DB (see chapter "AUTOHOTSPOT").
- Programming: You program the FM 451 functions you can implement directly in the user program.
- Testing and commissioning: You test and commission the FM 451 with the help of the *parameter assignment dialogs*.

Overview of the positioning module

- **3 axes, axes types:**
  - Linear axis
  - Rotary axis
- **4 digital outputs per axis**
- **4 digital inputs per axis**
- **Typical drives/motors:**
  - Standard motor, contactor-controlled
  - Standard motor on frequency inverter (e.g. MICROMASTER)
  - Asynchronous motor on power unit with vector control
- **Position measuring systems:**
  - Incremental encoder 5 V, symmetrical
  - Incremental encoder 24 V, asymmetrical
  - SSI absolute encoder
- **Monitoring functions:**
  - Operating range monitoring by means of software limit switches
  - Standstill monitoring
  - Encoder monitoring
  - Monitoring for axis motion and target approach
- **System environment:**
  - Central use SIMATIC S7-400
- **System integration:**
  - Module replacement without programming device is possible
  - Teleservice possible

Basics of positioning

2

2.1 Controlled positioning

Controlled positioning

Each positioning process is characterized by

- A start position
- The target of the positioning
- Parameters that determine the sequence of the positioning

The target is initially approached at a higher velocity (rapid traverse). At a specified distance from the target, the velocity switches to creep speed. The drive is switched off shortly before the axis reaches the target - also at a specified distance from the target. In doing so, the module monitors the target approach.

The drive is controlled via digital outputs with rapid traverse or creep speed and in the appropriate direction.

2.2 Ranges and switching points of the positioning module

Target

The target is the absolute or relative position on the axis that is approached during a positioning process.

Definition of the switching points and switching ranges

The following areas and positions can be assigned for each controlled positioning:

Range	Description
Operating range	defines the area that you define for your task by means of the software limit switches and the end of the rotary axis.
Changeover difference	defines the distance from the target at which the drive changes from rapid traverse to creep speed.
Changeover point	defines the position at which the drive changes from rapid traverse to creep speed.
Switch-off difference	defines the distance from the target at which the drive is switched off.
Switch-off point	defines the position at which the drive is switched off. The positioning module then adopts the monitoring functions from this point on.
Target range	defines the positioning precision for your application and surrounds the target symmetrically.
Standstill range	defines a symmetrical area around the target that will be monitored by the positioning module.

The following figure shows how the switching points and switching differences can be arranged for a positioning. For simplification purposes, it is assumed that the actual velocity changes linearly over the distance traversed. The emerging ramps can be explained by mechanical inertia or by the parameter assignment possibilities of the power section.

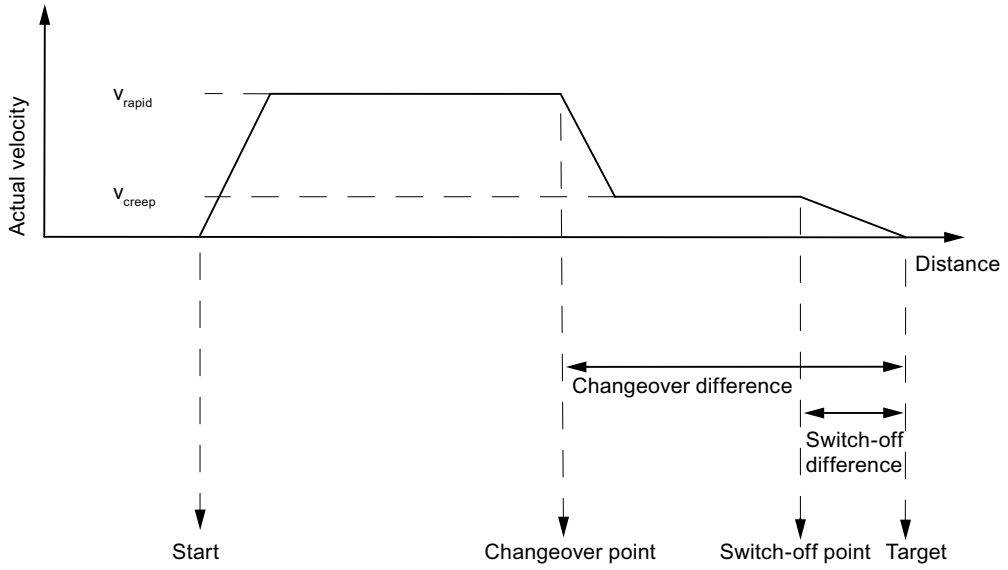


Figure 2-1 Switching points and switching differences

The following figure shows how the switching ranges can be arranged around the target.

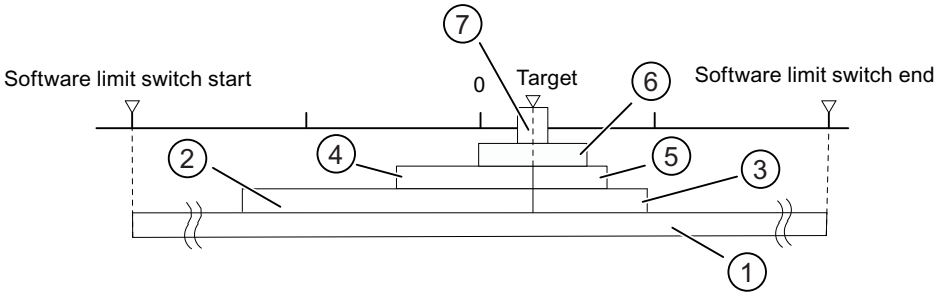


Figure 2-2 Switching ranges around a target

① Operating range
② Changeover difference in plus traversing direction
③ Changeover difference in minus traversing direction
④ Switch-off difference in plus traversing direction
⑤ Switch-off difference in minus traversing direction
⑥ Standstill range
⑦ Target range

Installing and removing the FM 451

3

Important safety rules

Certain important rules and regulations govern the integrating of an S7-400 with FM 451 in a plant or system. These are described in the Installation Manual Automation System S7-400: Hardware and Installation (http://support.automation.siemens.com/WW/view/en/1117849).

Selecting slots

Like a signal module, the FM 451 positioning module can be installed anywhere in a central rack or expansion rack.

Configuring the mechanical setup

Refer to the Installation Manual Automation System S7-400: Hardware and Installation (http://support.automation.siemens.com/WW/view/en/1117849) for options on the mechanical setup and how to proceed during configuration.

Installation and removal tools

You require a 4.5 mm screwdriver to install or remove the FM 451.

Installing the FM 451 positioning module

1. Hook the top of the FM 451 and swivel it downwards.
2. Screw-tighten the FM 451 (tightening torque approx. 0.8 Nm to 1.1 Nm).
3. Label the FM 451 with its slot number. Use the number wheel supplied with the rack for this purpose.
   The required numbering scheme and the procedure for defining the slot numbers are described in the Installation Manual Automation System S7-400: Hardware and Installation (http://support.automation.siemens.com/WW/view/en/1117849).

Removing the FM 451 positioning module

1. Switch off the power unit.
2. Loosen and remove the front connector.
3. Release the cover of the encoder interface.
4. Detach the sub D connector to the encoder.
5. Loosen the fixing screws on the module.
6. Swivel the module up, and then unhook it from the rail.

Wiring the FM 451

4

4.1 Important safety information

Important safety rules

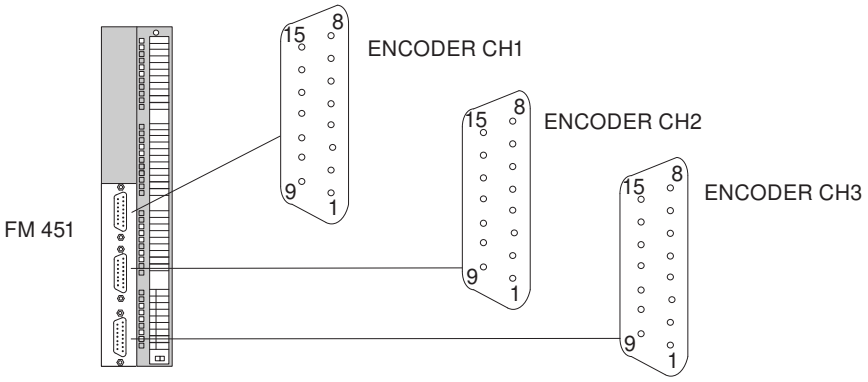
For the safety concept of the plant it is essential that the following switching elements are installed and adapted to the conditions of your plant.

- EMERGENCY STOP switch with which you can switch off the entire plant.
- Hardware limit switch that directly effects the power sections of all drives.
- Motor circuit-breaker

4.2 Description of the encoder interface

Location of the sub D sockets

The following figure shows the installation position and designation of the sockets on the module. You can connect an incremental encoder or absolute encoder (SSI) to the sub D sockets (see chapter "Incremental encoder (Page 127)" and chapter "Absolute encoders (Page 129)").



CH Channel

Figure 4-1 Position of the sub D sockets (CH1, CH2, and CH3 encoders)

Assignment of the encoder interfaces (CH1, CH2, and CH3 encoders)

Pin	Name	Incremental encoder (24V)	Incremental encoder (5V)	Absolute encoder
1	A*	Encoder signal A	---	---
2	CLS	---	---	SSI shift clock
3	/CLS	---	---	SSI shift clock inverse
4	B*	Encoder signal B	---	---
5	24 VDC	Encoder supply	Encoder supply	Encoder power supply
6	5.2 VDC	---	Encoder power supply	Encoder power supply
7	M	Ground	Ground	Ground
8	N*	Zero mark signal	---	---
9	RE	Current sourcing/current sinking[1)]	---	---
10	N	---	Zero mark signal	---
11	/N	---	Zero mark signal, inverse	---
12	/B	---	Encoder signal B, inverse	---
13	B	---	Encoder signal B	---
14	/A / /DAT	---	Encoder signal A, inverse	SSI data inverse
15	A / DAT	---	Encoder signal A	SSI data

[1)] See chapter "Wiring diagram of the incremental encoder Siemens 6FX 2001-4 (Up = 24 V; HTL) (Page 176)".

4.3 Connecting the encoders

More information

You can find information about suitable encoders and encoder cables in the chapters "Encoder (Page 127)" and "AUTOHOTSPOT".

Procedure

Proceed as follows to connect the encoder:

1. Connect the connecting cable to the encoder.
   For some encoders, the cable may have to be fabricated according to the manufacturer's specifications on the cable end for the encoder.
2. The encoder cables must be shielded.
3. Cables A and /A, B and /B, N and /N for the incremental encoder and cables DAT and /DAT, CLS and /CLS for the absolute encoder must be twisted in pairs.
4. Open the front panel and plug the sub D connector onto the FM 451.
5. Lock the connector using the finger screws. Close the front panel.
6. Remove the insulation material on the connecting cable and connect the cable shield to the shield/protective conductor bar.

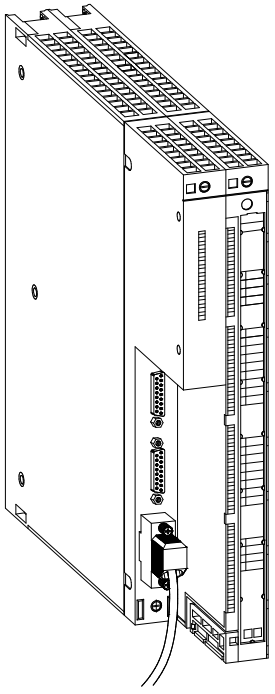


Figure 4-2 Connection of an encoder to the FM 451 positioning module

4.4 Description of the front connector

Front connector

You use the 48-pin front connector to connect the supply voltages of the encoders and the digital outputs. Then, the digital inputs and outputs assigned to the channels are connected.

Assignment of front connector (X1)

Terminal	Name	Meaning	Incremental encoder	Absolute encoder
1		Assigned; contains cable jumpers for detection of inserted front connector.		
2				
3	1L+	24 V DC auxiliary voltage for the encoder supply		
4 to 7		Not used		
8	1I0	Channel 1: Digital input 0	Reference point switch	Not used
9	1I1	Channel 1: Digital input 1	Reversing switch	Not used
10	1I2	Channel 1: Digital input 2	Enable input	
11	1I3	Channel 1: Digital input 3	Input for "Set actual value on-the-fly"/ length measurement/edge detection/external event for increment number 252	
12		Not used		
13	2L+	24 V DC auxiliary voltage for the load current supply		
14	2L+	Both terminals are internally connected on the module.		
15	2I0	Channel 2: Digital input 0	Reference point switch	Not used
16	2I1	Channel 2: Digital input 1	Reversing switch	Not used
17	2I2	Channel 2: Digital input 2	Enable input	
18	2I3	Channel 2: Digital input 3	Input for "Set actual value on-the-fly"/ length measurement/edge detection/external event for increment number 252	
19	3I0	Channel 3: Digital input 0	Reference point switch	Not used
20	3I1	Channel 3: Digital input 1	Reversing switch	Not used
21	3I2	Channel 3: Digital input 2	Enable input	
22	3I3	Channel 3: Digital input 3	Input for "Set actual value on-the-fly"/ length measurement/edge detection/external event for increment number 252	
23 to 24		Not used		
25	3L+	24 V DC auxiliary voltage for the load current supply		
26	3L+	Both terminals are internally connected on the module.		
27	1Q0	Channel 1: Digital output 0		
28	1Q1	Channel 1: Digital output 1		
29	1Q2	Channel 1: Digital output 2		
30	1Q3	Channel 1: Digital output 3		
31	2Q0	Channel 2: Digital output 0		
32	2Q1	Channel 2: Digital output 1		

Terminal	Name	Meaning	Incremental encoder	Absolute encoder
33	2Q2	Channel 2: Digital output 2		
34	2Q3	Channel 2: Digital output 3		
35 to 36		Not used		
37	4L+	24 V DC auxiliary voltage for the load current supply		
38	4L+	Both terminals are internally connected on the module.		
39	3Q0	Channel 3: Digital output 0		
40	3Q1	Channel 3: Digital output 1		
41	3Q2	Channel 3: Digital output 2		
42	3Q3	Channel 3: Digital output 3		
43 to 47		Not used		
48	M	Ground for auxiliary voltages 1L+, 2L+, 3L+, and 4L+		

Auxiliary voltage for the encoder supply (1L+, M)

Here, you connect a 24 VDC auxiliary voltage for the encoder supply. The reference potential of this supply (M) is connected to the ground of the load current supply (M) in the FM 451.

The 24 V DC auxiliary voltage for the encoder supply is monitored for undervoltage and wire break.

On the encoder interface (sub D sockets: CH1, CH2, and CH3 encoders) are provided with 24 V DC and 5.2 V DC for the different encoder types.

CAUTION

Verify the correct polarity of the 24 V DC auxiliary voltage for the encoder supply (1L+, M).

If you reverse the polarity of the 24 V DC auxiliary voltage for the encoder supply, the module will be damaged and will have to be replaced.

Auxiliary voltage for the load current supply (2L+, 3L+, 4L+, M)

You must connect the 24 V DC auxiliary voltages for the load current supply of the digital outputs to the 2L+, 3L+, 4L+, and M terminals.

CAUTION

Verify the correct polarity of the 24 V DC auxiliary voltage for the load current supply (2L+, 3L+, 4L+, M).

If you reverse the polarity of the 24 V DC auxiliary voltage for the load current supply, the module will be damaged and will have to be replaced.

Wiring information for 24 V DC

When wiring, note that the terminals 1L+ to 4L+ must be interconnected so that the module will operate error-free.

Start by wiring the 24 V DC to terminal 38 and connect the auxiliary voltage of terminal 37 to terminal 26. Use the same procedure for the other terminals.

Alternatively, you can also connect separate voltage supplies to the 1L+ (encoder), 2L+ (channel 1), 3L+ (channel 2), and 4L+ (channel 3) connections. Make sure that all voltage supplies have a common ground potential. In this case, synchronization of the axes will be retained following a power failure in the auxiliary voltages for the load current supply.

Load current supplies

The DC load current supply must meet the following requirements:

Only a safe, isolated extra-low voltage of ≤ 60 V DC may be used as the load current supply. Safe isolation can be implemented, for example, by adhering to the specifications

- VDE 0100 Part 410 / HD 384-4-41 / IEC 364-4-41 (as function low voltage with safe isolation) and/or
- VDE 0805 / EN 60950 / IEC 950 (as safety extra-low voltage SELV) or VDE 0106 Part 101.

12 digital inputs (1I0 to 3I3)

The FM 451 has 4 digital inputs per channel.

You can connect bounce-free switches (24V current sourcing) or non-contact sensors (2- or 3-wire proximity switches) to the 12 digital inputs.

The digital inputs are not monitored for short circuits or wire break and have a non-isolated connection to the encoder supply ground.

A separate LED indicates the state of each input.

12 digital outputs (1Q0 to 3Q3)

The FM 451 has 4 digital outputs per channel.

The power unit is controlled via the digital outputs. The function of the digital outputs depends on the control mode. You select the control mode (see chapter "Machine data of the drive (Page 66)") in the configuration software or in the parameter DB.

The digital outputs are not monitored for short circuits or wire break and have a non-isolated connection to the encoder supply ground.

The associated LED indicates the state of each output.

Table 4-1 Functions of the digital outputs, x for channel 1, 2, or 3

Output Q	**Control mode**			
	1	**2**	**3**	**4**
xQ0	Rapid speed	Rapid speed/Creep speed	Rapid speed	Rapid speed plus
xQ1	Creep speed	Position reached	Creep speed	Creep speed plus
xQ2	Travel plus	Travel plus	Travel plus	Rapid speed minus
xQ3	Travel minus	Travel minus	Travel minus	Creep speed minus

4.5 Wiring the power section

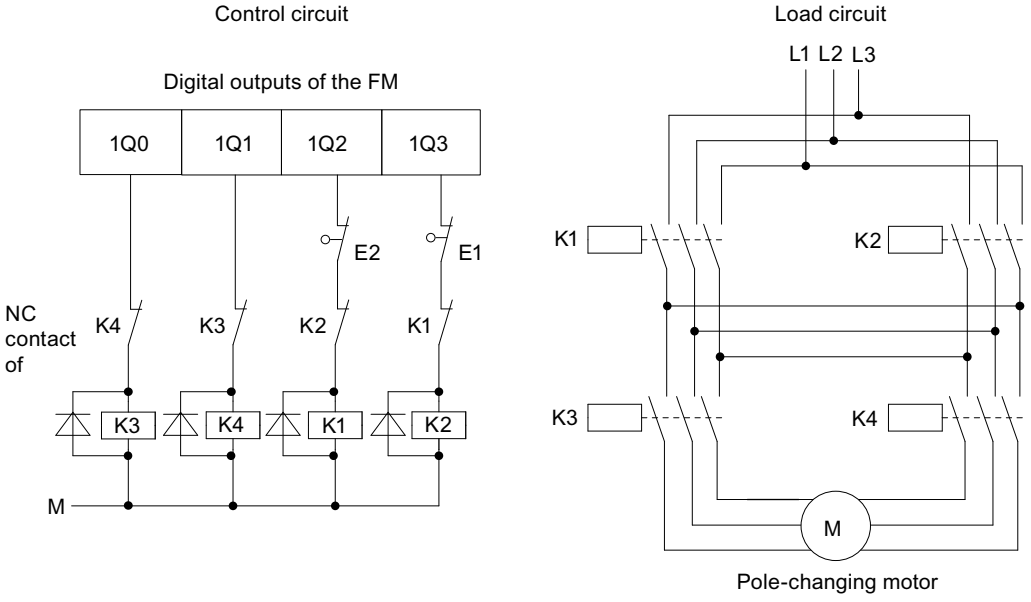
Power section

The power section, e.g. a simple contactor circuit, is connected to the digital outputs of the positioning module and controls the motor.

Contactor circuit

The following figure shows the control and load circuit of a power section.

The functions of the digital outputs correspond to control mode 1(refer to the section entitled "Machine data of the drive (Page 66)").



K1	Direction - plus
K2	Direction - minus
K3	Rapid traverse
K4	Creep speed
E1	Hardware limit switch minus
E2	Hardware limit switch plus

Figure 4-3 Contactor circuit

Operating principle of the contactor circuit

The contactors K1 and K2 control the rotational direction of the motor. Both contactors are mutually locked by means of the opening contacts K2 and K1. The hardware limit switches E1 and E2 are the limit switches minus / plus. The motor is switched off when one of these limit switches is overrun.

The contactors K3 and K4 switch the motor from rapid traverse to creep speed. Both contactors are mutually locked by means of the opening contacts K4 and K3.

⚠ CAUTION

Mutually lock the network contactors.

The previous figure shows the mutual locking of the network contactors.

Non-compliance with these instructions could cause a short circuit in the power network.

Note

Direct connection of inductances, e.g, of relays and contactors, is possible without an external protective circuit.

If SIMATIC output circuits can be switched off by means of additionally installed contacts, e.g. relay contacts, additional overvoltage protection devices must be provided for inductances. See the following example of overvoltage protection

Example for overvoltage protection

The following figure illustrates an output power circuit requiring additional overvoltage protectors. DC-activated coils will be wired with diodes or Z diodes.

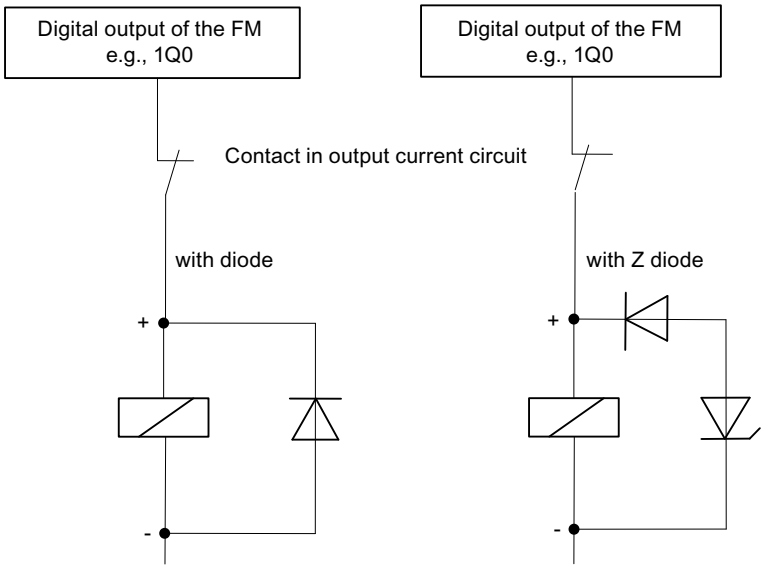


Figure 4-4 Relay contact in the output power circuit

4.6 Wiring the front connector

Connecting cables

- The cables for digital inputs and digital outputs must be shielded if they exceed a certain lengths:
  - Digital inputs: cable length > 50 m
  - Digital outputs: cable length > 100 m
- The shields on the cables must be attached on both ends.
- Flexible cable, cross section 0.25 to 1.5 mm^2
- End sleeves are not required. If you use want to use end sleeves then use only those without insulation collar (DIN 46228, Form A, short version).

Required tools

3.5 mm screwdriver or power screwdriver.

Wiring steps

⚠ WARNING

Risk of injury or material damage if the power supply is not shut off.

If you wire the FM 451 front connector while the system is in live state, you will risk injury from electric shock!

Always switch off power before you wire the FM 451!

If no EMERGENCY OFF switch is installed, damage may be caused by connected equipment units.

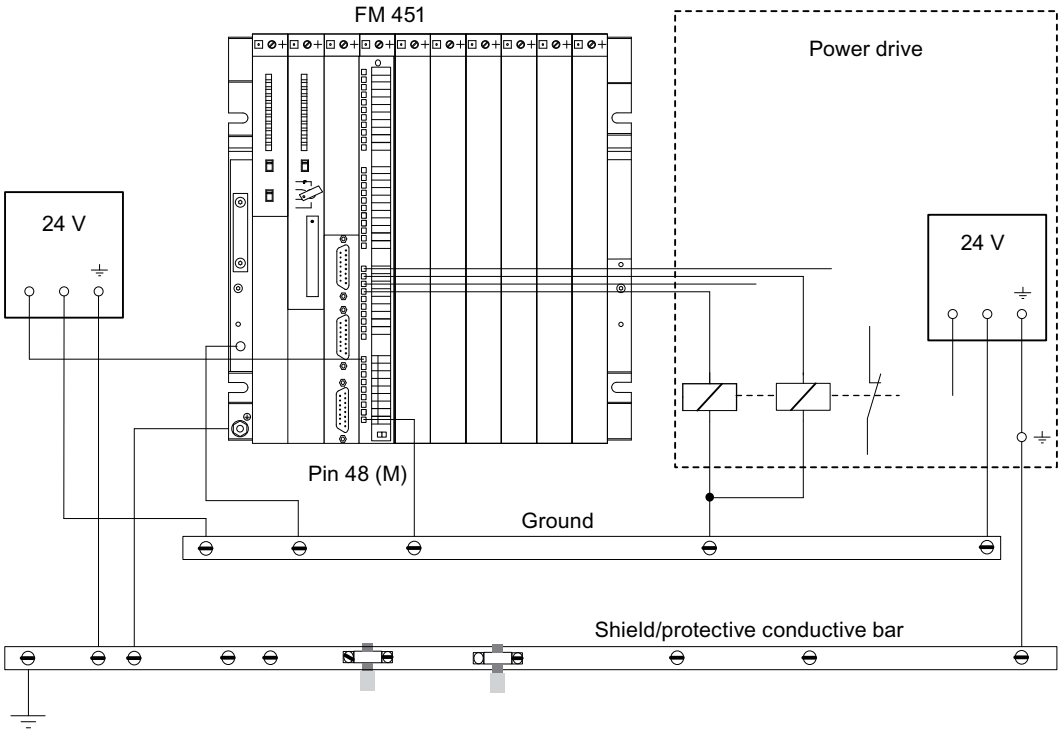
Install an EMERGENCY OFF switch to be able to shut down the connected drives when using the configuration software to operate the FM 451.

1. Remove the cover from the front connector.
2. Strip 6 mm of insulation from the cables, and press on end sleeves, if applicable.
3. Feed the accompanying strain relief clamp into the front connector.
4. To exit the cables at the bottom, start the wiring at the bottom, otherwise at the top. Screw-tighten any unused terminals. Tightening torque = 0.6 Nm to 0.8 Nm.
5. Attach the strain relief to the connector.
6. Tighten the strain relief for the cable strand.
7. Push the front connector into the operating position. To do this, press the interlock element.
8. Label the terminals on the enclosed labeling strip.

Non-isolation

The ground of the auxiliary voltages has a non-isolated connection to the CPU ground; i.e., you have to connect pin 48 (M) to the CPU ground using a low-resistance connection .

For an external encoder supply, you must also connect the ground of the external encoder supply to the CPU ground using a low-resistance connection.



Installing the configuration package

5

Requirement

Before starting to assign parameters for the positioning module, note the requirements in the readme.rtf file, in particular, regarding the required version of STEP 7. The readme.rtf file is available on the included CD.

Content of the configuration package

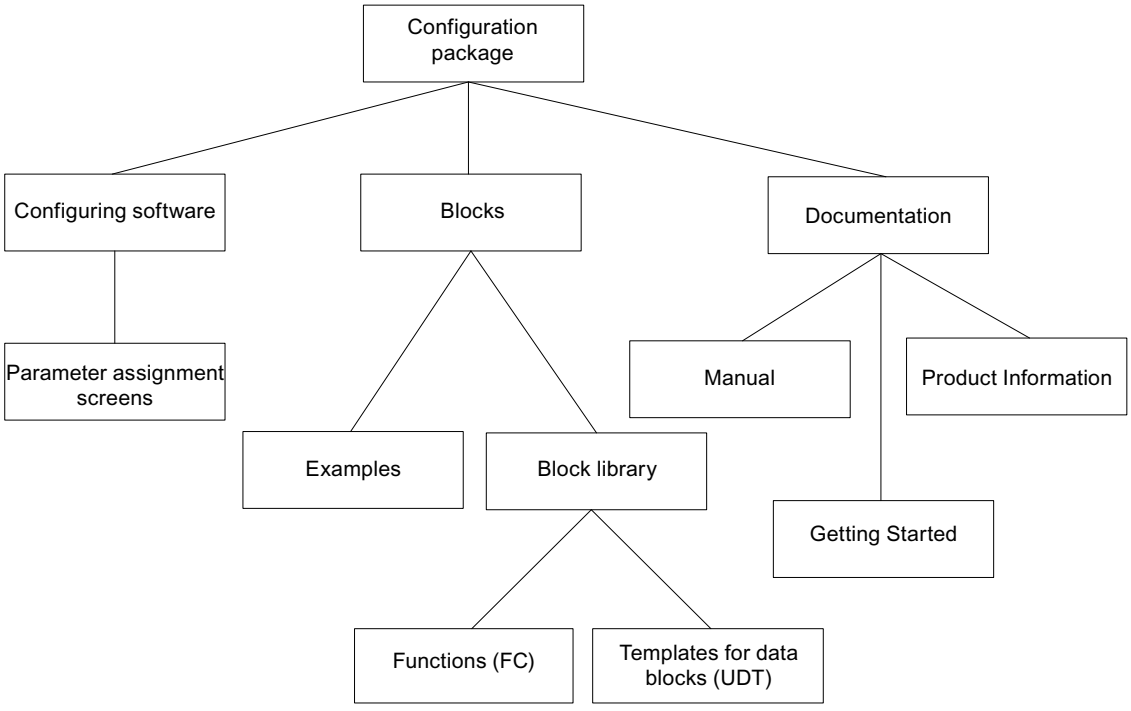


Figure 5-1 Content of the configuration package

Procedure

The entire configuration package can be located on the supplied CD.

1. De-install any already existing configuration packages.
2. Place the CD in the CD drive of your PC or PG.
3. Start Setup.exe and follow the step-by-step setup instructions displayed by the installation program.

Result

The components of the configuration package are installed in the following directories:

- **SIEMENS\STEP7\S7LIBS\FMx51LIB:** FCs, FBs, and UDTs
- **SIEMENS\STEP7\S7FABS:** configuration software, Readme, online help
- **SIEMENS\STEP7\EXAMPLES:** Examples
- **SIEMENS\STEP7\S7MANUAL\S7FABS:** Getting Started, manuals

Note

If, when installing STEP 7, you chose a directory other than SIEMENS\STEP7, then this directory will be entered.

Programming the FM 451

6

6.1 Basics of programming a positioning module

Task

You can assign parameters, control, and commission each channel of the positioning module via a user program. The following chapter illustrates how to design a user program to suit your application.

Preparation

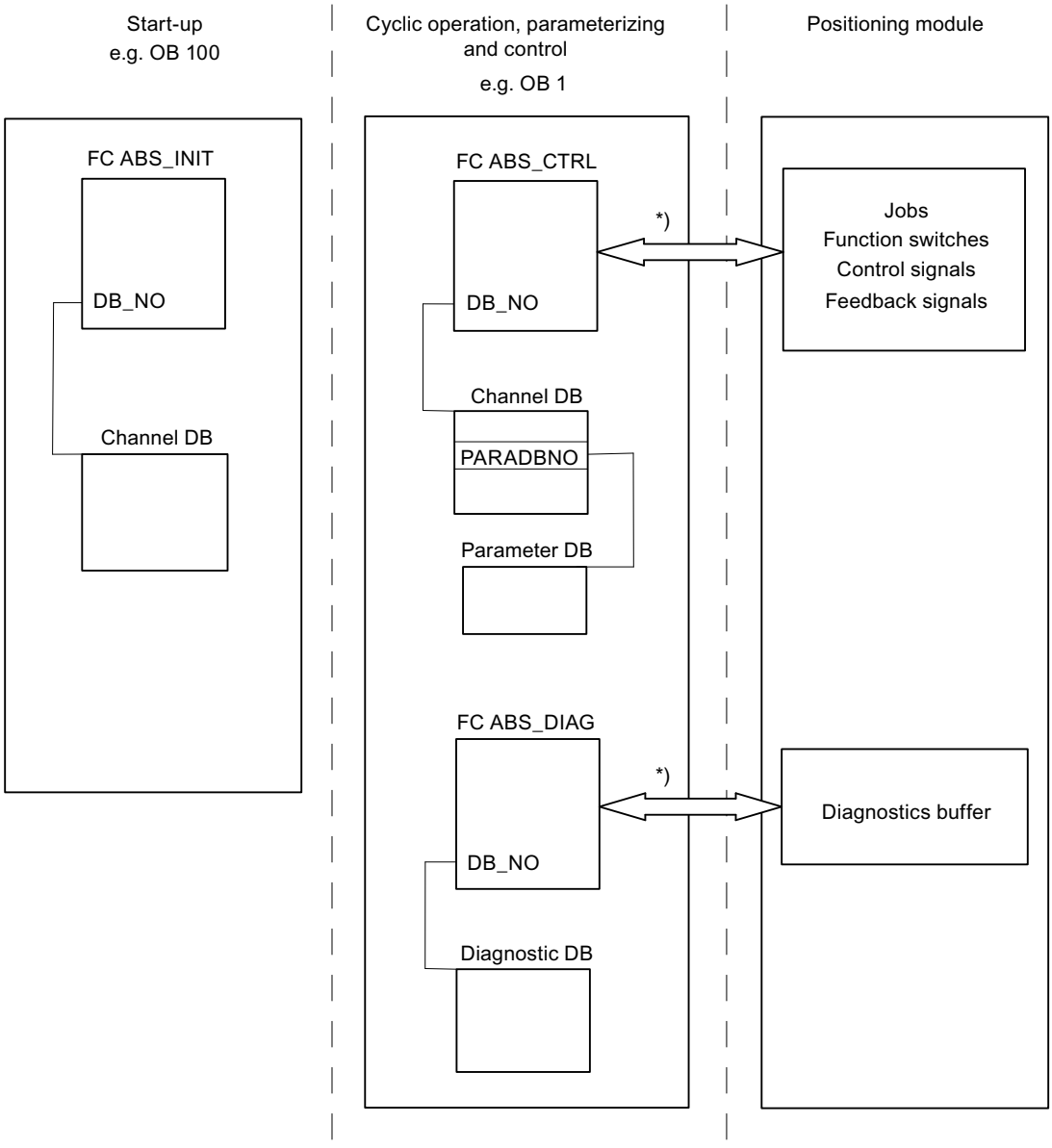
1. In SIMATIC Manager, open the block library FMx51LIB and copy the required functions (FC) and block templates (UDT) to the block container of your project. If the block numbers are already being used, assign new numbers. The block names are entered unchanged in the symbol table of your S7 program.

Name	Meaning
FC ABS_INIT (FC 0)	Required to initialize the channel DB after a module start-up
FC ABS_CTRL (FC 1)	Required for data exchange and for controlling
FC ABS_DIAG (FC 2)	Required if you are processing detailed diagnostic information in the program or want to make this available for a operator control and monitoring system
UDT ABS_CHANTYPE(UDT 1)	Required in order to create a channel DB for each channel; this is then used by the FC ABS_INIT and FC ABS_CTRL
UDT ABS_DIAGTYPE (UDT 2)	Required in order to create a diagnostic DB for each module; this is then used by the FC ABS_DIAG
UDT ABS_PARATYPE(UDT 3)	Required in order to create a parameter DB with parameters; this is then used by the FC ABS_CTRL in order to write or read machine data and increment tables

2. Create the data blocks (DBs) using the UDTs in the block container of your S7 program:
   - a separate channel DB for each channel.
   - If you want to write or read parameters using the user program, you need a separate parameter DB for each channel.
   - If you would like to execute the diagnostics using the user program, you require only a diagnostic DB for each module.

3. Enter the module address in the associated channel DB and, if necessary, also in the corresponding diagnostic DB in the "MOD_ADDR" parameter.
   Proceed as follows to enter the module address:
   - Recommended procedure:
     Assign the module address to the channel DB/diagnostic DB in the user program so that the assignment of the module address takes place when you call the user program in OB 100.
   - Alternative procedure:
     You can have the module address entered automatically if you select the module in HW Config, open the "Properties" dialog with the menu command **Edit > Object Properties**, and use the "Mod_Adr" button there to select a channel DB and diagnostic DB, if necessary. But in this case the values entered in the channel DB/diagnostic DB (including the module address) are reset to their initial values in the event of a consistency check (menu command **Edit > Check block consistency** opens the "Check block consistency" dialog) followed by a compilation (menu command **Program > Compile All** in the "Check block consistency" dialog box).
     The values are not changed if there is only a consistency check without compilation.
     The menu command **Edit > Compile All** is only required within the consistency check if the project was last edited with STEP 7 V5.0 Service Pack 2 or later.
4. Enter the channel number and, if necessary, the number of the parameter DB also in the respective channel DB.
5. If your programming device or PC is connected to a CPU, you can now download the FCs and DBs to the CPU.

The following figure shows you how the positioning module, FCs, DBs and OBs communicate with each other.



*) The module address (channel DB/diagnostic DB) entered in the "MOD_ADDR" parameter is used for accessing the module. We recommend you assign the module address to the channel DB/diagnostic DB in the user program so that the assignment of the module address takes place when you call the user program in OB 100.

Figure 6-1 Data exchange between FCs, DBs and positioning module

6.2 FC ABS_INIT (FC 0)

Task

The FC ABS_INIT deletes the following data in the channel DB:

- The control signals
- The checkback signals
- The trigger bits, done bits, and error bits of the jobs
- The function switches and their done bits and error bits
- The job management for the FC ABS_CTRL

Call

The function must be run through for each channel after start-up (supply voltage on) of the module or the CPU. Call the function, for example, in the start-up OB 100 and the insertion/ removal OB 83 or the initialization phase of your user program. This ensures that your user program does not access obsolete data after a CPU or module restart.

Data block used

Channel DB:

The module address must be entered in the channel DB.

Call parameters

Name	Data type	P-type	Meaning
DB_NO	INT	IN	Number of the channel DB

Return values

The specified function does not supply a return value.

6.3 FC ABS_CTRL (FC 1)

Tasks

You can use FC ABS_CTRL to read operating data for each channel of the module, assign channel parameters, and control the operation. For these tasks, you use control signals, checkback signals, function switches, and write and read jobs.

Each time it is called, the function performs the following actions:

- Read checkback signals:
  The FC ABS_CTRL reads all checkback signals for a channel and enters them in the channel DB. The control signals and jobs are not executed until this task is completed, which means the checkback signals reflect the channel status prior to the function call.
- Job management:
  The FC ABS_CTRL processes the write and read jobs and transmits data between the channel DB, parameter DB, and the module.
- Write control signals:
  The control signals entered in the channel DB are transmitted to the module.

Call

The FC ABS_CTRL must be called cyclically for each channel, e.g., in OB 1.

Before you call the FC ABS_CTRL, enter all the data needed to execute the required functions into the channel DB.

Data blocks used

- Channel DB:
  The module address and the channel number must be entered in the channel DB. Incorrect information can lead to I/O access errors or to an incorrect module accesses, which can produce data corruption.
- Parameter DB:
  If you want to write or read machine data using jobs, you require a parameter DB whose number must be entered in the channel DB.

Call parameters

Name	Data type	P-type	Meaning
DB_NO	INT	IN	Number of the channel DB
RET_VAL	INT	OUT	Return value

Return values

The function provides the following return values:

RET_VAL	BR	Description
1	1	At least 1 job active
0	1	No job active, no error
-1	0	Error: data error (DATA_ERR) or communication error (JOB_ERR) occurred

Jobs

Data exchange with the module other than the control and checkback signals is handled using jobs.

To start a job, set the corresponding trigger bit in the channel DB and provide the relevant data for write jobs. You then call FC ABS_CTRL to execute the job.

Due to the required confirmations from the module, a write job requires at least 3 calls or OB cycles. A read job is executed immediately.

Once a job has been completed, the function cancels the trigger bit. The next time the function is called, the subsequent job is identified and executed.

For each job there is not only a trigger bit (extension _EN as in "enable") but also a done bit and an error bit. In their names, they have the ending _D for "done" or _ERR for "error". The FC ABS_CTRL updates the done bits and error bits when execution of a job is complete. You should set these bits to 0 after they have been evaluated or before a job is started.

If you set the JOBRESET bit, all the done bits and error bits are reset before the pending jobs are processed. The JOBRESET bit is then reset to 0.

Function switches

The function switches activate and deactivate the states of the channel. A job for writing the function switches is only executed if changes were made to a switch setting. The setting of the function switch is latched after the job has been executed.

Function switches and jobs can be used at the same time in one FC ABS_CTRL call.

As with the jobs, there are trigger bits with the ending _ON/_OFF, done bits with the ending _D, and error bits with the ending _ERR for the function switches.

To be able to evaluate the done bits and error bits of the function switches, you should set these bits to 0 before you issue a job to change a function switch.

Job processing sequence

You can issues several jobs at the same time. If no jobs are active, the job management of the FC ABS_CTRL searches starting with the MDWR_EN job to determine whether trigger bits are set or changes have been made to function switches. If a job is found, it is processed. If the job is finished, the job management searches for the next job to be processed. If the search reaches the last job (ENCVAL_EN), searching starts over with the MDWR_EN job. This search is repeated until all jobs have been processed.

The jobs are processed in the following technologically appropriate order:

Sequence	Address in the channel DB	Name	Meaning	Reset by
Write jobs				
1	35.0	MDWR_EN	Write machine data	FC 1
2	35.1	MD_EN	Enable machine data	FC 1
	35.2	DELDIST_EN	Delete distance-to-go	
	35.3	AVALREM_EN	Cancel set actual value	
	36.4	DELDIAG_EN	Clear diagnostic buffer	
3	35.4	TRGL1WR_EN	Write increment table 1	FC 1
4	35.5	TRGL2WR_EN	Write increment table 2	FC 1
5	35.6	REFPT_EN	Set reference point	FC 1
6		Function switches:		User program
	34.0	PLOOP_ON	Loop approach in plus direction	
	34.1	MLOOP_ON	Loop approach in minus direction	
	34.2	EI_OFF	Do not evaluate enable input	
	34.3	EDGE_ON	Edge detection ON	
	34.4	MSR_ON	Length measuring ON	
7	35.7	AVAL_EN	Set actual value	FC 1
8	36.0	FVAL_EN	Set actual value on-the-fly	FC 1
9	36.1	ZOFF_EN	Set zero point offset	FC 1
10	36.2	TRG252_254_EN	Write increment for increment number 252/254	FC 1
11	36.3	TRG255_EN	Write increment for increment number 255	FC 1
Read jobs				
12	36.5	MDRD_EN	Read machine data	FC 1
13	36.6	TRGL1RD_EN	Read increment table 1	FC 1
14	36.7	TRGL2RD_EN	Read increment table 2	FC 1
15	37.0	MSRRD_EN	Read measured values	FC 1
16	37.1	ACTSPD_EN	Read current velocity, distance-to-go, and current increment	FC 1
17	37.2	ENCVAL_EN	Read encoder data	FC 1

This sequence enables you to initiate a complete positioning operation with a set of jobs and control signals. The jobs start with the writing and activating of machine data, and continue with the setting of the external enable input and, finally, the writing of increments for the incremental approaches.

Control signals

If a STOP signal or an operator error is pending or the drive enable is missing, the function resets the START, DIR_M, and DIR_P control signals.

You can restart an approach after you have acknowledged the operator error (OT_ERR_A=1). With this acknowledgement, you cannot issue additional jobs and control signals.

The function sets the acknowledgement for the operator error (OT_ERR_A) to 0 if there is no operator error pending.

The function resets the START, DIR_P, and DIR_M start signals when the channel signals the start of the approach, except in "Jog" mode.

The function withholds all control signals with the exception of the OT_ERR_A operator error acknowledgement if the axis parameters are not assigned.

Jobs and control signals

You can issue several jobs at the same time, if necessary, along with control signals required for the positioning. If at least one write job has been issued simultaneously with the START, DIR_M, or DIR_P control signal, the function withholds these control signals until the write jobs have been processed.

Jobs during active positioning

If issued during active positioning, the write jobs listed in the following table are withheld until positioning is finished and then implemented on the next call of the function.

Address	Name	Type	Initial value	Comment
34.0	PLOOP_ON	BOOL	FALSE	1 = Loop approach in plus direction
34.1	MLOOP_ON	BOOL	FALSE	1 = Loop approach in minus direction
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input
34.3	EDGE_ON	BOOL	FALSE	1 = Edge detection on
34.4	MSR_ON	BOOL	FALSE	1 = Length measurement on
35.1	MD_EN	BOOL	FALSE	1 = enable machine data
35.2	DELDIST_EN	BOOL	FALSE	1 = Delete distance-to-go
35.3	AVALREM_EN	BOOL	FALSE	1 = Cancel set actual value
35.6	REFPT_EN	BOOL	FALSE	1 = Set reference point coordinate
35.7	AVAL_EN	BOOL	FALSE	1 = Set actual value
36.1	ZOFF_EN	BOOL	FALSE	1 = Set zero offset
36.4	DELDIAG_EN	BOOL	FALSE	1 = Clear diagnostic buffer

Startup

Call FC ABS_INIT at the startup of the module or CPU (see chapter "FC ABS_INIT (FC 0) (Page 38)"). Among other things, this resets the function switches. The FC ABS_CTRL acknowledges the module startup. During this time, RET_VAL and JOBBUSY = 1.

Job status

You can read the status of the job execution using the RET_VAL return value and the JOBBUSY activity bit in the channel DB. You can determine the status of a single job by evaluating its trigger, done, and error bits.

	RET_VAL	JOBBUSY	Trigger bit _EN	Done bit _D	Error bit _ERR
Job active	1	1	1	0	0
Job completed without errors	0	0	0	1	0
Job completed with errors	-1	0	0	1	1
Write job aborted	-1	0	0	0	1

Reaction to errors

If faulty data have been written during a write job, the channel supplies checkback signal DATA_ERR = 1 in the channel DB. If an error occurs in the communication with the module during a write or read job, the error cause is stored in the JOB_ERR parameter in the channel DB.

- Error in a write job:

If an error occurs in a job, the trigger bit is canceled and error bit _ERR and done bit _D are set. The trigger bit is also canceled for all write jobs still pending, but only error bit _ERR is set. The pending write jobs are canceled because jobs could pile up in this case.

The pending read jobs will continue to be processed. JOB_ERR is reset again for each job.

- Error in a read job:

If an error occurs in a job, the trigger bit is canceled and error bit _ERR and done bit _D are set.

The read jobs still pending continue to be processed. JOB_ERR is reset again for each job.

For further error information, refer to the description of the JOB_ERR and DATA_ERR parameters (see chapters "Diagnostics (Page 131)" and "Data and structure of the diagnostic DB (Page 186)").

Program structure

The figure below shows the basic structure of a user program that is used to cyclically control a channel of the module after a one-time startup initialization. The RET_VAL return value of the FC ABS_CTRL is used in the user program for a general error evaluation.

For every other channel, a sequence according to the following figure can be executed independently in parallel.

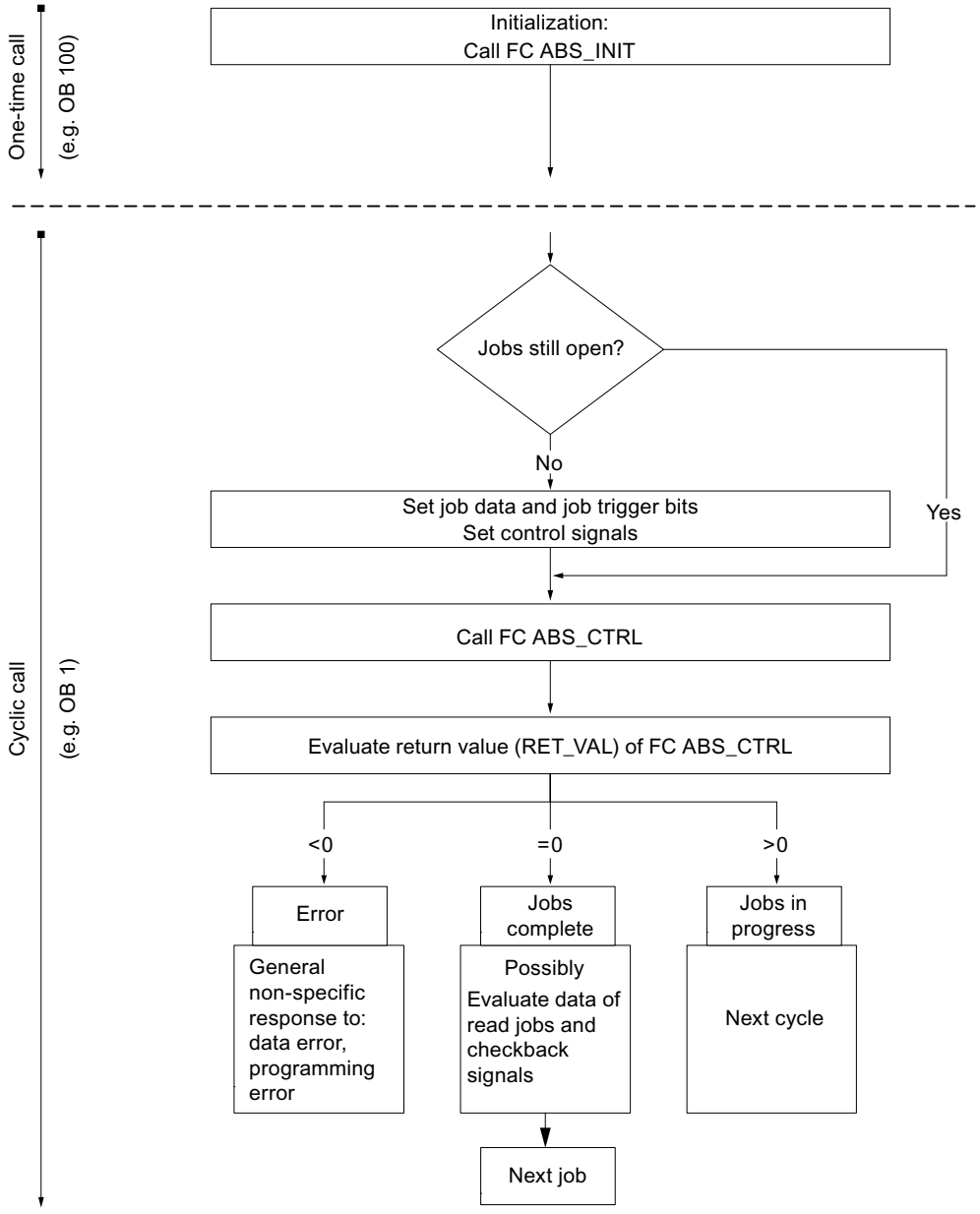


Figure 6-2 General program structure

6.4 FC ABS_DIAG (FC 2)

Tasks

With the FC ABS_DIAG you read out the diagnostic buffer of the module and make it available for a display in the HMI system or for a programmed evaluation.

Call

The function must be called cyclically, e.g., in OB 1. An additional call in an alarm OB is not allowed. At least two calls (cycles) are required for a complete execution of the function.

The function reads out the diagnostic buffer when checkback signal DIAG = 1 in the channel DB indicates a new entry in the diagnostic buffer. After reading the diagnostic buffer, the DIAG bit is set to 0 in the channel DB of the module.

Data block used

Diagnostic DB:

The module address must be entered in the diagnostic DB. The latest entry in the diagnostic buffer will be entered in the structure DIAG[1] and the oldest entry in the structure DIAG[9].

Call parameters

Name	Data type	P-type	Meaning
DB_NO	INT	IN	Number of the diagnostic DB
RET_VAL	INT	OUT	Return value

Return values

The function provides the following return values:

RET_VAL	BR	Description
1	1	Job active
0	1	No job is active, no error
-1	0	Error

Jobs

You can read the diagnostic buffer independent of a new entry by setting the trigger bit DIAGRD_EN in the diagnostic DB. After the diagnostic buffer is read, the trigger bit is set to 0.

Carry out this job after a CPU start-up and a module start-up. This way you can ensure that the content of the diagnostic DB corresponds with the content of the module´s diagnostic buffer, even if the module has not made a new entry in the diagnostic buffer.

Start-up

The function does not perform a start-up processing.

Reaction to errors

In the case of a faulty execution, the cause of the error can be found in the diagnostic DB in the JOB-ERR parameter (see chapter "Diagnostics (Page 131)" and chapter "Data and structure of the diagnostic DB (Page 186)").

6.5 Data blocks

6.5.1 Templates for data blocks

Block templates UDT

For each data block there is a block template UDT stored in the provided library (FMx51LIB). From these UDTs you can create data blocks with any numbers or names.

6.5.2 Channel DB

Task

The channel DB (refer to the section entitled Content of channel DB (Page 179)) is the data interface between the user program and the positioning module. It contains and accepts all data required for control and operation of a channel.

Structure

The channel DB is divided into different areas:

Channel DB
Module address *)
Channel number
Number of the parameter DB
Control signals
Checkback signals
Function switches
Trigger bits for write jobs
Trigger bits for read jobs
Done bits
Error bits
Job management for functions
Data for jobs

*) You can also enter the address using the configuration software

6.5.3 Diagnostic DB

Task

The diagnostic DB (refer to the section entitled Data and structure of the diagnostic DB (Page 186)) is the data storage for the FC ABS_DIAG and includes the diagnostic buffer of the module that has been prepared by this function.

Structure

Diagnostic DB
Module address
Internal data
Job status
Trigger bit
Processed diagnostic buffer

6.5.4 Parameter DB

Task

If you want to change the machine data and increment tables during operation, you require a parameter DB (refer to the section entitled Contents of parameter DB (Page 184)) in which this data is stored. The parameters can be changed from the user program or from an operator control and monitoring system.

You can export the data displayed in the configuration software into a parameter DB. You can also import a parameter DB into the configuration software and view it there.

Each module channel can have several sets of parameter assignment data, e.g., for different recipes. You can switch among these in your program.

Structure

Parameter DB
Machine data
Increment tables

6.6 Technical specifications of the FCs and DBs for the FM 451

Technical specifications

The following table offers you an overview of the technical specifications for the functions and data blocks.

Table 6-1 Technical specifications of the functions and data blocks for the FM 451

No.	Block name	Version	Assignment in load memory (bytes)	Assignment in work memory (bytes)	Assignment in local data area (bytes)	MC7 code / data (bytes)	System functions called
FC 0	FC ABS_INIT	1.0	184	130	2	94	
FC 1	FC ABS_CTRL	1.0	4548	4176	34	4140	SFC 58: WR_REC, SFC 59: RD_REC
FC 2	FC ABS_DIAG	1.0	1800	1658	42	1622	SFC 59: RD_REC
	Channel DB	-	638	184	-	148	
	Parameter DB	-	840	556	-	520	
	Diagnostic DB	-	524	388	-	352	

Module cycle

The checkback signals of a channel are updated by the module every 8 ms. The actual value is updated every 3 ms.

6.7 Quicker access to module data

Application

In special applications or in an alarm level, a particularly fast access to checkback and control signals could be required. You can reach this data directly via the input and output areas of the module.

For start-up coordination, after each start-up of the module (e.g. after connecting the module, after CPU STOP → RUN) you must call the FC ABS_CTRL until the end of the start-up is indicated by RET_VAL = 0. After this you must not use the FC ABS_CTRL any more.

Note

It is not possible to use the FC ABS_CTRL together with a write access.

Reading checkback signals by means of direct access

The byte addresses must be specified relative to the start address of the outputs of the respective channel. The names of the parameters correspond with the names in the channel DB (see chapter "Content of the channel DB (Page 179)").

Start address channel 1 = start address of the module

Start address channel 2 = start address of the module + 8

Start address channel 3 = start address of the module + 16

In STL, you access the data using the commands PEB (read 1 byte), PEW (read 2 bytes) and PED (read 4 bytes).

Address	Bit number							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte 0	PARA	Internal	Internal	DATA_ERR	OT_ERR	DIAG	Internal	Internal
Byte 1	CHGOVER	CUTOFF	ZSPEED	SPEED_OUT	0	WAIT_EI	WORKING	ST_ENBLD
Byte 2	MODE_OUT							
Byte 3	POS_RCD	0	FVAL_DONE	0	GO_P	GO_M	MSR_DONE	SYNC
Byte 4	ACT_POS							
Byte 5								
Byte 6								
Byte 7								

Example: Actual position value ACT_POS

The start address of the module is 512

STL

```
L PED 516          Read the current actual position value (ACT_POS) from channel 1
                   with direct access:
                   Start address of the channel + 4
```

Write control signals using direct access

The byte addresses must be specified relative to the start address of the inputs of the respective channel. The names of the parameters correspond with the names in the channel DB (see chapter "Content of the channel DB (Page 179)").

Start address channel 1 = start address of the module

Start address channel 2 = start address of the module + 8

Start address channel 3 = start address of the module + 16

In STL, you access the data using the commands PAB (write 1 byte), PAW (write 2 bytes) and PAD (write 4 bytes).

Address	Bit number							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte 0	0	0	0	0	OT_ERR_A	0	0	0
Byte 1	DRV_EN	SPEED252	0	0	DIR_P	DIR_M	STOP	START
Byte 2	MODE_IN							
Byte 3	MODE_TYPE							
Byte 4	Reserved							
Byte 5								
Byte 6								
Byte 7								

Example: START signals of channel 2

The start address of the module is 512

STL

```
L 2#10001000       Set DRV_EN and DIR_P to 1
T PAB 521          Write signals with direct access for channel 2:
                   Start address of the module +8 + 1
```

6.8 Parameter transmission paths

Parameters include the following machine data and increments.

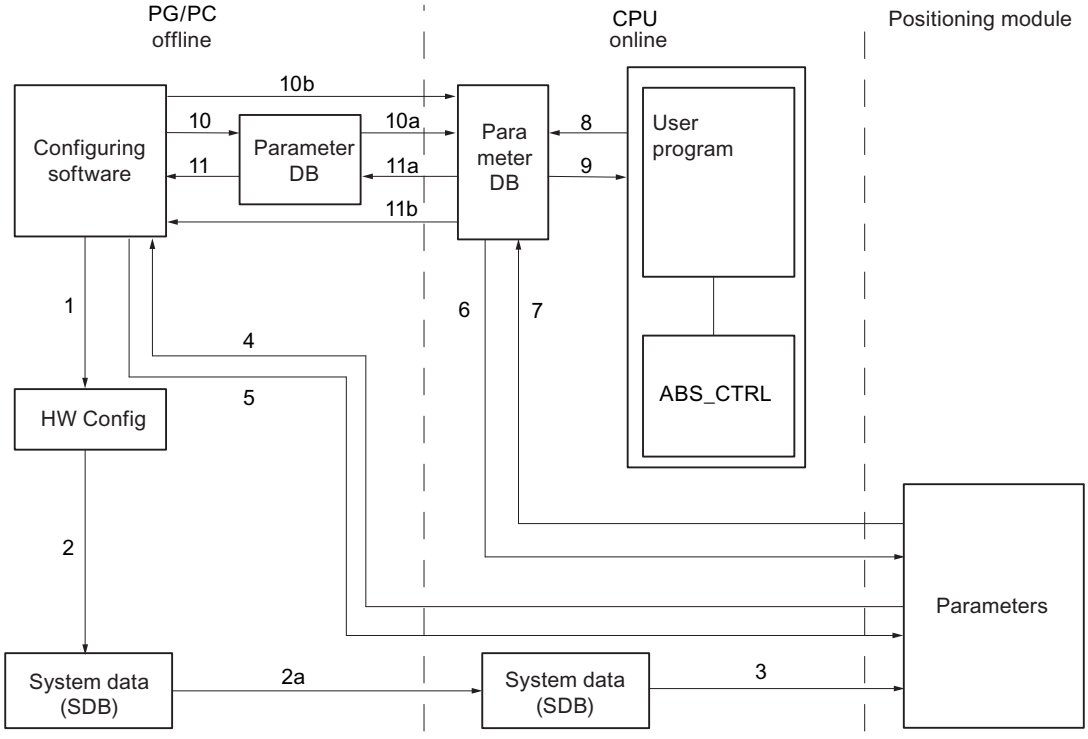


Figure 6-3 Parameter transmission paths

1 Saving parameters in the configuration software.

2 Save and compile the HW configuration.

2a Download the HW configuration to the CPU. The CPU automatically carries out step 3.

3 The CPU writes the parameters when system parameter assignments are carried out for the module.

4 With the command "download target system to PG" download the parameters of a channel of the module to the PG.

5 With the command "download target system" download the parameters from the configuration software into a channel of the module.

6 Write parameters using jobs of the user program in a channel of the module.

7 Read parameters using jobs of the user program from a channel of the module.

8 Store parameters from the user program into the online DB.

9 Read in parameters from the online DB into the user program.

10 Export parameters from the configuration software to the offline DB.

10a Download the offline DB to the CPU.

10b Export parameters from the configuration software to the online DB.

11 Import parameters from the offline DB into the configuration software.

11a Load parameters from the online DB to the PG.

11b Import parameters from the online DB into the configuration software.

Some applications for transmission of parameters:

- You process the parameters using the configuration software. The channels of the module should then be automatically assigned upon start-up.
  Carry out steps 1, 2, and 2a.
- You change the parameters during commissioning in debug mode in the configuration software:
  Carry out steps 4 and 5.
- The parameters changed during commissioning should then be automatically loaded upon start-up:
  Carry out steps 1, 2, and 2a.
- You create the parameters using the configuration software. The channels of the module should be assigned upon start-up only by the user program via the data blocks:
  Carry out steps 10, 10a and 6 or 10b and 6.
- You would like to create convenient stored data for recipes:
  Carry out steps 10 and 10a.
- You create the parameters using the configuration software. These should be made available to the user program for temporary changes.
  Carry out steps 1, 2 and 2a for the automatic parameter assignment.
  Carry out the steps 10, 10a, 9, 8 and 6 for access by the user program.
- You change existing parameters solely via the user program:
  Carry out steps 7, 9, 8 and 6.
- You would like to use the configuration software to view the data that has been changed via the user program:
  Carry out steps 11a and 11 or just 11b.
- The parameters changed by the user program should also be automatically loaded upon start-up:
  Carry out steps 11b or 11a, 11 and then 1, 2, 2a.

Commissioning the FM 451

7

Important Note

Please observe the points listed in the following warnings.

⚠ WARNING

Risk of injury and material damage.

In order to prevent injury and material damage:

- Install an EMERGENCY STOP switch in the area of the computer.
  This is the only way to ensure that the system can be switched off safely in the event of a computer or software failure.
- Install hardware limit switches that act directly on the power units of all drives.
- Always make sure to prevent access to the plant areas containing moving parts.
- Concurrent controlling and monitoring of the FM 451 from your user program and on the "Test > Commissioning" screen form can lead to conflicts with unforeseeable effects. Hence, always set the CPU to STOP when working in the Test screen form, or disable the user program.

Setting up a project

Create a project in *STEP 7*.

The section below describes the steps when using SIMATIC Manager (without assistance from the wizard).

Step	Action	✓
1	If not already done, install the configuration package.	❒
2	Create a new project in SIMATIC Manager (**File > New**).	❒
3	Add a station to your project (**Insert > Station**).	❒
4	Select the station, then run the "HW Config" configuration interface by double-clicking "Hardware".	❒
5	Insert a rack in your hardware configuration with the following: • Power supply module (PS) • CPU • Function module (FM 451)	❒
6	Save this hardware configuration in HW Config (**Station > Save**).	❒

Hardware installation and wiring

In this first section you install the FM 451 in your S7-400 and wire up the external peripheral elements.

Step	Action	✓
1	**Installing the FM 451** (see chapter "Installing and removing the FM 451 (Page 19)")	
	Insert the module in one of the slots available.	❒
2	**Wiring the FM 451** (see chapter "Wiring the FM 451 (Page 21)")	
	• Wire the front connector of the FM 451:	❒
	– Auxiliary voltage for the encoder supply	❒
	– Auxiliary voltage for the load current supply	❒
	– Digital inputs	❒
	– Digital outputs	❒
	• Encoder connection	
3	**Check the safety-relevant switches**	
	Check the function of the following:	
	• EMERGENCY STOP switches	❒
	• Hardware limit switches	❒
4	**Front connector**	
	The front connector must be engaged.	❒
5	Check the shielding of the individual cables.	❒
6	**Switch on the power supply**	
	Switch the CPU to STOP (safe state).	❒
	If necessary, switch on the 24 V supply for the auxiliary voltages.	❒

Getting prepared for programming

Create the necessary blocks in your project if you would like to access the module with the user program.

Step	Action	✓
1	Select the FMX51LIB library in SIMATIC Manager (**File > Open > Libraries**).	❒
2	Copy the FC 0 and FC 1 functions, and the channel DB template UDT 1 from the library to the blocks folder.	❒
3	Create a channel DB from the UDT 1 template for each channel and enter the channel number.	❒
4	If you want to use a programmed diagnostic evaluation, copy FC 2 and UDT 2 and create a diagnostic DB for each module.	❒
5	If you want to write or read machine data and increment tables in the user program, you need UDT 3 in order to create a parameter DB for each channel.	❒

Assigning parameters using the configuration software

For initial commissioning of the module, assign parameters for the module using the parameter assignment dialogs of the configuration software.

Step	Action	✓
1	Select the tier in the rack containing the FM 451 module.	❒
2	Next, double-click to open the parameter assignment dialogs for the FM 451.	❒
3	Select **File > Properties** to edit the following settings: • General You can edit the name and enter a comment. • Addresses If you change the start address, you must also change the end address. Note the module address displayed. **Note the module address displayed.** • Basic parameters You can set the interrupt class and the reaction to a CPU STOP.	❒
4	You assign the relevant parameters in the **Drive, Axis, Encoder,** and **Increments** dialog screens.	❒
5	You can create your channels in **Edit > Create channel**.	❒
6	Save the parameter assignment with **File > Save**.	❒
7	Close the parameter assignment dialogs with **File > Exit**.	❒
8	Save the hardware configuration in HW Config with **Station > Save and Compile**.	❒
9	Go online and download the hardware configuration to the CPU. This will transfer the parameter assignment data to the FM 451.	❒

Testing and commissioning

You can now test your entries and changes with the parameter assignment dialogs of the configuration software.

Step	Action	✓
1	To test your commissioning data, select the **Test > Commission**, **Test > Error Evaluation**, and **Test > Service** screen forms.	❒
2	You can change any incorrect machine data in the **Test > Commission** screen. These modifications remain valid until the next STOP-RUN transition on the CPU.	❒
3	You can save the corrected machine data in the CPU by repeating steps 6 to 9 of the previous sequence.	❒

Note

If you set the drive enable in the commissioning screen form when the CPU is in STOP mode and then close all the parameter assignment dialogs, the drive enable is canceled.

Test steps for operating modes, jobs, and function switches

The tests described in the next section help you to validate the FM 451 parameter assignment.

Step	Action		✓
1	Synchronize the axis		
	• Incremental encoder – Select "Set reference point". To do this enter the required value (see chapter "Configuring set reference point (Page 115)"). **or** – Select the "Reference point approach" mode (see chapter "Configuring reference point approach mode (Page 98)").	• Absolute encoder – The FM 451 is always synchronized immediately following parameter assignment. – Adjust the absolute encoder (see chapter "Determining the absolute encoder adjustment (Page 77)").	❒
	Check the actual status of the axis. The physical position must match the value output on the display.		❒
2	Select **Jog** mode.		❒
	Check the interconnection of the outputs (control mode) and the actual value. Approach in creep speed in the plus and minus directions. Approach in rapid traverse in the plus and minus directions.		❒
	• Check the encoder resolution (see chapter "Resolution (Page 80)") – Move the drive a defined distance in a defined direction. The actual traversing distance must agree with the value indicated in the **Debug > Commission** screen.		❒
3	Select **incremental approach** mode • **Absolute with increment number 255** – Check the process with the defined increment – And adapt the changeover difference and switch-off difference based on increment 255 to the circumstances of your system.		❒ ❒
4	Test the other function switches and jobs according to your application • e.g., loop approach, set actual value		❒

Preparing the channel DB

Step	Action	✓
1	Open the channel DB.	❒
2	Check the following entries: • The module address in the MOD_ADDR parameter (refer to the section entitled Basics of programming a positioning module (Page 35)) • The channel number in the CH_NO parameter • If applicable, the number of the parameter DB in the PARADBNO parameter	❒ ❒ ❒
3	Save the channel DB (**File > Save**).	❒

Preparing the diagnostic DB

Step	Action	✓
1	Open the diagnostic DB.	❒
2	Make sure that the module address is entered in the MOD_ADDR parameter (refer to the section entitled Basics of programming a positioning module (Page 35)).	❒
3	Save the diagnostic DB with **File > Save**.	❒

Integrating the functions

Step	Action	✓
1	Integrate the required functions in your user program.	❒

Downloading blocks to the CPU

Step	Action	✓
1	Select the blocks in SIMATIC Manager, then download these with **PLC > Download to CPU.**	❒

See also

Important safety information (Page 21)

Machine data and increment dimensions

8

8.1 Writing and reading machine data and increment tables

Changing and reading out parameters during operation

This chapter describes how you can use the user program to change and read out parameters during operation.

All parameters are stored in the parameter DB:

- Machine data is located in the parameter DB at the addresses 4.0 to 116.0.
- Increment tables are located in the parameter DB at the addresses 120.0 to 516.0.

The number of the parameter DB must be entered in the respective associated channel DB.

You can enter the parameters with the DB Editor or also easily using the dialog screens "Drive", "Axis", "Encoder" and "Increments" and then write in the parameter DB with the "Export" function.

You can use the function "Import" to import parameters that are in an already available parameter DB into the dialog screens.

Writing, enabling and reading machine data

You can use the machine data to adapt the positioning module to the axis and the encoder.

First parameter assignment

If the channel still contains no machine data, proceed as with a first parameter assignment without the parameter assignment screens in the following way:

1. Enter the new values in the parameter DB and then save these.
2. Download the parameter DB to the CPU.
3. Set the following trigger bit in the channel DB for the job:
   - Write machine data (MDWR_EN).
4. Call the FC ABS_CTRL in the cyclic user program.

Modifying machine data

Proceed as follows to change machine data using the user program:

1. Enter the new values in the parameter DB.
2. Set the trigger bits in the channel DB for the jobs:
   - Write machine data (MDWR_EN)
   - Enable machine data (MD_EN)
3. Call the FC ABS_CTRL in the cyclic user program.

If you set the trigger bits for these jobs all at once, the FC ABS_CTRL makes sure the jobs are processed in the correct order.

Otherwise change the machine data always in the following sequence:

- Write machine data
- Enable machine data

Reading machine data

In order to read the current machine data from a channel, proceed as follows:

1. Set the following trigger bit in the channel DB:
   – Reading machine data (MDRD_EN)
2. Call the FC ABS_CTRL in the cyclic user program.

The current machine data is then stored in the parameter DB on the CPU.

Excerpt from the channel DB

Address	Name	Type	Initial value	Comment
35.0	MDWR_EN	BOOL	FALSE	1 = write machine data
35.1	MD_EN	BOOL	FALSE	1 = enable machine data
36.5	MDRD_EN	BOOL	FALSE	1 = reading machine data

Writing and reading increment tables

First parameter assignment

If the channel still contains no increment tables, proceed as with a first parameter assignment without the configuration software in the following way:

1. Enter the new values in the parameter DB and then save these.
2. Download the parameter DB to the CPU.
3. Set the trigger bits in the channel DB for the jobs:
   – Write increment table 1 (TRGL1WR_EN) and / or increment table 2 (TRGL2WR_EN)
4. Call the FC ABS_CTRL in the cyclic user program.

Changing increment tables

Proceed as follows to change increment tables using the user program:

1. Enter the new values in the parameter DB.
2. Set the trigger bits in the channel DB for the jobs:
   – Write increment table 1 (TRGL1WR_EN) and / or increment table 2 (TRGL2WR_EN)
3. Call the FC ABS_CTRL in the cyclic user program.

Reading increment tables

In order to read the increment tables from a channel, proceed as follows:

1. Set the trigger bits in the channel DB for the jobs:
   – Read increment table 1 (TRGL1RD_EN) and / or increment table 2 (TRGL2RD_EN)
2. Call the FC ABS_CTRL in the cyclic user program.
   The increment tables are then stored in the parameter DB on the CPU.

Excerpt from the channel DB

Address	Name	Type	Initial value	Comment
35.4	TRGL1WR_EN	BOOL	FALSE	1 = write increment table 1 (1 ... 50)
35.5	TRGL2WR_EN	BOOL	FALSE	1 = write increment table 2 (51 ... 100)
36.6	TRGL1RD_EN	BOOL	FALSE	1 = read increment table 1 (1 ... 50)
36.7	TRGL2RD_EN	BOOL	FALSE	1 = read increment table 2 (51 ... 100)

Note

If synchronization-relevant parameters have been changed, when the machine data is enabled the module will carry out the following actions for the respective channel:

- the synchronization is deleted
- the function switches and zero offset are reset
- all the machine data and increment tables so far will become invalid

Synchronization-relevant parameters are:

- Axis type
- End of rotary axis
- Encoder type
- Distance per encoder revolution
- Increments per encoder revolution
- Number of revolutions
- Reference point coordinate
- Absolute encoder adjustment
- Type of reference point approach
- Counting direction

8.2 System of units

Choosing a system of units

In the configuration software of the positioning module, for the input and output of the data you can select from the following systems of units:

- mm (default)
- inch
- degrees

Note

If you change the system of units in the parameter assignment screens under STEP 7, the values are converted into the new system. This may lead to rounding errors.

If you change the system of units programmed via the jobs "Write machine data" and "Enable machine data", the values will not be automatically converted.

System of units in the parameter DB

Address	Name	Type	Initial value	Comment
8.0	UNITS	DINT	L#1	**System of units** 1 = 10^{-3} mm 2 = 10^{-4} inch 3 = 10^{-4} degrees 4 = 10^{-2} degrees 6 = 10^{-3} degrees

Standard system of units

In this manual we will always use the mm system of units to specify the **Limits**. To determine the limits in the other systems of units, carry out the following conversion:

To convert from		you calculate
mm → inch		Limit (inch) = limit (mm) × 0.1 [1]
mm → degrees	10^{-4} (4 decimal places)	Limit (degrees) = limit (mm) × 0.1
	10^{-3} (3 decimal places)	Limit (degrees) = limit (mm) × 1
	10^{-2} (2 decimal places)	Limit (degrees) = limit (mm) × 10

[1] The number of decimal places affects the number of pre-decimal places for the maximum value. Four decimal places are used in the "inch" system of units, which means the maximum entry your can make is 100,000.0000 inch. The "millimeter" system of units uses three decimal places, which means the maximum entry you can make is 1,000,000.000 mm.

Connection between increments and system of units

The encoder signals of a connected encoder will be evaluated by the positioning module and converted into the current system of units. The resolution is used for the conversion (refer to the section entitled "Resolution (Page 80)").

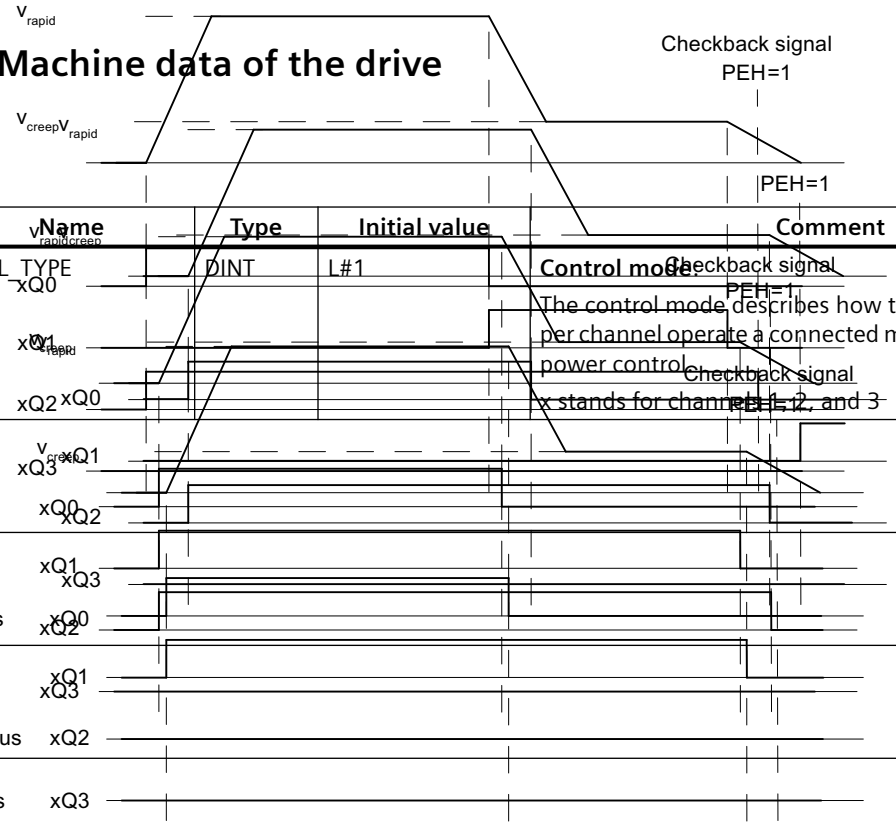
If the positioning module

- has counted 10 increments and
- a resolution of 100 µm per increment is assigned in the encoder data,

this means that the axis will be moved by a distance of 1 mm.

8.3 Machine data of the drive

Drive data



Address	Name	Type	Initial value	Comment
92.0	CTRL_TYPE	DINT	L#1	**Control mode:** The control mode describes how the 4 digital outputs per channel operate a connected motor by means of the power control. x stands for channels 1, 2, and 3
Control mode 1				
Rapid traverse	xQ0			
Creep speed	xQ1			
Traverse plus	xQ2			
Traverse minus	xQ3			
Control mode 2				
Rapid traverse	xQ0			
Traverse plus	xQ2			
Creep speed	xQ1			
Traverse minus	xQ3			
Control mode 3				
Rapid traverse plus	xQ0			
Traverse plus	xQ2			
Creep speed plus	xQ1			
Traverse minus	xQ3			
Rapid traverse minus	xQ2			
Control mode 4				
Creep speed minus	xQ3			

Table 8-1 Table with states of 4 outputs for each control mode, x stands for channels 1, 2, and 3

	Rapid speed		Creep speed		PEH position reached stop
	Direction +	Direction -	Direction +	Direction -	
Control mode 1					
xQ0	1	1	0	0	-
xQ1	0	0	1	1	-
xQ2	1	0	1	0	-
xQ3	0	1	0	1	-
Control mode 2					
xQ0	1	1	0	0	0
xQ1	0	0	0	0	1
xQ2	1	0	1	0	0
xQ3	0	1	0	1	0
Control mode 3					
xQ0	1	1	0	0	-
xQ1	1	1	1	1	-
xQ2	1	0	1	0	-
xQ3	0	1	0	1	-
Control mode 4					

	Rapid speed		Creep speed		PEH position reached stop
	Direction +	Direction -	Direction +	Direction -	
xQ0	1	0	0	0	-
xQ1	1	0	1	0	-
xQ2	0	1	0	0	-
xQ3	0	1	0	1	-

Address	Name	Type	Initial value	Comment
100.0	CHGDIF_P	DINT	L#5000	**Changeover difference plus**
104.0	CHGDIF_M	DINT	L#5000	**Changeover difference minus**
108.0	CUTDIF_P	DINT	L#2000	**Switch-off difference plus**
112.0	CUTDIF_M	DINT	L#2000	**Switch-off difference minus** Range: • 1 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • 1 µm to 100 000 000 µm at resolution of <1 µm/pulse

"Changeover difference" defines the changeover point from which the drive changes from rapid traverse to creep speed.

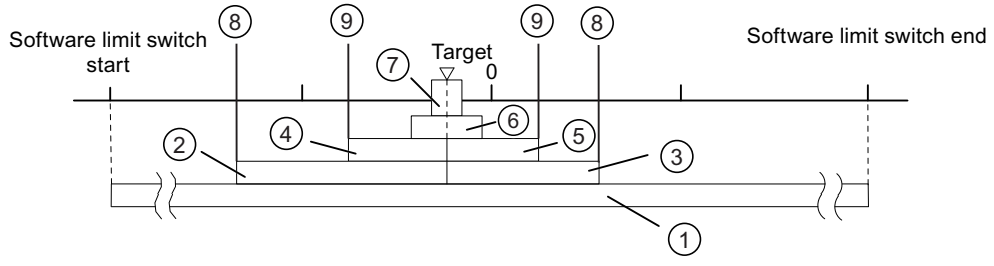
"Switch-off difference" defines the switch-off point starting from which the drive (creep speed) is switched off. Starting from this point, the FM 451 assumes monitoring functions.

The values apply to all targets that the FM 451 approaches, with the exception of the increment dimension 255.

Rules

- The values for the plus and minus directions can be different.
- The changeover difference must be greater than the switch-off difference.
- The changeover difference must lie within the operating range.
- The changeover difference must be less than the rotary axis end.
- The switch-off difference must be greater than half the target range.
- Select a sufficient distance between the changeover point and the switch-off point to ensure that the drive's speed can be safely reduced from rapid traverse to creep speed.
- Select the distance between the switch-off point and the target to ensure the drive comes to a standstill within the target range.
- The changeover point, the switch-off point, and the start of the target range must be separated from each other by at least 8 ms.

Further information on the layout of the ranges can be found in chapter "Ranges and switching points of the positioning module (Page 16)".



Address	Name	Type	Initial value	Comment
①	**Operating range**			
②③	**Changeover difference plus / minus**			
④⑤	**Switch-off difference plus / minus**			
⑥	**Standstill range**			
⑦	**Target range**			
⑧	**Changeover point**			
⑨	**Switch-off point**			

Address	Name	Type	Initial value	Comment
76.0	TRG_RANGE	DINT	L#1000	Target range • 0 = No monitoring Range: • 1 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • 1 µm to 100 000 000 µm at resolution of <1 µm/pulse
The target range lies symmetrically around the target. A value specification of 0 switches off the monitoring of the target range. For information about target approach, refer to chapter "End of a positioning (Page 87)".				

Address	Name	Type	Initial value	Comment
84.0	ZSPEED_R	DINT	L#1000	**Standstill range** • 0 = No monitoring Range: • 1 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • 1 µm to 100 000 000 µm at resolution of <1 µm/pulse
The standstill range lies symmetrically around the target. Monitoring is performed to determine whether the drive remains on an approached target position or drifts away from it. If the standstill range is exited without a valid traversing job, the FM 451 signals an error. A setting of 0 deactivates the standstill monitoring function. Recommendation: The standstill range should be greater than the target range. Also note chapter "End of a positioning (Page 87)", which presents the target approach and the individual monitoring functions and messages.				

Address	Name	Type	Initial value	Comment
88.0	ZSPEED_L	DINT	L#30000	**Standstill velocity** • 0 = No monitoring • 1 µm/min to 100 000 µm/min
The standstill velocity is used as the reference velocity for the end of positioning. (Refer also to chapter End of a positioning (Page 87)). A setting of 0 deactivates the standstill velocity monitoring function.				

Address	Name	Type	Initial value	Comment
80.0	MON_TIME	DINT	L#2000	**Monitoring time** • 0 = No monitoring • 1 to 100 000 ms

The module uses the monitoring time to monitor

- The movement of the axis up to the switch-off point.
  The monitoring time starts when the positioning starts and is retriggered on each actual value change in the traversing direction.
- The target approach.
  The positioning must end within the monitoring time.
  The monitoring time is retriggered when the switch-off difference is reached for the last time.
- The plausibility of the actual values at the switching points.
  An oscillation of the axis at the switching points results in operating errors.

A value specification of 0 switches off the monitoring functions.

Actual monitoring time

You can specify all values from the defined range for the monitoring time.

- 0: Monitoring is switched off.
- 1 to 100 000 ms: The FM 451 rounds the specified time to a multiple of 8 ms (module cycle). Ideally, you should therefore specify the monitoring time in 8 ms increments.

Address	Name	Type	Initial value	Comment
99.1	EI_TYPE	BOOL	FALSE	**Evaluate enable input** 0 = Level-controlled 1 = edge controlled

The enable input is an external input that can be used to execute positioning due to an external event.

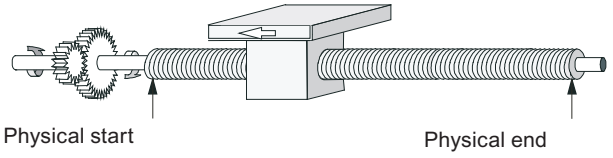
- **Level-controlled (EI_TYPE=0)**
  Traversing begins when you create a "1" signal at the enable input and is ended when you create a "0" signal at the enable input.
- **Edge-controlled (EI_TYPE=1)**
  Traversing begins with detection of a rising edge at the enable input. The additional signal characteristic at this input does not affect the course of the motion that was started.

8.4 Machine data of the axis

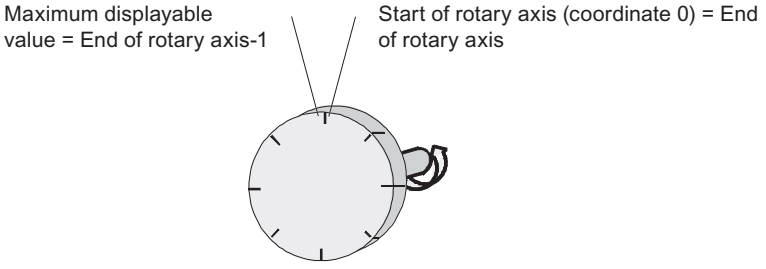
Axis data

Address	Name	Type	Initial value	Comment
12.0	AXIS_TYPE	DINT	L#0	**Axis type:** 0 = Linear axis 1 = Rotary axis

A linear axis has a limited physical traversing range.



A **rotary axis** is not restricted in its motion range by mechanical limit stops.



Address	Name	Type	Initial value	Comment
16.0	ENDROTAX	DINT	L#100000	**End of rotary axis**: Range: • 1 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • 1 µm to 100 000 000 µm at resolution <1 µm/pulse

The "end of rotary axis" value is the theoretical maximum actual value of the axis. However, the theoretical maximum value is never indicated, because it also represents the physical start position of the rotary axis (= zero).

The maximum value displayed for a rotary axis value is:

End of rotary axis [µm] - resolution [µm / pulse] * 1 [pulse]

Example: End of rotary axis 1000 mm, resolution 1000 µm / pulse

The displayed value jumps:

- from 999 mm to 0 mm, at a positive rotational direction
- from 0 mm to 999 mm, at a negative rotational direction

Rotary axis with absolute encoders

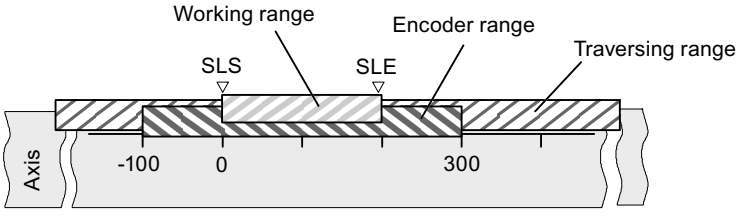
The rotary range (0 to end of rotary axis) of a rotary axis with an absolute encoder must correspond exactly to the encoder range of the absolute encoder.

$$\text{Rotary axis end[µm]} = \text{number of revolutions(encoder)} * \frac{\text{Distance[µm]}}{\text{Revolution}}$$

Address	Name	Type	Initial value	Comment
44.0	REFPT	DINT	L#0	**Reference point coordinate**: Range: • -1 000 000 000 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • -100 000 000 µm to 100 000 000 µm at resolution <1 µm/pulse
Incremental encoder: You require the reference point coordinate for the "Reference point approach" mode. If the axis is not synchronized following writing and activating of machine data, the actual value is set to the value of the reference point coordinate. **Absolute encoder (SSI)** You require the reference point coordinate for the mechanical adjustment of the encoder. For more information, refer to the description of absolute encoder adjustment in the chapter "Determining the absolute encoder adjustment (Page 77)", which explains the interaction of the absolute encoder adjustment with other data. The value of the reference point coordinate must lie within the operating range: • **Linear axis** Including the software limit switch • **Rotary axis** Greater than or equal to 0 and less than the "end of rotary axis" value (0 ≤ reference point coordinate < "End of rotary axis").				

Address	Name	Type	Initial value	Comment
52.0	REFPT_TYPE	DINT	L#0	**Type of reference point approach**: Ranges: 0 = Plus, reference point switch in plus direction 1 = Plus, reference point switch in minus direction 2 = Minus, reference point switch in plus direction 3 = Minus, reference point switch in minus direction
With **Type of reference point approach**, you determine the conditions for the axis synchronization. • First you specify the start direction of the reference point approach. • Then, you define the position of the zero mark that results in synchronization relative to the reference point switch. The use of this data is described in chapter "Configuring reference point approach mode (Page 98)".				

Address	Name	Type	Initial value	Comment
99.0	REFPT_SPD	BOOL	TRUE	**Start velocity for reference point approach** 0 = Rapid traverse 1 = Creep speed
You use this data to select the velocity for the start of a reference point approach.				

Address	Name	Type	Initial value	Comment
64.0	SSW_STRT	DINT	L#-100000000	**Software limit switch start**
68.0	SSW_END	DINT	L#100000000	**Software limit switch end** Range: • -1 000 000 000 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • -100 000 000 µm to 100 000 000 µm at resolution <1 µm/pulse
These axis data are only used for a linear axis. The software limit switches are monitored if the axis is synchronized. The range limited by the software limit switches is the **operating range**. The software limit switch start (SLS) must always be less than the software limit switch end (SLE).				
				
Incremental encoder The axis is initially not synchronized after each restart of the FM 451. The assigned software limit switches are not monitored until the axis is synchronized. **Absolute encoder (SSI)** The axis is synchronized once the FM 451 has received a complete, error-free message frame for the associated channel. The software limit switches are monitored starting from this time. The absolute encoder must cover **at least** the operating range including the software limit switches. **Relationship: operating range, encoder range, traversing range** • The "operating range" is defined by your task-specific software limit switch settings. • The "encoder range" represents the range explicitly covered by the encoder. For a linear axis, the module applies this range symmetrically across the operating range, i.e., it shifts the encoder range in order to equalize the distances between the software limit switches and the ends of the encoder range (see figure). • The "traversing range" represents the range of values that the FM 451 is capable of processing. The "traversing range" is dependent on the resolution.				

Address	Name	Type	Initial value	Comment
4.0	EDGEDIST	DINT	L#0	**Minimum edge distance** Range: • 0 to 1 000 000 000 µm at resolution ≥1 µm/pulse • 0 to 100 000 000 µm at resolution <1 µm/pulse
This machine data defines a range after detection of the start of a measurement for an edge detection. The measurement will be discarded if the measuring operation ends within this range.				

8.5 Machine data of the encoder

Definition

The encoder returns position data (see chapter "Encoder (Page 127)") to the module, where they are evaluated and converted into an actual value based on the set resolution.

The correct definition of the encoder's machine data is essential for ensuring consistency between the calculated and physical actual position of the axis.

Data in the parameter DB

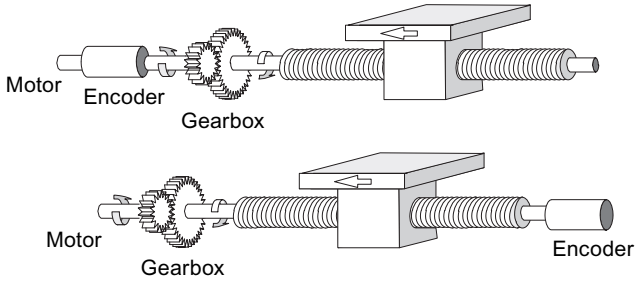
Address	Name	Type	Initial value	Comment
20.0	ENC_TYPE	DINT	L#1	**Encoder type and message frame length**: Range of values: 1 = 5 V incremental 2 = 24 V incremental 3 = SSI 13-bit message frame length 4 = SSI 25-bit message frame length
With the "message frame length" you define the clock frame output by the positioning module.				

Address	Name	Type	Initial value	Comment
24.0	DISP_REV	DINT	L#80000	**Distance per encoder revolution**: Range of values: 1 µm to 1 000 000 000 µm

With the "Distance per encoder revolution" machine data, you inform the positioning module about the distance covered by the drive system per encoder revolution.

The "Distance per encoder revolution" value depends on the axis configuration and the way in which the encoder is mounted. You must take all transmission elements, such as couplings or gears, into account.

Chapter "Resolution (Page 80)" describes the relationship between the "Distance per encoder revolution" machine data and "Increments per encoder revolution".



Address	Name	Type	Initial value	Comment
32.0	INC_REV	DINT	L#500	**Increments per encoder revolution**: Range of values: 1 to 2^{25}

The machine data "increments per encoder revolution" defines the number of increments output by an encoder per revolution. The positioning module calculates the resolution based on this value and the "Distance per encoder revolution" machine data.

Incremental encoder

Any value within the range of values can be input. The module evaluates the increments in 4 operations (see chapter "Incremental encoder (Page 127)").

Absolute encoder

The individual encoder models must be differentiated for the limits. Only values in powers of 2 are allowed for the input (see chapter "Absolute encoders (Page 129)").

- Single-turn encoder with (number of revolutions = 1) 13-bit message frame length:
  - Minimum value = 4
  - Maximum value = 8192
- Multiturn encoder (number of revolutions > 1) with 25-bit message frame length:
  - Minimum value = 4
  - Maximum value = 8192
- Single-turn encoder with 25-bit message frame length and number of revolutions = 1:
  - Minimum value = 4
  - Maximum value = 2^{25}

Linear scales are assigned as multiturn encoders as follows:

- Increments per encoder revolution = 8192
- Number of revolutions x 8192 ≥ number of increments of the linear scale

Address	Name	Type	Initial value	Comment
36.0	NO_REV	DINT	L#1	**Number of encoder revolutions**: Range of values: 1 (single-turn encoder) 2 to 4096 in powers of 2 (multiturn encoder)

The machine data "number of encoder revolutions" is only used for absolute encoders. You use it to define the maximum possible number of revolutions for this encoder.

The **overall number of steps of the encoder** is not machine data. It is calculated as follows:

Total number of steps = increments per encoder revolution x number of revolutions

Address	Name	Type	Initial value	Comment
40.0	BAUDRATE	DINT	L#0	**Baud rate**: Range of values: 0 = 125 kHz 1 = 250 kHz 2 = 500 kHz 3 = 1000 kHz
With the "baud rate" machine data, you define the data transmission rate between the SSI encoder and the positioning module. This entry is irrelevant for incremental encoders. The maximum baud rate depends on the cable length: • 320 m → 125 kHz • 160 m → 250 kHz • 63 m → 500 kHz • 20 m → 1000 kHz				

Address	Name	Type	Initial value	Comment
59.0	CNT_DIR	BOOL	FALSE	**Count direction:** 0 = Normal 1 = Inverted
With the "count direction" machine data, you adapt the position feedback direction to the direction of the axis movement. Also, take the rotation directions of all transmission elements into account (for example, couplings and gears). • Normal = incremental count pulses (incremental encoder) or encoder values (absolute encoder) represent increasing actual position values • Inverted = incremental count pulses (incremental encoder) or encoder values (absolute encoder) represent decreasing actual position values				

Address	Name	Type	Initial value	Comment
				Monitoring functions:
63.0	MON_WIRE	BOOL	TRUE	1 = Wire break
63.1	MON_FRAME	BOOL	TRUE	1 = Message frame error (must always be 1)
63.2	MON_PULSE	BOOL	TRUE	1 = Missing pulses

Wire break

When monitoring is activated, the positioning module monitors all cables for a 5 V incremental encoder and an absolute encoder. The monitoring detects:

- Wire break
- Short circuit on individual cables
- Edge interval of counting pulses (also for 24 V incremental encoder)

For monitoring for a 24 V incremental encoder, you must set a monitoring time MON_TIME > 0.

For 5 V incremental encoders without zero marks, you must disable the wire break monitoring or interconnect the N and /N signals externally (see chapter "Incremental encoder (Page 127)").

Message frame error

The module monitors the message frame of an absolute encoder (SSI):

- Start and stop bit errors

Message frame error monitoring cannot be disabled for absolute encoders (SSI).

Missing pulses (incremental encoder)

An incremental encoder must always return the same number of increments between two successive zero marks. The positioning module checks whether the zero mark of an incremental encoder coincides with the correct encoder value.

You must disable missing pulse monitoring for encoders without zero marks.

You must also disable wire-break monitoring or interconnect the zero mark inputs N and /N externally.

8.6 Determining the absolute encoder adjustment

Definition

The absolute encoder adjustment and the reference point coordinate is used to explicitly map the encoder's value range to the coordinate system of the axis.

Determining the correct absolute encoder adjustment

After the first configuration further steps must be taken to ensure that a correct relationship is created between the encoder and coordinate system. The order of events is shown using the parameter assignment screens.

1. Traverse the axis to a defined, reproducible point to which a unique coordinate is assigned. This could, for example, be the "software limit switch end".
2. Call the job "Set reference point" with the coordinate of the point defined under 1.
   The positioning module now determines an encoder value for the reference point coordinate entered in the channel DB (REFPT in channel DB), namely the absolute encoder adjustment. You can read out this value in the service screen of the parameter assignment interface.
3. Enter the value read out from the service screen in the "Absolute encoder adjustment" field on the "Axis" tab of the parameter assignment interface.
4. Save your parameter assignment to the corresponding parameter DB using the export function.
5. Close the parameter assignment interface by selecting Save and Exit.
6. Download the data in HW Config to the CPU.
7. Restart the CPU (cold restart) to apply the data.

Note

You perform this adjustment just once during the commissioning. After a configuration, the position module is synchronized during start-up as soon as a complete, faultless message frame of the encoder is received after start-up.

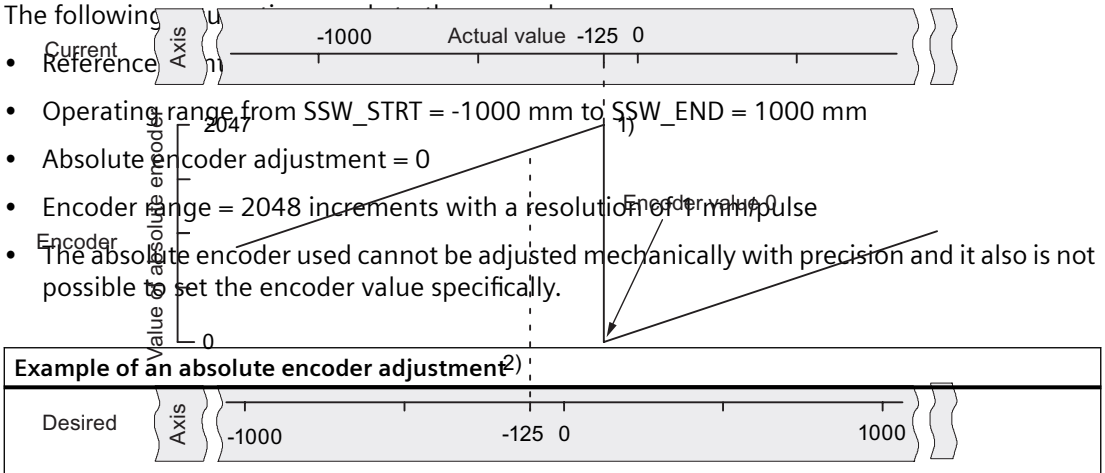
Data in the parameter DB

Address	Name	Type	Initial value	Comment
44.0	REFPT	DINT	L#0	**Reference point coordinate** Range: • -1 000 000 000 µm to 1 000 000 000 µm at resolution ≥1 µm/pulse • -100 000 000 µm to 100 000 000 µm at resolution < 1 µm/pulse
48.0	ENC_ADJ	DINT	L#0	**Absolute encoder adjustment**: Range: 0 to (2^{25}-1)

Example of an absolute encoder adjustment

The following u

- Reference m
- Operating range from SSW_STRT = -1000 mm to SSW_END = 1000 mm
- Absolute encoder adjustment = 0
- Encoder range = 2048 increments with a resolution of 1 mm/pulse
- The absolute encoder used cannot be adjusted mechanically with precision and it also is not possible to set the encoder value specifically.



Example of an absolute encoder adjustment

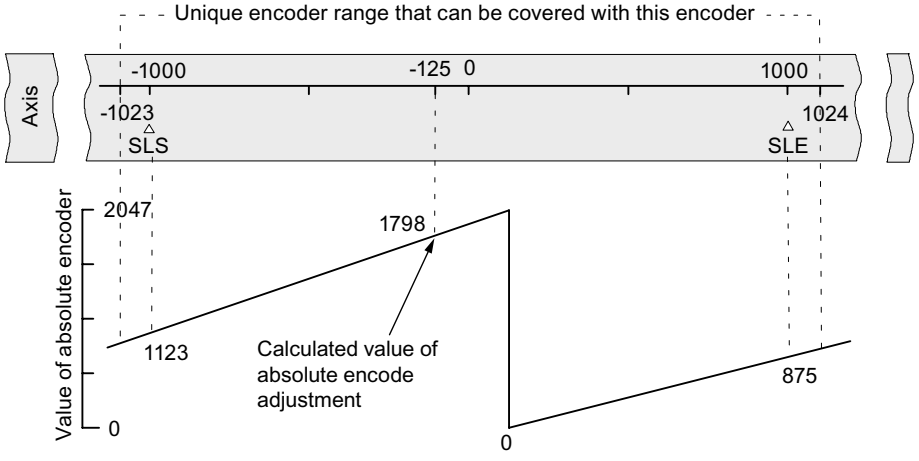
1) Assignment of the coordinate system to the encoder values with the specified absolute encoder adjustment. The encoder value 0 corresponds to the actual value -125.

2) Desired classification of the coordinate system to the encoder. At this position the coordinate should be -125.

Result in accordance with "Set reference point"

After "Set reference point" the relationship looks as follows:

The reference point coordinate on the axis (-125) is assigned to the encoder value (1798) determined from the absolute encoder adjustment.



The encoder supplies 2048 unique values. The operating range is established by the software limit switches. Because of the selected resolution of 1 mm per pulse, the encoder however can cover a greater operating range than the one provided by the software limit switches.

With the set resolution, the operating range is already covered with 2001 values. Therefore, in the example, 47 pulses "remain" and these are symmetrically positioned around the operating range.

Otherwise: Mechanical adjustment of the encoder

A correct relationship between the coordinate system and the encoder can be achieved as follows:

1. Traverse the axis to a reproducible position (e.g., the software limit switch start).
2. Enter this coordinate value in the machine data as the reference point coordinate.
3. Read the encoder value shown at this position from the service screen of the configuration software.
4. Enter this value in the machine data as the absolute encoder adjustment.

After the parameter assignment a correct actual value will always be shown.

Instead of steps 3 and 4, you can also set the encoder to zero via "Reset", if available, and enter the value "0" in the machine data as the absolute encoder adjustment.

8.7 Resolution

Definition

The resolution indicates the traversing distance corresponding to one **pulse**. It is a measurement for the precision of the positioning and also determines the possible maximum traversing range of the positioning module.

The resolution (RES) can be calculated as in the following table:

	Incremental encoder	Absolute encoder
Input values	• Distance per encoder revolution • Increments per encoder revolution: – Pulse evaluation: 4x – 1 increment = 4 pulses	• Distance per encoder revolution • Increments per encoder revolution: – 1 increment = 1 pulse
Calculation	$RES = \frac{\text{Distance}}{\text{Encoder revolution}} \div \frac{\text{Pulses}}{\text{Encoder revolution}}$	

Note

All position information is rounded up to the integral multiple of the resolution. This way the entered values differentiate from the used values.

Range of values of the resolution

The chosen system of units determines the range of values of the resolution:

System of units	Information in ...	Range of values of the resolution
mm	10^{-3} mm	$0{,}1 \cdot 10^{-3}$ .... $1000 * 10^{-3}$ mm/pulse
inch	10^{-4} inch	$0{,}1 \cdot 10^{-4}$ .... $1000 * 10^{-4}$ inch/pulse
degrees	10^{-4} degrees	$0{,}1 \cdot 10^{-4}$ .... $1000 * 10^{-4}$ degrees/pulse
	10^{-3} degrees	$0{,}1 \cdot 10^{-3}$ .... $1000 * 10^{-3}$ degrees/pulse
	10^{-2} degrees	$0{,}1 \cdot 10^{-2}$ .... $1000 * 10^{-2}$ degrees/pulse

Example

- An incremental encoder has the following data:
  - Increments per encoder revolution: 5000
  - Distance per encoder revolution: 1000 mm
  - 1 increment = 4 pulses

  This results in the resolution (4 x evaluation):

$$\text{Resolution} = \frac{1000\ \text{mm}}{5000\ \text{increments}} = 0.2000\ \frac{\text{mm}}{\text{Increment}} = 0.2000\ \frac{\text{mm}}{4\ \text{pulses}}$$

$$= 0.0500\ \frac{\text{mm}}{\text{Pulse}}$$

- An SSI encoder has the following data:
  - Increments per encoder revolution: 4096
  - Distance per encoder revolution: 1000 mm
  - 1 increment = 1 pulse

This results in the resolution:

$$\text{Resolution} = \frac{1000\ \text{mm}}{4096\ \text{increments}} = 0.2441\ \frac{\text{mm}}{\text{Increment}} = 0.2441\ \frac{\text{mm}}{\text{Pulse}}$$

Relationship between the traversing range and resolution

The traversing range is restricted by the numerical representation in the position module. This numerical representation varies depending on the resolution. You should thus make sure that your specifications are always within the permitted limits.

The maximum traversing range is illustrated in the following table:

Resolution (RES) lies in the range	Maximum traversing range
0,1 $^{\mu m}/_{pulse} \leq$ RES $< 1\ ^{\mu m}/_{pulse}$	-10^8 µm to 10^8 µm (-100 m to +100 m)
$1\ ^{\mu m}/_{pulse} \leq$ AUFL $\leq 1000\ ^{\mu m}/_{pulse}$	-1 0^9 µm to 10^9 µm (-1000 m to +1000 m)

8.8 Increment

8.8.1 Increments

Definition

Increments are target specifications that can be controlled by the positioning module with the **relative/absolute incremental approach** mode.

Prerequisites for increments

The target that is to be approached must be at a distance in front of the respective software limit switch of at least one-half the target range.

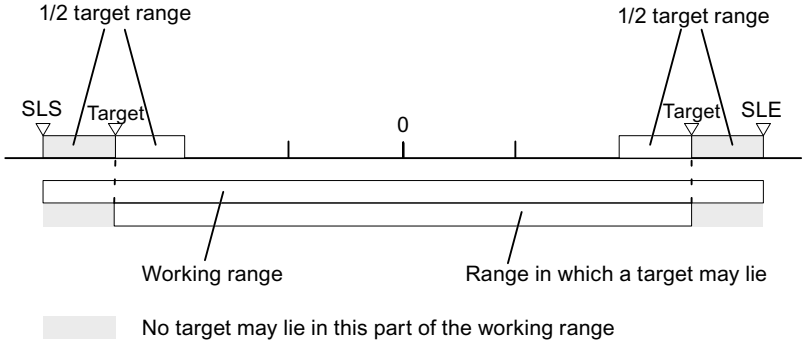


Figure 8-1 Limits for increment specifications

8.8.2 Increment number 1 to 100

Increment number 1 to 100

You have the option of entering up to 100 increments in a table. These are valid both for the **relative incremental approach** as well as for the **absolute incremental approach**.

Note that the positioning module does not permit negative values for the **relative incremental approach**. The values will be interpreted by the positioning module - depending on the direction of movement - as either a positive or a negative difference.

Note

The entry is made in the unit in accordance with the set system of units. In doing so, please observe the post-decimal places.

Numerical example:

- **Incremental**: 800 mm
- **System of units**: 10^{-3} mm
- **Entry in the parameter DB**: 800000

Tip: in the increment table define separate areas for relative and absolute increments.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
35.4	TRGL1WR_EN	BOOL	FALSE	1 = write increment table 1 (increments 1 ... 50)
35.5	TRGL2WR_EN	BOOL	FALSE	1 = write increment table 2 (increments 51 ... 100)
36.6	TRGL1RD_EN	BOOL	FALSE	1 = read increment table 1 (increments 1 ... 50)
36.7	TRGL2RD_EN	BOOL	FALSE	1 = read increment table 2 (increments 51 ... 100)

Data used in the parameter DB

Address	Name	Type	Initial value	Comment	
120.0	TRGL1.TRG[1]	DINT	L#0	Increment number 1	Increment table 1
. . .	. . .	. .	. . .	. . .	
316.0	TRGL1.TRG[50]	DINT	L#0	Increment number 50	
320.0	TRGL2.TRG[51]	DINT	L#0	Increment number 51	Increment table 2
. . .	. . .	. . .	. . .	. . .	
516.0	TRGL2.TRG[100]	DINT	L#0	Increment number 100	

8.8.3 Increment number 252

Increment number 252

The increment number 252 gives you the option of moving the drive initially in a specified direction without a target (continuous traversing) and positioning the drive at the assigned target (increment) on occurrence of an external event at digital input xI3.

The entries from the parameter DB for this increment are applicable to the changeover and switch-off differences.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
36.2	TRG252_254_EN	BOOL	FALSE	1 = Înc rement for increment number 252 or 254
96.0	TRG252_254	DINT	L#0	Increment for increment number 252 or 254

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
100.0	CHGDIF_P	DINT	L#5000	Changeover difference plus
104.0	CHGDIF_M	DINT	L#5000	Changeover difference minus
108.0	CUTDIF_P	DINT	L#2000	Switch-off difference plus
112.0	CUTDIF_M	DINT	L#2000	Switch-off difference minus

8.8.4 Increment number 254

Increment number 254

You can use the increment number 254 as an additional distance specification independent of the increment table. The entries from the parameter DB for this increment are applicable to the changeover and switch-off differences.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
36.2	TRG252_254_EN	BOOL	FALSE	1 = Write increment for increment number 252 or 254
96.0	TRG252_254	DINT	L#0	Write increment for increment number 252 or 254

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
100.0	CHGDIF_P	DINT	L#5000	Changeover difference plus
104.0	CHGDIF_M	DINT	L#5000	Changeover difference minus
108.0	CUTDIF_P	DINT	L#2000	Switch-off difference plus
112.0	CUTDIF_M	DINT	L#2000	Switch-off difference minus

8.8.5 Increment number 255

Increment number 255

Increment number 255 provides you an additional distance specification.

You transfer the switch-off differences and the changeover differences together with the increment. Unlike the other increments, increment 255 uses the values specified in the channel DB for the switch-off and changeover differences. The entries from the machine data are not applicable for this increment.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
36.3	TRG255_EN	BOOL	FALSE	1 = Write increment for increment number 255
100.0	TRG255	DINT	L#0	Increment for increment number 255
104.0	CHGDIF255	DINT	L#0	Changeover differences for increment number 255
108.0	CUTDIF255	DINT	L#0	Switch-off differences for increment number 255

Operating modes and jobs

9

9.1 End of a positioning

Definition

The end of a positioning is indicated by the checkback signal WORKING = 0. It can be reached in three different ways:

- Target approach
- Shutdown
- Cancel

Monitoring functions

During the end of a positioning, the following monitoring functions are active:

- Monitoring time
  The monitoring time is retriggered at the switch-off point for the last time and loses its validity at the end of the positioning.
  The end of the positioning must be reached within this time; otherwise, the outputs are switched off and the "Error during target approach" operating error (error number 5) is signaled.
- Monitoring of target range
  The FM 451 places a symmetrical range around each target, thereby defining the positioning accuracy of your application. During a target approach, the axis must come to a standstill within this range. A value specification of 0 switches off the tolerance for the target approach.
- Monitoring of standstill velocity
  The standstill velocity is used to determine that the drive comes to a standstill within the target range. It is checked for violation after the switch-off point is reached.
  The drive velocity must be below the standstill velocity within the target range; otherwise, the FM 451 signals the "Target range overrun" operating error (error number 10).
  Falling short of the standstill velocity is monitored only once per target approach.
  Note that the standstill velocity can be fallen below briefly for the velocity determination of the module if the axis moves at a very low positioning velocity (less than 2 pulses per 8 ms).
- Monitoring of standstill range
  After the end of a positioning, the drive is monitored to determine whether it stays at or drifts off the approached target position.
  The standstill range is monitored
  - After the FM 451 has signaled the checkback signal "PEH"
  - If the monitoring time is exceeded
  - If the standstill velocity is fallen below

  If the standstill range is exited without a valid traversing job, the FM 451 signals the "Standstill range exited" operating error (error number 6).

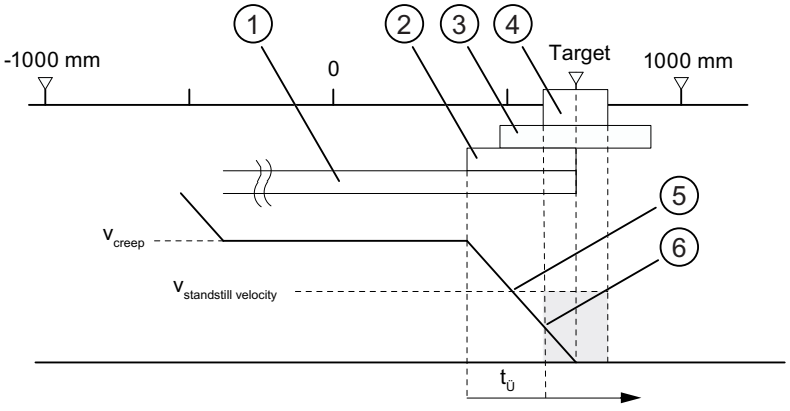
Target approach

The target approach in the "Absolute/relative incremental approach" modes starts when the switch-off point is reached. Starting from this point, the drive is switched off and the FM 451 assumes monitoring functions.

Depending on the assigned monitoring functions, there are different scenarios for generating the "PEH (POS_RCD)" checkback signal. The positioning is canceled as soon as a checkback signal "PEH (POS_RCD)" is not generated.

Case 1: You have assigned:

- Target range (TRG_RANGE) > 0
- Standstill velocity (ZSPEED_L) > 0
- Monitoring time (MON_TIME) > 0
  PEH is generated if the velocity falls below the standstill velocity and the target range is reached. It makes no difference which condition is satisfied first.
  PEH is not generated if the actual value does not reach the target range within the monitoring time or the target range is overrun without the velocity falling below the standstill velocity.

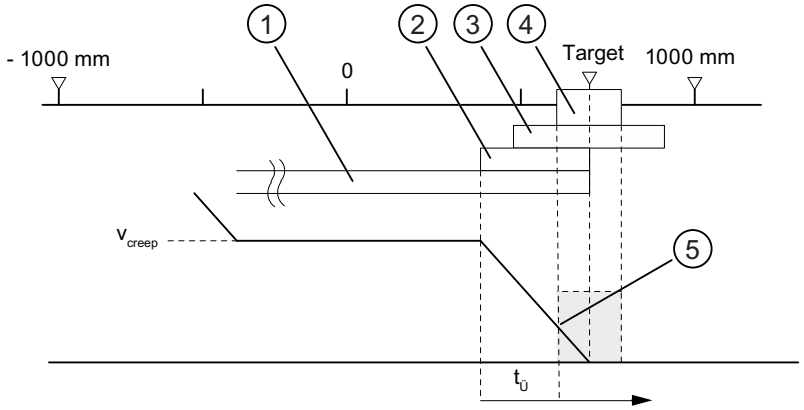


① Changeover difference plus
② Switch-off difference plus
③ Standstill range
④ Target range
⑤ Standstill velocity reached
⑥ Target range reached at V_{Still}: PEH is set
$t_Ü$ Monitoring time

Figure 9-1 Target approach of an incremental approach

Case 2: You have assigned:

- Target range (TRG_RANGE) > 0
- Standstill velocity (ZSPEED_L) = 0
- Monitoring time (MON_TIME) > 0
  PEH is generated if the target range is reached.
  PEH is not generated if the actual value does not reach the target range within the monitoring time.

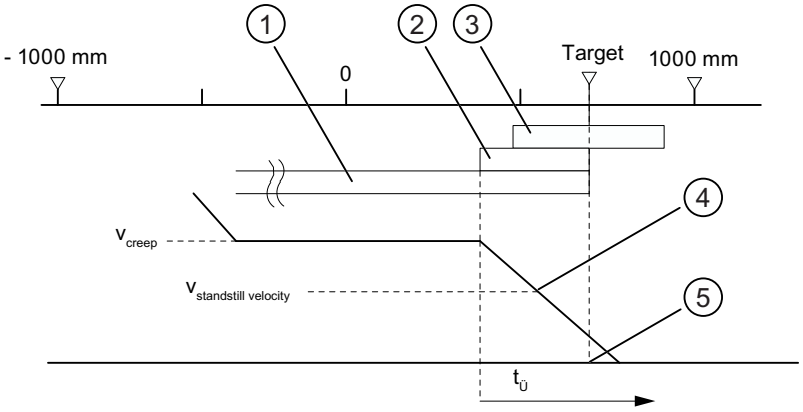


① Changeover difference plus
② Switch-off difference plus
③ Standstill range
④ Target range
⑤ Target range reached at V_{Still}: PEH is set
$t_Ü$ Monitoring time

Figure 9-2 Target approach of an incremental approach

Case 3: You have assigned:

- Target range (TRG_RANGE) = 0
- Standstill velocity (ZSPEED_L) > 0
- Monitoring time (MON_TIME) > 0
  PEH is generated if the velocity falls below the standstill velocity and the target is then reached.
  PEH is not generated if the actual value does not reach the target within the monitoring time or the target range is overrun without the velocity falling below the standstill velocity.

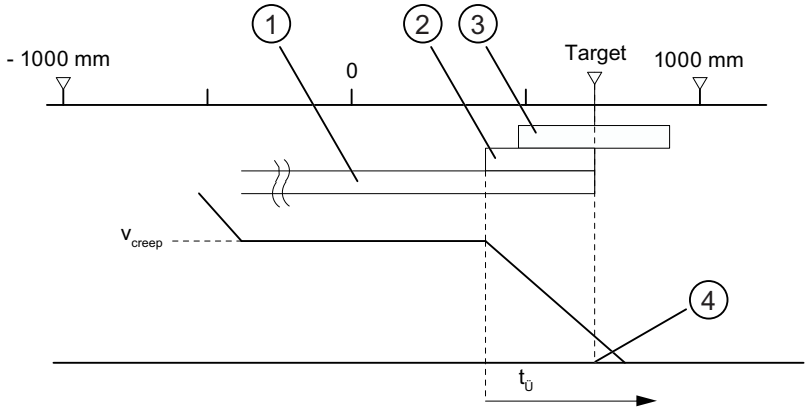


① Changeover difference plus
② Switch-off difference plus
③ Standstill range
④ Standstill velocity reached
⑤ Target reached: PEH is set
$t_Ü$ Monitoring time

Figure 9-3 Target approach of an incremental approach

Case 4: You have assigned:

- Target range (TRG_RANGE) = 0
- Standstill velocity (ZSPEED_L) = 0
- Monitoring time (MON_TIME) > 0
  PEH is generated if the target is reached.
  PEH is not generated if the actual value does not reach the target within the monitoring time.



① Changeover difference plus
② Switch-off difference plus
③ Standstill range
④ Target reached: PEH is set
$t_Ü$ Monitoring time

Figure 9-4 Target approach of an incremental approach

Case 5: You have assigned:

- Target range (TRG_RANGE) ≥ 0
- Standstill velocity (ZSPEED_L) ≥ 0
- Monitoring time (MON_TIME) = 0
  In this scenario, if the positioning comes to a standstill prior to the target range, the end of the positioning is not recognized. PEH is not generated, and the WORKING checkback signal remains set. You can only cancel the positioning by canceling the drive enable (DRV_EN = 0).

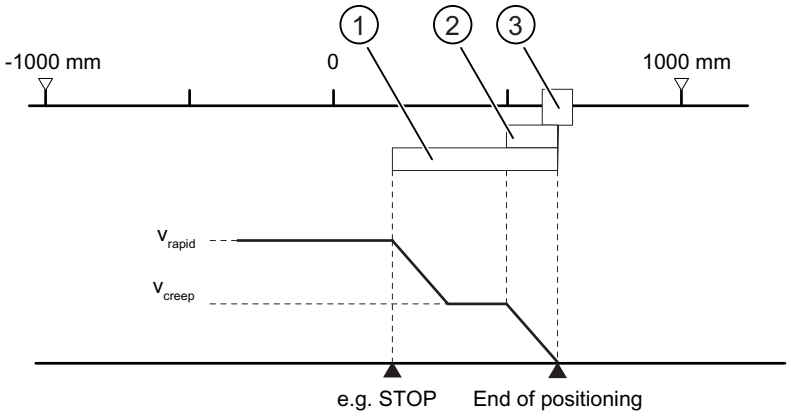
Shutdown without specified target

Shutdown means: the positioning operation is terminated in a controlled manner, complying with the differences of rapid traverse via creep speed.

The positioning is shut down, if

- The FM 451 receives a STOP signal (STOP=1)
- The "Jog" and "Reference point approach" modes are terminated
- Operator error or operating error number 9 occurs

The "PR (POS_RCD)" checkback signal is not set. The sequences are analogous to target approach.



① Changeover difference plus
② Switch-off difference plus
③ Target range

Figure 9-5 Shutdown of a positioning

Cancel

Cancel means: the positioning is immediately ended without using the changeover difference and switch-off difference from rapid traverse or creep speed to standstill. All the relevant outputs of the respective control mode are switched off immediately, and:

- Increment = actual value
- Distance-to-go = zero

The positioning is canceled if

- The drive enable signal is deleted (DRV_EN=0)
- The CPU goes to STOP
- Diagnostic error or any operating error except the "Target overrun" operating error (error number 9) occurred

The "PR (POS_RCD)" checkback signal is not set in "Incremental approach" mode.

If a standstill velocity is assigned, the standstill monitoring is activated as soon as the velocity falls below the standstill velocity. If the standstill velocity is not assigned, the standstill monitoring is activated when the outputs are switched off.

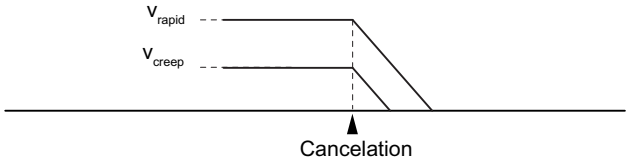


Figure 9-6 Cancelation of a positioning

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
76.0	TRG_RANGE	DINT	L#1000	Target range
80.0	MON_TIME	DINT	L#2000	Monitoring time
84.0	ZSPEED_R	DINT	L#1000	Standstill range
88.0	ZSPEED_L	DINT	L#30000	Standstill velocity

Checkback signals in the channel DB

Address	Name	Type	Initial value	Comment
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
25.7	POS_RCD	BOOL	FALSE	1 = Position reached

9.2 Configuring jog mode

Definition

In "Jog" mode you move the drive in one direction by pushing a button. You must install one button each for the two directions (plus and minus). You can use "Jog" mode for both synchronized and non-synchronized axes.

For a non-synchronized axis, jogging involves a positioning in the specified direction.

For a synchronized axis (linear axis), jogging involves a positioning to the software limit switches.

Requirement

The axis parameters must be assigned.

Sequence of "Jog" mode sequence

The buttons for the positive and negative traversing direction must be installed for each channel.

1. Set the control signal for jog mode (MODE_IN=1).
2. Set the control signal for the drive enable (DRV_EN=1).
3. Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.
4. Enter the start velocity.
   - Rapid traverse (MODE_TYPE=1)
   - Creep speed (MODE_TYPE=0)

5. Set the control signal for traversing direction plus or minus (DIR_P=1 or DIR_M=1).
6. Call the FC ABS_CTRL.

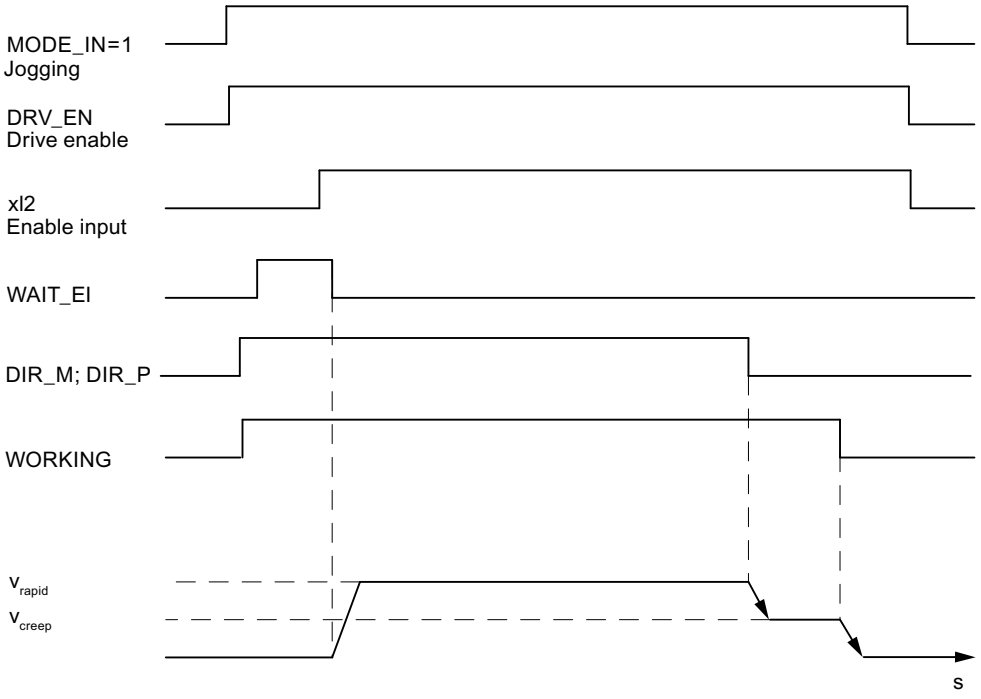


Figure 9-7 Example for "Jog" mode

Data used in the channel DB

Address	Name	Type	Initial value	Comment
15.2	DIR_M	BOOL	FALSE	1 = Minus direction
15.3	DIR_P	BOOL	FALSE	1 = Plus direction
15.7	DRV_EN	BOOL	FALSE	1 = Switch on drive enable
16.0	MODE_IN	BYTE	B#16#0	1 = Jog
17.0	MODE_TYPE	BYTE	B#16#0	1 = Rapid traverse 0 = Creep speed
23.0	ST_ENBLD	BOOL	FALSE	1 = Start enabled
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
23.2	WAIT_EI	BOOL	FALSE	1 = Axis waits for external enable
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input

Shutdown of jogging

"Jog" mode is shut down, if

- You open the button used for jogging (DIR_M or DIR_P=0)
- The FM 451 receives a STOP signal (STOP=1)
- The actual value reaches the limit of the operating range for a synchronized linear axis The axis can only continue moving in the opposite direction.

After traversing is shut down, it can continue in any direction.

Canceling jogging

"Jog" mode is canceled, if

- The drive enable signal is deleted (DRV_EN=0)
- A traversing range limit has been overrun for a linear axis

Monitoring functions

In jog mode, the following monitoring functions are not active at the end of the positioning:

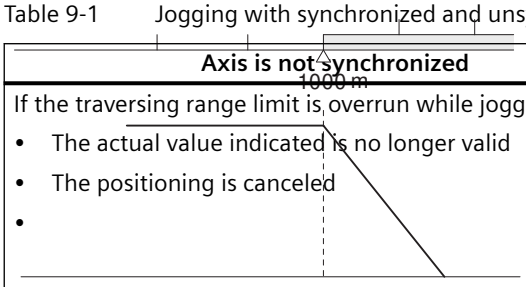
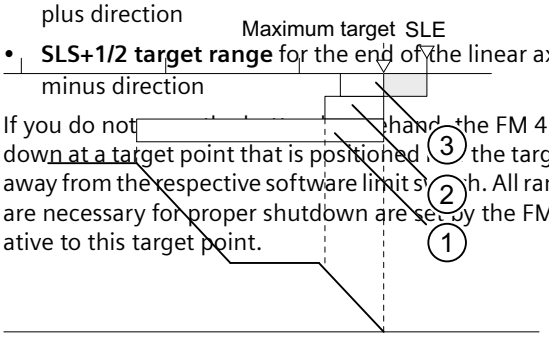
- Monitoring of standstill range
- Monitoring of target range
- Monitoring of standstill velocity

This operation does not result in proper positioning for which the "Position reached" signal is finally set.

Operating range limit for a linear axis

The limits for "Jog" mode differ between a synchronized and an unsynchronized axis.

Table 9-1 Jogging with synchronized and unsynchronized axes

Axis is not synchronized	Axis is synchronized
If the traversing range limit is overrun while jogging, • The actual value indicated is no longer valid • The positioning is canceled •  The actual value indicated is no longer valid	Jogging involves a positioning to targets that are removed from the software limit switches by a distance equal to the whole target range. The operating range limits are determined from: • **SLE 1/2 target range** for the end of the linear axis in the plus direction • **SLS+1/2 target range** for the end of the linear axis in the minus direction  If you do not [illegible] hand, the FM 451 shuts down at a target point that is positioned [illegible] the target range away from the respective software limit switch. All ranges that are necessary for proper shutdown are set by the FM 451 relative to this target point. = Part of operating range in which a target position cannot be located ① = Changeover difference plus ② = Switch-off difference plus ③ = 1/2 Target range

9.3 Configuring reference point approach mode

Definition

The "Reference point approach" mode can be used to synchronize the axis based on a recurring external event.

Requirements

- Incremental encoder with zero mark.
- The axis parameters must be assigned.

Connections	Channel 1	Channel 2	Channel 3
Home position switch	Digital input 1I0	Digital input 2I0	Digital input 3I0
	The reference point switch should be provided such that the drive can safely brake from rapid traverse to creep speed in the range of the switch.		
Reversing switch	Digital input 1I1	Digital input 2I1	Digital input 3I1
	When assigning parameters, ensure that the start of the reference point approach is assigned in the direction of the reversing switch. This is necessary to ensure that the reference point switch is always found.		
Enable input	Digital input 1I2	Digital input 2I2	Digital input 3I2

Sequence of "Reference point approach" mode

1. Set the value for the reference point coordinate in the parameter DB (REFPT).
2. Enter the type of "Reference point approach" in the parameter DB.
   Options:

Start in direction ...	Triggers synchronization ...	
plus	First zero mark after exiting the reference point switch in **plus** direction	REFPT_TYPE=0
plus	First zero mark after exiting the reference point switch in **minus** direction	REFPT_TYPE=1
minus	First zero mark after exiting the reference point switch in **plus** direction	REFPT_TYPE=2
minus	First zero mark after exiting the reference point switch in **minus** direction	REFPT_TYPE=3

1. Enter the start velocity.
   - Rapid traverse (REFPT_SPD=0)
   - Creep speed (REFPT_SPD=1)
2. Write and enable machine data.
3. Set the control signal for reference point approach mode (MODE_IN=3).
   - The buttons for the positive and negative traversing direction must be installed for each channel.

4. Set the control signal for the drive enable (DRV_EN=1).
5. Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.
6. Set the control signal for traversing direction plus or minus or the start signal (DIR_P=1, DIR_M=1, or START=1).
7. Call the FC ABS_CTRL.

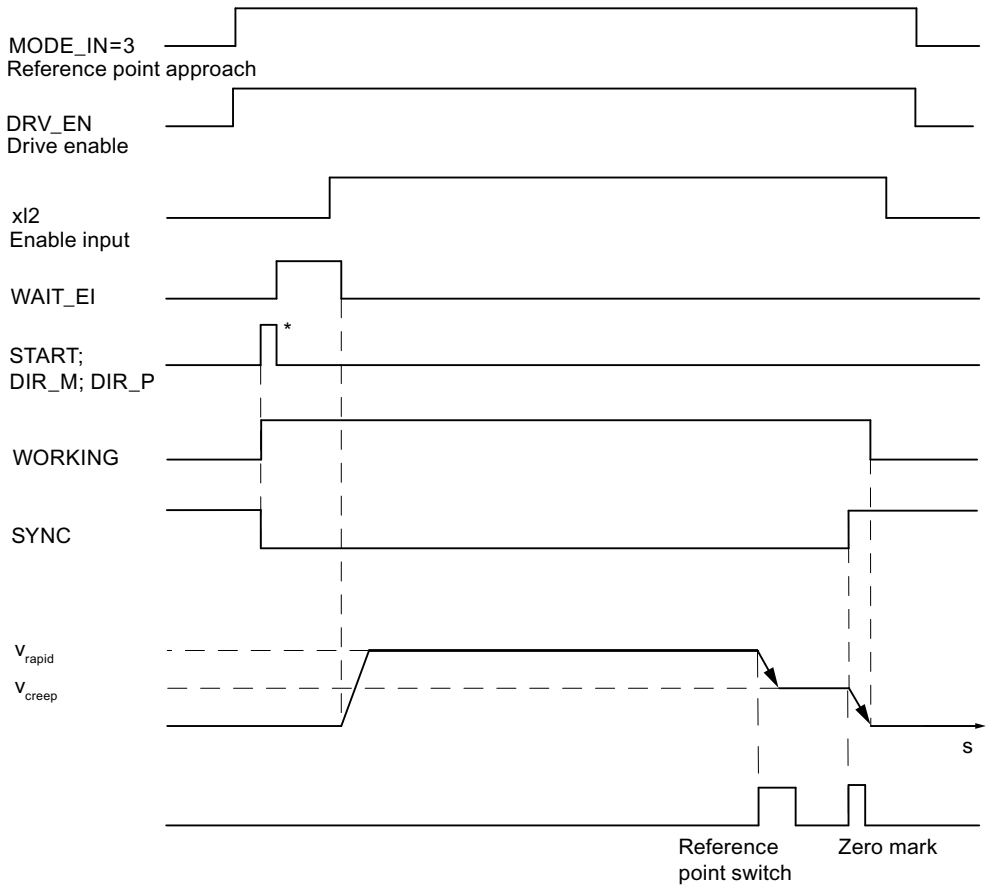
Table 9-2 Start commands for a reference point approach

Start command	Task	Comment
DIR_P	The drive starts in the direction of positive values. Therefore it moves in the direction of the traversing range end.	If a negative direction is entered in the machine data, the FM 451 signals an operator error. No reference point approach is performed.
DIR_M	The drive starts in the direction of negative values. Therefore, it moves in the direction of the traversing range start.	If a positive direction is entered in the machine data, the FM 451 signals an operator error. No reference point approach is performed.
START	The drive starts in the direction that was entered in the machine data.	

Note

The following applies to the rotary axis: Reproducibility of the reference point is only ensured if the ratio of the **End of rotary axis** value and the **Distance per encoder revolution** value is an integer.

Example for "Reference point approach" mode



* The start signals are reset by the FC ABS_CTRL.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
15.0	START	BOOL	FALSE	1 = Start positioning
15.2	DIR_M	BOOL	FALSE	1 = Minus direction
15.3	DIR_P	BOOL	FALSE	1 = Plus direction
15.7	DRV_EN	BOOL	FALSE	1 = Switch on drive enable
16.0	MODE_IN	BYTE	B#16#0	3 = Reference point approach
23.0	ST_ENBLD	BOOL	FALSE	1 = Start enabled
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
23.2	WAIT_EI	BOOL	FALSE	1 = Axis waiting for external enable
25.0	SYNC	BOOL	FALSE	1 = Axis is synchronized
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
44.0	REFPT	DINT	L#0	Reference point coordinate
52.0	REFPT_TYPE	DINT	L#0	Type of reference point approach
99.0	REFPT_SPD	BOOL	TRUE	Start velocity for reference point approach 0 = Rapid traverse 1 = Creep speed

Effects of the operating mode

- Synchronization is canceled when traversing starts.
- The actual position is set to the value of the reference point coordinate when the "SYNC" checkback signal is set.
- The operating range is specified on the axis.
- The individual points within the operating range maintain their original value, but have new physical positions.
- The reference point switch must be connected
  - For channel 1 at digital input I1
  - For channel 2 at digital input I5
- The reference point switch must be furnished such that the drive can safely brake from rapid traverse to creep speed in the range of the switch.
- When assigning parameters, ensure that the start of the reference point approach is assigned in the direction of the reversing switch. This is necessary to ensure that synchronization is achieved.
- The reversing switch must be connected
  - For channel 1 at digital input I2
  - For channel 2 at digital input I6
- If the enable input is to be evaluated, connect
  - The switch to digital input I3 for channel 1
  - The switch to digital input I7 for channel 2
- The channel for which a reference point approach is to be performed must be assigned.
- You have defined the following in the machine data:
  - Type of reference point approach
  - Start velocity for a reference point approach

Canceling the reference point approach

"Reference point approach" mode is canceled, if

- The drive enable signal is deleted (DRV_EN=0)
- A traversing range limit has been overrun for a linear axis

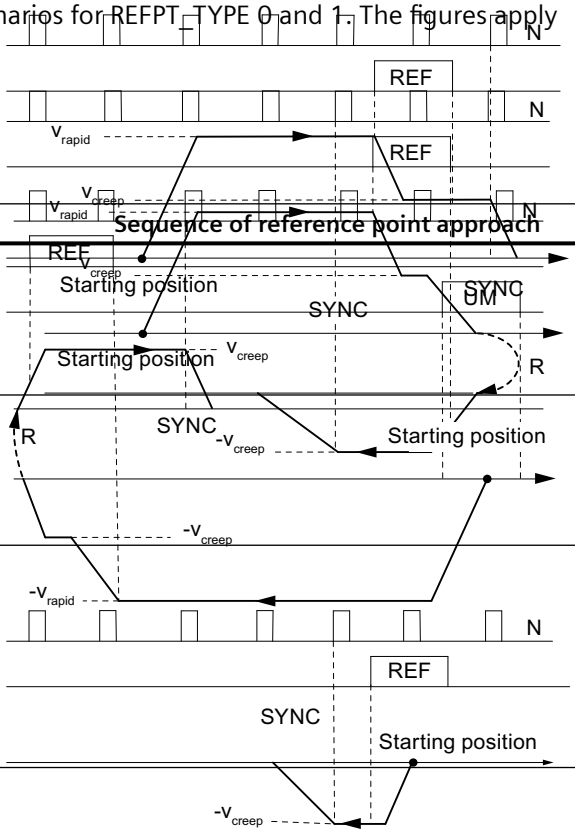
Reference point approach as a function of the start position

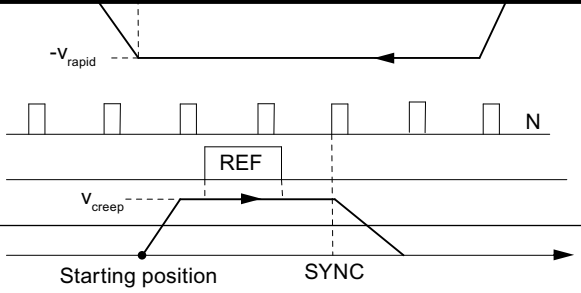
For a reference point approach you must distinguish between various scenarios that depend on the following:

- Location of the drive at the time a reference point approach is started
- Assigned start direction
- Assigned location of the zero mark relative to the reference point switch

The following table describes the scenarios for REFPT_TYPE 0 and 1. The figures apply analogously to REFPT_TYPE 2 and 3.

Table 9-3 Options for reference point approach

Conditions for reference point approach	Sequence of reference point approach
Example of reference point approach (REFPT_TYPE=0): • Start direction is plus. • Position of zero mark of reference point switch is assigned in the plus direction.	
Example of reference point approach (REFPT_TYPE=1): • Start direction is plus. • Position of zero mark of reference point switch is assigned in the minus direction.	
Example of reference point approach (REFPT_TYPE=0): • Start direction must be assigned in the plus direction. • Position of zero mark of reference point switch is assigned in the plus direction. • The reversing switch is more positive than the reference point switch.	
Example of reference point approach (REFPT_TYPE=1): • Start direction is plus. • Position of zero mark of reference point switch is assigned in the minus direction. • Start position of reference point approach is on the reference point switch.	

Conditions for reference point approach	Sequence of reference point approach
Example of reference point approach (REFPT_TYPE=0): • Start direction is plus. • Position of zero mark of reference point switch is assigned in the plus direction. • The reversing switch is more positive than the reference point switch.	
Example of reference point approach (REFPT_TYPE=0): • Start direction is plus. • Position of zero mark of reference point switch is assigned in the plus direction. • Start velocity= creep speed	
R = Direction reversal REF = Reference point switch UM = Reversing switch N = Zero mark of the encoder SYNC = Synchronization has been achieved	

9.4 Configuring incremental approach mode

Definition

With "incremental approach", the FM 451 can move the drive

- To **absolute** targets
- **Relatively** by an incremental distance in a specified direction

You specify the target or the relative distances as increments of the FM 451. You have the option of entering up to 100 increments in a table. These are applicable to **relative incremental approach** mode and to **absolute incremental approach** mode. You can use the increment 254 and increment 255 to specify the distance independent of the increment table (see chapter "Increments (Page 82)").

The increment 252 gives you the option of moving the drive initially in a specified direction without a target (continuous traversing) and positioning the drive at the assigned target on occurrence of an external event (xI3).

Requirements

- The axis parameters must be assigned.
- The axis must be synchronized.
- The increments must be available on the module.

Interpretation of the increments

Depending on which incremental approach you select, the FM 451 interprets the specifications differently.

- Absolute incremental approach:
  The increments are interpreted as an absolute target position.
  With a rotary axis, the end of the rotary axis must not be overrun.
- Relative incremental approach:
  The increments are interpreted as a relative distance from the start position.
  With a rotary axis, the end of the rotary axis must not be overrun (multiple rotations are permissible).

Note

Only positive increments are allowed for the "Relative incremental approach" mode. The signs of the increments result from the DIR_P and DIR_M direction specifications.

Sequence of "Incremental approach" mode with increment number 1 - 100

Step	Absolute incremental approach	Relative incremental approach
	Increment number 1 - 100	
1	Set the control signal for the "Absolute incremental approach" mode (MODE_IN=5).	Set the control signal for the "Relative incremental approach" mode (MODE_IN=4).
2	Enter the increments in the tables (TRGL1; TRGL2).	
3	Write the increment tables (TRGL1/2WR_EN=1).	
4	Set the control signal for the drive enable (DRV_EN=1).	
5	Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.	
6	Enter the increment number (MODE_TYPE=1...100).	
7	Set the control signal: • Linear axis: – START; the direction is determined explicitly by the target and the current actual value. • Rotary axis: – START; the target is approached on the shortest path. – DIR_P; start in plus direction – DIR_M; start in minus direction	Set the control signal: • Linear axis: – DIR_P; start in plus direction – DIR_M; start in minus direction • Rotary axis: – DIR_P; start in plus direction – DIR_M; start in minus direction
8	Call the FC ABS_CTRL.	
Steps 2 and 3 are only necessary if no increments are yet available or the existing increments are to be changed.		

Sequence of "Incremental approach" mode with increment number 252

Step	Absolute incremental approach	Relative incremental approach
	Increment number 252	
1	Set the control signal for the "Absolute incremental approach" mode (MODE_IN=5).	Set the control signal for the "Relative incremental approach" mode (MODE_IN=4).
2	Set the control signal for the drive enable (DRV_EN=1).	
3	Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.	
4	Enter the incremental dimension number (MODE_TYPE=252).	
5	Enter the start velocity. • Rapid traverse (SPEED252=1) • Creep speed (SPEED252=0)	
6	Enter the increment for the increment number 252 (TRG252_254).	
7	Set the trigger bit for writing the increment (TRG252_254_EN=1).	
8	Set the control signal: • Linear axis/rotary axis: – DIR_P; start in plus direction – DIR_M; start in minus direction	

Step	Absolute incremental approach	Relative incremental approach
	Increment number 252	
9	Call the FC ABS_CTRL.	
10	When an external event occurs (digital input xI3), the positioning to the assigned target (increment) is performed.	
The actions listed in items 6 and 7 can also be performed only during traversing. In this case, the FM 451 module controls a target up to the increment specification. This target is located a distance in front of the respective software limit switch equal to half the target range.		

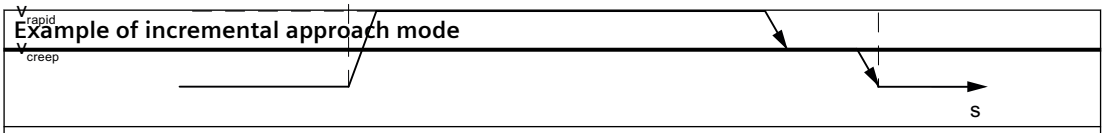
Sequence of "Incremental approach" mode with increment number 254

Step	Absolute incremental approach	Relative incremental approach
	Increment number 254	
1	Set the control signal for the "Absolute incremental approach" mode (MODE_IN=5).	Set the control signal for the "Relative incremental approach" mode (MODE_IN=4).
2	Set the control signal for the drive enable (DRV_EN=1).	
3	Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.	
4	Enter the increment number (MODE_TYPE=254).	
5	Enter the increment for the increment number 254 (TRG252_254).	
6	Set the trigger bit for writing the increment (TRG252_254_EN=1).	
7	Set the control signal: • Linear axis: – START; the direction is determined explicitly by the target and the current actual value. • Rotary axis: – START; the target is approached on the shortest path. – DIR_P; start in plus direction – DIR_M; start in minus direction	Set the control signal: • Linear axis: – DIR_P; start in plus direction – DIR_M; start in minus direction • Rotary axis: – DIR_P; start in plus direction – DIR_M; start in minus direction
8	Call the FC ABS_CTRL.	

Sequence of "Incremental approach mode" with increment number 255

Step	Absolute incremental approach	Relative incremental approach
	Increment number 255	
1	Set the control signal for the "Absolute incremental approach" mode (MODE_IN=5).	Set the control signal for the "Relative incremental approach" mode (MODE_IN=4).
2	Set the control signal for the drive enable (DRV_EN=1).	
3	Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.	
4	Enter the increment number (MODE_TYPE=255).	
5	Enter the increment for the increment number 255 (TRG255).	
6	Enter the value for the changeover difference of the increment number 255 (CHGDIF255).	

Step	Absolute incremental approach	Relative incremental approach
	Increment number 255	
7	Enter the value for the switch-off difference of the increment number 255 (CUTDIF255).	
8	Set the trigger bit for writing the increment, switch-off difference, and changeover difference (TRG255_EN=1).	
9	Set the control signal: • Linear axis: – START; the direction is determined explicitly by the target and the current actual value.* • Rotary axis: – START; the target is approached on the shortest path. – DIR_P; start in plus direction – DIR_M; start in minus direction	Set the control signal: • Linear axis: – DIR_P; start in plus direction – DIR_M; start in minus direction • Rotary axis: – DIR_P; start in plus direction – DIR_M; start in minus direction
10	Call the FC ABS_CTRL.	



* The start signals are reset by the FC ABS_CTRL.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
15.0	START	BOOL	FALSE	1 = Start positioning
15.2	DIR_M	BOOL	FALSE	1 = Minus direction
15.3	DIR_P	BOOL	FALSE	1 = Plus direction
15.6	SPEED252	BOOL	FALSE	Start velocity for incremental approach with increment number 252 0 = Creep speed 1 = Rapid traverse
15.7	DRV_EN	BOOL	FALSE	1 = Switch on drive enable
16.0	MODE_IN	BYTE	B#16#0	4 = Relative incremental approach 5 = Absolute incremental approach
17.0	MODE_TYPE	BYTE	B#16#0	Increment number 1 - 100, 252, 254, or 255
23.0	ST_ENBLD	BOOL	FALSE	1 = Start enabled
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
23.2	WAIT_EI	BOOL	FALSE	1 = Axis waiting for external enable
25.7	POS_RCD	BOOL	FALSE	1 = Position reached
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input
36.2	TRG252_254_EN	BOOL	FALSE	1 = Write increment for increment number 252 or 254
36.3	TRG255_EN	BOOL	FALSE	1 = Write increment for increment number 255

Address	Name	Type	Initial value	Comment
35.4	TRGL1WR_EN	BOOL	FALSE	1 = Write increment table 1 (increment number 1...50)
35.5	TRGL2WR_EN	BOOL	FALSE	1 = Write increment table 2 (increment number 51...100)
96.0	TRG252_254	DINT	L#0	Write increment for increment number 252 or 254
100.0	TRG255	DINT	L#0	Increment for increment number 255
104.0	CHGDIF_255	DINT	L#0	Changeover difference for increment number 255
108.0	CUTDIF_255	DINT	L#0	Switch-off difference for increment number 255

Data used in the parameter DB

Address	Name	Type	Initial value	Comment	
100.0	CHGDIF_P	DINT	L#5000	Changeover difference plus	
104.0	CHGDIF_M	DINT	L#5000	Changeover difference minus	
108.0	CUTDIF_P	DINT	L#2000	Switch-off difference plus	
112.0	CUTDIF_M	DINT	L#2000	Switch-off difference minus	
120.0	TRGL1.TRG[1]	DINT	L#0	Increment number 1	Increment table 1
. . .	. . .	. . .	. . .	. . .	
316.0	TRGL1.TRG[50]	DINT	L#0	Increment number 50	
320.0	TRGL2.TRG[51]	DINT	L#0	Increment number 51	Increment table 2
. . .	. . .	. . .	. . .	. . .	
516.0	TRGL2.TRG[100]	DINT	L#0	Increment number 100	

Distance-to-go

The distance-to-go is the difference between the target (increment) and actual value. This is:

- Positive, if the target has not yet been reached
- Negative, if the target has already been overrun

Shutdown of incremental approach

Incremental approach mode is shut down when the FM 451 receives a STOP signal (STOP=1).

After traversing is shut down, there is distance-to-go remaining.

The remaining distance-to-go for relative incremental approach and absolute incremental approach with increment number 252 can be traveled to the end if all of the following conditions are met:

- The operating mode is unchanged
- The increment number is unchanged

- The direction is unchanged
- The remaining distance-to-go is greater than the assigned switch-off difference

You traverse the distance-to-go by starting the relative incremental approach or the absolute incremental approach with increment number 252 again without making any changes.

Canceling the incremental approach

The incremental approach mode is canceled when the "drive enable" signal is deleted (DRV_EN=0).

Deleting the distance-to-go

The "Delete distance-to-go" job deletes a pending distance-to-go.

For incremental approach with increment number 252, traversing restarts with continuous traversing after deleting the distance-to-go.

You also delete the pending distance-to-go when you call another operating mode or start the operating mode in the opposite direction.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
35.2	DELDIST_EN	BOOL	FALSE	1 = Delete distance-to-go

9.5 Configuring set actual value/set actual value on-the-fly/cancel set actual value

Definition

You use the "Set actual value" or "Set actual value on-the-fly" jobs to assign a new coordinate to the current encoder value. The operating range is projected on a different range of the axis.

You determine the shift in the operating range with (**ACT**$_{new}$ - **ACT**$_{current}$).

- **ACT**$_{new}$ is the specified value
- **ACT**$_{current}$ is the actual value at the time of execution

Requirements

- The axis parameters must be assigned.
- The axis must be synchronized.

The positioning must be ended for "Set actual value".

Job sequence

1. Enter the coordinate for the actual value (**ACT**$_{new}$) (AVAL, FVAL).
   - Linear axis:
     You must select the specified actual value such that the software limit switches are still within the permissible traversing range after the job is called.
     The amount of the shift resulting from (**ACT**$_{new}$ - **ACT**$_{current}$) must be less than or equal to the amount of the permitted traversing range (maximum 100 m or 1000 m).
   - Rotary axis:
     Rule for the specified actual value:
     0 ≤ actual value < end of rotary axis
2. Set the relevant trigger bit (AVAL_EN=1, FVAL_EN=1).

"Set actual value" is executed immediately.

"Set actual value on-the-fly" is executed at the next positive edge at digital input xI3.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
35.7	AVAL_EN	BOOL	FALSE	1 = Set actual value
36.0	FVAL_EN	BOOL	FALSE	1 = Set actual value on-the-fly
84.0	AVAL	DINT	L#0	Coordinate for "Set actual value"
88.0	FVAL	DINT	L#0	Coordinate for "Set actual value on-the-fly"

Effects of the job

In the example "set actual value" to 300 mm, you can see how this job projects the operating range onto a certain position of the axis. This produces the following effects:

- The actual position is set to the value of the actual value coordinate.
- The o ted on the axis.
- The ., software limit switch end) within the operating range maintain the have new physical positions.

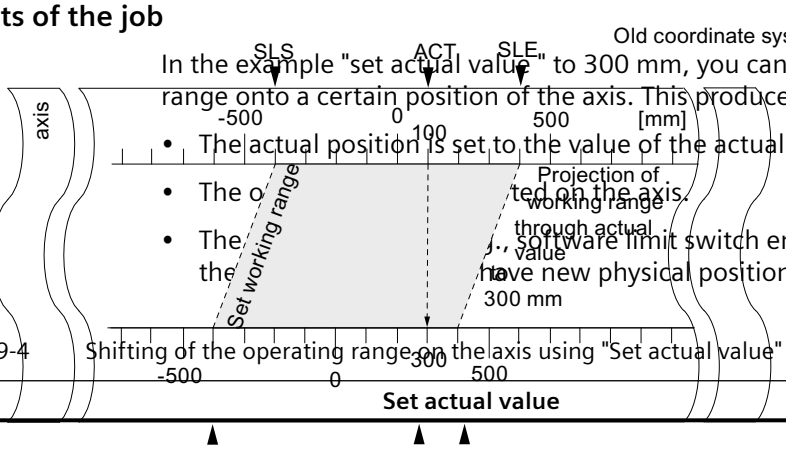


Table 9-4 Shifting of the operating range on the axis using "Set actual value"

Set actual value	SLS	ACT	SLE
	-400	100	400
	-400	300	400

Canceling the job

The "Cancel set actual value" job can be used to reset the **most recent** operating range shift caused by "Set actual value".

Once "Set actual value on-the-fly" has been initiated, it can no longer be canceled before execution by a positive edge at digital input xI3. However, it can be overwritten by a new "Set actual value on-the-fly". These jobs are reset the next time the module starts up.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
35.3	AVALREM_EN	BOOL	FALSE	1 = Cancel set actual value

9.6 Configuring zero offset

Definition

The "zero offset" job lets you shift the zero point in the coordinate system by a defined value.

The sign determines the offset direction in the coordinate system.

Determining a new coordinate

All values of the shifted coordinate system can be calculated according to the following formula:

Coordinate$_{new}$ **= Coordinate**$_{old}$ **- (ZPO**$_{new}$ **- ZPO**$_{old}$**)**

ZPO$_{old}$ designates an existing zero offset.

If no zero offset was active prior to the call, set the value 0 for **ZPO**$_{old}$.

You can use this to determine the coordinate values for the software limit switches, for example.

Requirements

- The positioning must be ended.
- The axis parameters must be assigned.

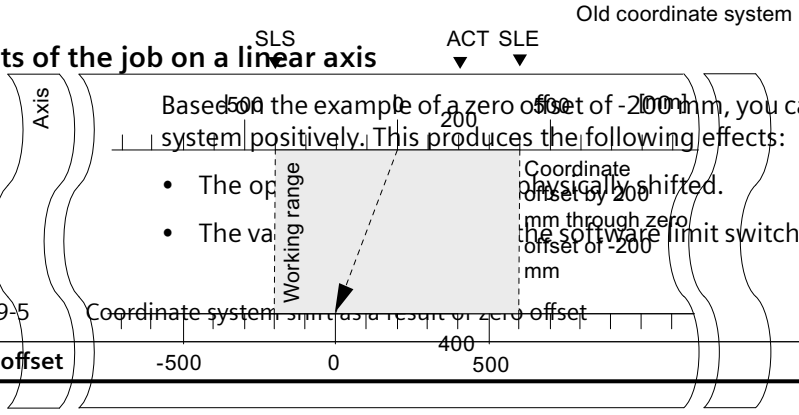
Job sequence

1. Enter the value for the zero offset (ZOFF).
   - Linear axis:
     The zero offset must be selected so that the software limit switches remain within the permissible numerical range after the job is called.
   - Rotary axis:
     Rule for the zero offset:
     value of zero offset ≤ end of rotary axis
2. Set the relevant trigger bit (ZOFF_EN=1).

Data used in the channel DB

Address	Name	Type	Initial value	Comment
36.1	ZOFF_EN	BOOL	FALSE	1 = Set zero offset
80.0	ZOFF	DINT	L#0	Zero offset

Effects of the job on a linear axis



Based on the example of a zero offset of -200 mm, you can see that this job shifts the coordinate system positively. This produces the following effects:

- The op[illegible]physically shifted.
- The va[illegible]the software limit switches) are assigned new coordinate values.

Table 9-5 Coordinate system shift as a result of zero offset

Zero offset	SLS	ACT	SLE
-400	-400	200	400
-200	-200	400	600

Effects of the job on a rotary axis

Based on the example of a zero offset by -45°, you can see how this job **rotates** the coordinate system:

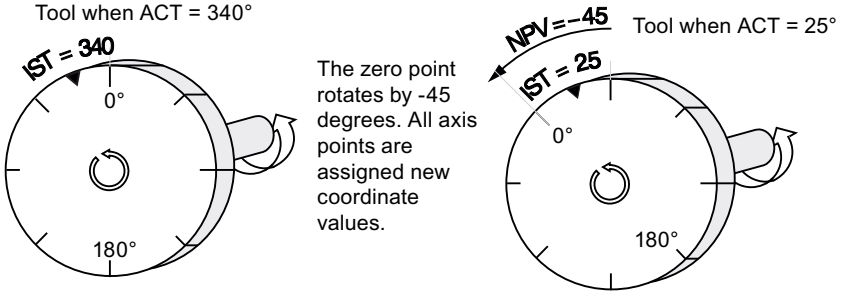


Figure 9-8 Rotation of the coordinate system as a result of zero offset

Including a $\mathbf{ZPO_{old} = 0}$, the result is a new value of 385°.

Because the actual value starts over at 0 at the end of the rotary axis with a positive direction of rotation, the actual value of 25° is calculated from:

$$\mathbf{Coordinate_{new} = Coordinate_{old} - (ZPO_{new} - ZPO_{old}) - end\ of\ rotary\ axis}$$

Loss of synchronization

If synchronization is lost due to an error or is reset due to "reference point approach", a zero offset **remains** active.

Canceling the job

A zero offset of 0 mm resets any existing zero offset.

9.7 Configuring set reference point

Definition

You use the "set reference point" job to synchronize the axes. The job shifts the operating range. All the shifts that were created with set actual value are retained.

The setting projects the operating range on the axis. Therefore, by entering different values, the operating range can be moved to any position within the physical area of the axis.

Prerequisites

- The positioning must have ended.
- The axis parameters must be assigned.

Job sequence

1. Enter the value for the reference point coordinate (REFPT).
   - Linear axis:

     The reference point coordinate must not lie outside of the software limit switches. This also applies to the reference point coordinate in a shifted coordinate system.
   - Rotary axis:
     Rule for the reference point coordinate:
     0 ≤ reference point coordinate < end of rotary axis
2. Set the respective trigger bit (REFPT_EN).

Data used in the channel DB

Address	Name	Type	Initial value	Comment
25.0	SYNC	BOOL	FALSE	1 = axis is synchronized
35.6	REFPT_EN	BOOL	FALSE	1 = set reference point
92.0	REFPT	DINT	L#0	Reference point coordinate

Effects of the job

In the example "set reference point" to 400 mm you can see how this job projects the operating range onto a specific, physical position of the axis. This has the following results:

- The actual position is set on the value of the reference point coordinate.
- The operating range is shifted on the axis.
- The individual points (e.g. software limit switch end) maintain their original value, but are located at new positions.
- The SYNC bit in the checkback signals is set.

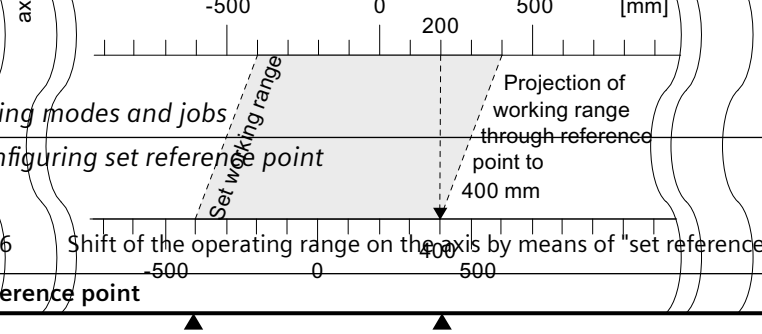
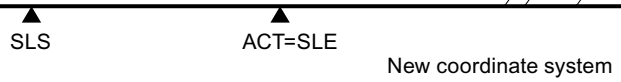


Table 9-6 Shift of the operating range on the axis by means of "set reference point"

Set reference point	SLS	ACTUAL	SLE
	-400	200	400
	-400	400	400

Special features of the absolute encoder

This job is required for an absolute adjustment (refer to section entitled "Determining the absolute encoder adjustment (Page 77)").

9.8 Configuring length measurement / edge detection

Definition

The "length measurement" and "edge detection" let you determine the length of a workpiece.

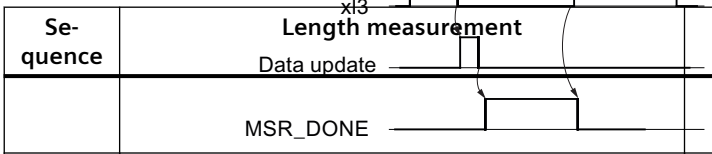
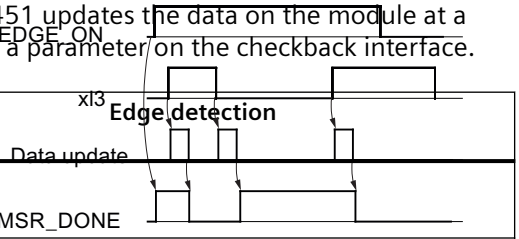
The "length measurement" or "edge detection" function switch is active and remains active until you disable it or select the other measuring method. If you select both measuring methods in parallel, FC ABS_CTRL activates the length measurement.

Requirements

- The positioning must be ended.
- The axis parameters must be assigned.
- The axis must be synchronized.
- A **bounce-free** switch must be connected to input xI3.
- If these jobs are selected during a positioning, "length measurement" and "edge detection" can only be executed with the next positioning.

Job sequence

Depending on the type of measurement, the FM 451 updates the data on the module at a different time. The FM 451 reports each update in a parameter on the checkback interface.

Se-quence		
1	Set the function switch for "length measurement" (MSR_ON).	Enter a value for the minimum edge distance (EDGEDIST) in the parameter DB. Write and enable machine data.
2	Start a positioning.	Set the "edge detection" function switch (EDGE_ON). This sets the MSR_DONE parameter.
3	A positive edge at input xI3 starts the length measurement.	Start a positioning.
4	A negative edge at input xI3 stops the current measurement. The FM 451 updates the start value, end value, and length data.	A positive edge at input xI3 starts the measurement. After the "minimum edge distance" is traversed, the measurement is valid. This is signaled with MSR_DONE=0. The results of the measurement are updated and can be read out, and the start value of the measurement is entered; the end value and length assume the value -1.
5	When parameter MSR_DONE is set, the FM 451 reports the data update. The parameter indicates completion of the measurement. The results of the measurement can be read out.	After the update, the FM 451 reports the change by resetting the MSR_DONE parameter.
6	The next start of a measurement at a positive edge at xI3 resets the MSR_DONE parameter.	A negative edge at input xI3 stops the current measurement. The FM 451 updates the data for the end value of the measurement and length.

Se-quence	Length measurement	Edge detection
7	-	After the update, the FM 451 reports the change by setting the MSR_DONE parameter. The results of the measurement can be read out.
8	-	The next start of a measurement at a positive edge at xI3 resets the MSR_DONE parameter.

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
4.0	EDGEDIST	DINT	L#0	Minimum edge distance for edge detection
The measurement will be discarded if the end of the measuring operation is within this range (BEG_VAL, END_VAL, and LEN_VAL=-1).				

Data used in the channel DB

Address	Name	Type	Initial value	Comment
25.1	MSR_DONE	BOOL	FALSE	1 = Length measurement/edge detection completed
34.3	EDGE_ON	BOOL	FALSE	1 = Edge detection ON
34.4	MSR_ON	BOOL	FALSE	1 = Length measurement ON
35.0	MDWR_EN	BOOL	FALSE	1 = Write machine data
35.1	MD_EN	BOOL	FALSE	1 = Enable machine data
37.0	MSRRD_EN	BOOL	FALSE	1 = Read measured values
136.0	BEG_VAL	DINT	L#0	Start value of length measurement/edge detection
140.0	END_VAL	DINT	L#0	End value of length measurement/edge detection
144.0	LEN_VAL	DINT	L#0	Length

Boundary conditions for a length measurement

- The CPU program requires an interval of sufficient length between the off and on edges at input xI3 in order to correctly evaluate the result of the measurement before a new measurement starts.
- The minimum interval between the positive and negative edges at input xI3 and between the negative edge and the next positive edge at input xI3 must be greater than 8 ms.

Faulty measurement

The FM 451 returns the length value -1 in the event of a faulty length measurement/edge detection. A length measurement is faulty if:

- The length measured for a rotary axis is greater than 2^{31}.
- The on and off edges are detected simultaneously by the FM 451 (for example, due to switch bounce).

9.9 Configuring loop approach

Definition

You use "loop approach" to specify the direction in which a target is approached with a frictional connection. You can use loop approach if a frictional connection between the motor and axis can only be ensured in one direction.

A target that is approached in the opposite direction is initially overrun. Then, the FM 451 performs a direction reversal and approaches the target in the specified direction.

Requirements

- The axis parameters must be assigned.
- The axis must be synchronized.
- For a loop approach to the target in the direction opposite to the traversing direction, the maximum target position is:
  - In the plus traversing direction
    Target < SLE - $^1/_2$ Target range - Switch-off difference plus - Changeover difference minus
  - In the minus traversing direction
    Target > SLS + $^1/_2$ Target range + Switch-off difference minus + Changeover difference plus
- A loop approach is **not** performed if the target is approached in the direction of the loop approach. In this case, an incremental approach without direction reversal is performed.
- The sequence of the "incremental approach" mode must be known (see chapter "Configuring incremental approach mode (Page 104)").

Loop approach sequence

1. Set the control signal for the absolute/relative incremental approach mode (MODE_IN=4/5).
2. Set the control signal for the drive enable (DRV_EN=1).
3. Set the function switch for "Do not evaluate enable input" (EI_OFF=1) or wire the enable input for the corresponding channel.
4. Enter the increment number (MODE_TYPE=1...100, 254, 255). Increment number 252 is not permissible in this case.
5. Set the function switch (PLOOP_ON / MLOOP_ON=1).
6. Start the incremental approach.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
15.0	START	BOOL	FALSE	1 = Start positioning
15.2	DIR_M	BOOL	FALSE	1 = Minus direction

Address	Name	Type	Initial value	Comment
15.3	DIR_P	BOOL	FALSE	1 = Plus direction
15.7	DRV_EN	BOOL	FALSE	1 = Switch on drive enable
16.0	MODE_IN	BYTE	B#16#0	4/5 = Relative/absolute incremental approach
17.0	MODE_TYPE	BYTE	B#16#0	Increment number 1 - 100 or 254 or 255
34.0	PLOOP_ON	BOOL	FALSE	1 = Loop approach in plus direction
34.1	MLOOP_ON	BOOL	FALSE	1 = Loop approach in minus direction
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input

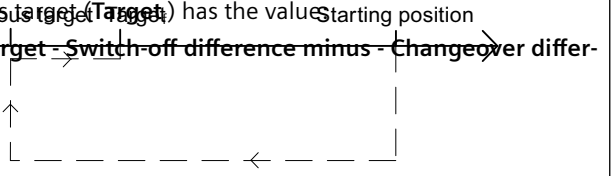
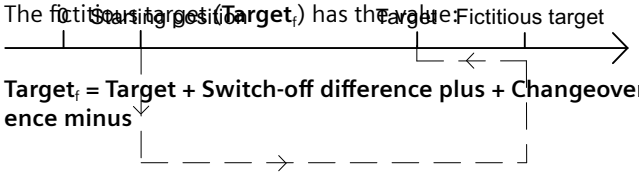
Fictitious target

If you start a positioning to a target that is located in the direction opposite that of the assigned loop approach, the FM 451 determines a fictitious target for this target. The FM 451 performs a direction reversal at the fictitious target and then approaches the target in the proper direction.

This fictitious target must be at a distance in front of the respective software limit switch of at least one-half the target range.

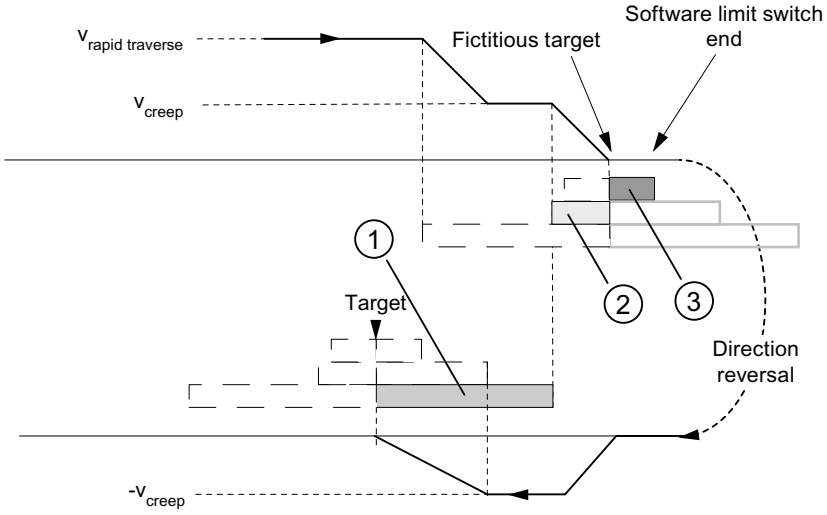
The distance of the fictitious target from the assigned target is direction dependent.

Table 9-7 Calculation of the location of the fictitious target for loop approach

Specifications	Position of the fictitious target
Parameter assignment: Loop + (frictional connection plus) and travel in minus direction.	The fictitious target (**Target**$_f$) has the value: **Target$_f$ = Target - Switch-off difference minus - Changeover difference plus** 
Parameter assignment: Loop - (frictional connection minus) and travel in plus direction.	The fictitious target (**Target**$_f$) has the value: **Target$_f$ = Target + Switch-off difference plus + Changeover difference minus** 

Example

Based on a positioning with loop approach to a maximum target in the plus direction, you see the position of the fictitious target.



① Negative changeover difference
② Positive switch-off difference
③ 1/2 target range

Figure 9-9 Loop approach to a maximum target in plus direction

9.10 Enable input

Definition

The enable input is an external input that can be used to execute a positioning due to an external event.

Evaluate enable input (EI_OFF=0)

The relevant enable input (xI2) must be wired for the channel.

You have the option to prepare for the start of a positioning. You start the positioning independent of the program sequence of your user program by applying a "1" signal at the enable input.

You have the following options for evaluating the enable inputs:

- **Level-controlled (EI_TYPE=0)**
  - Traversing begins when you apply a "1" signal at the enable input and is ended when you apply a "0" signal at the enable input.
- **Edge-controlled (EI_TYPE=1)**
  - Traversing begins with detection of a rising edge at the enable input. The additional signal characteristic at this input no longer affects the course of the motion that was started.

Do not evaluate enable input (EI_OFF=1)

If you disable the evaluation of the enable input, an operating mode starts immediately after the start signal is detected. In this case, you cannot prepare an operating mode and start it at a future specified time.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input

Data used in the parameter DB

Address	Name	Type	Initial value	Comment
99.1	EI_TYPE	BOOL	FALSE	0 = Level-controlled 1 = Edge-controlled

9.11 Read position data

Definition

With the "read position data" job you can read the increment, distance-to-go and speed at the current time.

Job sequence

1. Set the trigger bit in the channel DB (ACTSPD_EN=1).
2. The data is then stored in the channel DB.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
37.1	ACTSPD_EN	BOOL	FALSE	1 = read position data
112.0	ACTSPD	DINT	L#0	Current speed
116.0	DIST_TO_GO	DINT	L#0	Distance-to-go
120.0	ACT_TRG	DINT	L#0	Current increment

9.12 Read encoder data

Definition

With the "read encoder data" job you can read the current data of the encoder as well as the value for the absolute encoder adjustment.

Prerequisites

You can read the value for the absolute adjustment after you have carried out the "set reference point" job (refer to the section entitled "Determining the absolute encoder adjustment (Page 77)").

Job sequence

1. Set the trigger bit in the channel DB (ENCVAL_EN=1).
2. The data is then stored in the channel DB.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
37.2	ENCVAL_EN	BOOL	FALSE	1 = read encoder values
124.0	ENCVAL	DINT	L#0	Actual encoder value (internal representation)
128.0	ZEROVAL	DINT	L#0	Last zero mark value (internal representation)
132.0	ENC_ADJ	DINT	L#0	Absolute encoder adjustment

9.13 Checkback signals for the positioning

Definition

The checkback signals for the positioning inform you about the current status of the positioning.

Sequence

The data will be saved to the channel DB at each call of FC ABS_CTRL.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
23.0	ST_ENBLD	BOOL	FALSE	1 = Start enabled
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
23.2	WAIT_EI	BOOL	FALSE	1 = Axis waiting for external enable
23.4	SPEED_OUT	BOOL	FALSE	0 = Creep speed 1 = Rapid traverse
23.5	ZSPEED	BOOL	FALSE	1 = Axis is located in the standstill range
23.6	CUTOFF	BOOL	FALSE	1 = Axis is located in the switch-off range
23.7	CHGOVER	BOOL	FALSE	1 = Axis is located in the changeover range
24.0	MODE_OUT	BYTE	B#16#0	Active operating mode
25.2	GO_M	BOOL	FALSE	1 = Axis moves in minus direction
25.3	GO_P	BOOL	FALSE	1 = Axis moves in plus direction
25.5	FVAL_DONE	BOOL	FALSE	1 = Set actual value on-the-fly completed
25.7	POS_RCD	BOOL	FALSE	1 = Position reached
26.0	ACT_POS	DINT	L#0	Current actual value (current position of axis)

9.14 Checkback signal for the diagnostics

Definition

The "checkback signal for the diagnostics" informs you of occurring diagnostic events.

Sequence

1. If the module enters a new event in the diagnostic buffer, it sets the DIAG bit in all the channels in the checkback interface. Every time an error occurs, all of the error classes listed in the appendix "AUTOHOTSPOT" create an entry in the diagnostic buffer. The DIAG bit is also set when the diagnostic buffer is deleted.
2. If it is not possible to call an operating mode or control an active operating mode, or if this was carried out incorrectly, the module sets an operator error (OT_ERR) in the checkback interface. The cause of error is then entered in the diagnostic buffer. While the operating error exists, you can neither start a new operating mode nor continue with the halted one. You acknowledge an existing operating error with OT_ERR_A=1.
3. If the module detects a write job with faulty data, it sets the DATA_ERR bit. The cause of error is then entered in the diagnostic buffer.
4. The checkback signals are stored in the channel DB.
5. When the diagnostic buffer is read, the module sets the DIAG bit back to 0 in all channels.

Data used in the channel DB

Address	Name	Type	Initial value	Comment
22.2	DIAG	BOOL	FALSE	1 = Diagnostic buffer changed
22.3	OT_ERR	BOOL	FALSE	1 = Operator error
22.4	DATA_ERR	BOOL	FALSE	1 = Data error

Encoder

10

10.1 Incremental encoder

Connectable incremental encoders

Only incremental encoders with two pulses electrically offset at 90° with or without zero marks are supported:

- Encoders with asymmetrical output signals with 24 V level
  - Limit frequency = 50 kHz
  - cable up to 100 m long
- Encoders with symmetrical output signals with 5 V differential interface in accordance with RS 422
  - Limit frequency = 500 kHz
  - with 5 V voltage supply: cable up to 32 m long
  - with 24 V voltage supply: cable up to 100 m long

Note

If the 5 V encoder does not output a zero mark signal and wire-break monitoring is enabled, you must interconnect the zero mark signal inputs N and /N externally so that the inputs will exhibit different signal levels (for example, N to 5V, /N to ground).

Signal forms

The following figure illustrates the signal forms of encoders with asymmetrical and symmetrical output signals.

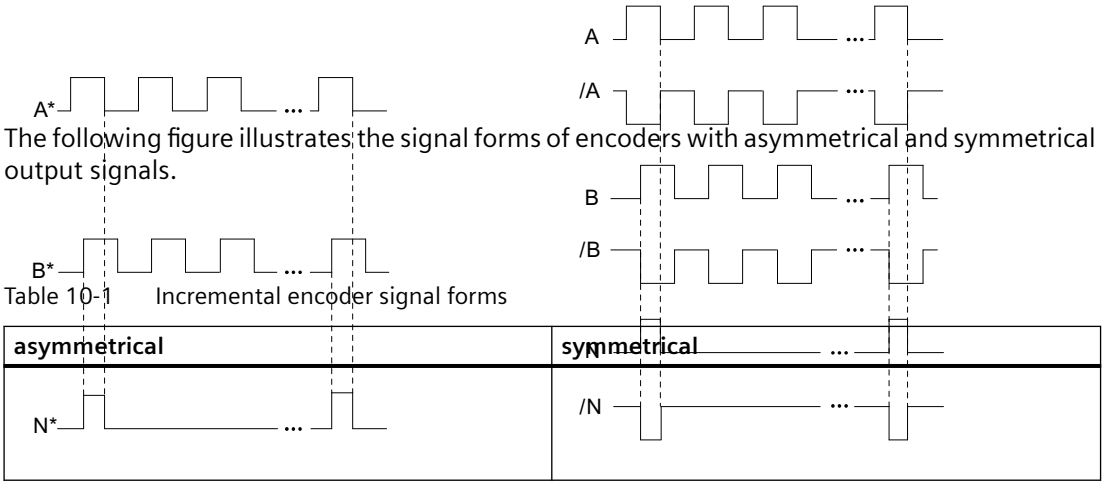


Table 10-1 Incremental encoder signal forms

Signal evaluation

increments

An increment identifies a signal period of the two signals (A and B) of an encoder. This value is specified in the technical specifications of an encoder and / or on its ID plate.

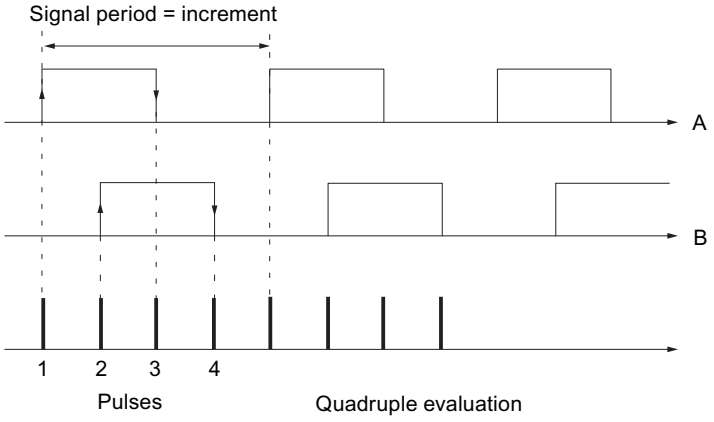


Figure 10-1 Increments and pulses

Pulses

The positioning module evaluates all 4 edges of signals A and B in every increment (quadruple evaluation).

Pulses
1 increment (encoder specification) = 4 pulses (FM evaluation)

Response times

The positioning module has the following response times for connected incremental encoders:

Response times
Response time = switching cycle of the connected switching elements

Note

You can compensate for the minimum response time by assigning the changeover difference and switch-off difference accordingly.

Indecision

The indecision influences the precision of the positioning. In the case of incremental encoders the indecision is negligible.

10.2 Absolute encoders

Single-turn and multiturn encoders

Absolute encoders are divided into the categories:

- Single-turn encoder
  The total range of single-turn encoders is scaled to one revolution.
- Multiturn encoder
  The total range of multiturn encoders is scaled to several revolutions.

Connectable absolute encoders

Absolute encoders with serial interface are supported. Position data are transferred synchronously using the SSI protocol (**S**ynchronous**S**erial**I**nterface). FM 451 only supports GRAY code. The arrangement of the data bits in the message frames produce the data formats 25-bit (fir tree) and 13-bit (half fir tree).

Encoder type	Message frame length
Single-turn encoder	13 bit
Single-turn encoder	25 bit
Multiturn encoder	25 bit

Data transmission

The data rate for data transmission depends on the cable length (see appendix "AUTOHOTSPOT").

Pulse evaluation of absolute encoder

Pulse evaluation of absolute encoder
1 increment (encoder default) = 1 pulse (FM evaluation)

Response times

With absolute encoders, the FM 451 has the following response times:

Response times
Minimum response time = message frame runtime + switching time of the connected switching elements
Maximum response time = 2 x message frame runtime + monoflop time + switching time of the connected switching elements
With programmable absolute encoders: Maximum response time = message frame runtime + monoflop time + switching time of the connected switching elements +1/ max. step sequence rate

Monoflop time

The monoflop time is 64 µs.

Encoders with values outside the limits indicated here are not permitted.

Message frame runtimes

The message frame runtimes depend on the baud rate:

Baud rate	Message frame runtime for 13 bits	Message frame runtime for 25 bits
0.125 MHz	112 µs	208 µs
0.250 MHz	56 µs	104 µs
0.500 MHz	28 µs	52 µs
1.000 MHz	14 µs	26 µs

Example of response times

The following example shows how to calculate the minimum and maximum response times. In the example a programmable encoder is not used.

- Switching time of the hardware: Approx. 150 µs
- Message frame runtime: 26 µs at a baud rate of 1 MHz (25-bit message frame)
- Monoflop time: 64 µs

Minimum response time = 26 µs + 150 µs = 176 µs

Maximum response time = 2 x 26 µs + 64 µs + 150 µs = 266 µs

Note

You can compensate for the minimum response time by assigning the changeover and switch-off differences accordingly.

Indecision

The indecision is the difference between the minimum and maximum response times. With an absolute encoder it is as follows:

Indecision
Indecision = Message frame runtime + monoflop time
With programmable absolute encoders: Indecision = Message frame runtime + monoflop time+ 1/max. step sequence frequency

Diagnostics 11

11.1 Possibilities of error display and error evaluation

Information regarding errors

You receive information regarding errors in the following ways:

- Observe the error LEDs on the module.
  You can look up the meaning of the error LEDs in the section entitled "Significance of the error LED (Page 133)".
- Connect your PG with the CPU and open the error evaluation screen of the configuration software. The current (error) status of the module is shown with the error class, error number, and in plain text. If necessary, update the display by pressing the "update" button. Causes and remedies for the displayed error messages can be found in the error list, in the appendix under "Error classes (Page 189)".
- Provide your user program with a detailed error evaluation (refer to the section entitled "Error display with OP (Page 134)") or a response to a diagnostic alarm (refer to the sections entitled "Error display with OP (Page 134)" and "Diagnostic interrupts (Page 140)").
- For a display in an OP: Read out the diagnostic buffer of the module cyclically in your user program. Evaluate the diagnostic DB in the OP. The meaning of error class and error number can be found in the error list, in the appendix under "Error classes (Page 189)".

Delete diagnostic buffer

In order for you to chronologically organize error messages better, the positioning module offers the possibility of completely deleting the diagnostic buffer. But this is then only possible when the positioning has already ended and the channel has been assigned.

11.2 Types of error

11.2.1 Synchronous errors

Description

These errors occur synchronously to a job or to the start of a positioning. Synchronous errors are operator errors (error class 2), data errors (error class 4), machine data errors (error class 5), increment table errors (error class 6) (refer to the appendix for a description of error classes).

11.2.2 Asynchronous errors

Description

These errors occur during operation on account of external events. They trigger a diagnostic interrupt. Asynchronous errors are operating errors (error class 1) and diagnostic errors (error class 128) (refer to the appendix for a description of error classes).

11.3 Significance of the error LED

Error LED

The status and error display indicate various error states. The LEDs are lit, even with errors that occur briefly, for at least 3 seconds.

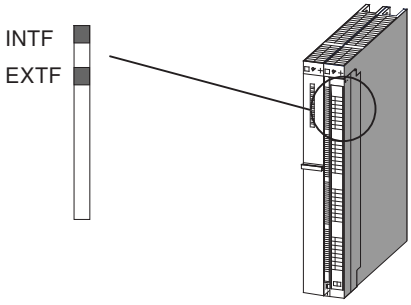


Figure 11-1 Status and error displays of FM 451

Display	Meaning	Notes
INTF (red) LED - ON	Group error for internal error	This LED indicates the following error state of the FM 451: • Module defect • Internal (channel) error • The FM 451 is not configured. Configure the module.
EXTF (red) LED - ON	Group error for external error	This LED indicates an external (channel) error.

11.4 Error display with OP

Program structure

The following figure shows the "General program structure" presented in chapter "FC ABS_CTRL (FC 1) (Page 39)", expanded to include the readout of the diagnostic buffer for display on an OP. The FC ABS_DIAG stores the diagnostic buffer in a DB that can be displayed by the OP.

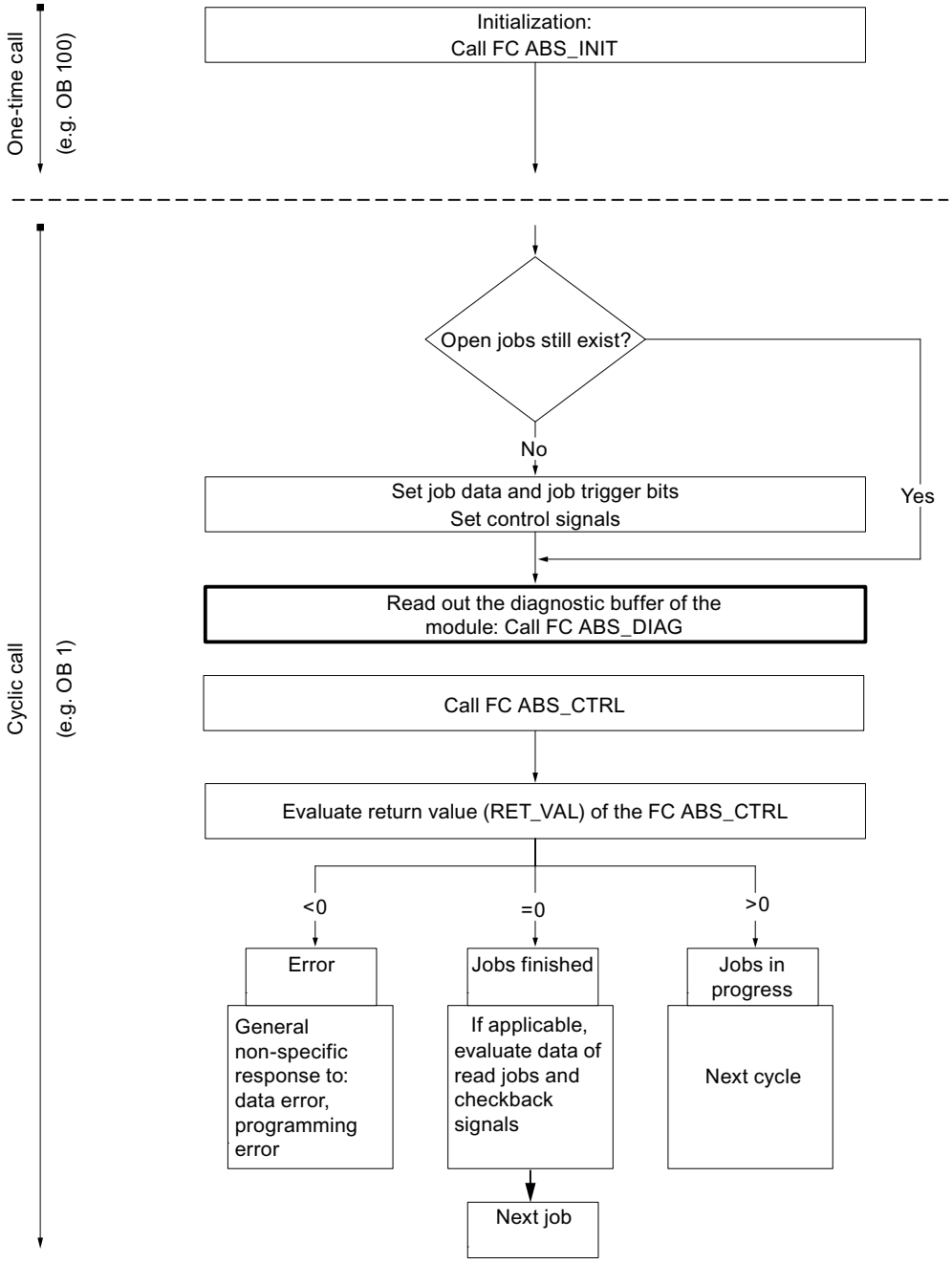


Figure 11-2 Program structure with diagnostic display for the OP

11.5 Error evaluation in the user program

Error response in the user program

In the user program you can respond selectively to errors. The following methods can be used:

- The return value (RET_VAL) of the integrated standard FCs:
  this value is redetermined each time the function is called.
  RET_VAL = -1 is a group display for a synchronous error in a job or when communicating with the module.
- An error bit (_ERR) belongs to each job. This is a group display for an error in the job or one of its predecessors in a job chain:
  the error bit is set for a write job and its subsequent jobs when a data error is reported by the module or a communication error occurs.
  With reading jobs the error bit is set for the job in question when a communication error occurs.
  The FC ABS_CTRL resets the error bits after a job has been processed. These should however be cancelled by the user program in the case of an error assessment.
- The checkback signal DATA_ERR as a group display for an error that the module has detected during a write job. The signal will be established again with the next write job.
- The checkback signal OT_ERR (operator error) as a group display for an error that the module has detected when starting a traverse. The error must be acknowledged with OT_ERR_A=1 after the cause has been remedied.
- The checkback signal DIAG is set when the contents of the diagnostic buffer have changed. This signal can come along later than the signals DATA_ERR and OT_ERR.
- The communication error JOB_ERR includes the error code in the case of a communication problem between the FC and the module (refer to list of JOB_ERR messages in the appendix "List of JOB_ERR messages (Page 188)"). The value is redetermined after a job has been processed and is stored in the channel DB for the FC ABS_CTRL and in the diagnostic DB for the FC ABS_DIAG.
- The FC ABS_DIAG for reading out the diagnostic buffer of the module. Here you can discover the error causes for synchronous and asynchronous events.
- Diagnostic interrupts for the fast response to events in the diagnostic interrupt OB (OB 82).

In the following figure you will find a possible program structure with which you can respond to the checkback signals "data error" (DATA_ERR), "operating error" (OT_ERR) and the error bits of the job (_ERR).

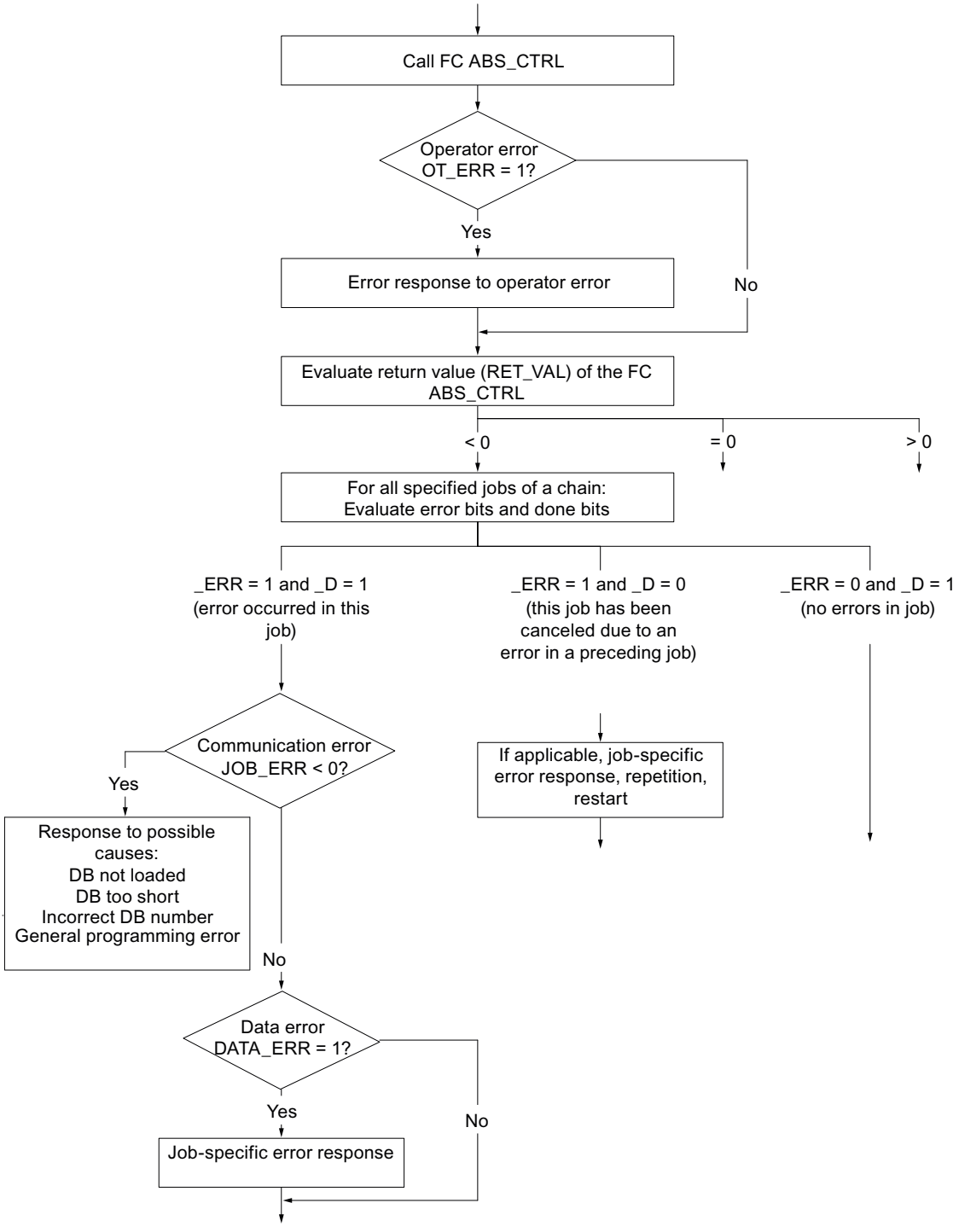


Figure 11-3 User program with evaluation of the error bits in the jobs

The following image offers a possible program structure using which you can evaluate all the errors via the entries in the diagnostic DB. In this way you can respond to the program if one or more errors are reentered in the diagnostic buffer of the module. Some possible program responses are listed in the following detailed figures.

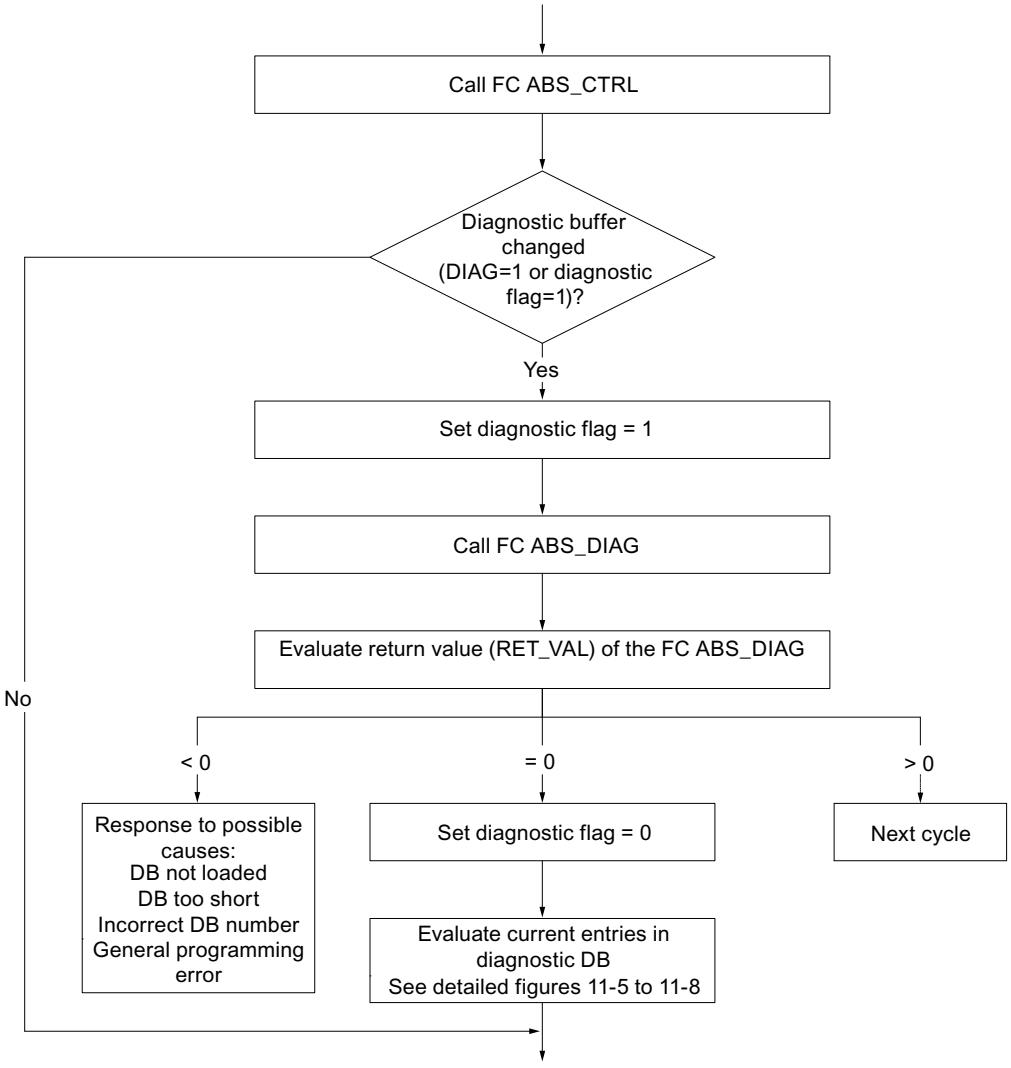


Figure 11-4 User program with complete error evaluation via the diagnostic DB

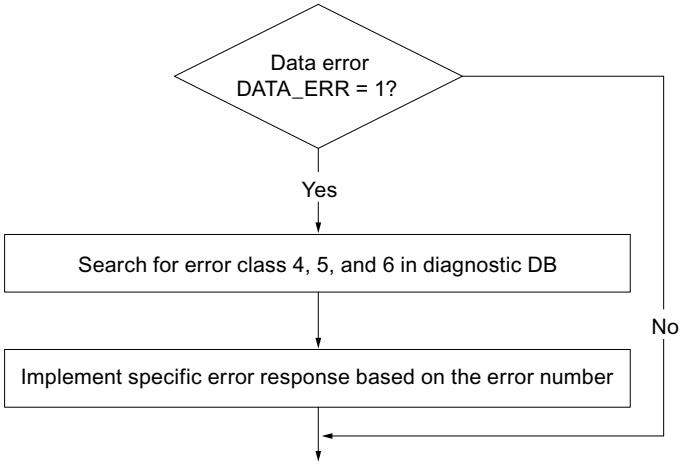


Figure 11-5 Possible evaluation of a data error

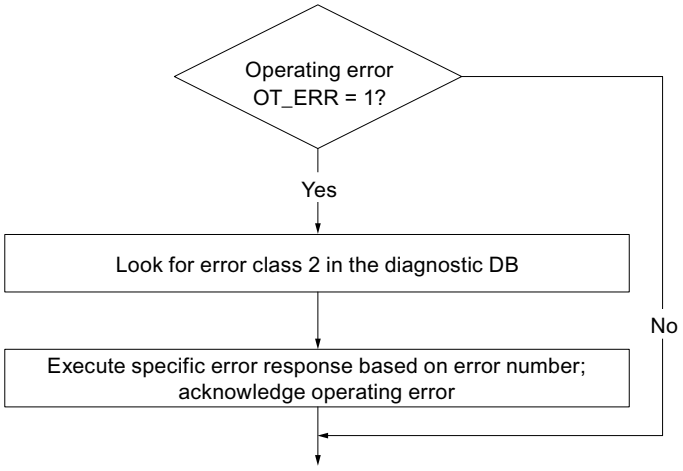


Figure 11-6 Possible evaluation of an operating error

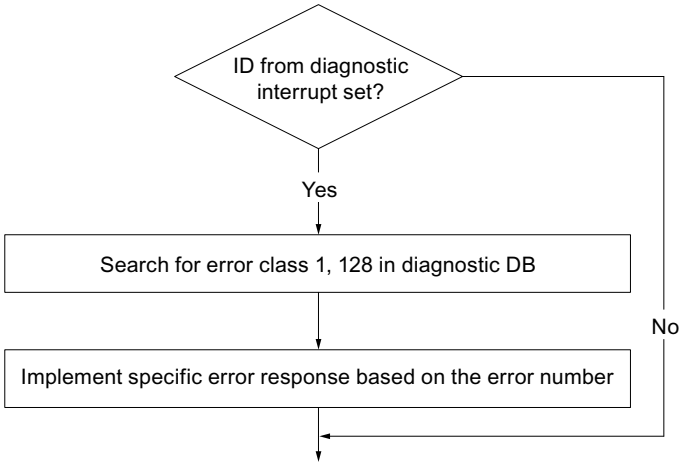


Figure 11-7 Possible evaluation of a diagnostic interrupt

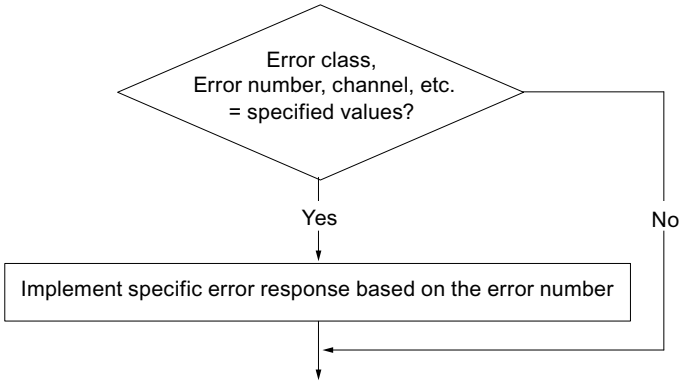


Figure 11-8 Possible evaluation of a specifically stipulated error

11.6 Diagnostics buffer of the module

Diagnostic events

The module´s diagnostic buffer includes maximum 9 diagnostic events and is organized as a ring buffer.

A diagnostic event is written in the buffer if an "incoming" (error) message is detected. This can be a message, a synchronous error (data error, operator error) or even an asynchronous error (operational error and diagnostics error). From a cause of error several entries can occur as follow-up errors. Outgoing messages do not create any entries in the diagnostic buffer.

For each diagnostic event the following is given:

- Status (always incoming)
- Internal error
- External error
- Error class
- Error number
- Channel number
- Increment number (in the case of increment table errors)

When a diagnostic event is written in the diagnostic buffer, the checkback signal DIAG=1 is set in all assigned channels.

With the FC ABS_DIAG, the diagnostic buffer can be transferred as a whole into a data block (diagnostic DB) or displayed via the error evaluation screen of the configuration software. If the diagnostic buffer is read, the module sets the checkback signal DIAG=0.

Note

If the diagnostic buffer is read simultaneously from the FC ABS_DIAG and the error evaluation screen, it is possible that a new diagnostic event is not detected by the program.

11.7 Diagnostic interrupts

Interrupt processing

The FM 451 can trigger diagnostic interrupts. You process these interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU goes to STOP mode (refer to the *Programming with STEP 7* Manual).

You enable the processing of diagnostic interrupts as follows:

1. Select the module in HW Config
2. Select **Edit > Object Properties > Basic Parameters** and enable the diagnostic interrupt.
3. Save and compile the hardware configuration.
4. Download the hardware configuration to the CPU.

Overview of the diagnostic interrupts

Events and errors triggering a diagnostic interrupt:

- Operating error
- Incorrect machine data (when parameters assigned with SDB)
- Diagnostic errors

For the meaning of error classes and error numbers, refer to the error list in the appendix "Error classes (Page 189)".

Reaction of FM 451 to an error with diagnostic interrupt

- The positioning is canceled.
- The synchronization is canceled when the following diagnostic interrupts occur:
  - Front connector missing, external auxiliary voltage for encoder supply missing
  - Zero mark error detected, cable fault (5 V encoder signals)
  - Traversing range exited (indicated by an operating error)
  - Set actual value cannot be executed (indicated by an operating error).
- With one exception, control signals START, DIR_P, and DIR_M are no longer processed
  Exception:
  When an operating error occurs, jogging in the direction of the operating range is still possible.
- Function switches and jobs continue to be processed.

FM 451 detects an error ("incoming")

A diagnostic interrupt is an "incoming" event if at least one error is pending. If all errors were not eliminated, the remaining pending errors are reported again as "incoming" events.

Sequence:

1. The FM 451 detects one or more errors and generates a diagnostic interrupt. Either the "INTF" or "EXTF" LED illuminates. The error is entered in the diagnostic buffer.
2. The operating system of the CPU calls OB 82.
3. You can now evaluate the start information of OB 82.
4. The OB82_MOD_ADDR parameter indicates which module triggered the interrupt.
5. For further information, call FC ABS_DIAG.

FM 451 detects the transition to the error-free state ("outgoing")

A diagnostic interrupt is an "outgoing" event only if the last error on the module has been eliminated.

Sequence:

1. The FM 451 detects that all errors have been eliminated and triggers a diagnostic interrupt. The "INTF" or "EXTF" LED is no longer lit. The diagnostic buffer is not changed.
2. The operating system of the CPU calls OB 82.
3. The OB82_MOD_ADDR parameter indicates which module triggered the interrupt.
4. Evaluate the OB82_MDL_DEFECT bit.
   When this bit is "0", no errors are present on the module. You can close the evaluation session at this point.

Diagnostic interrupt as a function of the CPU status

- Diagnostic interrupts are blocked by the FM 451 when the CPU is in STOP mode.
- If not all of the pending errors are eliminated while the CPU is in STOP mode, the FM 451 reports the remaining errors as "incoming" events again at the next CPU transition to RUN.
- If all pending errors are eliminated while the CPU is in STOP mode, the FM 451 does **not** report its error-free state with a diagnostic interrupt at the next CPU transition to RUN.

Evaluation of a diagnostic interrupt in the user program

The FM 451 sets the following entries in the local data of the diagnostic interrupt OB (OB 82). The errors are also entered in the diagnostic buffer (error class 128, for meaning and possible remedies, see appendix "Error classes (Page 189)"):

Address	Name	Type	Comment
0.0	OB82_EV_CLASS	BYTE	Event class and identifiers: B#16#38: Outgoing event B#16#39: Incoming event
1.0	OB82_FLT_ID	BYTE	Error code (B#16#42)
2.0	OB82_PRIORITY	BYTE	Priority class: B#16#1A in RUN mode B#16#1C in START mode

Address	Name	Type	Comment
3.0	OB82_OB_NUMBR	BYTE	OB number (82)
4.0	OB82_RESERVED_1	BYTE	Reserved
5.0	OB82_IO_FLAG	BYTE	Input module: B#16#54
6.0	OB82_MDL_ADDR	INT	Logical base address of the module where the error occurred
8.0	OB82_MDL_DEFECT	BOOL	Module fault
8.1	OB82_INT_FAULT	BOOL	Internal error
8.2	OB82_EXT_FAULT	BOOL	External error
8.3	OB82_PNT_INFO	BOOL	Channel error present
8.4	OB82_EXT_VOLTAGE	BOOL	External auxiliary voltage missing
8.5	OB82_FLD_CONNCTR	BOOL	Front connector missing
...	Not used		
10.3	OB82_WTCH_DOG_FLT	BOOL	Watchdog timer responded
...	Not used		
12.0	OB82_DATE_TIME	DATE_AND_TIME	Date and time when the OB was called

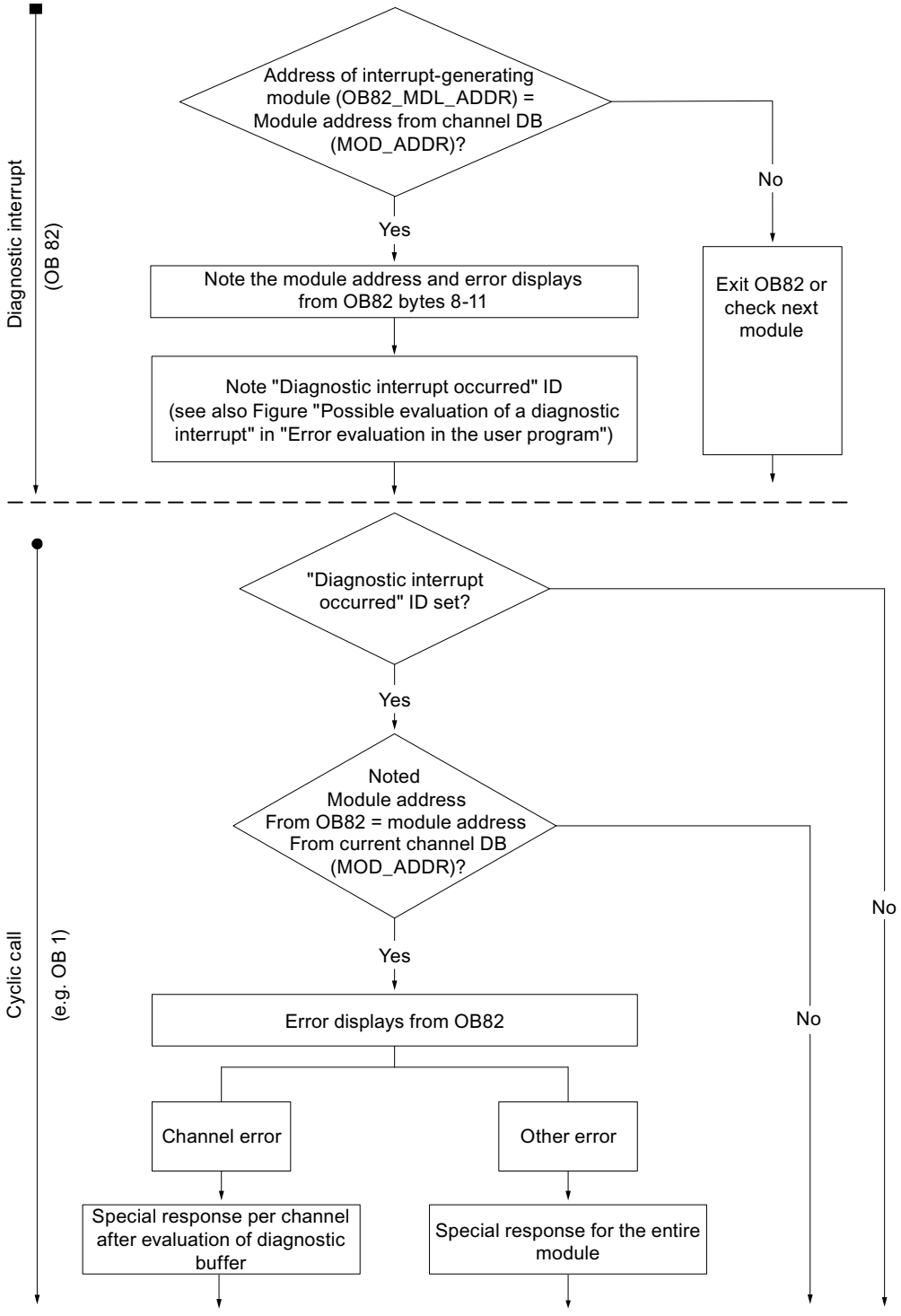


Figure 11-9 Possible evaluation of a diagnostic interrupt

Examples

12

12.1 Introduction

Example project

The FM 451 configuration package you installed contains example projects showing you several typical applications based on a number of selected functions.

The English example project is located in the following folder:

...\STEP7\EXAMPLES\zDt18_01 folder

It contains several S7 programs of various complexities and objectives.

12.2 Prerequisites

Conditions for executing the examples

The following requirements must be met:

- You have installed and completely wired an S7 station, consisting of a power supply module, a CPU, and an FM 451 module, version V2 or higher. The behavior of older versions may deviate from that described here.
- STEP 7 as well as the configuration package for the FM 451 are correctly installed on your PC or programming device. The description of handling is based on STEP 7 V5.0. Deviations may occur in the case of other versions.
- The programming device is connected to the CPU.

You can operate an FM 351 or an FM 451 with the examples.

12.3 Prepare examples

Procedure

In order to work through the examples online, you must prepare as follows:

1. Use SIMATIC Manager to open the example project **zEn18_01_FMx51___Prog** in the **\STEP7\EXAMPLES** folder (use the detailed representation to display the symbolic name) and copy it under a suitable name in your project directory (**File > Save as**).
2. Insert in your project a station that complies with your hardware set-up.
3. Configure all of the hardware with HW Config and save the configuration.
4. Select an example program and copy the program to the offline CPU.
5. Assign parameters for the FM 451 based on the "Getting Started". Use **File > Export** to export the parameters that are adapted to your system to the parameter DBs of all the examples, except for the "Getting Started" example.
6. Enter the module address in the associated channel DB and, if necessary, also in the corresponding diagnostic DB in the "MOD_ADDR" parameter (refer to the section entitled Basics of programming a positioning module (Page 35)).
7. Download the hardware configuration to your CPU.
8. Download the blocks to your CPU.
9. If you would like to try the next example, go to step 4.

12.4 Example codes

Examples in STL

The examples are written in STL. You can view them directly via the LAD/FBD/STL editor.

Select the view with "symbolic display", "icon selection" and "comment". If you have sufficient space on the screen, you can also view the "icon information".

12.5 Testing an example

Test sequence

Once you have made all the entries necessary for the respective example, download the entire block container to the CPU.

The example programs include variable tables (VATs) you can use to view and change data blocks online, i.e. in CPU RUN mode. Select the views "icon" and "icon comment" from the variable table. Open a variable table, connect it with the configured CPU and cyclically monitor the variables. This way the displayed variables are constantly updated. By transmitting the control values you can change the values in the online data blocks.

All examples assume that you have entered and saved the machine data with the parameter assignment screens. This allows you to work through the examples sequentially.

12.6 Continuing to use an example

Procedure

You can continue using the code of examples directly as a user program.

The code of examples is not optimized and also is not designed for all eventualities. Error evaluations have not been extensively programmed in the example programs so as not to make the programs too comprehensive.

The "AllFunctions" example program can be used as a copy template in which, by means of modifying, you can compile the functions that can then be used as a basic template for your user program.

The examples are prepared for channel 1 ("severalchannels" for channel 1 and 2). Use the LAD/FBD/STL editor to change the channel number.

12.7 Example program 1 "FirstSteps"

Objective

With this example you can commission your positioning module whose parameters you have assigned with the aid of "Getting Started".

This example expands the program in the "Linking to the User Program" chapter of the "Getting Started" by an error evaluation.

Requirements

You have assigned the positioning module parameters as described in "Getting Started".

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

Startup

In the start-up OB (OB 100) you call the FC ABS_INIT, which resets all the control and checkback signals as well as the job management in the channel DB.

Cyclic operation

Open the variable table (VAT_CTRL_1), create the connection to the configured CPU and then monitor the variables. Transfer the prepared control values. Activate the "CHAN_1".DRV_EN: the drive is now enabled ("CHAN_1".ST_ENBLD=1). If the drive is not enabled, please check your enable inputs.

⚠ CAUTION

Start the drive by means of the two next steps.

You can stop the drive again by using one of the following measures:

- Reset the control value for the direction to 0 and activate
- Reset the control value for the drive enable to 0 and activate
- Bring the CPU to STOP

Set DIR_P=1 to be able to move in the plus direction with the selected "Jog" mode. If you set DIR_P=0, the drive is shut down properly.

Error evaluation

Create a data error by setting in the VAT_CTRL_1 the reference point coordinate "CHAN_1".REFPF outside of the operating range or the end of rotary axis. Then activate the job "set reference point" with "CHAN_1".REFPT_EN=1. The CPU goes to STOP. In an example, this is the simplest method of indicating an error. You can of course program a different error evaluation.

Open HW Config and double-click the FM 451. This opens the configuration software. Display the cause of error via the **Debug > Error evaluation** screen.

The status values in the VAT_CTRL_1 still show the status before the STOP of the CPU. Update the status values in order to view the done bits and error bits of the jobs.

Proceed as follows to remedy the error:

1. Enter a permissible value in the control value.
2. Switch the CPU to STOP.
3. Switch the CPU to RUN mode.
4. Enable the control values. If you have already enabled the control values before the CPU is restarted, the initialization will reset them again in the OB 100 and they will therefore be ineffective.

12.8 Example program 2 "Commissioning"

Aim

In this example you commission the positioning module without using the parameter assignment screens. You control and monitor by means of variable tables (VAT).

Requirements

You have assigned the positioning module parameters as described in "Getting Started".

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

In the diagnostic DB, the address of your module is entered correctly in the MOD_ADDR parameter.

The supplied channel DB already includes the DB number 30 of the parameter DB for the machine data in the PARADBNO parameter.

The machine data of your system are stored in the PARADB_1 data block.

Start-up

In the start-up OB (OB 100) call the FC ABS_INIT in order to initialize the channel DB. Then set the trigger bits for all jobs that you require after start-up of the module.

Cyclic operation

Open the variable table (VAT_CTRL_1), create the connection to the configured CPU and then monitor the variables.

Transfer the prepared control values. "Jog" mode is set and the necessary enables are set. The drive turns by means of DIR_P=1. The actual value must change. In order to stop the drive, set STOP to "1" and transfer the control values.

Activate and transfer the control value "CHAN_1".REFPT_EN (set reference point). The checkback signal "CHAN_1".SYNC =1 means: the channel is synchronized.

In VAT_DIAG you can see the most important entries of the diagnostic buffer of the module. The meaning of the error classes and error numbers can be found in the manual in the appendix section entitled "Error classes (Page 189)".

Error evaluation

Try to create more errors:

- Specify a reference point coordinate that is greater than the operating range or the end of rotary axis.
- Switch off the external auxiliary voltage.
- Delete the PARADB_1 on the online CPU and try to write the machine data. In the example, the error evaluation is programmed in such a way that the CPU goes to STOP. When you update VAT_CTRL_1 again, the error code for this error is displayed in the "CHAN_1".JOB_ERR. The meaning of the error codes can be found in the manual in the appendix section entitled "List of JOB_ERR messages (Page 188)".

12.9 Example program 3 "AllFunctions"

Objective

This example uses all the functions of the FM 351 / 451:

- Operating modes
- Function switch
- Write jobs
- Read jobs

You can use the example programs as copy templates. By means of modification, compile the functions that will form the basic template for your user program. The data that you must adapt to your application are identified with ***. Some functions are only available with the FM 451.

Responses to external events and the error evaluation are system-specific and are therefore not included in this example.

Requirements

You have assigned the positioning module parameters as described in "Getting Started".

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

The supplied channel DB already includes the DB number 30 of the parameter DB for the machine data in the PARADBNO parameter.

The machine data of your system are stored in the PARADB_1 data block.

Startup

In the startup OB (OB 100) call the FC ABS_INIT in order to initialize the channel DB. Then set the trigger bits for all jobs that you require after startup of the module.

Operation

The CPU is in STOP. Open the variable table USER_VAT and enter the necessary job number in the control values for your user program. The job numbers are explained in the code of the example.

In doing so, the correct combination of user data "USER_DB".CTRL_SIG, "USER_DB".FUNC_SW, "USER_DB".WR_JOBS, "USER_DB".RD_JOBS and "USER_DB".RETVAL_CTRL is necessary.

For more information, refer to the section entitled "Operating modes and jobs (Page 87)".

Create the connection to the configured CPU and transfer and activate the control values.

Start the CPU (STOP > RUN). Monitor the checkback signals and actual values.

You can repeat the processing of the step chain by means of a new STOP RUN transition of the CPU. Obviously, this action is not suitable for continuous operation. In the example we use this action so that the module is always reinitialized.

12.10 Example program 4 "OneChannel"

Objective

In this example you control a drive by means of the user program. The user program commissions the module after a CPU restart. Next, it executes a step sequence that is triggered by certain events.

Using the variable tables, you define events, monitor the reactions of the module, and evaluate the diagnostic buffer.

In this slightly more complex example, you can get to know the following block possibilities:

- Issuing several jobs simultaneously
- Mixing write and read jobs
- Reading with a continuous job, without waiting for the end of the job
- Evaluation of the checkback signals of the block
- Evaluation of the checkback signals for an individual job
- Resetting of done bits and error bits for individual jobs or all jobs
- Central call of ABS_CTRL at the end of the user program

Requirements

You have assigned the positioning module parameters as described in "Getting Started".

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

The supplied channel DB already includes the DB number 30 of the parameter DB for the machine data in the PARADBNO parameter.

The machine data of your system are stored in the PARADB_1 data block.

Startup

In the start-up OB (OB 100) you set the start-up identifier (step 0) for the user program in the associated instance DB (USER_DB).

Operation

The CPU is in STOP. Open the variable table USER_VAT, adapt the increment ("USER_DB".TRG_INC_1, "USER_DB".TRG_INC_2), the changeover difference ("USER_DB".CHGDIF) and the switch-off difference ("USER_DB".CUTDIF) to your system and transfer the control values.

Start the CPU (STOP > RUN). Observe the step number of the step chain ("USER_DB".STEPNO), the checkback signals and the actual values. After the initialization a "relative incremental approach" is carried out. The drive travels in a negative direction to its first position ("USER_DB".TRG_INC_1).

Then the program waits in step 6 for an external trigger ("USER_DB".START_INC_2), in order to commence the next incremental approach in direction plus. When the position is reached, the step chain is at its end value (-2). The incremental approach with increment number 255 allows the transfer of the changeover difference and switch-off difference. With that you can test the conduct of your target approach.

You can repeat the processing of the step chain by means of a new start (STOP > RUN) of the CPU. Obviously, this procedure is not suitable for continuous operation. In the example we use this to achieve that the module is always reinitialized.

Error evaluation

In the case of an error in the processing, the step chain is brought to a halt. Step number -1 will be entered.

Try to create errors that will be stored by the central error evaluation as group errors in the "USER_DB".ERR bit.

- In the USER_VAT, enable the prepared control value for the increment number 1 ("USER_DB".TRG_INC_1), which is greater than the software limit switch.
  The step chain is brought to a stop and -1 is shown as the step number. Check the errors by means of the error evaluation screen.
- In the USER_VAT enable further control values one after the other for the increment number 1 ("USER_DB".TRG_INC_1), increment number 255 ("USER_DB".TRG_INC_2), and the changeover difference ("USER_DB".CHGDIF) and switch-off difference ("USER_DB".CUTDIF). For the error inspection proceed as you would with increment 1.

User program FB 1 (USER_PROG)

The user program uses the data in the module-specific data blocks (USER_DB) in the form <block name>.<symbolic identifier>. This way, the user program can operate a channel precisely.

In this program mode you can access the data in the data block by means of the symbolic identifiers. The indirect addressing for several channels can be found in the example program 6 "SeveralChannels".

The user program executes a step sequence as follows:

Step 0: The positioning module is initialized. Associated data is set to the jobs that are to be executed when the module is restarted.

Step 1: The program waits for the jobs set in Step 0 to be executed.

Step 2: The assigned value of the increment "USER_DB".TRG_INC_1 is entered in the increment table. Then the increment table is written in the module. The control signals for the first incremental approach will be issued simultaneously. The FC ABS_CTRL ensures the correct sequence of execution from step 2.

Step 3: The program waits for the set write job to be executed.

Step 4: The program waits for the checkback signal "PR" and the updated position values from the first incremental approach.

Step 5: The assigned values for the second incremental approach, changeover difference, and switch-off difference are entered in the channel DB. Then, with "USER_DB".START_INC_2 the second incremental approach is started with increment number 255.

Step 6: The program waits for the set jobs to be executed.

Step 7: The program waits for the checkback signal "PR" and the updated position values form the second incremental approach.

12.11 Example program 5 "DiagnosticsAndInterrupts"

Objective

This example includes a user program with the same formulation as in the example program 4 "OneChannel". In addition, we show you how you evaluate a diagnostic interrupt for specific modules and then make this into a general module error in the user program.

Requirements

You have assigned the positioning module parameters as described in "Getting Started".

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

In the diagnostic DB, the address of your module is entered correctly in the MOD_ADDR parameter.

The supplied channel DB already includes in the PARADBNO parameter the DB number (30) of the parameter DB for the machine data.

The machine data of your system are stored in the PARADB_1 data block.

In the HW Config, enable the diagnostic interrupt for this module via **Edit > Object properties > Basic parameters > Select interrupt > Diagnostics**. Compile the hardware configuration, and then download it to the CPU.

Startup

In the startup OB (OB 100) you set the startup identifier (step 0) for the user program in the instance DB.

Operation

As in example program 4 "OneChannel".

Error evaluation

In the case of an error in the processing, the step chain is brought to a halt. Step number -1 will be entered. In the USER_VAT you will find the latest entry of the diagnostic buffer. You can determine the cause of error via the error class and error number (refer to the appendix section entitled "Error classes (Page 189)").

Try to create errors that will be stored by the central error evaluation as group errors in the "USER_DB".ERR bit.

- In the USER_VAT, enable the prepared control value for the increment number 1 ("USER_DB".TRG_INC_1), which is greater than the software limit switch.
  The step chain is brought to a stop and -1 is shown as the step number. Check the errors via the error evaluation screen or the diagnostic data in the USER_VAT.
- In the USER_VAT enable further control values one after the other for the increment number 1 ("USER_DB".TRG_INC_1), increment number 255 ("USER_DB".TRG_INC_2), and the change-over difference ("USER_DB".CHGDIF) and switch-off difference ("USER_DB".CUTDIF). For the error inspection proceed as you would with increment 1.
- Create the diagnostic interrupts by disconnecting the auxiliary voltage of the module or removing the front connector. The diagnostics error "USER_DB".ERR_MOD and group error "USER_DB".ERR will be 1 and the step number will be -1.

User program (FB PROG)

The formulation is as in example program 4 "OneChannel".

In this example, no special measures are taken for placing after the error remedy.

Diagnostic interrupt (OB 82)

In the diagnostic interrupt, depending on the address of the interrupt-triggering module (OB82_MDL_ADDR) the error identifier in the associate instance DB (USER_DB) of the user program is entered. A response takes place in the cyclic user program.

12.12 Example program 6 "SeveralChannels"

Objective

This example contains the same user program as example program 4 "OneChannel", but it operates 2 channels of the module. The user program uses a separate instance of ABS_CTRL and ABS_DIAG for each channel, a multiple instance is not possible. The user program expects a channel number as input parameter. The DB numbers for channel and diagnostic DBs associated with this channel are stored as constants in the program and can by adjusted by you.

Requirements

You have assigned the channel 1 parameters as described in "Getting Started". Use **Edit > Copy channel** to copy channel 1 to channel 2. If necessary, adapt the parameters of channel 2. Save the hardware configuration and download it to the CPU.

In the channel DB, the address of your module is entered correctly in the MOD_ADDR parameter, and the channel number is correctly entered in the CH_NO parameter.

In the diagnostic DB, the address of your module is entered correctly in the MOD_ADDR parameter.

The supplied channel DBs already include the DB number 30 or 31 of the parameter DB for the machine data in the PARADBNO parameter.

In the data blocks PARADB_1 and PARADB_2 the machine data is stored for in each case one channel of your system.

In HW Config, enable the diagnostic interrupt for this module with **Edit > Object Properties > Basic Parameters > Interrupt Selection > Diagnostics**. Compile the hardware configuration, and then download it to the CPU.

A variable table is set up for each channel.

Startup

In the startup OB (OB 100) you set the startup identifier (step 0) for the user program in both instance DBs (USER_DB_1, USER_DB_2).

Operation

The CPU is in STOP. Open the USER_VAT_1 and USER_VAT_2 and transfer their control values.

Start the CPU (STOP > RUN). You can see how the actual positions of both channels change.

Error evaluation

As in example program 5 "DiagnosticsAndInterrupts", however separately for each channel.

User program (FB PROG)

Objective and order of events of the user program are as in example program 5 "DiagnosticsAndInterrupts" and in example program 4 "OneChannel".

The user program is designed for operation with several channels, as it indirectly accesses the module-specific data blocks (channel DBs, diagnostic DB and parameters DBs). The channel number specified during call up is used in the user program to select the instance DBs. With this type of programming, you cannot use symbolic names for the data in the data blocks because of the "Open global data block" instruction used in the user program.

Diagnostic interrupt (OB 82)

In the diagnostic interrupt, the error identifier is entered in the associated instance DB of the user program according to the address of the interrupt-triggering channel (OB82_MDL_ADDR).

Technical Specifications 13

13.1 General technical specifications

The following technical data are described in the SIMATIC S7-400 Automation System S7-400 Module Data Manual (http://support.automation.siemens.com/WW/view/en/1117740).

- Electromagnetic compatibility
- Transport and storage conditions
- Mechanical and climatic environmental conditions
- Specifications for insulation tests, protection class, and degree of protection
- Standards, certificates, and approvals

Observe installation guidelines

SIMATIC products meet the requirements if you follow the installation instructions described in the manuals when installing and operating the equipment.

13.2 Technical Specifications of the FM 451

Technical specifications

Technical specifications	
Dimensions and weight	
Dimensions W x H x D (mm)	50 × 290 × 280
Weight	Approx. 1300 g
Current, voltage and power	
Current consumption from backplane bus	Typ. 550 mA
Power loss	Typ. 12 W
Auxiliary voltage for the encoder supply	Auxiliary voltage: 24 V DC (X1, terminal 3) (permissible range: 20.4 to 28.8 V)
Encoder supply	• 5 V encoder supply – 5.2 V ± 2% – Max. 300 mA/axis – Short-circuit-proof • 24 V encoder supply – 1L+ -2 V – Max. 300 mA/axis – Short-circuit-proof • Current consumption from 1L+ (without load): Max. 100 mA (X1, terminal 3)
Auxiliary voltage for the load current supply	Auxiliary voltage: 24 V DC (X1, terminal 13, 14, 25, 26, 37, and 38) (permissible range: 20.4 to 28.8 V)
Power supply of the digital inputs and outputs	Current consumption from 2L+ (channel 1), 3L+ (channel 2), 4L+ (channel 3) (without load): Max. 50 mA • Insulation test voltage: 500 V DC
Load voltage polarity reversal protection	No
Encoder inputs	
Position detection	• Incremental • Absolute
Signal voltages	• Symmetrical inputs: 5 V in accordance with RS 422 • Asymmetrical inputs: 24 V/ typ. 9 mA
Input frequency and cable length for symmetrical incremental encoder with 5 V supply	Max. 500 kHz for 32 m shielded cable length
Input frequency and cable length for symmetrical incremental encoder with 24 V supply	Max. 500 kHz for 100 m shielded cable length
Input frequency and cable length for asymmetrical incremental encoder with 24 V supply	Max. 50 kHz for 100 m shielded cable length

Technical specifications	
Data transmission rate and cable length for absolute encoder	• Max. 125 kHz for 320 m shielded cable length • Max. 250 kHz for 160 m shielded cable length • Max. 500 kHz for 63 m shielded cable length • Max. 1 MHz for 20 m shielded cable length
Listen mode with absolute encoder	No
Input signals	• Incremental: 2 pulse trains, 90° phase shift, 1 zero pulse • Absolute: absolute value
Digital inputs	
Number of digital inputs	12
Number of simultaneously controllable digital inputs	12
Galvanic isolation	No
Status display	Yes, one green LED per digital input
Input voltage	• 0 signal: -30 ... 5 V • 1 signal: 11 ... 30 V
Input current	• 0 signal: 1.5 mA at 2.5 V • 1 signal: 9 mA at 24 V
Input delay (1I0, 1I1, 1I2, and 2I0, 2I1, 2I2, and 3I0, 3I1, 3I2)	• 0 → 1 signal: Typ. 3 ms • 1 → 0 signal: Typ. 3 ms
Input delay (1I3, 2I3 and 3I3)	• 0 → 1 signal: Typ. 300 µs • 1 → 0 signal: Typ. 300 µs
Connection of a 2-wire BERO	Supported
Unshielded cable length	Max. 50 m at 1I3, 2I3, and 3I3 Max. 100 m at 1I0, 1I1, 2I0, 2I1, 2I2, 3I0, 3I1, and 3I2
Shielded cable length	Max. 600 m
Dielectric test	VDE 0160
Digital outputs	
Number of outputs	12
Galvanic isolation	No
Status display	Yes, one green LED per digital output
Output current	• 0 signal: 0.5 mA • 1 signal: 0.5 A (permissible range: 5 ... 600 mA) • Lamp load: 5 W
Output delay at output current 0.5 A	• 0 → 1 signal: Max. 300 µs • 1 → 0 signal: Max. 300 µs
Signal level for 1 signal	2L+ - 0.8 V, 3L+ - 0.8 V, 4L+ - 0.8 V
Control of a digital input	Yes
Control of a count input	Yes
Short-circuit protection	Yes, electronic clocking in case of overtemperature
Limiting of inductive switch-off voltage	2L+ - 39 V, 3L+ - 39 V, 4L+ - 39 V
Switch rate	• Resistive load: Max. 100 Hz • Inductive load: Max. 0.5 Hz

Technical specifications	
Total current of digital outputs	Demand factor 100%: At 20 °C and 60 °C: 6 A
Unshielded cable length	Max. 100 m
Shielded cable length	Max. 600 m
Dielectric test	VDE 0160

⚠ DANGER

An overload in the output current of the digital outputs can destroy the module.

Make sure not to exceed 600 mA.

13.3 Standards and approvals

13.3.1 Currently valid markings and approvals

Introduction

This section contains:

- The standards and test values to which the FM 451 Positioning Module complies and which it fulfills.
- The test criteria according to which the FM 451 was tested.

Technical specifications of the FM 451 Positioning Module

You can find the technical specifications of the FM 451 Positioning Module in the equipment documentation. If there are deviations between the statements in this document and the equipment documentation, the statements in the equipment documentation take priority.

Validity of the information on the components

NOTICE
Markings and approvals In the documentation, you can find the markings and approvals which are generally possible or planned in the system. However, only the marking or approval printed on the components of the automation system is valid.

Reference

You can find the certificates for the markings and approvals on the Internet under Service&Support (https://support.industry.siemens.com/cs/ww/de/).

Safety instructions

⚠ WARNING
Personal injury and damage to property may occur Note the following information for use in hazardous areas: • Personal injury and material damage can occur if you establish or disconnect an electrical circuit while the automation system is in operation. • Always be sure to de-energize the system before removing the plug connections.

Note

The FM 451 Positioning Module is intended for use in industrial areas. If used in residential areas, it may interfere with radio/TV reception.

13.3.2 CE approval

Introduction

The FM 451 Positioning Module fulfills the requirements and protective aims of the following EC directives and conforms with the harmonized European standards (EN) that have been published for programmable logic controllers in the Official Journals of the European Community:

- Low-Voltage Directive
- EMC Directive
- Explosion Protection Directive

The EC Declaration of Conformity can be downloaded from the Internet (https://support.industry.siemens.com/cs/document/16693331).

Low-Voltage Directive

2014/35/EU "Electrical Equipment Designed for Use within Certain Voltage Limits" (Low-Voltage Directive)

The FM 451 Positioning Modules are tested according to the requirements of EN 61131-2, which fall under the Low-Voltage Directive.

EMC Directive

2014/30/EU "Electromagnetic Compatibility" (EMC Directive)

Use in industry

SIMATIC products are designed for industrial applications.

Area of application	Interference requirements	Immunity requirements
Industry	EN 61000-6-4 + A1	EN 61000-6-2

Adhere to the installation guidelines

SIMATIC products meet the requirements if you comply with the installation guidelines described in the manuals during installation and operation.

13.3.3 CCC approval

Certificate:

2020322309002744

Ex nA IIC T4 Gc

According to the following standards:

- GB 3836.1-2010 (Explosive atmospheres - Part 1: Equipment - General requirements)
- GB 3836.8-2014 (Explosive atmospheres-Part 8: Equipment protection by type of protection "n")

13.3.4 UKCA approval

DEKRA 21UKEX0018 X

Importer UK:

Siemens plc

Manchester M20 2UR

13.3.5 Explosion protection

ATEX approval DEKRA 21ATEX0010 X

Type examination certificate number	DEKRA 21ATEX0010 X	
Standards	EN IEC 60079-0	
	EN 60079-7	
Marking	Ex	II 3 G Ex ec IIC T4 Gc
The certificate is valid for the "DEKRA 21ATEX0010 X (https://support.industry.siemens.com/cs/document/109475140)" products listed in the certificate.		

Special conditions

- The device may only be used in areas with a pollution degree of no more than 2 according to EN 60664-1.
- The modules must be installed in a suitable enclosure which provides a degree of protection of at least IP54 in accordance with EN 60079-7, taking into account the ambient conditions of use.
- Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient disturbance voltages.

IECEx approval IECEx DEK 21.0008X

Certificate number	IECEx DEK 21.0008X
Standards	IEC 60079-0
	IEC 60079-7
Marking	Ex ec IIC T4 Gc
The certificate is valid for the "IECEx DEK 21.0008X (https://support.industry.siemens.com/cs/document/109795939)". products listed in the certificate.	

Special conditions

- The device may only be used in areas with a pollution degree of no more than 2 according to IEC 60664-1.
- The modules must be installed in a suitable enclosure which provides at least IP54 degree of protection in accordance with IEC 60079-7 and taking into account the ambient conditions of use.
- Measures must be taken to prevent exceeding the rated voltage by more than 119 V of transient disturbance voltages.

13.3.6 cULus approval

Underwriters Laboratories Inc. in accordance with:

- UL 508 (Industrial Control Equipment)
- CSA C 22.2 No. 142 (Process Control Equipment)

13.3.7 cULus HAZ. LOC. approval

HAZ. LOC.

Underwriters Laboratories Inc. in accordance with:

- UL 61010-2-201 (Industrial Control Equipment)
- CSA / CAN 61010-2-201 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

Approved for use in:

Class I, Division 2, Group A, B, C, D Tx;

Class I, Zone 2, Group IIC Tx

13.3.8 cFMus approval



Factory Mutual Research (FM) in accordance with:

- Approval Standards FM Class 3600:2018, FM Class 3611:2018, FM Class 3810:2018,
- ANSI/UL 121201.2017,
- ANSI/UL 61010-1:2018

APPROVED for use in:

- Class I, Division 2, Group A, B, C and D
- Class I, Zone 2, Group IIC, hazardous (classified) locations
- Ordinary (unclassified) locations with an ambient temperature rating of 0 °C to + 70 °C, indoor environments

13.3.9 Approval for Australia and New Zealand



The SIMATIC S7-400 product series meets the requirements of the standard EN 61000-6-4:2007 + A1:2001.

13.3.10 Approval for the Korea and South Korea



The SIMATIC S7-400 product series complies with Korean safety standards:

Registration of Broadcasting and Communication Equipment KCC-REM-S49-S7400

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Wiring diagram

14

14.1 Overview

Overview

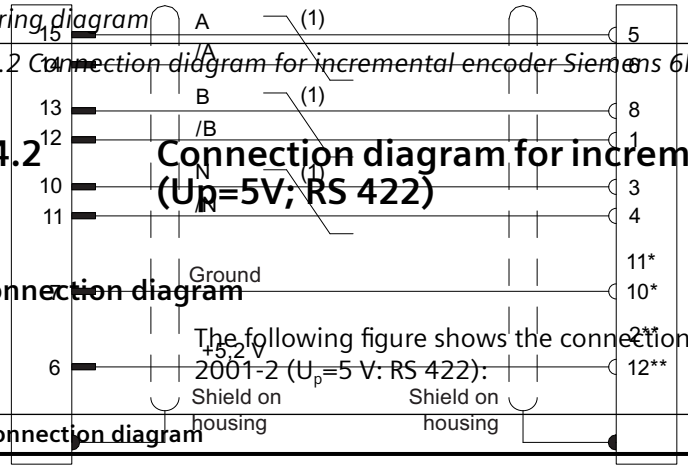
The following table describes encoders that you can connect to the positioning module. The connection diagrams for these encoders are described in this appendix:

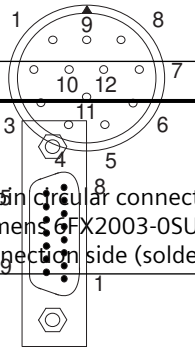
In the chapter	... you will find the pin assignment for	Connecting cable	Comment
Connection diagram for incremental encoder Siemens 6FX2001-2 (Up=5 V; RS 422)	**Incremental encoder** Siemens 6FX2001-2	4 x 2 x 0.25 + 2 x 1 mm^2	Incremental encoders: U_p=5 V, RS 422
Connection diagram for incremental encoder Siemens 6FX2001-2 (Up=24 V; RS 422)	**Incremental encoder** Siemens 6FX2001-2	4 x 2 x 0.5 mm^2	Incremental encoders: U_p=24 V, RS 422
Connection diagram for incremental encoder Siemens 6FX2001-4 (Up=24 V; HTL)	**Incremental encoder** Siemens 6FX2001-4	4 x 2 x 0.5 mm^2	Incremental encoders: U_p=24 V, HTL
Connection diagram for absolute encoder Siemens 6FX2001-5 (Up=24 V; SSI)	**Absolute encoder** Siemens 6FX2001-5	4 x 2 x 0.5 mm^2	Absolute encoder: U_p=24 V, SSI

14.2 Connection diagram for incremental encoder Siemens 6FX 2001-2 (Up=5V; RS 422)

Connection diagram

The following figure shows the connection diagram for the incremental encoder Siemens 6FX 2001-2 (U_p=5 V: RS 422):

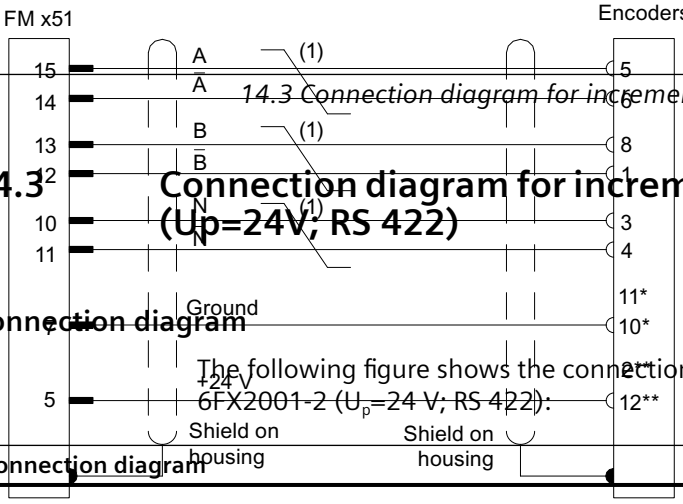


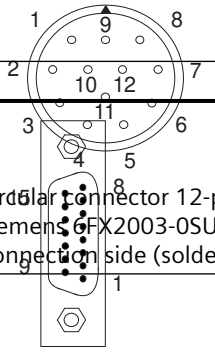
Connection diagram	
Cable 4 × 2 × 0.25 + 2 × 1 mm2 (1) Twisted-pair cables * Pins 10 and 11 are internally bridged. ** Pins 2 and 12 are internally bridged.	 12-pin circular connector Socket Siemens 6FX2003-0SU12 Connection side (solder side) 15-pin sub D connector, connection side (solder side) metallized housing with screw interlock 6FC9341-1HC

14.3 Connection diagram for incremental encoder Siemens 6FX 2001-2 (Up=24V; RS 422)

Connection diagram

The following figure shows the connection diagram for an incremental encoder Siemens 6FX2001-2 (U_p=24 V; RS 422):

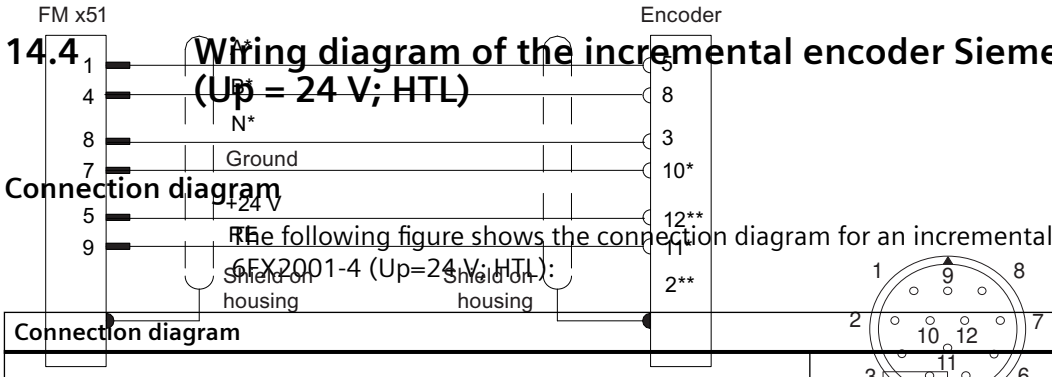


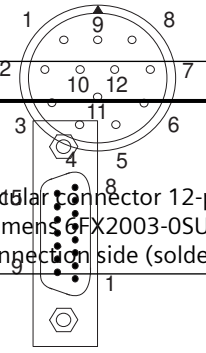
Connection diagram	
Line 4 × 2 × 0.5 mm²	 Circular connector 12-pin socket Siemens 6FX2003-0SU12 Connection side (solder side)
(1) Twisted-pair cables	
* Pins 10 and 11 are internally bridged. ** Pins 2 and 12 are internally bridged.	15-pin sub D connector, connection side (solder side) metallized housing with screw interlock 6FC9341-1HC

14.4 Wiring diagram of the incremental encoder Siemens 6FX 2001-4 (Up = 24 V; HTL)

Connection diagram

The following figure shows the connection diagram for an incremental encoder Siemens 6FX2001-4 (Up=24 V; HTL):



Connection diagram	
Cable 4 x 2 x 0.5 mm2 * Pins 10 and 11 are internally bridged. ** Pins 2 and 12 are internally bridged.	 Circular connector 12-pin socket Siemens 6FX2003-0SU12 Connection side (solder side) 15-pin sub D connector, connection side (solder side) metallized housing with screw interlock 6FC9341-1HC

Note

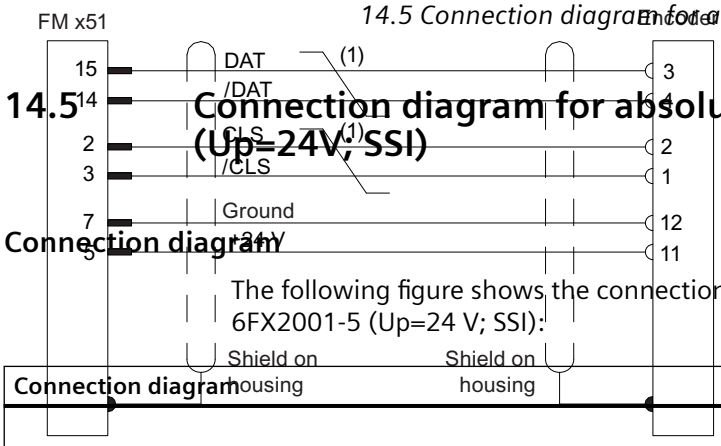
To connect a non-SIEMENS incremental encoder in a push-pull configuration (current sourcing/ sinking), observe the following:

- Current sourcing: Connect RE (9) to ground (7).
- Current sinking: Connect RE (9) to +24 V (5).

14.5 Connection diagram for absolute encoder Siemens 6FX 2001-5 (Up=24V; SSI)

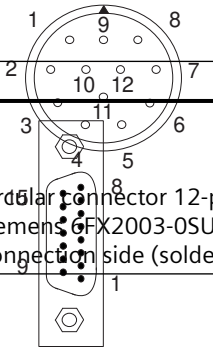
Connection diagram

The following figure shows the connection diagram for an absolute encoder Siemens 6FX2001-5 (Up=24 V; SSI):



Cable 4 x 2 x 0.5 mm2

(1) Twisted-pair cables



Circular connector 12-pin socket
Siemens 6FX2003-0SU12
Connection side (solder side)

15-pin sub D connector, connection side (solder side) metallized housing with screw interlock
6FC9341-1HC

Data blocks and error lists

15

15.1 Content of the channel DB

Data of channel DB

Note

Do not modify any data not listed in this table.

Table 15-1 Content of the channel DB

Address	Name	Type	Initial value	Comment
Addresses				
0.0	MOD_ADDR	INT	0	Module address
2.0	CH_NO	INT	1	Channel number
10.0	PARADBNO	INT	-1	Number of the parameter DB
Control signals				
14.3	OT_ERR_A	BOOL	FALSE	1 = Acknowledge operator error
15.0	START	BOOL	FALSE	1 = Start positioning
15.1	STOP	BOOL	FALSE	1 = Stop active traversing
15.2	DIR_M	BOOL	FALSE	1 = Minus direction
15.3	DIR_P	BOOL	FALSE	1 = Plus direction
15.6	SPEED252	BOOL	FALSE	Start velocity for incremental approach with increment number 252: 0 = Creep speed 1 = Rapid traverse
15.7	DRV_EN	BOOL	FALSE	1 = Switch on drive enable
16.0	MODE_IN	BYTE	B#16#0	Required operating mode 0 = No operating mode 1 = Jog 3 = Reference point approach 4 = Relative incremental approach 5 = Absolute incremental approach
17.0	MODE_TYPE	BYTE	B#16#0	• Start velocity for jog mode 0 = Creep speed 1 = Rapid traverse • Increment number for the incremental approach mode
Checkback signals				
22.2	DIAG	BOOL	FALSE	1 = Diagnostic buffer changed

Address	Name	Type	Initial value	Comment
22.3	OT_ERR	BOOL	FALSE	1 = Operator error occurred
22.4	DATA_ERR	BOOL	FALSE	1 = Data error
22.7	PARA	BOOL	FALSE	1 = Axis parameters assigned
23.0	ST_ENBLD	BOOL	FALSE	1 = Start enabled
23.1	WORKING	BOOL	FALSE	1 = Positioning running (processing running)
23.2	WAIT_EI	BOOL	FALSE	1 = Axis waiting for external enable
23.4	SPEED_OUT	BOOL	FALSE	0 = Creep speed 1 = Rapid traverse
23.5	ZSPEED	BOOL	FALSE	1 = Axis is located in the standstill range
23.6	CUTOFF	BOOL	FALSE	1 = Axis is located in the switch-off range
23.7	CHGOVER	BOOL	FALSE	1 = Axis is located in the changeover range
24.0	MODE_OUT	BYTE	B#16#0	Active operating mode
25.0	SYNC	BOOL	FALSE	1 = Axis is synchronized
25.1	MSR_DONE	BOOL	FALSE	1 = Length measurement/edge detection completed
25.2	GO_M	BOOL	FALSE	1 = Axis moves in minus direction
25.3	GO_P	BOOL	FALSE	1 = Axis moves in plus direction
25.5	FVAL_DONE	BOOL	FALSE	1 = Set actual value on-the-fly completed
25.7	POS_RCD	BOOL	FALSE	1 = Position reached
26.0	ACT_POS	DINT	L#0	Current actual value (current position of axis)
Function switches				
34.0	PLOOP_ON	BOOL	FALSE	1 = Loop approach in plus direction
34.1	MLOOP_ON	BOOL	FALSE	1 = Loop approach in minus direction
34.2	EI_OFF	BOOL	FALSE	1 = Do not evaluate enable input
34.3	EDGE_ON	BOOL	FALSE	1 = Edge detection ON
34.4	MSR_ON	BOOL	FALSE	1 = Length measurement ON
Trigger bits for write jobs				
35.0	MDWR_EN	BOOL	FALSE	1 = Write machine data
35.1	MD_EN	BOOL	FALSE	1 = Enable machine data
35.2	DELDIST_EN	BOOL	FALSE	1 = Delete distance-to-go
35.3	AVALREM_EN	BOOL	FALSE	1 = Cancel set actual value
35.4	TRGL1WR_EN	BOOL	FALSE	1 = Write increment table 1 (increment number 1...50)
35.5	TRGL2WR_EN	BOOL	FALSE	1 = Write increment table 2 (increment number 51...100)
35.6	REFPT_EN	BOOL	FALSE	1 = Set reference point
35.7	AVAL_EN	BOOL	FALSE	1 = Set actual value
36.0	FVAL_EN	BOOL	FALSE	1 = Set actual value on-the-fly
36.1	ZOFF_EN	BOOL	FALSE	1 = Set zero offset
36.2	TRG252_254_EN	BOOL	FALSE	1 = Write increment for increment number 252 or 254
36.3	TRG255_EN	BOOL	FALSE	1 = Write increment for increment number 255
36.4	DELDIAG_EN	BOOL	FALSE	1 = Clear diagnostic buffer
Trigger bits for read jobs				
36.5	MDRD_EN	BOOL	FALSE	1 = Read machine data
36.6	TRGL1RD_EN	BOOL	FALSE	1 = Read increment table 1 (increment number 1...50)
36.7	TRGL2RD_EN	BOOL	FALSE	1 = Read increment table 2 (increment number 51...100)

Address	Name	Type	Initial value	Comment
37.0	MSRRD_EN	BOOL	FALSE	1 = Read measured values
37.1	ACTSPD_EN	BOOL	FALSE	1 = Read actual velocity, distance-to-go, and current increment
37.2	ENCVAL_EN	BOOL	FALSE	1 = Read encoder values
Done bits for function switches				
38.0	PLOOP_D	BOOL	FALSE	1 = "Loop approach in plus direction" job completed
38.1	MLOOP_D	BOOL	FALSE	1 = "Loop approach in minus direction" job completed
38.2	EI_D	BOOL	FALSE	1 = "Do not evaluate enable input" job completed
38.3	EDGE_D	BOOL	FALSE	1 = "Edge detection ON" job completed
38.4	MSR_D	BOOL	FALSE	1 = "Length measurement ON" job completed
Done bits for write jobs				
39.0	MDWR_D	BOOL	FALSE	1 = "Write machine data" job completed
39.1	MD_D	BOOL	FALSE	1 = "Activate machine data" job completed
39.2	DELDIST_D	BOOL	FALSE	1 = "Delete distance-to-go" job completed
39.3	AVALREM_D	BOOL	FALSE	1 = "Cancel set actual value" job completed
39.4	TRGL1WR_D	BOOL	FALSE	1 = "Write increment table 1" job completed
39.5	TRGL2WR_D	BOOL	FALSE	1 = "Write increment table 2" job completed
39.6	REFPT_D	BOOL	FALSE	1 = "Set reference point" job completed
39.7	AVAL_D	BOOL	FALSE	1 = "Set actual value" job completed
40.0	FVAL_D	BOOL	FALSE	1 = "Set actual value on-the-fly" job completed
40.1	ZOFF_D	BOOL	FALSE	1 = "Set zero offset" job completed
40.2	TRG252_254_D	BOOL	FALSE	1 = "Write increment for increment number 252 or 254" job completed
40.3	TRG255_D	BOOL	FALSE	1 = "Write increment for increment number 255" job completed
40.4	DELDIAG_D	BOOL	FALSE	1 = "Clear diagnostic buffer" job completed
Done bits for read jobs				
40.5	MDRD_D	BOOL	FALSE	1 = "Read machine data" job completed
40.6	TRGL1RD_D	BOOL	FALSE	1 = "Read increment table 1" job completed
40.7	TRGL2RD_D	BOOL	FALSE	1 = "Read increment table 2" job completed
41.0	MSRRD_D	BOOL	FALSE	1 = "Read measured values" job completed
41.1	ACTSPD_D	BOOL	FALSE	1 = "Read actual velocity, distance-to-go, and current increment" job completed
41.2	ENCVAL_D	BOOL	FALSE	1 = "Read encoder values" job completed
Error bits for function switches				
42.0	PLOOP_ERR	BOOL	FALSE	1 = Error in "Loop approach in plus direction" job
42.1	MLOOP_ERR	BOOL	FALSE	1 = Error in "Loop approach in minus direction" job
42.2	EI_ERR	BOOL	FALSE	1 = Error in "Do not evaluate enable input" job
42.3	EDGE_ERR	BOOL	FALSE	1 = Error in "Edge detection ON" job
42.4	MSR_ERR	BOOL	FALSE	1 = Error in "Length measurement ON" job
Error bits for write jobs				
43.0	MDWR_ERR	BOOL	FALSE	1 = Error in "Write machine data" job
43.1	MD_ERR	BOOL	FALSE	1 = Error in "Activate machine data" job
43.2	DELDIST_ERR	BOOL	FALSE	1 = Error in "Delete distance-to-go" job

Address	Name	Type	Initial value	Comment
43.3	AVALREM_ERR	BOOL	FALSE	1 = Error in "Cancel set actual value" job
43.4	TRGL1WR_ERR	BOOL	FALSE	1 = Error in "Write increment table 1" job
43.5	TRGL2WR_ERR	BOOL	FALSE	1 = Error in "Write increment table 2" job
43.6	REFPT_ERR	BOOL	FALSE	1 = Error in "Set reference point" job
43.7	AVAL_ERR	BOOL	FALSE	1 = Error in "Set actual value" job
44.0	FVAL_ERR	BOOL	FALSE	1 = Error in "Set actual value on-the-fly" job
44.1	ZOFF_ERR	BOOL	FALSE	1 = Error in "Set zero offset" job
44.2	TRG252_254_ERR	BOOL	FALSE	1 = Error in "Write increment for increment number 252 or 254" job
44.3	TRG255_ERR	BOOL	FALSE	1 = Error in "Write increment for increment number 255" job
44.4	DELDIAG_ERR	BOOL	FALSE	1 = Error in "Clear diagnostic buffer" job
Error bits for read jobs				
44.5	MDRD_ERR	BOOL	FALSE	1 = Error in "Read machine data" job
44.6	TRGL1RD_ERR	BOOL	FALSE	1 = Error in "Read increment table 1" job
44.7	TRGL2RD_ERR	BOOL	FALSE	1 = Error in "Read increment table 2" job
45.0	MSRRD_ERR	BOOL	FALSE	1 = Error in "Read measured values" job
45.1	ACTSPD_ERR	BOOL	FALSE	1 = Error in "Read actual velocity, distance-to-go, and current increment" job
45.2	ENCVAL_ERR	BOOL	FALSE	1 = Error in "Read current encoder values" job
Job management for FC ABS_CTRL				
48.0	JOB_ERR	INT	0	Error number of communication error
50.0	JOBBUSY	BOOL	FALSE	1 = At least one job is busy
50.1	JOBRESET	BOOL	FALSE	1 = Reset all error bits and done bits
Data element for "Zero offset" job (FM 451)				
80.0	ZOFF	DINT	L#0	Zero offset
Data element for "Set actual value" job				
84.0	AVAL	DINT	L#0	Coordinate for "Set actual value"
Data element for "Set actual value on-the-fly" job (FM 451)				
88.0	FVAL	DINT	L#0	Coordinate for "Set actual value on-the-fly"
Data element for "Set reference point" job				
92.0	REFPT	DINT	L#0	Coordinate for "Set reference point"
Data element for "Write increment for increment number 252 or 254" job				
96.0	TRG252_254	DINT	L#0	Write increment for increment number 252 or 254
Data for "Write increment for increment number 255" job				
100.0	TRG255	DINT	L#0	Increment for increment number 255
104.0	CHGDIF255	DINT	L#0	Changeover difference for increment number 255
108.0	CUTDIF255	DINT	L#0	Switch-off difference for increment number 255
Data for "Read position data" job				
112.0	ACTSPD	DINT	L#0	Current velocity
116.0	DIST_TO_GO	DINT	L#0	Distance-to-go
120.0	ACT_TRG	DINT	L#0	Current increment
Data for "Read encoder data" job				
124.0	ENCVAL	DINT	L#0	Actual encoder value (internal representation)

Address	Name	Type	Initial value	Comment
128.0	ZEROVAL	DINT	L#0	Last zero mark value (internal representation)
132.0	ENC_ADJ	DINT	L#0	Absolute encoder adjustment
Data for "Length measurement/edge detection" job (FM 451)				
136.0	BEG_VAL	DINT	L#0	Start value of length measurement/edge detection
140.0	END_VAL	DINT	L#0	End value of length measurement/edge detection
144.0	LEN_VAL	DINT	L#0	Length

15.2 Content of the parameter DB

Data of parameter DB

Note

Do not modify any data not listed in this table.

Table 15-2 Content of the parameter DB

Address	Name	Type	Initial value	Comment
Machine data				
4.0	EDGEDIST	DINT	L#0	Minimum edge distance
8.0	UNITS	DINT	L#1	System of units
12.0	AXIS_TYPE	DINT	L#0	0 = Linear axis 1 = Rotary axis
16.0	ENDROTAX	DINT	L#100000	End of rotary axis
20.0	ENC_TYPE	DINT	L#1	Encoder type, message frame length
24.0	DISP_REV	DINT	L#80000	Distance per encoder revolution
32.0	INC_REV	DINT	L#500	Increments per encoder revolution
36.0	NO_REV	DINT	L#1	Number of encoder revolutions
40.0	BAUDRATE	DINT	L#0	Baud rate
44.0	REFPT	DINT	L#0	Reference point coordinate
48.0	ENC_ADJ	DINT	L#0	Absolute encoder adjustment
52.0	REFPT_TYPE	DINT	L#0	Type of reference point approach
59.0	CNT_DIR	BOOL	FALSE	Count direction: 0 = Normal 1 = Inverted
63.0	MON_WIRE	BOOL	TRUE	1 = Wire break monitoring
63.1	MON_FRAME	BOOL	TRUE	1 = Message frame error monitoring
63.2	MON_PULSE	BOOL	TRUE	1 = Missing pulses monitoring
64.0	SSW_STRT	DINT	L#-100000000	Software limit switch start
68.0	SSW_END	DINT	L#100000000	Software limit switch end
76.0	TRG_RANGE	DINT	L#1000	Target range
80.0	MON_TIME	DINT	L#2000	Monitoring time [ms]
84.0	ZSPEED_R	DINT	L#1000	Standstill range
88.0	ZSPEED_L	DINT	L#30000	Upper limit of standstill velocity
92.0	CTRL_TYPE	DINT	L#1	Control mode (1 - 4)
99.0	REFPT_SPD	BOOL	TRUE	Start velocity for reference point approach: 0 = Rapid traverse 1 = Creep speed
99.1	EI_TYPE	BOOL	FALSE	Enable input: 0 = Level-controlled 1 = Edge-controlled

Address	Name	Type	Initial value	Comment	
Machine data					
100.0	CHGDIF_P	DINT	L#5000	Changeover difference plus	
104.0	CHGDIF_M	DINT	L#5000	Changeover difference minus	
108.0	CUTDIF_P	DINT	L#2000	Switch-off difference plus	
112.0	CUTDIF_M	DINT	L#2000	Switch-off difference minus	
Increment table 1					
120.0	TRGL1.TRG[1]	DINT	L#0	Increment number 1	Increment table 1
. . .	. . .	. . .	. . .	. . .	
316.0	TRGL1.TRG[50]	DINT	L#0	Increment number 50	
Increment table 2					
320.0	TRGL2.TRG[51]	DINT	L#0	Increment number 51	Increment table 2
. . .	. . .	. . .	. . .	. . .	
516.0	TRGL2.TRG[100]	DINT	L#0	Increment number 100	

15.3 Data and structure of the diagnostic DB

Data and structure of the diagnostic DB

Note

You must not change any data that is not listed in this table.

Table 15-3 Structure of the diagnostic DB

Address	Name	Type	Initial value	Comment
0.0	MOD_ADDR	INT	0	Module address
256.0	JOB_ERR	INT	0	Error number of the communication error
258.0	JOBBUSY	BOOL	FALSE	1 = job active
258.1	DIAGRD_EN	BOOL	FALSE	1 = definitely read diagnostics buffer
260.0	DIAG_CNT	INT	0	Number of valid entries in the list
262.0	DIAG[1]	STRUCT		Diagnostics data - latest entry
272.0	DIAG[2]	STRUCT		Diagnostics data - second entry
282.0	DIAG[3]	STRUCT		Diagnostics data - third entry
292.0	DIAG[4]	STRUCT		Diagnostics data - fourth entry
302.0	DIAG[5]	STRUCT		Diagnostics data - fifth entry
312.0	DIAG[6]	STRUCT		Diagnostics data - sixth entry
322.0	DIAG[7]	STRUCT		Diagnostics data - seventh entry
332.0	DIAG[8]	STRUCT		Diagnostics data - eighth entry
342.0	DIAG[9]	STRUCT		Diagnostics data - ninth entry

The structure of the diagnostics entry DIAG[n] is developed as follows:

Table 15-4 Structure of the diagnostics entry

Address	Name	Type	Initial value	Comment
+0.0	STATE	BOOL	FALSE	0 = incoming event 1 = outgoing event
+0.1	INTF	BOOL	FALSE	1 = internal error
+0.2	EXTF	BOOL	FALSE	1 = external error
+2.0	FCL	INT	0	Error class: 1: Operating error 2: Operating errors 4: Data error 5: Machine data error 6: Increment table error 15: Messages 128: Diagnostics errors

Address	Name	Type	Initial value	Comment
+4.0	FNO	INT	0	Error number
+6.0	CH_NO	INT	0	Channel number
+8.0	TRG_NO	INT	0	Increment number

15.4 List of JOB_ERR messages

JOB_ERR messages

JOB_ERR (Hex)	JOB_ERR (Dez)	JOB_ERR (Int)	Meaning
80A0	32928	-32608	Negative acknowledgement when reading from the module. The module has been removed during the read operation - or the module is faulty.
80A1	32929	-32607	Negative acknowledge when writing to the module. The module has been removed during the write operation - or the module is faulty.
80A2	32930	-32606	DP protocol error with layer 2
80A3	32931	-32605	DP protocol error with user interface / user
80A4	32932	-32604	Communication on C bus interrupted
80B0	32944	-32592	Data record / job unknown.
80B1	32945	-32591	Incorrect length specification. Parameter FM_TYPE in the channel DB is not correctly set for the module being used.
80B2	32946	-32590	The configured slot is not assigned.
80B3	32947	-32589	Actual module type dissimilar to the set module type.
80C0	32960	-32576	The module does not yet have ready the data to be read.
80C1	32961	-32575	The data of a same-named write job is not yet ready on the module.
80C2	32962	-32574	The module is currently processing the possible maximum of jobs.
80C3	32963	-32573	Required equipment (memory etc.) is currently in use.
80C4	32964	-32572	Communication error
80C5	32965	-32571	Distributed I/O unavailable.
80C6	32966	-32570	Priority class cancellation (restart or background)
8522	34082	-31454	Channel DB or parameter DB too short. The data cannot be read from the DB. (write job)
8532	34098	-31438	The DB number of the parameter is too large. (write job)
853A	34106	-31430	Parameter DB does not exist. (write job)
8544	34116	-31420	Error with the n-th (n > 1) read access on a DB after an error has occurred. (write job)
8723	34595	-30941	Channel DB or parameter DB too short. The data cannot be written in the DB. (read job)
8730	34608	-30928	Parameter DB in the CPU is write-protected. The data cannot be written in the DB (read job).
8732	34610	-30926	The DB number of the parameter is too large. (read job)
873A	34618	-30918	Parameter DB does not exist. (read job)
8745	34629	-30907	Error with the n-th (n > 1) write access on a DB after an error has occurred. (read job)
The errors 80A2..80A4 as well as 80Cx are temporary, i.e. they can be remedied after a waiting time without you having to do anything.			

15.5 Error classes

Error classes

Class 1: Operating error

Operating errors are detected asynchronously to an operator input/control. Operating errors cause the positioning to be canceled, except in the case of error number 9. Error number 9 causes the positioning to be shut down.

No.	Meaning		Diagnostic interrupt
1	**Software limit switch start overrun**		Yes
	Cause	The actual value is outside the operating range	
2	**Software limit switch end overrun**		Yes
	Cause	The actual value is outside the operating range	
3	**Traversing range start overrun**		Yes
	Cause	Traversing range limit overrun (coordinates of the traversing range limits also belong to the traversing range)	
4	**Traversing range end overrun**		Yes
	Cause	Traversing range limit overrun (coordinates of the traversing range limits also belong to the traversing range)	
5	**Error during target approach**		Yes
	Cause	Target range was not reached within the monitoring time	
6	**Standstill range exited**		Yes
	Cause	The actual value is outside the standstill range	
7	**Positive feedback**		Yes
	Cause	Actual value change > 1/2 standstill range in the wrong direction	
8	**Missing actual value change or actual value change is too small**		Yes
	Cause	No actual value change or an actual value change opposite the desired direction within the monitoring time	
9	**Target overrun (FM 451)**		Yes
	Cause	The target was overrun during "Set actual value on-the-fly"	
10	**Target range overrun**		Yes
	Cause	Target range was overrun after target approach	
11	**Changeover point switched incorrectly**		Yes
	Cause	Axis is oscillating in the changeover point.	
12	**Switch-off point switched incorrectly**		Yes
	Cause	Axis is oscillating in the switch-off point/reversal point	
13	**Target range start switched incorrectly**		Yes
	Cause	Axis is oscillating in the target range	
14	**Change greater than half the rotary axis range**		Yes
	Cause	The velocity/frequency is too high or there are faulty actual value jumps	

No.	Meaning		Diagnostic interrupt
15	**Change greater than the rotary axis range**		Yes
	Cause	The velocity/frequency is too high or there are faulty actual value jumps	
16	**Increment for increment number 252 not transferred (FM 451)**		Yes
	Cause	The increment was not transferred	
17	**Increment for increment number 252 cannot be approached (FM 451)**		Yes
	Cause	The distance between the current actual position and the specified increment is less than the changeover difference or switch-off difference	
18	**Incorrect increment for increment number 252 (FM 451)**		Yes
	Cause	The increment is outside the operating range	

Class 2: Operator errors

Operator errors are detected when control signals in the user data area are changed. The operator errors cause the positioning to shut down.

No.	Meaning		Diagnostic interrupt
1	**Impermissible operating mode**		No
	Cause	The selected operating mode is not permissible	
3	**Impermissible interface job**		No
	Cause	The selected signal is not permitted with this operating mode	
4	**Incorrect operating mode parameter**		No
	Cause	• In "jog" mode the velocity specification is not equal to the rapid traverse or creep speed • In "incremental approach" mode, the increment is a value other than 1 - 100, 252, 254, or 255	
5	**Start enable not found**		No
	Cause	Start enable for starting not found	
7	**Target/target range is outside the operating range**		No
	Cause	Specified or calculated target is outside the software limit switches	
8	**Axis parameters not assigned**		No
	Cause	Incorrect machine data or no machine data were assigned for the axis	
9	**Axis not synchronized**		No
	Cause	The "incremental approach" mode is possible only with an already synchronized axis	
10	**Target/distance increment cannot be positioned**		No
	Cause	The distance between the current actual position and the specified target is less than the switch-off difference	
17	**Reference point approach not possible**		No
	Cause	An SSI encoder was connected	

No.	Meaning		Diagnostic interrupt
18	**Relative or absolute incremental approach not possible**		No
	Cause	The increment is invalid.	
19	**Switch-off difference is less than 1/2 the target range with increment number 255**		No
	Cause	The switch-off difference for increment 255 is less than half the target range	
20	**Traversing in specified direction not allowed**		No
	Cause	The distance to the software limit switch is insufficient	

Class 4: Data error

Data errors are detected synchronously to an operator input/control. Data errors do not result in an error response.

No.	Meaning		Diagnostic interrupt
6	**Specified increment too large**		No
	Cause	The value is outside ±100 m or ±1000 m. The distance increment/target must not be greater than the traversing range. For a rotary axis, the coordinate must be ≥0 and less than the end of rotary axis.	
10	**Zero offset error**		No
	Cause	The zero offset is greater than ±100 m or ±1000 m. The software limit switches are outside the traversing range (-100 m to +100 m or -1000 m to +1000 m) after setting the zero offset. Rotary axis: The absolute value of the zero offset is greater than the end of rotary axis.	
11	**Faulty actual value specification**		No
	Cause	Linear axis: The coordinate lies outside the current (possibly offset) software limit switches. Rotary axis: The coordinate is < 0 or greater than the end of the rotary axis.	
12	**Reference point error**		No
	Cause	Linear axis: The coordinate lies outside the current (possibly offset) software limit switches. Rotary axis: The coordinate is < 0 or greater than the end of the rotary axis.	
20	**Enable machine data not permitted**		No
	Cause	There are no new (error-free) machine data on the module.	
27	**Illegal bit-coded setting**		No
	Cause	Unused and, in this case, unwritten bits are not 0.	
29	**Illegal bit coding**		No
	Cause	Unused and, in this case, unwritten bits are not 0.	

No.	Meaning		Diagnostic interrupt
34	**Cancel set actual value not possible**		No
	Cause	With an SSI encoder and a linear axis, the actual position value would be outside the operating range after making the setting.	
36	**Changeover difference error with increment number 255**		No
	Cause	The value is outside the permitted numeric range of ±100 m or ±1000 m. For a rotary axis, the coordinate must be ≥0 and less than the end of rotary axis.	
37	**Switch-off difference error with increment number 255**		No
	Cause	The value is outside the permitted numeric range of ±100 m or ±1000 m. The switch-off difference must be less than the changeover difference.	
107	**Axis parameters not assigned**		No
	Cause	The axis has no machine data or the machine data are not activated.	
108	**Axis not synchronized**		No
	Cause	A "set actual value" or "set actual value on-the-fly" job was initiated although the axis is not synchronized.	

Class 5: Machine data error

The diagnostic interrupt is only triggered if an error is detected in the system data block (SDB). Machine data errors do not result in an error response.

No.	Meaning		Diagnostic interrupt
5	**Error in hardware interrupt setting**		Yes
	Cause	You have attempted to select a hardware interrupt that the module does not support	
6	**Incorrect minimum edge distance (FM 451)**		Yes
	Cause	You have entered a value < 0 or > 10^9 µm as the minimum edge distance	
7	**Incorrect system of units**		Yes
	Cause	The value for the system of units is outside the permitted range of 1 to 4 and 6	
8	**Incorrect axis type**		Yes
	Cause	You have specified neither 0 nor 1 as the axis type	
9	**Incorrect end of rotary axis**		Yes
	Cause	The value for the end of rotary axis is outside the permitted range of 1 to 10^9 µm or 1 to 10^8 µm (depending on the resolution)	
10	**Incorrect encoder type**		Yes
	Cause	The value for the encoder type is outside the permitted range of 1 to 4	

No.	Meaning		Diagnostic interrupt
11	**Incorrect distance per encoder revolution**		Yes
	Cause	The value for distance per encoder revolution is outside the permitted range of 1 to 10^9 µm (regardless of the resolution)	
13	**Incorrect number of increments per encoder revolution** (see chapter "Machine data of the encoder (Page 73)")		Yes
14	**Incorrect number of revolutions** (see chapter "Machine data of the encoder (Page 73)")		Yes
15	**Incorrect baud rate**		Yes
	Cause	You have specified a baud rate value outside the permitted range of 0 to 3	
16	**Incorrect reference point coordinate**		Yes
	Cause	The coordinate is outside the range of -100 m to +100 m or -1000 m to +1000 m (depending on the resolution). Linear axis: The coordinate is outside the operating range. Rotary axis: The coordinate is greater than the end of rotary axis or < 0.	
17	**Incorrect absolute value adjustment**		Yes
	Cause	SSI encoder: The value of the absolute encoder adjustment is not in the encoder range (increments per encoder revolution x number of revolutions - 1).	
18	**Incorrect type of reference point approach**		Yes
	Cause	You have specified a value other than 0, 1, 2, and 3	
19	**Incorrect count direction**		Yes
	Cause	You have specified a value other than 0 and 1	
20	**Hardware monitoring not possible**		Yes
	Cause	You have set message frame error monitoring to "FALSE" in the parameter DB The monitoring of missing pulses is not possible with the encoder used. Disable the MON_PULSE parameter.	
21	**Incorrect software limit switch start**		Yes
	Cause	Linear axis: The software limit switch start is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m, depending on the resolution). Linear axis: The software limit switch start (including any existing zero offset) is less than -100 m or -1000 m (depending on the resolution).	
22	**Incorrect software limit switch end**		Yes
	Cause	Linear axis: The software limit switch end is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m, depending on the resolution) or is less than the software limit switch start. Linear axis: The software limit switch end (including any existing zero offset) is greater than +100 m or +1000 m (depending on the resolution).	
23	**Incorrect maximum velocity**		Yes
	Cause	The data that are not listed in the parameter DB must be 0.	

No.	Meaning		Diagnostic interrupt
24	**Incorrect target range**		Yes
	Cause	Linear axis: Range between 0 to 100 m or 1000 m, depending on the resolution. Rotary axis: Range greater than the end of rotary axis.	
25	**Incorrect monitoring time**		Yes
	Cause	The value for the monitoring time is outside the permitted range of 0 to 100 000 ms	
26	**Incorrect standstill range**		Yes
	Cause	Linear axis: Range between 0 to 100 m or 1000 m, depending on the resolution. Rotary axis: Range greater than the end of rotary axis.	
127	**Incorrect standstill velocity**		Yes
	Cause	The value for the standstill velocity is outside the permitted range of 0 to 100 000 µm/min	
128	**Incorrect control mode**		Yes
	Cause	You have specified a control mode value outside the permitted range of 1 to 4	
129	**Incorrect start velocity for the reference point approach**		Yes
	Cause	You have specified neither 0 nor 1 as the start velocity	
130	**Incorrect changeover difference in plus direction**		Yes
	Cause	Linear axis: Range between 0 to 100 m or 1000 m (depending on the resolution). Rotary axis: Range greater than the end of rotary axis and less than 1/2 the target range.	
131	**Incorrect changeover difference in minus direction**		Yes
	Cause	Linear axis: Range between 0 to 100 m or 1000 m (depending on the resolution). Rotary axis: Range greater than the end of rotary axis and less than 1/2 the target range.	
132	**Incorrect switch-off difference in plus direction**		Yes
	Cause	The switch-off difference is greater than the plus changeover difference, less than 1/2 target range, or is outside the permissible range between 0 to 100 m or 0 to 1000 m (depending on resolution).	
133	**Incorrect switch-off difference in minus direction**		Yes
	Cause	The switch-off difference is greater than the minus changeover difference, less than 1/2 target range, or is outside the permissible range between 0 to 100 m or 0 to 1000 m (depending on resolution).	
200	**Incorrect resolution**		Yes
	Cause	You have specified a resolution < 0.1 µm/pulse or >1000 µm/pulse. You have specified a distance per encoder revolution and a number of pulses per encoder revolution, that results in a resolution of < 0.1 or > 1000.	

No.	Meaning		Diagnostic interrupt
201	**Encoder does not match the operating range/rotary axis range**		Yes
	Cause	SSI encoder and rotary axis: The encoder does not cover the exact rotary axis range. Linear axis: The encoder does not cover at least the operating range (including software limit switches).	

Class 6: Increment table error

The increment table errors do not result in an error response.

No.	Meaning		Diagnostic interrupt
6	**Specified increment in the increment table is too large**		No
	Cause	The value is outside ±100 m or ±1000 m. The distance increment/target must not be greater than the traversing range. For a rotary axis, the coordinate must be ≥0 and less than the end of rotary axis.	

Class 15: Messages

Messages do not result in an error response.

No.	Meaning		Diagnostic interrupt
1	**Start of parameter assignment**		No
	Cause	The module has detected a parameter assignment via a system data block	
2	**End of parameter assignment**		No
	Cause	The module has processed the parameter assignment via a system data block error-free	
11	**Distance to changeover point too short**		No
	Cause	The hardware response times cannot be adhered to because the distance between the switching points is too short	
12	**Distance to reversal point too short**		No
	Cause	The hardware response times cannot be adhered to because the distance between the switching points is too short	
14	**Distance to switch-off point too short**		No
	Cause	The hardware response times cannot be adhered to because the distance between the switching points is too short	
15	**Distance to target range start too short**		No
	Cause	The hardware response times cannot be adhered to because the distance between the switching points is too short	

Class 128: Diagnostic errors

No.	Meaning		Diagnostic interrupt
4	**External auxiliary voltage missing**		Yes
	Cause	• External auxiliary 24 V voltage is not connected or has failed • Fuse on the module is defective • Undervoltage • Ground wire break • Short circuit (e.g., at the connected encoder)	
	Effect	• The positioning is canceled on all channels • Outputs are switched off • Cancelation of synchronization for incremental encoders if the auxiliary voltage for the encoder supply is missing • The FM 451 parameters are not assigned • The start enable is cleared	
	Remedy	Make sure that the 24 V connection is correct (If the 24 V connection is correct, then the module is defective)	
5	**Front connector missing (FM 451)**		Yes
	Cause	Front connector of the positioning module is not inserted	
	Effect	• Missing external auxiliary 24 V voltage • Module is not ready for operation	
	Remedy	Insert the front connector onto the positioning module	
51	**Watchdog timer responded**		Yes
	Cause	• Strong interference on the FM 451 • Error in the FM 451	
	Effect	• Module is reset • All outputs are switched off • Provided that after resetting the module no module defect is detected, the module is ready for operation again • The module signals the expired WATCHDOG with "incoming" and "outgoing"	
	Remedy	• Eliminate the interference • Contact the relevant sales department who will require details of the circumstances leading to the error • Replace the FM 451	

No.	Meaning		Diagnostic interrupt
144	**Encoder wire break**		Yes
	Cause	• Encoder cable cut or not plugged in • Encoder has no transverse signals • Incorrect pin assignment • Cable length too long • Encoder signals short-circuited • Edge error of encoder signals • Maximum input frequency of encoder input exceeded • Encoder supply failure
	Effect	• The positioning is canceled • Outputs are switched off • With incremental encoders, synchronization is canceled • The start enable is cleared
	Remedy	• Check the encoder cable • Comply with the encoder specifications • Monitoring can be temporarily disabled using the parameter assignment dialog, but at the responsibility of the operator • Comply with the technical specifications of the module
145	**Absolute encoder error**		Yes
	Cause	The message frame traffic between the FM 451 and the absolute encoder (SSI) is incorrect or interrupted: • Encoder cable cut or not plugged in • Incorrect encoder type • Encoder incorrectly set (programmable encoders) • Message frame length incorrectly specified • Encoder returns incorrect values (encoder defective) • Interference injection on measuring system cable • Selected baud rate is too high • Monoflop time of encoder greater than 64 µs
	Effect	• The positioning is canceled • Outputs are switched off • The start enable is cleared
	Remedy	• Check the encoder cable • Check the encoder • Check the message frame traffic between the encoder and FM 451

No.	Meaning		Diagnostic interrupt
146	**Missing pulses of incremental encoder**		Yes
	Cause	• Encoder monitoring has detected missing pulses • Number of increments per encoder revolution incorrectly entered • Encoder defective: does not return the defined number of pulses • Faulty or missing zero mark • Interference on the encoder cable
	Effect	• The positioning is canceled • Outputs are switched off • The start enable is cleared
	Remedy	• Enter the correct number of increments per encoder revolution (parameter assignment screen) • Check the encoder and its cable • Comply with shielding and grounding regulations • Monitoring can be temporarily disabled using the parameter assignment screen, but at the responsibility of the operator

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