SIEMENS

SIMATIC

FM 351 Positioning Function Module
Installation and Parameter Assignment

Manual

EWA 4NEB 720 6001-02

Edition 1

Safety Guidelines

This manual contains notices which you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows according to the level of danger:

Danger

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

Warning

indicates that death, severe personal injury or substantial property damage **can** result if proper precautions are not taken.

Caution

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

Note

draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

Qualified Personnel

The device/system may only be set up and operated in conjunction with this manual. Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical description, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Disclaimer of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

Preface

Purpose

This manual describes all the steps that are necessary to effectively use the FM 351 Positioning Function Module.

Audience

This manual describes the hardware and software of the FM 351 Positioning Function Module. The manual contains the following subjects:

- Principles of positioning
- Installing and removing the FM 351
- Wiring the FM 351
- Assigning the FM 351 parameters
- Programming the FM 351
- Setting up the FM 351
- Reference information
- Appendices

Additional Assistance

For queries about the use of products described in this manual, the answers to which you cannot find here, please consult your Siemens contact person at the appropriate representatives and offices. You will find addresses, for example, in the appendix “SIEMENS Worldwide” to the manual *S7-300 Programmable Controller, Hardware and Installation*.

With queries or comments about the manual itself, please fill in the reply slip located at the end of the manual and return it to the stated address. Please also enter your personal assessment in the manual reply slip.

We offer courses designed to make your introduction to the SIMATIC S7 Programmable Controller easier. To obtain information about these, please contact your regional training center or the central training center in D-90027 Nuremberg, Tel. +49-911-895-3154.

Scope of this Manual

This manual contains the description of the FM 351 Positioning Function Module which is valid at the time of publication. We reserve the right to describe changes to the functional features of the FM 351 in product information.

CE Labeling

Our products fulfill the requirements of the EU guideline 89/336/EWG “Electromagnetic Compatibility” and of the harmonized European standards (EN) listed in it.

The EU declarations of conformity are kept available for the responsible authorities according to the above-mentioned EU guideline at:

Siemens Aktiengesellschaft
Automation Division
AUT E 148
P.O. Box 1963
D-92209 Amberg
Germany

Other References

In the appendix you will find a list of other references about the S7-300 and programmable logic controllers.

How to Use This Manual

The manual contains the following access aids to make it easier for you to access special information:

- At the beginning of the manual you will find a comprehensive contents list together with lists of figures and tables contained in the complete manual.
- In the chapters you will find information giving you an overview of the section's contents in the left-hand column on each page.
- Following the reference chapter, you will find a glossary in which the important specialist terms used in the manual are defined.
- At the end of the manual you will find a comprehensive index, enabling you quick access to the required information.

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Product Overview

1

FM 351

The FM 351 Positioning Function Module for rapid and creep speed drives is used for controlled positioning. The module consists of two independent channels and can therefore control rotary or linear axes. An incremental or absolute encoder (SSI) can be connected to the module for each channel.

The module operates automatically. A user program in S7 controls the positioning module.

Functions

The FM 351 Positioning Function Module for rapid and creep speed drives is equipped with powerful operating modes, settings and commands. The most important of these are listed below:

- Absolute and relative incremental modes
- Search for reference
- Set actual value, set reference point
- Loop mode and many more.

The FM 351 Positioning Function Module for rapid and creep speed drives does not need any maintenance and requires no batteries.

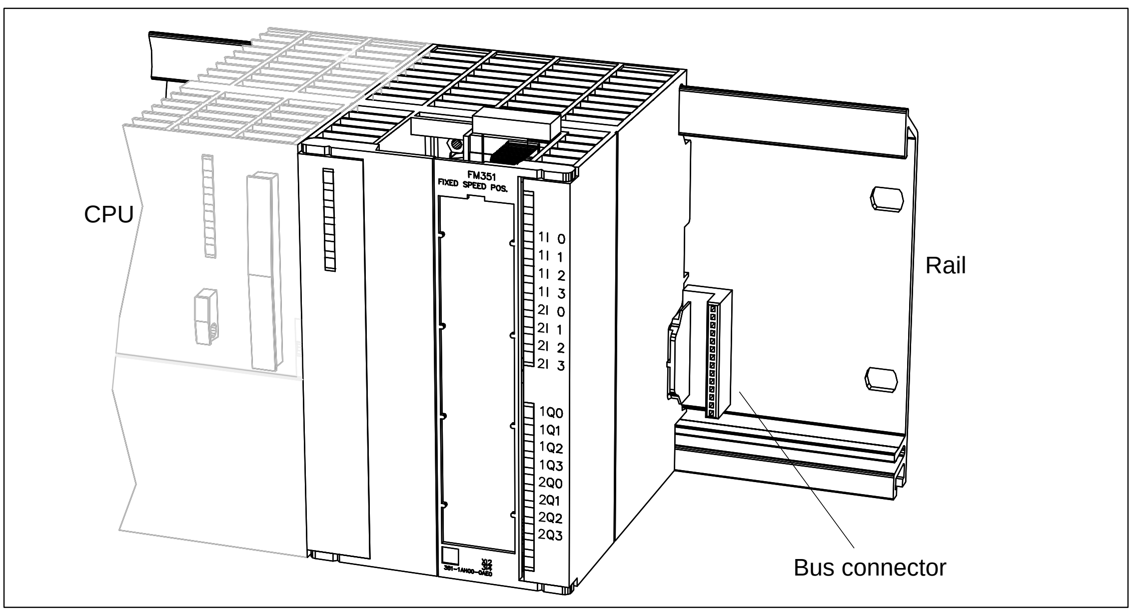

Figure 1-1 View of the FM 351 Positioning Function Module

FM 351 in the S7-300

The S7-300 Programmable Controller consists of a CPU and various signal modules which are mounted on a rail.

You can operate a number of FM 351 Positioning Function Modules simultaneously. Combinations with other FM/CP modules are also possible. A typical application is the combination with an FM 352 Electronic Cam Controller.

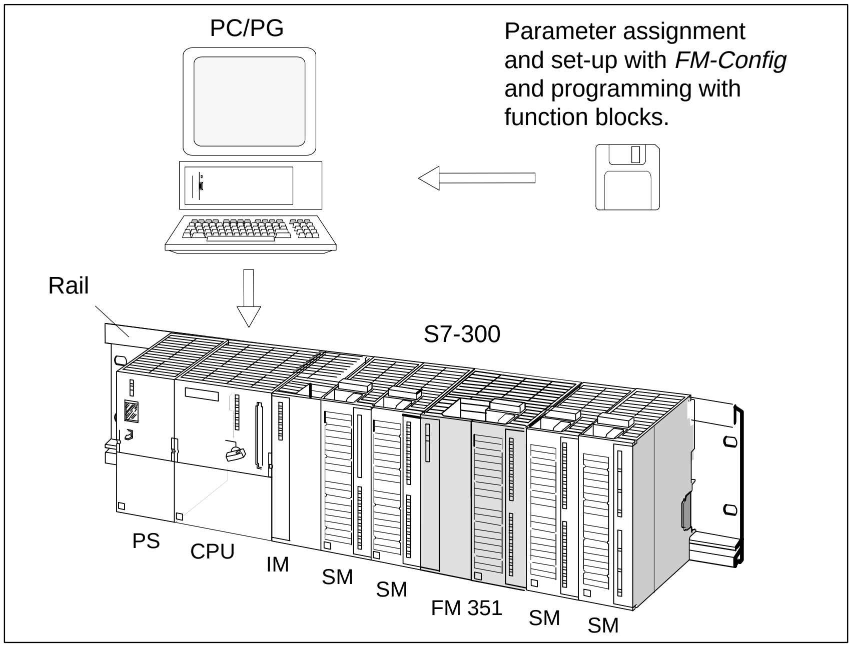

Figure 1-2 FM 351 in the S7-300

Chapter Overview

You will find the following subjects in this chapter:

1.1 FM 351 Fields of Application

Fields of Application

Below are a few examples from the field of controlled positioning which show the variation of applications possible with the FM 351.

Control of Feed Processes

Various wooden parts are processed with a profile machine. Different working steps and routing heads are required to process the wood. The various heads are changed by a controlled positioning process.

Simple Handling Processes

The molded parts in an injection molding machine are removed from the tool by a gripper arm. The arm is controlled by the positioning module.

High-Bay Warehouse

Standard containers are stored in a high-bay warehouse.

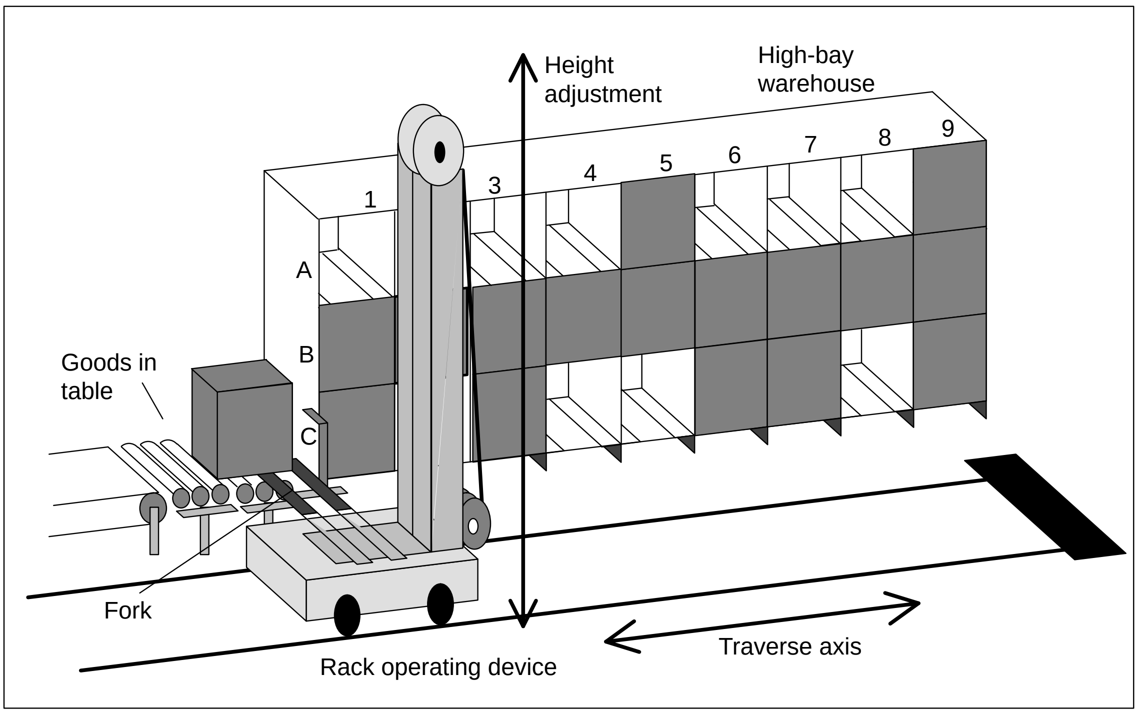

Figure 1-3 Example of a High-Bay Warehouse

1.2 Components in Open-Loop Positioning

Control Circuit

In Figure 1-4 you can see the control circuit and components of an open-loop positioning system.

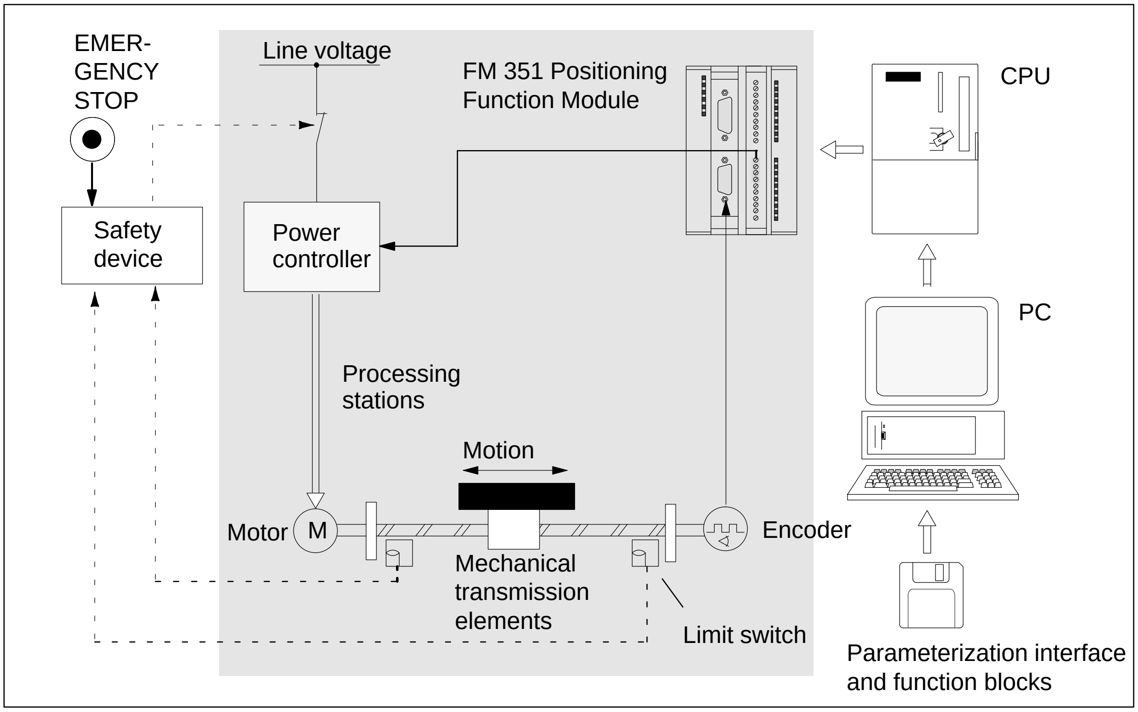

Figure 1-4 Electronic Cam Controller

Power Controller

The power controller is controlled via digital outputs. It may, for example, consist of a contactor circuit.

The power controller switches the motor off:

- When operating faults occur (user presses EMERGENCY STOP switch)
- When the limit switch is reached (safety device trips the power controller)

Motor

The motor is controlled by the power controller and drives the axis.

FM 351 Positioning Function Module

The FM 351 Positioning Function Module determines the present actual position of the axis via an encoder. Here, pulses are measured which are proportional to the distance moved.

On reaching certain axis positions the power controller is controlled appropriately via the digital outputs.

Mechanical Transmission Elements (Axis)

The mechanical transmission elements include:

- Toothed belts
- Spindle
- Toothed rack/pinion
- Hydraulic cylinder
- Gear unit
- Coupling systems

CPU

The CPU executes the controlling user program (sequential program). Data and signals are interchanged via function blocks.

PC/PG (Programming Device)

The PC/PG (programming device) is used for

- Parameterization: You parameterize the FM 351 with the parameterization interface.
- Testing and setting up with the parameterization interface.
- Programming: You program the FM 351 with function blocks which you can directly link into the user program.

Principles of Positioning

2

What Does 'Controlled Positioning' Mean?

Encoders supply pulses or numerical values as output signals. The encoder output signals describe the displacement of the load to be positioned. When the displacement reaches a specified setpoint, then with controlled positioning the drive is switched over or switched off.

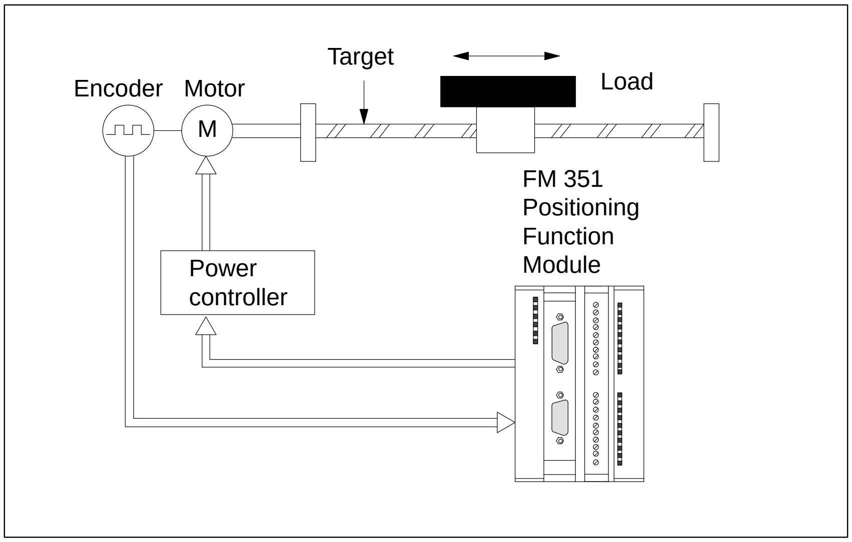

Figure 2-1 Controlled Positioning

Open-Loop Positioning

Each positioning process has the following features:

- A target position to which the load is positioned.
- A travel range.
- Parameters determining the positioning sequence.

The target position is first approached at high speed (rapid speed). At a specified distance from the target position the speed is switched to a lower speed (creep speed). Shortly before the axis reaches the target position, and also at a specified distance from the target position, the drive is switched off. The FM 351 executes the target approach and ensures reliable positioning. The FM 351 is a positioning module for open-loop positioning.

If you carry out open-loop positioning with the FM 351, the drive is controlled with rapid and creep speeds in the appropriate direction using digital outputs.

With the FM 351 Positioning Function Module for rapid and creep speed drives you can position two axes independently of one another. These axes can be rotary or linear axes.

Chapter Overview

You will find the following subjects in this chapter:

2.1 Ranges and Switching Points in the Region of the Target Position

2

Introduction

This chapter gives information about the combined effects of individual machine data. You will find a description of the machine data in Chapter 8.

Definition of the Switching Points and Ranges

Each target position is characterized by a number of ranges which you parameterize by entering values. Each range carries out a different task:

Range	Explanation
Switchover difference	A specified displacement, defining the distance to the target, at which the drive switches from rapid speed to creep speed.
Switch-off difference	A specified displacement, defining the distance to the target, at which the drive is switched off.
Standstill range	A symmetrical range about the target position. This range becomes active when PEH is signaled. If the range is left without a valid request, the FM 351 signals an error.
Target range	A symmetrical range about the target position. The target is reached when the drive undercuts the standstill velocity within this range.

Position of the Switching and Monitoring Ranges

The figure shows you how the switching points and ranges about the target position are arranged.

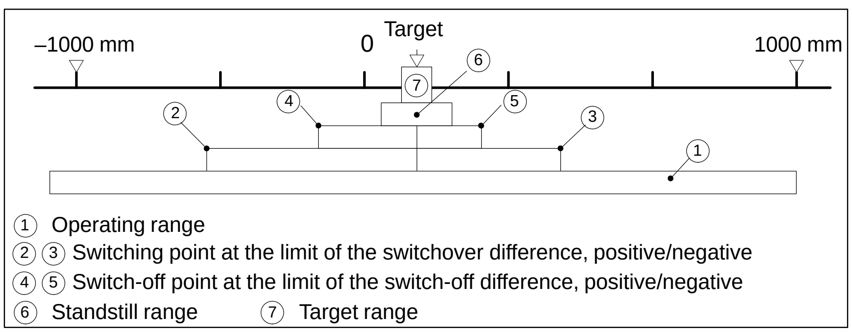

Figure 2-2 Ranges and Switching Points Around the Target

Rules for the Ranges

Note the following rules for the ranges shown:

- The half target range must be smaller than the switch-off difference (incl. the limits).
- The switch-off difference must lie within the relevant switchover difference.
- The dynamic characteristics of the drive must be considered when inputting values so that a reliable approach to the target is possible.

2.2 Positioning Velocity Curve

Introduction

This chapter gives an overview of the basic curve for positioning on a target.

Velocity Curve on Approaching a Target Position

The velocity and also the basic curve mainly depend on the possibilities provided by the power controller which you are using.

We show you the basic sequence on approaching a target position in Fig. 2-3 below.

For the sake of simplicity we have assumed that the velocity changes linearly over the distance traveled.

The following basic curve for positioning is then produced:

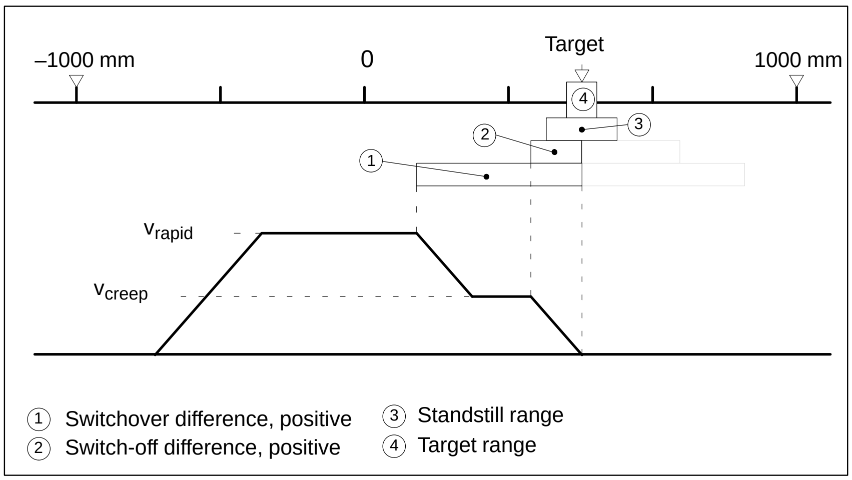

Figure 2-3 Velocity Curve on Approaching a Target Position (Basic Shape)

Target Approach

Please refer to Chapter 2.3 for the **target approach**.

The effect of the FM 351 monitoring is shown. In addition, you can see when the FM 351 signals reaching a position.

Evaluation by Program

You can determine all the statuses during positioning from the response signals. Please read Chapter 12 for more information.

2.3 Target Approach

Definition

During a target approach the FM 351 makes various monitoring features and signals available.

This achieves the following:

- The target approach is monitored.
- The signal **Position reached** is generated. You obtain the signal on the parameter POS_RCD of the FC INC_MOD (see Chapter 6.2.1).
- The standstill condition in the standstill range is monitored.

Target Approach

The target approach, which we are going to examine in the following, begins when the switch-off point is reached.

The following sequence should be noted.

1. The FM 351 starts the target-approach monitoring on reaching the switch-off point.
2. The actual value must have reached the target range within the monitoring period.
3. The actual value reaches the target range.
4. When the velocity becomes slower or equal to the value of the standstill velocity within the target range, the FM 351 signals with the signal POS_RCD (**Position reached**) that it has detected the reaching of the target position.

Note

The undercutting of the standstill velocity is only monitored once per target approach.

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5. The monitoring period for the target approach is switched off.
6. The standstill monitoring is switched on. The standstill range is positioned symmetrically about the target position and monitored.

   If the actual value leaves the standstill range without a new start request being issued, the FM 351 signals an error.

Schematic: Target Approach

The figure clearly illustrates the sequence.

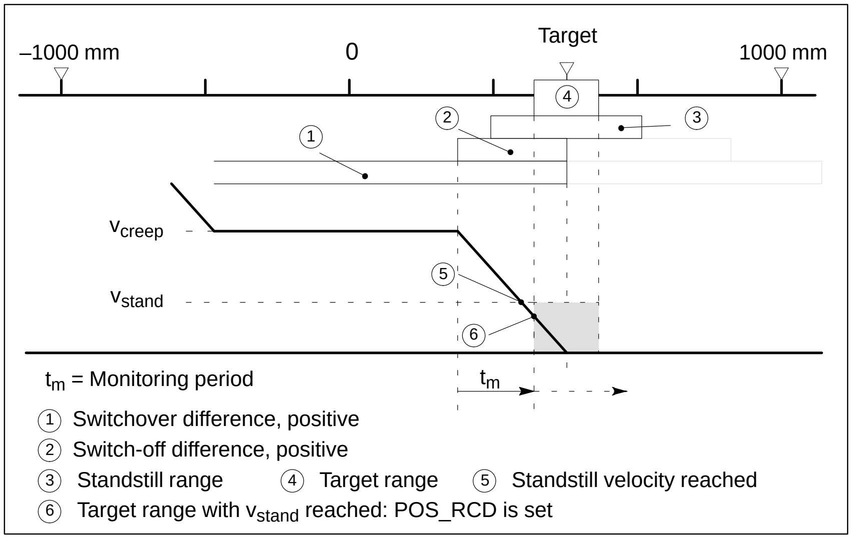


Figure 2-4 Target Approach of Positioning

2.4 End of Positioning

Definition

You must differentiate between two cases for the end of positioning:

- The positioning is correctly terminated via the switchover and switch-off differences. This process is termed the **end** in the following.
- The positioning is immediately terminated by a “hard” action. This process is termed **abort** in the following.

End

End signifies that the positioning process is terminated at the switching points conforming to the differences from rapid speed via creep speed.

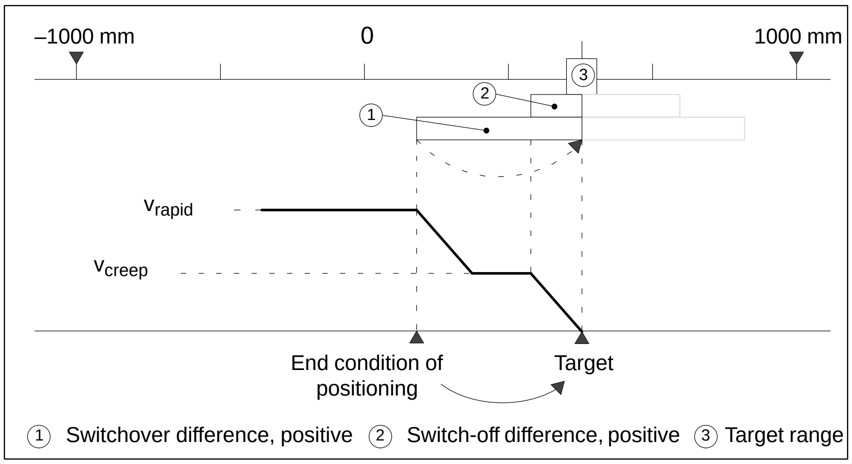


Figure 2-5 End of Positioning

POS_RCD

Pay attention to the following behavior of the signal POS_RCD at the end of positioning:

- POS_RCD is set when the specified target has been properly reached during the incremental mode.
- POS_RCD is **not** set:
  - When the operating mode is terminated during the incremental mode with STOP before the specified target is reached.
  - During the operating modes jogging or reference-searching.

Abort

Abort means that the positioning process is terminated immediately without application of the switchover and switch-off differences from the rapid and creep speeds to standstill.

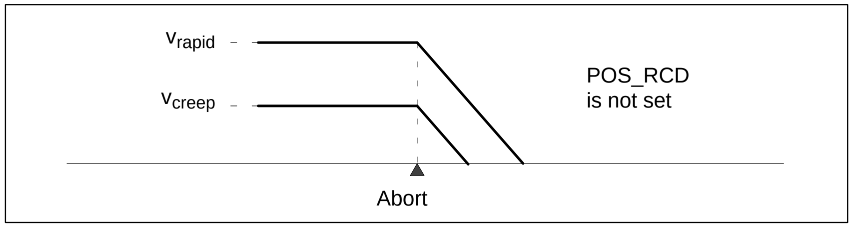


Figure 2-6 Abort of Positioning; The Signal POS_RCD is Not Set

Installing and Removing the FM 351 3

Planning the Mechanical Installation

Information on the options of mechanical installation and how you must proceed during the project planning will be found in the manual *S7-300 Programmable Controller, Hardware and Installation*.

Only supplementary information is given in the following.

Mounting Position

Horizontal mounting in the system on the rail should be preferred.

When mounted vertically, you must pay attention to the restricted ambient temperatures (max. 40 °C [104°F]).

What Must You Take into Consideration during Mechanical Installation?

The FM 351 Positioning Function Module can be mounted at any module location for signal modules on the rail.

When planning the mechanical installation of your controller, you must observe the following rules:

1. The maximum number of modules is restricted by the length of the rail and the width of the modules.

   The FM 351 Positioning Function Module needs 80 mm (3.15 in) module width.

2. The maximum number is restricted by the sum of the current consumptions from the 5 V backplane bus supply of all modules to the right of the CPU.

   The current consumption of the FM 351 from the backplane bus is 200 mA. Pay attention to the maximum current consumption from the backplane bus on the S7-300.

Chapter Overview

You will find the following subjects in this chapter:

3.1 Installing the FM 351 Positioning Function Module

Rules

No special protective measures (ESD guidelines) are required for the installation of the FM 351 Positioning Function Module.

Warning

Only mount the FM 351 Positioning Function Module when the CPU is in the STOP operating state.

If you disregard this stipulation, damage may be caused to the connected peripheral equipment.

Tool Required

You will need a 4.5 mm (0.25 in) screwdriver to install the FM 351 Positioning Function Module.

Procedure

The following list describes how you mount the FM 351 Positioning Function Module onto the rail. Further information about the installation of modules can be found in the manual *S7-300 Programmable Controller, Hardware and Installation.*

1. An expansion bus is included with the FM 351 Positioning Function Module. Plug this onto the module bus plug to the left of the FM 351 Positioning Function Module. (The bus plug is located on the back panel, and you must loosen the module again if necessary).
2. If further modules are to be mounted to the right, then first plug the expansion bus of the next module to the right-hand bus plug on the FM 351 Positioning Function Module.

   If the FM 351 Positioning Function Module is the last module in the row, do not plug in any expansion bus.
3. Screw the FM 351 Positioning Function Module firmly (tightening torque approx. 80 ... 110 Ncm).
4. After installation you can allocate a module location number to the FM 351 Positioning Function Module. For this, there are module location labels which are included with the CPU.

   The scheme to be adopted for numbering and how you fit the module location labels can be found in the manual *S7-300 Programmable Controller, Hardware and Installation.*
5. Mount the shield support element.

   Order No.: 6ES7 390-5AA00-0AA0

3.2 Removing the FM 351 Positioning Function Module

Tool Required

You will need a 4.5 mm (0.25 in) screwdriver to remove the FM 351 Positioning Function Module.

Procedure

The following list describes how you remove the FM 351 Positioning Function Module:

1. Switch off the power controller.
2. Switch off the 24 V supply to the FM 351 Positioning Function Module.
3. Switch the CPU to the STOP state.
4. Open the front doors. Take out the labeling strips, if present.
5. Release the front plug and withdraw it.
6. Loosen the subminiature Cannon connector to the encoders.
7. Loosen the fixing screw on the module.
8. Swivel the module from the rail and unhinge the module.

Wiring the FM 351

4

Important Rules

It is essential for the safety of the system to install the switching elements mentioned below and to adapt them to your system conditions.

- EMERGENCY STOP switch enabling you to switch off the complete system.
- Start/finish limit switches which directly switch off the power controller.
- Motor protecting switch to protect the motors.

Other Literature

Please also pay attention to the following chapters in the manual *S7-300 Programmable Controller, Hardware and Installation:*

- Guideline for Handling Modules at Risk from Electrostatic Discharge (ESD): Appendix D.
- Planning the Electrical Installation: Chapter 4.

As a further source of information on the subject of EMC guidelines, we recommend the publication: *Equipment for Machine Tools, EMC Guidelines for WS/W*F Techniques, Order No.: 6ZB5440-0QX01-0BA1.

Standards and Regulations

You must observe the appropriate VDE guidelines when wiring the open-loop positioning system.

Wiring Diagram

In Figure 4-1 you can see a wiring diagram for an open-loop positioning system using the FM 351 Positioning Function Module.

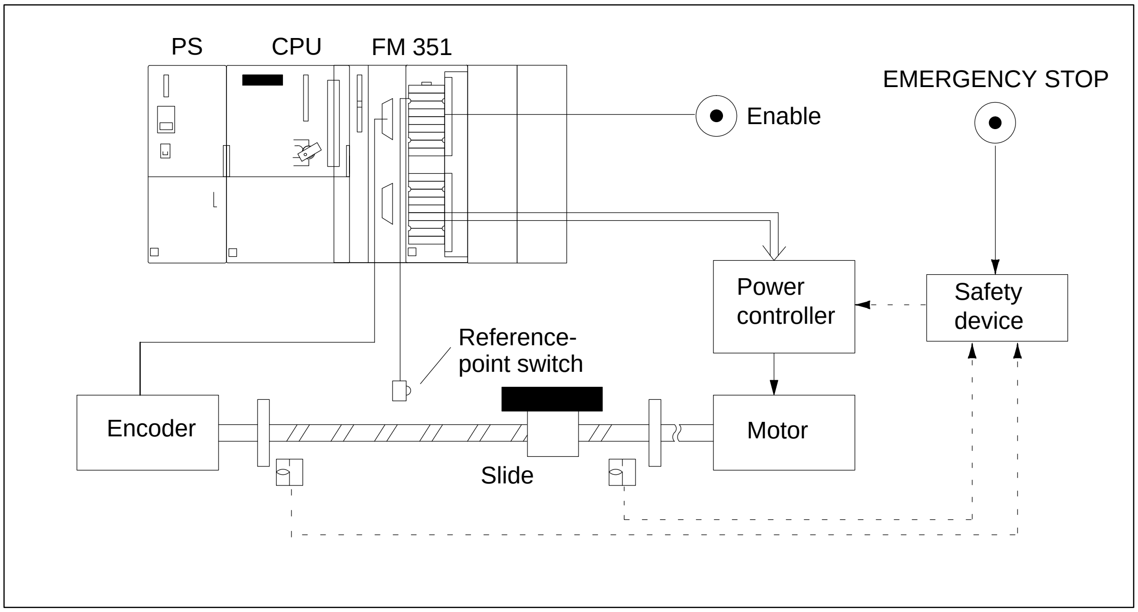


Figure 4-1 Wiring Diagram for an Open-Loop Positioning System

Installation in a Cabinet

A diagram of a cabinet installation is shown in Figure 4-2. The FM 351 Positioning Function Module, the CPU and power supply module are situated in the right part of the cabinet. The power controller is accommodated in the left part of the cabinet. The right and left parts of the cabinet are separated spatially by a grounded partition.

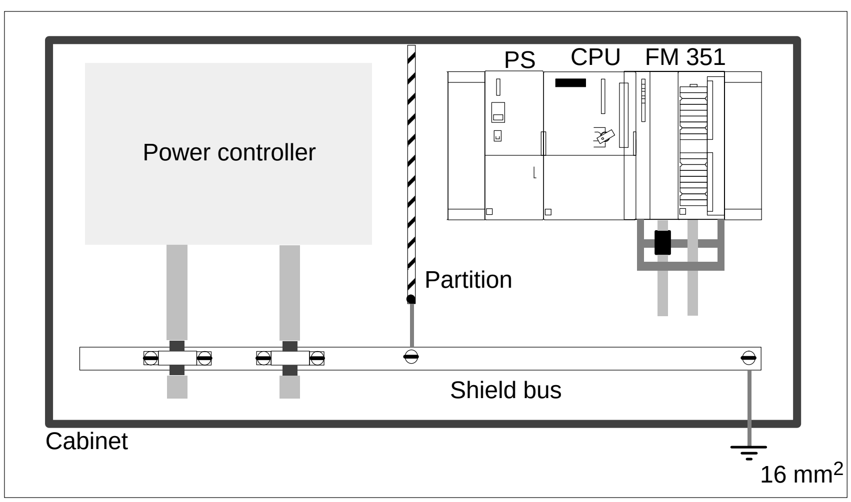


Figure 4-2 Installation in a Cabinet

Shielding

The cable connections for the encoders should be implemented using shielded cables.

To ensure operation free of interference it is essential that the connecting encoder cables are grounded at both ends. The cable shield to the encoder must be joined both to the shield connector block on the FM 351 Positioning Function Module as well as in the peripheral connector plug.

Chapter Overview

You will find the following subjects in this chapter:

4.1 Wiring the Power Controller

Power Controller

The power controller is connected to the digital outputs on the FM 351. The motor is controlled by the power controller.

The power controller may for example consist of a simple contactor circuit.

Contactor Circuit

In Figure 4-3 you can see the control and load circuits of a power controller. The functions of the digital outputs correspond to Control Mode 1.

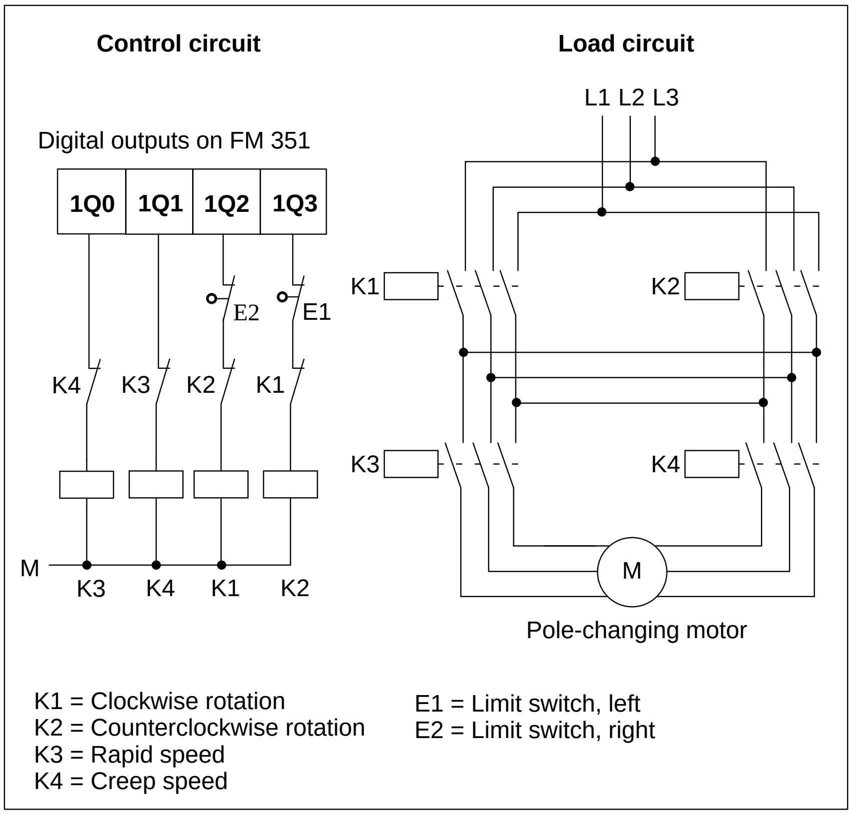


Figure 4-3 Contactor Circuit

Working Principle of the Contactor Circuit

The contactors K1 and K2 control the clockwise and counterclockwise motor rotation. Both contactors are interlocked against one another by the normally closed contacts K2 and K1. The limit switches E1 and E2 are the start/finish limit switches. If these limit switches are activated, the motor (clockwise or counterclockwise rotation) is switched off.

The contactors K3 and K4 switch the motor from rapid to creep speed. Both contactors are interlocked against one another by the normally closed contacts K4 and K3.

Caution

Interlock the line contactors against one another.

Mutual interlocking of the line contactors is shown in Figure 4-3.

If you do not observe this rule, then a short circuit can occur in the line network.

4.2 Description of the Encoder Interface

Position of the Subminiature Cannon Sockets

The mounting position and the designation of the sockets on the module are shown in Figure 4-4. Incremental or absolute encoders (SSI) can be connected to the two subminiature Cannon sockets.

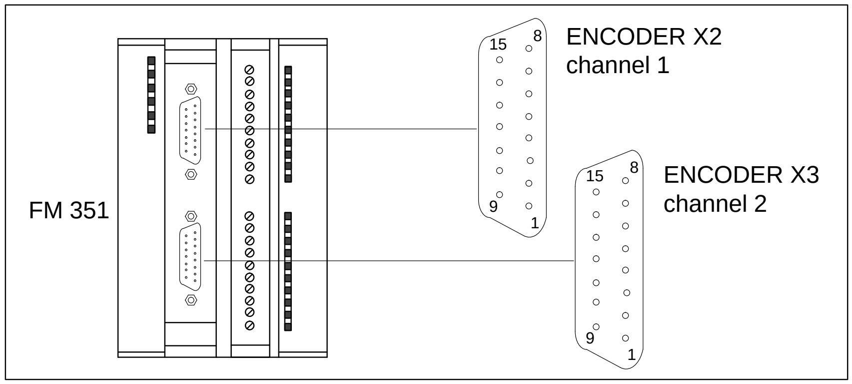


Figure 4-4 Position of the Subminiature Cannon Sockets X2 and X3

Assignment of the Sockets X2 and X3

Table 4-1 shows the assignment of the 15-pin subminiature Cannon sockets:

Table 4-1 Assignment of the 15-Pin Subminiature Cannon Sockets X2 and X3

Pin	Name	Incremental Encoder	Absolute Encoder
1	A*	Encoder signal A (24 V)	---
2	CLS	---	SSI shift clock
3	$\overline{CLS}$	---	SSI shift clock inverse
4	B*	Encoder signal B (24 V)	---
5	24 VDC	Encoder supply 24 V	
6	5.2 VDC	Encoder supply 5.2 V	
7	M	Ground	
8	N*	Zero mark signal (24 V)	---
9	RE	Current sourcing/sinking (See Chap. B.3)	---
10	N	Zero mark signal (5 V)	---
11	$\overline{N}$	Zero mark signal inverse (5 V)	---
12	$\overline{B}$	Encoder signal B inverse (5 V)	---
13	B	Encoder signal B (5 V)	---
14	$\overline{A}$ / $\overline{DAT}$	Encoder signal A inverse (5 V)	SSI data inverse
15	A /DAT	Encoder signal A (5 V)	SSI data

4.3 Connecting the Encoders

Selecting the Right Encoder

You parameterize the type of encoder in the parameterization interface in the dialog field Encoder Data. Here, you can set the following types of encoders:

- 5 V incremental encoder
- 24 V incremental encoder
- Absolute encoder (SSI)
  - 13 bit
  - 25 bit

You will find the technical data and manufacturers' specifications for the listed encoders in Reference Chapter 10.

Connecting Cables

You should use cables with integral connectors for connecting the encoders. You will find terminal diagrams and the order numbers for the connecting cables in Appendix B.

The connecting cables with integral connectors offered in Appendix B provide the optimum interference immunity and an adequate cross-sectional area for the encoder supply.

Shield Supporting Element

With shielded cables, this element can be inserted into the rail for terminating the shield.

Order number: 6ES7 390-5AA00-0AA0

You will find further information in the manual *S7-300 Programmable Controller, Hardware and Installation*.

Note

When you replace an encoder, you must set the machine data for the axis again.

Connecting the Encoders

The connection of an encoder to the FM 351 Positioning Function Module is shown in Figure 4-5.

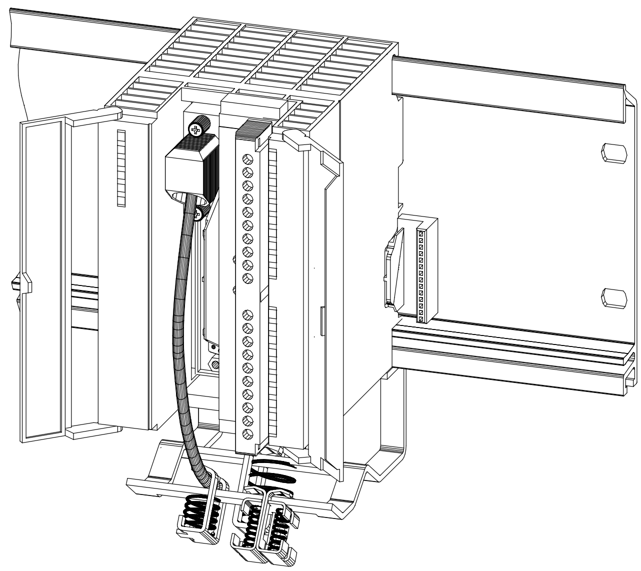


Figure 4-5 Connection of an Encoder to the FM 351 Positioning Function Module

Procedure

Proceed as follows to connect the encoders:

1. Connect the connecting cable to the encoder.

   With absolute encoders it may be necessary to assemble the cable (cable-end at the encoder) according to the manufacturer’s specification.

2. Open the front door and plug the subminiature Cannon connector to the FM 351 Positioning Function Module.

3. Lock the connector with the aid of the knurled screws. Close the front door.

4. Remove the insulating material on the connecting cable and clamp the cable shield in the shield supporting element. To do this, use the shield terminal.

4.4 Description of the Peripheral Interface

Position of the Front Connector

The FM 351 Positioning Function Module with the front doors open is illustrated in Figure 4-6. The front connector X1 is shown in the wiring position. Here you connect the supply voltages, switches and the power controller.

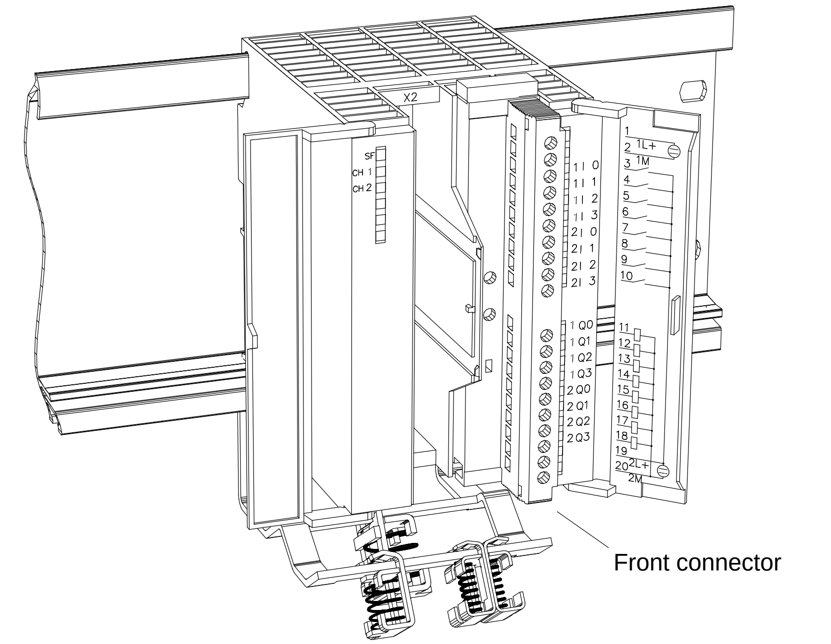


Figure 4-6 Position of the Front Connector

Display Elements

The current status of the peripheral interface is indicated by LEDs which you will find to the right, next to the front connector.

- 8 LEDs for the digital inputs (1I0 to 2I3)
- 8 LEDs for the digital outputs (1Q0 to 2Q3)

Front Connector Assignment

Table 4-2 shows the assignment of the 20-pin front connector.

Table 4-2 Front connector assignment

Teminal	Name	Meaning
1	1L+	24 VDC encoder supply
2	1M	Ground, encoder supply
3	1I 0	Digital input 0 of channel 1
4	1I 1	Digital input 1 of channel 1
5	1I 2	Digital input 2 of channel 1
6	1I 3	Digital input 3 of channel 1
7	2I 0	Digital input 0 of channel 2
8	2I 1	Digital input 1 of channel 2
9	2I 2	Digital input 2 of channel 2
10	2I 3	Digital input 3 of channel 2
11	1Q 0	Digital output 0 of channel 1
12	1Q 1	Digital output 1 of channel 1
13	1Q 2	Digital output 2 of channel 1
14	1Q 3	Digital output 3 of channel 1
15	2Q 0	Digital output 0 of channel 2
16	2Q 1	Digital output 1 of channel 2
17	2Q 2	Digital output 2 of channel 2
18	2Q 3	Digital output 3 of channel 2
19	2L+	24 VDC load power supply
20	2M	Ground, load power supply

Encoder Supply (1L+, 1M)

Here connect a 24 VDC encoder supply for the encoder. The reference potential of this supply (1M) is connected to the ground of the load power supply (2M) in the FM 351.

The 24 VDC encoder supply is monitored for undervoltage and wire breakage.

The 24 VDC encoder supply is converted internally to 5 VDC. This means that 24 VDC and 5 VDC are provided on the encoder interface (Cannon connector X2 and X3) for the different types of encoders.

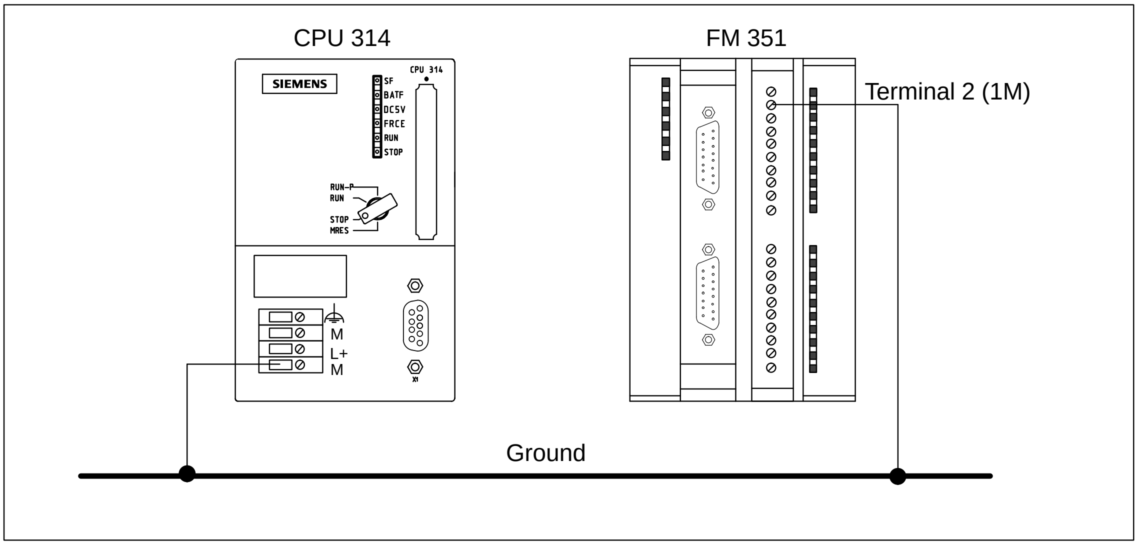
Caution

Make sure the polarity of the encoder supply (1L+, 1M) is correct.

If you connect the encoder supply with incorrect polarity, then the module will become defective and must be replaced.

Connected Potentials

The ground of the encoder supply is non-isolated with respect to the CPU ground, that is, Terminal 2 (1M) should be connected with low resistance to the CPU ground.



8 Digital Inputs (1I 0 bis 2I 3)

The FM 351 has 4 digital inputs per channel.

Here, you can connect bounce-free switches (24 V current sourcing) or non-contact sensors (2 or 3-wire proximity switches).

The digital inputs are not monitored for short circuit or wire breakage. The digital inputs are isolated with respect to the module ground.

Function of the Digital Inputs

The function of the digital inputs depends on the encoder used:

Table 4-3 Digital Input Functions

Digital Input	Incremental Encoder	Absolute Encoder
1I0; 2I0	Reference point switch	Not used
1I1; 2I1	Reversing switch	Not used
1I2; 2I2	Enable input	Enable input
1I3; 2I3	Not used	Not used

Function of the Digital Outputs

The power stage is controlled by the digital outputs. The function of the digital outputs depends on the control mode. You select the control mode in the parameterization interface.

Table 4-4 Digital Output Functions

Output Q	Control Mode			
	1	**2**	**3**	**4**
1Q0/2Q0	Rapid speed	Rapid/creep speed	Rapid speed	Rapid speed, positive
1Q1/2Q1	Creep speed	Position reached	Creep speed	Creep speed, positive
1Q2/2Q2	Approach, positive	Approach, positive	Approach, positive	Rapid speed, negative
1Q3/2Q3	Approach, negative	Approach, negative	Approach, negative	Creep speed, negative

Load Power Supply (2L+, 2M)

You must connect a 24 V load power supply for the digital outputs to the terminals 2L+ and 2M. The FM 351 Positioning Function Module does not operate if the polarity is reversed.

Caution

Pay attention to the correct polarity for the load power supply (2l+, 2M).

If you connect the load power supply with incorrect polarity, the module is defective and must be replaced.

4.5 Wiring the Peripheral Interface

Wiring the Front Connector

Figure 4-7 shows the wiring of the front connector.

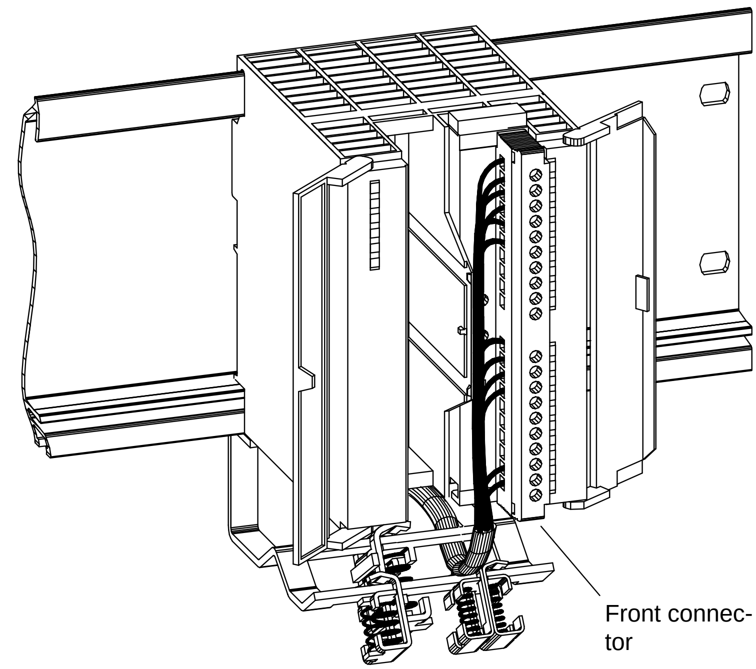


Figure 4-7 Wiring of the Front Connector

Connecting Wires

Flexible wire, cross-sectional area 0.25 mm^2 to 1.5 mm^2.

Wire end ferrules are not required.

You can use wire end ferrules without insulating collars (DIN 46228, Form A, long version).

You can connect two wires each with 0.25 mm^2 to 0.75 mm^2 in one wire end ferrule.

Note

If you connect touch probes or proximity switches, then you must use shielded wires to obtain the optimum interference immunity.

Tool Required

Screwdriver or motor-driven screwdriver, 3.5 mm (0.14 in).

Procedure

To wire the front connector, proceed as follows:

1. Strip 6 mm (0.25 in) from the wire, fitting a wire end ferrule if required.
2. Open the front door, bring the front connector to the wiring position.
3. Fit the strain relief to the connector.
4. If you bring out the wires downwards, begin the wiring from below, otherwise at the top. Also screw down terminals which are not used.

   The tightening torque is 60 Ncm to 80 Ncm.
5. Pull the strain relief for the cable tree.
6. Push the front connector into the operating position (pressing the locking element).
7. You can fill in the enclosed label and insert it into the front door.

Note

No shielded cables are required when wiring the digital inputs and outputs up to the following cable lengths:

- Digital inputs: max. 100 m (110 yds)
- Digital outputs: max. 100 m (110 yds)

FM 351 Parameterization

5

Introduction

You parameterize the positioning module with the parameterization software. The software is intended for the FM 351 and the FM 451. The description of operation can be found in the integrated help.

Requirements

Before you begin the parameterization of the FM 351 Positioning Function Module, you should check the following requirements:

- STEP 7 from V2.0 is correctly installed on your programming device/PC.

Installation

The complete software (parameterization software and function blocks) is located on a 3.5 in. diskette. You install the software as follows:

1. Insert the diskette into the disk drive on your programming device/PC.
2. Under Windows 95 start the dialog on the installation of the software by double clicking the symbol “Software” in “System Control”.
3. In the dialog select the disk drive and the file **Setup.exe** and start the installation process.
4. Step by step follow the instructions which the installation program displays.

   Result: The software is installed in the following folders:

   – Function blocks: **STEP7_V2\S7LIBS\FM_POS**

   – Example: **STEP7_V2\EXAMPLES\FM_POSP**

Note

If you selected a folder other than STEP7_V2 for the STEP 7 installation, this folder is recorded.

Configuration

For configuration it is assumed that you have created a project in which you can store the parameterization. You will find further information on the configuration of modules in your user manual *Standard Software for S7 and M7, STEP 7*. Only the most important steps are explained below.

1. Start the *SIMATIC Manager* and call the configuration table into your project.
2. Select a module rack and allocate it.
3. Open the rack.
4. Select the FM 351 Positioning Function Module with the relevant order number from the module catalog.
5. Drag the FM 351 Positioning Function Module into the appropriate line in the configuration table.
6. From the configuration table note the input address for the FM 351 Positioning Function Module, for example 336.

   The value which you read out is displayed in decimal format.

Parameterization

Now you can start the parameterization of the FM 351 Positioning Function Module.

During parameterization you adjust the interface-specific parameters. The parameterization is carried out with the parameterization software.

1. Double click the order number for the FM 351 Positioning Function Module in the configuration table or use the menu command **Edit ▸ Open object....**

   Result: You enter the dialog field “Basic parameters”.
2. Parameterize the basic parameters for the FM 351 Positioning Function Module.
3. Click the button “Parameters...”.

   Result: You enter the parameterization interface.
4. Parameterize and test the FM 351 Positioning Function Module and save the entered parameters with **File ▸ Save** to the configuration interface.
5. Terminate the parameterization software.
6. Save your project in the configuration interface.
7. Load the parameterization data with the CPU in the STOP state using **Target system ▸ Load ▸ Project.**

   Result: The data is loaded in the CPU memory and is directly transferred to the FM 351.
8. Execute a CPU start.

Integrated Help

The parameterization interface is equipped with integrated help which supports you when parameterizing the positioning module. You call the integrated help as follows:

- Via the menu command **Help ▸ Help topics...**
- By pressing the **F1** key.

Supply Channel DB

Before you program the module with the user program, you must supply the channel DB with important data.

1. From STEP 7 call the channel DB **DB_ABS** or **DB1** (project folder) of a channel using the *Program Editor.*
2. At the address MOD_ADR enter the module address of the FM 351 Positioning Function Module in hexadecimal notation, for example 336.
3. At the address CH_ADR enter the channel start address in hexadecimal notation. The channel address is channel specific:
   – Channel 1: Channel start address (xxx.x) = (Module address in hexadecimal notation · 8) (for example, 336 · 8).
   – Channel 2: Channel start address (xxx.x) = (Module address in hexadecimal notation + 8) · 8 (for example, (336+8) · 8).
4. At the address DS_OFFS enter the channel offset in hexadecimal notation. The channel offset is channel specific:
   – Channel 1: Channel offset = 0
   – Channel 2: Channel offset = 40
5. Save the channel DB.

Programming the FM 351

6

The Programming Package

In order that you can use the FM 351 effectively, you have the functions available in the form of a number of FCs. These function blocks are subdivided into three groups:

- Function blocks (FCs) which **control** the FM 351.
- Function blocks (FCs) which **write** data, settings and commands to the FM 351.
- Function blocks (FCs) which **read** data from the FM 351.

The Learning Objective

In this chapter we describe how you can link the separate functions into your user program. In addition you become familiar with and obtain experience of the conditions surrounding the FCs, and what role the channel DB plays.

At the end of the chapter you will be able to control your FM 351 from your program.

Reference

You will find a description of all FCs in the Chapters 6.2 to 6.4. These explain all the parameters.

Chapter 6.1 explains how you call the separate FCs.

Chapter Overview

You will find the following subjects in this chapter:

6.1 Principles of Programming an FM 351

Requirements for Programming

The following requirements must be fulfilled if you want to control the FM 351 from your user program:

- Your S7-300 system must be configured.
- STEP 7 from Version 2.0 must be installed on a computer.
- The computer must be connected to the CPU on the S7-300.
- Your FM 351 must be parameterized. You have created the following data in the parameterization interface:
  - Machine data
  - Incremental dimensions
- The channel DBs are required for the program sequence and must therefore be present in the CPU.
- The relevant channel DB must be correctly assigned with data before each function is called. An example of this is given in Chapter 6.3.
- Prepare the channel DB for operation with the FM 351.

Preparing the Channel DB

When working with the FM 351 you must enter the module allocation in the channel DBs. You achieve this with the following entries:

Table 6-1 Entries in the Channel DB

Entries in the Channel DB	Description
MOD_ADR	Here enter in hexadecimal notation the module address which was displayed in the configuration interface in the line for the order number.
CH_ADR	The channel addresses are as follows: • Channel 1: MOD_ADR · 8 (in hexadecimal notation) • Channel 2: (MOD_ADR + 8) · 8 (in hexadecimal notation)
DS_OFFS	The data record offset is • for Channel 1 always “0” (in hexadecimal format) • for Channel 2 always “40” (in hexadecimal format)

Programming Rules

When you now write your program code, note that you only need to link the FCs which you actually need for your application.

Make sure that the separately written functions are mutually interlocked. Generally, only one write job at a time may be executed on the FM 351.

Irrespective of the extent of the interlocks which you program, you should ensure that the FC DIAG_INF is only called when really needed, that is with a diagnostic interrupt. You set the condition for reading in the interrupt OB (OB 82).

Note

Calling the FC DIAG_INF is not possible in the interrupt OB.

Decentralized Operation

The parallel calling of a number of functions in one cycle is not permitted. You must program suitable interlocking mechanisms to prevent parallel calling.

Centralized Operation

Centralized operation enables the parallel calling of the separate functions in one cycle.

Chapter Overview

6.1.1 Principle of Communication between CPU and FM 351

Introduction

We introduced you to the three-way subdivision of the function blocks for the FM 351 in the overview to Chapter 6. In this Chapter we will show you how the separate function blocks control the communication between the CPU and FM 351.

Overview of the Function Blocks

First of all, we would like to briefly introduce you to all the available blocks with their names and tasks. You will see that for your application you only need to select blocks.

Table 6-2 Overview of All Available Function Blocks

Block				Overview of Task	Reference in Chapter
Task	**Name**	**Type**	**No.**		
Control	INC_MOD	FC	0	Incremental operating mode; approach to positions in incremental table and to increments 254 and 255.	6.2.1
	JOG_MODE	FC	10	Jogging operating mode for traversing the axis manually.	6.2.2
	REF_MODE	FC	11	Seek-reference-point operating mode; finding the reference point for synchronizing the axis.	6.2.3
Write	REFPT	FC	1	Setting - Set reference point.	6.3.1
	ACT_VAL	FC	2	Setting - Set process variable.	6.3.2
	SNG_FCT	FC	5	Transfer separate settings.	6.3.3
	SNG_COM	FC	6	Call separate commands.	6.3.4
	TG254	FC	12	Transfer Increment 254 for incremental mode.	6.3.5
	TG253_5	FC	13	Transfer Increment 255 and associated difference values for the incremental mode.	6.3.6
Read	DIAG_INF	FC	8	Read the diagnostic data from the FM 351.	6.4.1
	ACT_DAT	FC	9	Read the operating and service data.	6.4.2

Communication

The following summarizing figure shows you how a communication is executed.

The following abbreviations are used in the figure:

- MD = Machine data
- IT = Incremental table (set values)
- DB* = Channel DB for channel *

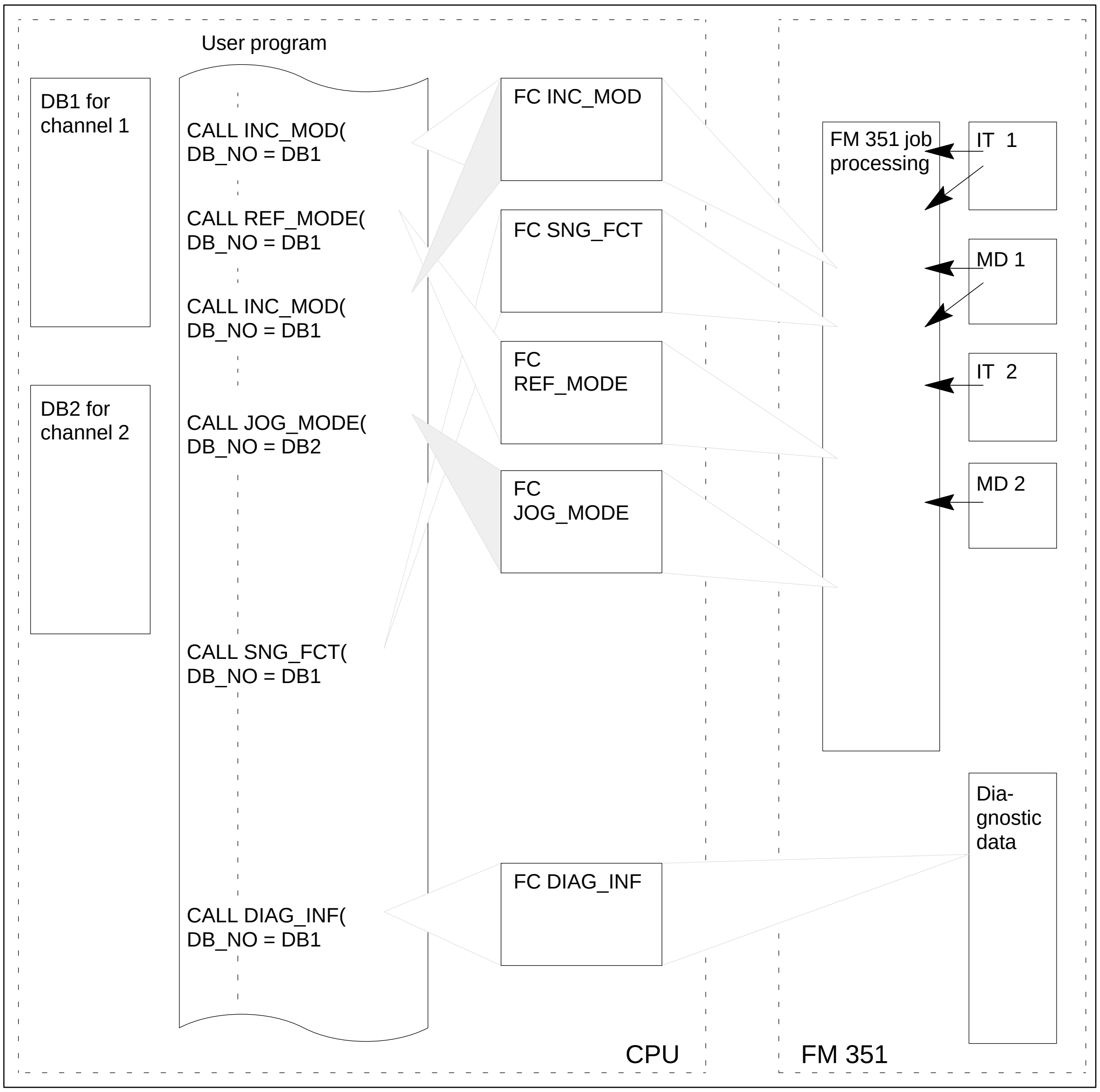


Figure 6-1 Principle of Communication between the CPU and FM 351

6.1.2 Calling Functions

Requirements

When you link the FM 351 into your program, please pay attention to the following requirements.

- The parameterization for the two channels in the FM 351 has been completed. That is, there is valid data in the CPU.
- The channel DB is present and assigned appropriate to the configuration of the system. That is, you have pre-assigned the channel DB for use with the FM 351.
- You have set up the FM 351 properly and optimized it.

Loading Parameterization Data into the FM 351

The module is automatically parameterized by the system. The CPU loads all data into the FM 351. The FM 351 checks the data and is parameterized if no error occurs.

1. Switch the CPU from STOP to RUN.
2. The complete restart OB is run.
3. The CPU starts executing the program at the start of OB1.

Rules for Calling the Functions

Take note of the following rules for calling the FCs.

- The relevant function block must be called separately for each channel.
- Only link FCs into your program which you really need. Sharing the functional features across many FCs helps to keep down the memory requirement for the applications.
- Functions which write data must not be active simultaneously.
- Functions which write data must remain called until the initiated job has been completely processed.
- The data must be valid. To ascertain this, interrogate the PARA bit from the channel DB.

Centralized Operation

For each channel you must ensure that:

- Only **one** mode block **is called and is active**.
- In parallel to this, only **one** FC **is called and active** for writing data.
- In parallel to this, **one or more** FCs **are called and are active** for reading data.

Decentralized Operation

Per channel always only **one** mode block may be **called and active**.

For each module you must ensure that:

- Always only **one** FC for the writing of data **is called and active.**
- Parallel to this, **one** FC for the reading of data **is called and active.**

Interlocking the FC Calls

You must prevent the parallelism of a number of function calls and writing FCs by using suitable interlocking measures. Have a look at the example on the enclosed diskette.

Duration of the Call

You communicate with the FM 351 through the FC calls. In order that the data transfers and control processes can run without errors, the FCs contain parameters which inform you of the status of the process.

You start a job with the in/out parameter IN_**** (present in all FCs which write data).

While ever this parameter is set, the FM 351 has not executed the job.

This is particularly important for all writing functions, because you may call a new write function only when this parameter has been reset.

The in/out parameter IN_**** is reset by the relevant FC.

Other in/out parameters in all mode FCs are the parameters START, STOP, DIR_N, DIR_P.

Data Transfer Status

You interrogate the data transfer status for each write FC with the parameter JP_****.

6.1.3 Interrupt Handling

Types of Interrupt

The FM 351 can release diagnostic interrupts in the CPU.

Requirements

You must have programmed the diagnostic interrupt OB for handling diagnostic interrupts.

Note

If you have **not** programmed the interrupt OB (OB 82), the CPU goes to STOP in the event of an interrupt.

Interrupt Information

The operating system makes available 4 bytes of interrupt information as group information which you must evaluate for error analysis. You can read further data from the FM 351. To do this, use the FC DIAG_INF which you call in the **cyclic** program.

Reading Diagnostic Data

The following notes about OB 82 and OB 1 show how you read diagnostic data from the FM 351 in the event of an interrupt. You call the FC DIAG_INF in the **cyclic** program.

Note

If an FC which writes or reads data to the FM 351 is already started in the OB 1 cycle, no further FC (for example, FC DIAG_INF) may be called in the interrupt OB.

Read Diagnostic Data: Preparation in OB 82

OB 82 must be programmed for diagnostic interrupts. The following assignment would be possible as a minimum program.

STL	Explanation
`SET;`	`RLO is set to “1”`
`S     DIAGNOSTIC INTERRUPT;`	`Enable calling of FC DIAG_INF`

If a number of modules capable of diagnosis are mounted in your system, you must also incorporate evaluation for identifying the source of the interrupt.

Calling the FC DIAG_INF in OB 1

You read the diagnostic information from the FM 351, depending on the parameter DIAGNOSTIC INTERRUPT, in OB1 or in an FC which is called from OB 1.

```
STL                                          Explanation
        CALL    DIAG_INF(                    // Call FC DIAG_INF
        DB_NO   := DB_ABS,
        RET_VAL := Error code_read fct.
        IN_DIAG := DIAGNOSTIC INTERRUPT);    // Parameter was set in OB 82
        A       DIAGNOSTIC INTERRUPT;        // Start bit is still set
        JC      NWE;
        AN      BR;                          // Communication error
        S       Disp_error_readfct_Z;        // Display error during read function
NWE:    NOP 0;
```

Diagnostic Information

You evaluate the diagnostic data via OB 82 or the channel DB. The parameters which you can evaluate can be taken from the following table:

Table 6-3 Evaluating the Diagnostic Information from the FM 351

Error		Evaluation via OB 82	Channel DB via FC DIAG_INF		
			Byte	Bit	Channel DB via FC DIAG_INF
Module fault		OB82_MDL_DEFECT	72	0	Bit 0 of DIAGNOSTIC_INT_INFO.BYTE0
Internal fault		OB82_INT_FAULT		1	Bit 1 of DIAGNOSTIC_INT_INFO.BYTE0
External fault		OB82_EXT_FAULT		2	Bit 2 of DIAGNOSTIC_INT_INFO.BYTE0
Channel error		OB82_PNT_INFO		3	Bit 3 of DIAGNOSTIC_INT_INFO.BYTE0
No ext. aux. volt.		OB82_EXT_VOLTAG		4	Bit 4 of DIAGNOSTIC_INT_INFO.BYTE0
Internal time monitoring		OB82_WTCH_DOG_F	74	3	Bit 3 of DIAGNOSTIC_INT_INFO.BYTE2
Channel error	Encoder wire breakage		80*	0	Bit 0 of DIAGNOSTIC_INT_INFO.BYTE8
	Error, absolute encoder			1	Bit 1 of DIAGNOSTIC_INT_INFO.BYTE8
	Error pulse, incremental encoder			2	Bit 2 of DIAGNOSTIC_INT_INFO.BYTE8
	Operational error			7	Bit 7 of DIAGNOSTIC_INT_INFO.BYTE8
	Machine data error		81*	0	Bit 0 of DIAGNOSTIC_INT_INFO.BYTE9
	Error in incremental table			1	Bit 1 of DIAGNOSTIC_INT_INFO.BYTE9

* These details refer to Channel 1. The following values in the channel DB apply for Channel 2: Byte 82 and 83.

6.2 Functions which Control the FM 351

Definition

In the FM 351 programming package there are functions which you can call as required for all operating modes.

Table 6-4 Brief Description of the Mode FCs

Function	Brief Description of the Task
FC INC_MOD	The incremental mode is the standard mode for the FM 351. You can approach predefined targets in the working range with this mode.
FC REF_MODE	You synchronize the axes with the seek-reference-point mode.
FC JOG_MODE	With jogging you move the drive in a certain direction for the duration of the key pressure.

Requirements

Take note of the following requirements which must be satisfied when calling the FCs:

- The functions may only be called in the cyclic program.
- Always only one operating mode per channel may be called and be active.
- When using a number of channels, call the function for each channel separately.
- All necessary data and setpoint values must be present in the FM 351 or in the channel DB before calling.

Start Commands

A number of start commands are available depending on the operating mode. The possible selection depends on the parameterization and the type of axis which you want to operate.

Basically, the commands for operating the FM 351 have the following meaning:

Table 6-5 Start Commands for the Operating Modes

Commands	Meaning
START	Starts the present operating mode; the direction is determined by the FM 351.
DIR_M	Starts the present operating mode in the negative direction.
DIR_P	Starts the present operating mode in the positive direction.
STOP	Terminates the present operating mode.

Information about the possibilities and any restrictions on calling operating modes can be found in Chapter 9 of this manual.

OT_ERR

If it is not possible to call an operating mode or the control of an active operating mode is not possible or has been incorrectly carried out, the relevant module signals this by setting the parameter OT_ERR. The operating mode cannot be controlled until the error is acknowledged by a signal on the input OT_ERR_A.

“Cannot be controlled” means that you cannot start a new operating mode nor continue the stopped operating mode.

Binary Result BIE

After the FC has been executed, the binary result is set to BIE = 1.

Specific Parameters

Apart from the general parameters for controlling the operating mode blocks and handling the errors from them, there are special input and output parameters for each operating mode. These parameters are introduced and explained in the description of the function blocks.

General Parameters

All function calls for operating modes use the following parameters, the description of which is identical:

Parameter	Meaning
DRV_EN	Drive enable: • TRUE - the drive enable is switched on. • FALSE - the drive enable is switched off.
OT_ERR	Operating error; the FM 351 signals an operating error. An operating error can be more exactly analyzed via the parameterization interface.
OT_ERR_A	Operating error acknowledgment; You acknowledge a prevailing operating error by setting the parameter to the value “1”. The movement cannot be continued nor a new approach be started while ever the operating error is present.
START	Starts the present operating mode; the direction is determined by the FM 351. The FC resets the parameter when the FM 351 has accepted the command.
DIR_M	Starts the present operating mode in the negative direction. The FC resets the parameter when the FM 351 has accepted the command.
DIR_P	Starts the present operating mode in the positive direction. The FC resets the parameter when the FM 351 has accepted the command.
STOP	Terminates the present operating mode.
EN;EN0	These parameters are only necessary in the LAD representation. Here, pay attention to the user manual *Standard Software for S7 and M7; STEP 7*.

6.2.1 FC INC_MOD

Task

The FC INC_MOD is the main block for programming the FM 351. When the FC is called you immediately set the incremental operating mode. This is independent of the assignment of the individual parameters.

The FM 351 signals the acceptance of the operating mode with the set parameter INC_MD_A.

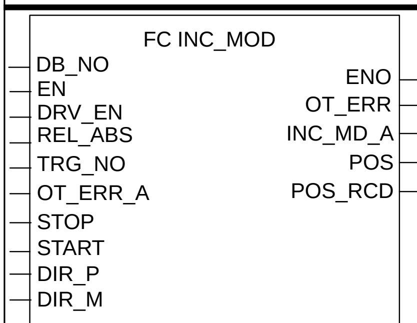
You then operate the incremental mode via the individual parameters.

With the FC you have the following functions available:

- Setting the incremental operating mode.
- Controlling the incremental operating mode.
- Reading the check-back signals (e.g. actual value). The read data is saved in the channel DB by the FC.

Calling Methods

Calling in LAD Representation	Calling in STL Representation




```
CALL  INC_MOD(
      DB_NO              := ,
      DRV_EN             := ,
      REL_ABS            := ,
      TRG_NO             := ,
      OT_ERR_A           := ,
      STOP               := ,
      OT_ERR             := ,
      INC_MD_A           := ,
      POS                := ,
      POS_RCD            := ,
      START              := ,
      DIR_P              := ,
      DIR_M              := );
```

The FC INC_MOD works in combination with the channel DB. When calling you indicate the number with the parameter DB_NO.

Requirements

Take note of the following requirements which must be satisfied for calling the FC INC_MOD:

- Take into account the generally applicable requirements of Chapter 6.2.
- Before you can start an incremental approach, you must supply the FM 351 with the appropriate incremental dimensions.

Description of the Parameters

The following table describes the parameters in the function block FC INC_MOD.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
DRV_EN	BOOL	I	Drive enable; the missing signal initiates an abort of the current positioning.
REL_ABS	BOOL	I	Relative/absolute incremental mode; • TRUE - relative incremental mode. • FALSE - absolute incremental mode.
TRG_NO	BYTE	I	Incremental number of target that is to be approached. Possible figures are 1 to 100, 254 and 255.
OT_ERR_A	BOOL	I	Operating error acknowledgment.
STOP	BOOL	I	Stop; TRUE - Abort of a momentary incremental approach.
OT_ERR	BOOL	O	Operating error; the FM 351 signals an operating error.
INC_MD_A	BOOL	O	Incremental operating mode active; With this parameter the FM 351 signals that it has set the incremental operating mode.
POS	BOOL	O	Positioning running; The parameter indicates the positioning status. • TRUE - Positioning has started or is being processed. • FALSE - Positioning is terminated.
POS_RCD	BOOL	O	Position reached; The parameter is set when the approach is terminated and the target position has been reached. The parameter is reset again with the start of a new incremental approach.
START	BOOL	I/O	Start; Start of an incremental approach.
DIR_P	BOOL	I/O	Direction positive; start of an incremental approach in positive direction.
DIR_M	BOOL	I/O	Direction negative; start of an incremental approach in negative direction.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter.

6.2.2 FC JOG_MODE

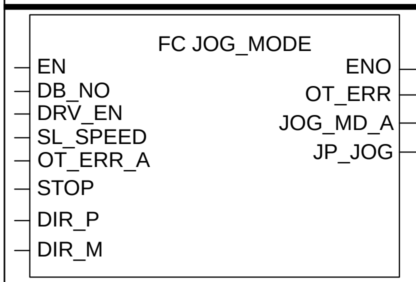
Task

With the FC JOG_MODE you set the jogging operating mode. All commands and parameters are specified with the FC. The FC carries out the following actions:

- Sets the jogging operating mode.
- Controls the **jogging** operating mode.
- Reads the check-back signals (for example, the actual value). The read values are saved by the FC in the channel DB (CHECKBACK_SIGNALS).

Calling Methods

Calling in LAD Representation



Calling in STL Representation

```
CALL    JOG_MODE(
        DB_NO          :=,
        DRV_EN         :=,
        SL_SPEED       :=,
        OT_ERR_A       :=,
        STOP           :=,
        DIR_P          :=,
        DIR_M          :=,
        OT_ERR         :=,
        JOG_MD_A       :=,
        JP_JOG         :=);
```

Requirements

Take into account the generally applicable requirements of Chapter 6.2 which must be fulfilled when calling the FC JOG_MODE.

Parameter Description

The following table describes the parameters in the function block FC JOG_MODE.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
DRV_EN	BOOL	I	Drive enable.
SL_SPEED	BOOL	I	False = Creep speed True = Rapid speed
OT_ERR_A	BOOL	I	Operating error acknowledgment.
STOP	BOOL	I	Stop.
DIR_P	BOOL	I	Direction positive - starts jogging in positive direction.
DIR_M	BOOL	I	Direction negative - starts jogging in negative direction.
OT_ERR	BOOL	O	Operating error.
JOG_MD_A	BOOL	O	Jogging mode active.

Name	Data Type	P Type	Meaning
JP_JOG	BOOL	O	Jog mode running; • TRUE - running • FALSE - is terminated

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

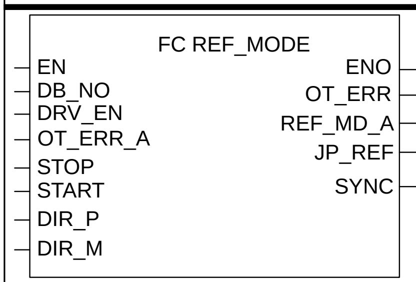
6.2.3 FC REF_MODE

Task

With the FC REF_MODE you start the seek-reference-point mode. The FC executes the following actions:

- Sets the seek-reference-point operating mode.
- Controls the seek-reference-point operating mode.
- Reads the check-back signal (for example, actual value). The read values are saved by the FC in the channel DB (CHECKBACK_SIGNALS).

Calling in LAD Representation



Calling in STL Representation

```
CALL    REF_MODE(
        DB_NO           :=,
        DRV_EN          :=,
        OT_ERR_A        :=,
        STOP            :=,
        OT_ERR          :=,
        REF_MD_A        :=,
        JP_REF          :=,
        SYNC            :=,
        START           :=,
        DIR_P           :=,
        DIR_M           :=);
```

Requirements

Note the following requirements which must be satisfied when calling the FC REF_MODE:

- Take into account the generally applicable requirements of Chapter 6.2.

Parameter Description

The following table describes the parameters in the function block FC REF_MODE.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
DRV_EN	BOOL	I	Drive enable.
OT_ERR_A	BOOL	I	Operating error acknowledgment.
STOP	BOOL	I	Stop.
OT_ERR	BOOL	O	Operating error.
REF_MD_A	BOOL	O	Seek-reference-point operating mode active.
JP_REF	BOOL	O	Seek-reference-point running; • TRUE - running. • FALSE - is terminated.
SYNC	BOOL	O	Axis is synchronized.
START	BOOL	I/O	Start - starting seek-reference-point.

Name	Data Type	P Type	Meaning
DIR_P	BOOL	I/O	Direction positive - starts seek-reference-point in positive direction.
DIR_M	BOOL	I/O	Direction negative - starts seek-reference-point in negative direction.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.3 Functions which Write Data to the FM 351

Write Definition

All functions which transfer data to a channel in the FM 351 are included in the group of write functions. The data is situated in the channel DB.

Introducing the FCs

In Table 6-6 you will find all the FCs which have write access to the FM 351 channels.

Table 6-6 List of the FCs which Write Data to the FM 351

FC Name	FC Task
REFPT	...used for the call setting the reference point.
ACT_VAL	...used for the call setting the actual value.
SNG_FCT	...used for the call setting single settings • Creep speed • Do not evaluate enable input.
SNG_COM	...used for calling the single commands. • Delete residual distance. • Set actual value / undo Set flying actual value.
TG254	...used for transferring the value for the Increment 254.
TG253_5	...used for transferring the selection for the Increment 255.

Requirements

With all FCs pay attention to the general requirements quoted here in addition to the specific requirements:

Table 6-7 Requirements for Calling Writing Functions

Centralized Structure	Decentralized Structure
Make sure that no other function blocks (FCs) access **this** channel for writing.	Make sure that no other function blocks (FCs) access **this module** for writing.
The function may only be called in the cyclic program.	
When using a number of channels, the block for each channel must be called separately.	
The channel DB must be assigned with the appropriate values.	
The parameter IN_**** must be set to start the FC.	
The FC must remain called until the parameter IN_**** is reset by the FC.	

Task of all FCs

Irrespective of their specific task, all FCs read the check-back signals from the FM 351 (for example, the momentary actual value). The read values are then entered by the relevant FC in the channel DB.

Note

The read values give the status which the FM351 had before the call (for example, the actual value before the call setting the reference point).

Binary Result BIE

All FCs affect the binary result BIE.

- BIE=1: The data transfer has been terminated without any errors.
- BIE=0: The data transfer has been terminated with an error.

In the case of an error (BIE=0) the parameter RET_VAL provides further information.

Parameters

In all of the FCs parameters are set which are identical in name and effect. They are therefore only comprehensively explained once. With the separate FCs they are only explained in the list with a brief key word.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number for the current FM 351; Only one channel DB is present per FM 351 channel. All parameters are deposited in it.
RET_VAL	INT	O	Return code of the SFC WR_REC; All writing FCs use the SFC WR_REC for transferring the data. If an error has occurred during transfer (BIE=0), you can evaluate the parameter RET_VAL. Read the reference manual *System Software for the S7-300 and S7-400, System and Standard Functions*, Chapter 2 for how you can evaluate the parameters.
DATA_ERR	BOOL	O	Data error; If the FM 351 detects a data error during the checking of the transferred data, the parameter is set. You can analyze the error more precisely via the parameterization interface.
IN_****	BOOL	I/O	By setting the parameter you inform the FC, that a data transfer is to be started. When the FC starts the data transfer, the FM 351 resets this parameter. For each FC the **** must be substituted by the specific designation. • TRUE - The transfer is enabled. • FALSE - The parameter is reset by the FC when the job has been carried out without error.

Name	Data Type	P Type	Meaning
JP_****	BOOL	O	The FC signals the data transfer status with this parameter. • TRUE - Data transfer is active. • FALSE - Data transfer is terminated. For each FC the **** must be substituted by the specific designation.
EN;EN0	BOOL	I;O	This parameter is only necessary in the LAD representation. In this respect, pay attention to the user manual *Standard Software for S7 and M7, STEP 7*.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

Chapter Overview

6.3.1 FC REFPT

Task

With the FC REFPT you call **Set reference point.** The FC executes the following actions:

- Transfer of the value for the setting of the reference point from the channel DB to the FM 351.

The FM 351 sets the new reference point if no error occurs.

Calling Methods

Calling in LAD Representation	Calling in STL Representation

FC REFPT
EN — ENO
DB_NO — RET_VAL
IN_REFPT — DATA_ERR
JP_REFPT
	`CALL REFPT(`
	`DB_NO :=,`
	`RET_VAL :=,`
	`DATA_ERR :=,`
	`JP_REFPT :=,`
	`IN_REFPT :=);`

6

Requirements

Take note of the following requirements which must be satisfied for calling the FC REFPT:

- The value for the new reference point must be set in the channel DB in the parameter SETTING_REFERENCE_POINT.
- All the requirements of Chapter 6.3 must be satisfied.

Parameter Overview

The following table describes the parameters for the function block FC REFPT.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
IN_REFPT	BOOL	I/O	Start: Set reference point; • TRUE - Data transfer is enabled. • FALSE - When job has been carried out.
JP_REFPT	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

Calling Example

The following shows you a calling example for the function FC REFPT.

```
STL                                              Explanation
      A     Write fct_R;                              // No new function start.
      JC    REFP;                                     // Call FC REFPT.

      L     L#1000;
      T     DB_ABS.SETTING_REFERENCE_POINT;           // Enter reference point
                                                      // in channel DB.
      S     Start_write fct;                          // Set start parameters.
      S     Write fct_R;                              // Write job being processed.

REFP: CALL  REFPT(                                    // CALL FC REFPT.
      DB_NO := DB_ABS,
      RET_VAL          := Error code_write fct,
      DATA_ERR         := Data error,
      JP_REFPT         := DUE_S_L,
      IN_REFPT         := Start_write fct);

      O     Start_write fct;                          // Start bit is still set
      O     DUE_S_L;                                  // or write funct. still runs.
      JC    NWE;

      R     Write fct_L;                              // Write funct. terminated.

      ON    BR;                                       // Communication error.
      O     Data error;                               // Data error.
      S     Disp_err_write fct;                       // Display error dur. write fnct.

NWE:
```

Symbols

The table shows the symbols for the calling example.

Symbols	Absolute (example)	Comment
Start_write function	M 31.2	Start parameter for write function.
Disp_err_write fct	M 13.3	Display “Error during write function”.
Data error	M 31.4	Data error.
DB_ABS	DB 1	Channel DB for FM 351.
DB_ABS.SETTING_REF-ERENCE_POINT	DB1.DBD56	Reference point coordinates.
DUE_S_L	M 31.3	Data transfer for write function running.
Error code_write fct	MW 34	RET_VAL of the SFC WR_REC.
Write fct_L	M 31.0	Write function running.
REFPT	FC 1	FC for setting reference point.

6.3.2 FC ACT_VAL

Task

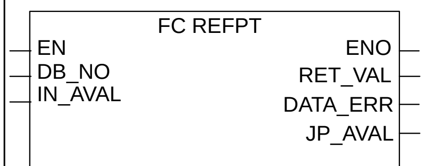
With the FC ACT_VAL you call **Set actual value**. The FC carries out the following actions:

- Transfer of the value for setting the actual value from the channel DB to the FM 351.

By calling the FC you set a new actual value for the current axis position.

Calling Methods

Calling in LAD Representation



Calling in STL Representation

```
CALL  ACT_VAL(
      DB_NO                :=  ,
      RET_VAL              :=  ,
      DATA_ERR             :=  ,
      JP_AVAL              :=  ,
      IN_AVAL              :=  );
```


Requirements

Take note of the following requirements which must be satisfied for calling the FC ACT_VAL:

- The value for the new actual value must be set in the channel DB in the parameter SETTING_ACT_VALUE.
- All the requirements of Chapter 6.3 must be satisfied.

Parameter Description

The following table describes the parameters of the function block FC ACT_VAL.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
IN_AVAL	BOOL	I/O	Start: Set actual value; • TRUE - Data transfer is enabled. • FALSE - When job is finished.
JP_AVAL	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.3.3 FC SNG_FCT

Task

With the FC SNG_FCT you can call the individual settings **Creep speed** and **Do not evaluate enable input** on the FM 351. The FC carries out the following actions:

- Transfer of the data area SINGLE_FUNCTIONS from the channel DB to the FM 351.

By calling the FC you set or remove all individual settings according to the selection from the channel DB.

Calling Methods

Calling in LAD Representation	Calling in STL Representation

FC SNG_FCT
EN — ENO
DB_NO — RET_VAL
IN_SNG_F — DATA_ERR
JP_SNG_F
	`CALL SNG_FCT(`
	`DB_NO := ,`
	`RET_VAL := ,`
	`DATA_ERR := ,`
	`JP_SNG_F := ,`
	`IN_SNG_F := );`

Requirements

Take note of the following requirements which must be satisfied for calling the FC SNG_FCT:

- The data for the individual settings must be set in the channel DB in the data area SINGLE_FUNCTIONS. Ensure that all the parameters in the data area contain correct data.
- All the requirements of Chapter 6.3 must be satisfied.

Parameter Description

The following table describes the parameters of the function block FC SNG_FCT.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
IN_SNG_F	BOOL	I/O	Start: Call individual settings; • TRUE - Data transfer is enabled. • FALSE - When job is finished.
JP_SNG_F	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.3.4 FC SNG_COM

Task

With the FC SNG_COM you call the single commands **Undo set actual value** and **Delete residual distance** on the FM 351. The FC carries out the following actions:

- Transfer of the data area SINGLE_COMMANDS from the channel DB to the FM 351.

By calling the FC, the single commands are executed according to your selection.

Calling Methods

Calling in LAD Representation	Calling in STL Representation

FC SNG_COM
EN — ENO
DB_NO — RET_VAL
IN_SNG_C — DATA_ERR
JP_SNG_C
	`CALL SNG_COM(`
	`DB_NO := ,`
	`RET_VAL := ,`
	`DATA_ERR := ,`
	`JP_SNG_C := ,`
	`IN_SNG_C := );`

Requirements

Take note of the following requirements which must be satisfied for calling the FC SNG_COM:

- The data for the single commands must be set in the channel DB in the data area SINGLE_COMMANDS. Ensure that all the parameters in the data area contain correct data.
- All the requirements of Chapter 6.3 must be satisfied.

Parameter Description

The following table describes the parameters of the function block FC SNG_COM.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
IN_SNG_C	BOOL	I/O	Start: Call single commands; • TRUE - Data transfer is enabled. • FALSE - When job is finished.
JP_SNG_C	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

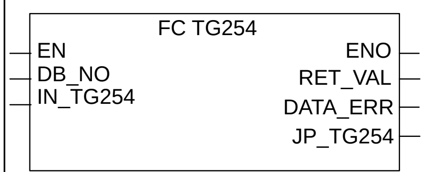
6.3.5 FC TG254

Task

With the FC TG254 you transfer the Increment 254 for the incremental operating mode. The FC carries out the following actions:

- Transfer of the value for the Increment 254 to the FM 351.

Calling Methods

<table>
<tr><th>Calling in LAD Representation</th><th>Calling in STL Representation</th></tr>
<tr><td>
</td><td>

```
CALL   TG254(
       DB_NO         :=,
       RET_VAL       :=,
       DATA_ERR      :=,
       JP_TG254      :=,
       IN_TG254      :=);
```

</td></tr>
</table>

Requirements

Take note of the following requirements which must be satisfied for calling the FC TG254:

- All the requirements of Chapter 6.3 must be satisfied.
- You store the selection for the Increment 254 in the relevant channel DB in the parameter TARGET_254.

Parameter Description

The following table describes the parameters of the function block FC TG254.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
IN_TG254	BOOL	I/O	Start: Load Increment 254; • TRUE - Data transfer is enabled. • FALSE - When job is finished.
JP_TG254	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

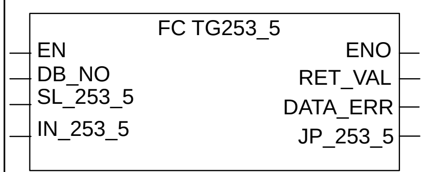
6.3.6 FC TG253_5

Task

With the FC TG253_5 you transfer the Increment 255 and the values for the switch-off and switchover difference for the incremental operating mode to the FM 351. The FC carries out the following actions:

- Transfer of the values for the Increment 255 to the FM 351.
- Transfer of the differences to the FM 351.

Calling Methods

Calling in LAD Representation	Calling in STL Representation
	**CALL TG253_5(** **DB_NO :=,** **SL_253_5 :=,** **RET_VAL :=,** **DATA_ERR :=,** **JP_253_5 :=,** **IN_253_5 :=);**

Requirements

Take note of the following requirements which must be satisfied for calling the FC TG253_5:

- All the requirements of Chapter 6.3 must be satisfied.
- You place the selection for the Increment 255 and the associated difference values in the relevant DB in the data area TARGET_255.

Parameter Description

The following table describes the parameters of the function block FC TG253_5.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC WR_REC.
DATA_ERR	BOOL	O	Data error.
SL_253_5	BOOL	O	Must always be TRUE. • TRUE - Increment 255
IN_TG253_5	BOOL	I/O	Start: Load Increment 255. • TRUE - Data transfer is enabled. • FALSE - When job is finished.
JP_TG253_5	BOOL	O	• TRUE - Data transfer is active. • FALSE - Data transfer is terminated.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.4 Functions which Read Data from the FM 351

Read Definition

All data which is to be read from a channel on the FM 351 is included in the group of reading functions.

The reading of the check-back signals which is carried out by each FC is **not** included.

Introducing the FCs

In Table 6-8 you will find all the FCs which have read access to the FM 351 channels.

Table 6-8 FCs which Read Data

FC Name	FC Task
DIAG_INF	... reads the complete diagnostic information made available by the FM 351 in the event of a diagnostic interrupt.
ACT_DAT	...reads the current operating data.

Requirements

In addition to the specific requirement, take note of the general requirements quoted here for all FCs:

- The function may only be called in the cyclic program.

Note

Only call read functions when you really want to read data. A complete, cyclic call of the read functions has the following effects:

- Increase in the bus load.
- Heavy load on the OB 1 cycle.
- Heavy FM 351 load.

- When using a number of channels the block must be separately called for each channel.
- The channel DB must be assigned the appropriate values.
- The parameter IN_**** must be set to start the FC.
- The FC must remain called until the parameter IN_**** is reset by the FC.

Task of all FCs

Irrespective of their special task, all FCs read the check-back signals from the FM 351 (for example, the current actual value). The read values are then entered in the channel DB by the relevant FC.

Binary Result BIE

All FCs affect the binary result BIE:

- BIE=1: the data transfer has been terminated without any errors.
- BIE=0: the data transfer has been terminated with an error.

In the case of an error (BIE=0) the parameter RET_VAL provides further information.

Parameters

In all of the FCs parameters are set which are identical in name and effect. They are therefore only comprehensively explained once. With the separate FCs they are only explained in the list with a brief key word.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number for the current FM 351; Only one channel DB is present per FM 351 channel. All parameters are deposited in it.
RET_VAL	INT	O	Return code of the SFC RD_REC; All read FCs use the SFC RD_REC for transferring the data. If an error has occurred during transfer (BIE=0), you can evaluate the parameter RET_VAL. Read the reference manual *System Software for the S7-300 and S7-400, System and Standard Functions*, Chapter 2 for how you can evaluate the parameters.
IN_****	BOOL	I/O	By setting the parameter you inform the FC, that a data transfer is to be started. When the FC starts the data transfer, the FM 351 resets this parameter. For each FC the **** must be substituted by the specific designation. • TRUE - The transfer is enabled. • FALSE - The parameter is reset by the FC when the job has been carried out without error. In decentralized operation the reading of the data takes a number of block calls. The parameter remains set during this period.
EN;ENO	BOOL	I;O	This parameter is only necessary in the LAD representation. In this respect, pay attention to the user manual *Standard Software for S7 and M7, STEP 7*.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

Chapter Overview

6.4.1 FC DIAG_INF

Task

With the FC DIAG_INF you read the diagnostic information in the event of a diagnostic interrupt from the FM 351. The FC carries out the following actions:

- Reading of 14 bytes of diagnostic information from the FM 351 and entering in the channel DB in the data area DIAGNOSTIC_INT_INFO.
- Reading of the check-back signals (for example, actual value). The read values are placed by the FC in the channel DB.

Calling Methods

Calling in LAD Representation	Calling in STL Representation

FC DIAG_INF
EN ENO
DB_NO RET_VAL
IN_DIAG
	`CALL DIAG_INF(`
	`DB_NO := ,`
	`RET_VAL := ,`
	`IN_DIAG := );`

Requirements

Take note of the following requirements which must be satisfied for calling the FC DIAG_INF:

- All the requirements of Chapter 6.4 must be satisfied.
- Calling the FC DIAG_INF is possible in OB 82 if you ensure that during the calling period no other FC has write or read access to an FM.

Parameter Description

The following table describes the parameters of the function block FC DIAG_INF.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC RD_REC.
IN_DIAG	BOOL	I/O	Start: Read diagnostic data; • TRUE - The transfer of the diagnostic data from the FM 351 into the channel DB is enabled. • FALSE - The parameter is reset by the FC when the job has been carried out without error.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.4.2 FC ACT_DAT

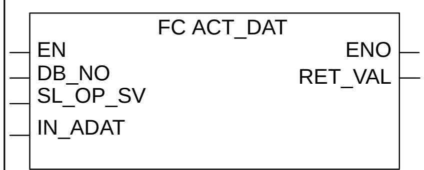
Task

With the FC ACT_DAT you read the basic operating data or the service data from the FM 351. The FC carries out the following functions:

- Reading of the data from the FM 351 and entry in the channel DB:
  - Basic operating data in the data area OPERATING DATA.
  - Service data in the data area SERVICE DATA.
- Reading of the check-back signals (for example, actual value). The read values are placed in the channel DB by the FC.

Calling Methods

Calling in LAD Representation



Calling in STL Representation

```
CALL  ACT_DAT(
      DB_NO                :=,
      SL_OP_SV             :=,
      RET_VAL              :=,
      IN_ADAT              :=);
```

Requirements

Take note of the following requirements which must be satisfied for calling the FC ACT_DAT:

- All the requirements of Chapter 6.4 must be satisfied.

Parameter Description

The following table describes the parameters of the function block FC ACT_DAT.

Name	Data Type	P Type	Meaning
DB_NO	BLOCK_DB	I	Channel DB number.
RET_VAL	INT	O	Return code of the SFC RD_REC.
SL_OP_SV	BOOL	I	Selection of the data which is to be read; • TRUE - Service data. • FALSE - Basic operating data.
IN_ADAT	BOOL	I/O	Start: Read service or operating data; • TRUE - Data transfer is enabled. • FALSE - When the job has been carried out without error.

Parameter types: I = Input Parameter; O = Output Parameter; I/O = In/Out Parameter (start parameter).

6.5 Programming Example

Introduction

On the enclosed diskette you will find a programming example with which you can test the basic functional features of the FM 351. In this chapter we describe the required surrounding conditions and the controlling elements.

Parameterization

In this example project special machine data is deposited. If you would like to test the example program in your own installation, enter your special machine data.

Blocks

In the project all blocks must be linked which are required for execution of the task.

Table 6-9 Blocks in the Example Project

Block	Name	Use
DB1	DB_FM	Channel DB
FC0	INC_MOD	Incremental mode
FC1	REFPT	Set reference point
FC5	SNG_FCT	Call single settings
FC6	SNG_COM	Call single commands
FC8	DIAG_INF	Read diagnostic information
FC9	ACT_DAT	Read service or basic operating data
FC10	JOG_MODE	Jogging
FC11	REF_MODE	Seek reference point
FC12	TG254	Transfer Increment 254
FC13	TG253_5	Transfer Increment 255
FC100	AUFR_TF	Call the function
OB1	CYCL_EXC	Free PLC cycle
OB82	I/O_FLT1	Diagnostic interrupt
OB100	CRST	Restart

Hardware

The example is designed for the following hardware set-up:

- A programming device (for example, PG 740) with STEP 7 software installed from Version 2.0 must be present.
- Two simulation modules (32 digital inputs) in slots 3 and 4.
- Two simulation modules (32 digital outputs) in the slots 5 and 6.
- FM 351 in slot 7.
- Incremental encoder connected to Channel 1.

Inputs and Outputs

The inputs and outputs are allocated to memory markers in OB 1.

Input	Marker	Description
0.0	0.0	Relative/absolute incremental mode
0.1	0.1	Jogging rapid/creep speed
0.2	0.2	Drive enable
0.3	0.3	Operating error acknowledgment
0.4	0.4	Start
0.5	0.5	Positive direction
0.6	0.6	Negative direction
0.7	0.7	Stop
1.4 1.5 1.6 1.7	1.4 1.5 1.6 1.7	Operating mode selection • 0: Is ignored • 1: Incremental mode • 2: Set up • 3: Seek reference point
4.0 4.1 4.2 4.3	4.0 4.1 4.2 4.3	Write function selection • 0: Not allowed • 1: Set reference point • 2: Do not evaluate enable input • 3: Evaluate enable input • 4: Delete residual distance • 5: Transfer Increment 254 • 6: Transfer Increment 255 • >6: Is ignored
5.0	5.0	Execute write function
5.1	5.1	Read basic operating data
5.2	5.2	Read diagnostic information

Output	Marker	Description
8.0	8.0	Incremental mode active
8.1	8.1	Jog mode active
8.2	8.2	Seek-reference-point mode active
9.0	9.0	Approach in positive direction
9.1	9.1	Approach in negative direction
9.2	9.2	Axis has reached position
9.3	9.3	Axis is synchronized
9.4	9.4	Enable start
12.0	12.0	Data transfer for write function is active
12.1	12.1	Data transfer for read function is active
13.0	13.0	Processing running
13.2	13.2	Operating error
13.3	13.3	Error during write function
13.4	13.4	Error during read function
13.6	13.6	FM 351 has initiated diagnostic interrupt

Input	Marker	Description	Output	Marker	Description
5.6	5.6	Delete interrupt display			
5.7	5.7	Delete error display			

Marker

The table gives a brief overview of the memory markers used.

Marker	Description
M 31.0	Write function running
M 31.1	Edge trigger flag for write initiation
M 31.2	Start parameter for write function
M 31.3	Data transfer for write function running
M 31.4	Data error
M 32.0	Set reference point running
M 32.1	Do not evaluate enable input (single setting)
M 32.2	Evaluate enable input (single setting)
M 32.3	Delete residual distance (single command)
M 32.4	Transfer Increment 254
M 32.5	Transfer Increment 255
M 36.0	Start edge trigger marker
M 36.1	Edge trigger marker, positive direction
M 36.2	Edge trigger marker, negative direction
M 36.4	Parameter START mode block
M 36.5	Parameter DIR_P mode block
M 36.6	Parameter DIR_M mode block
M 41.0	Read function running
M 41.2	Start parameter for read function
MB 20	Increment number
MB 28	Mode selection
MB 30	Write function selection (settings, single settings)
MW 0	Replica, Input Word 1
MW 4	Replica, Input Word 2
MW 8	Replica, Output Word 1
MW 12	Replica, Output Word 2
MW 34	Error code for write function
MW 44	Error code for read function

6.6 Technical Data

Technical Data

The following table gives you an overview of the technical data of the FM 351 technological functions.

Table 6-10 Technical Data for the FM 351 Technological Functions

Block Number	Block Name	Version	Space Occupied in Load Memory	Space Occupied in Main Memory	Space Occupied in Local Data Area	Space Occupied in Data Area	Called System Functions
FC 0	INC_MOD	1.0	420 Bytes	274 Bytes	10 Bytes	1)	None
FC 1	REFPT	1.0	420 Bytes	286 Bytes	28 Bytes	1)	SFC 58: WR_REC
FC 2	ACT_VAL	1.0	420 Bytes	286 Bytes	28 Bytes	1)	SFC 58: WR_REC
FC 5	SNG_FCT	1.0	420 Bytes	286 Bytes	28 Bytes	1)	SFC 58: WR_REC
FC 6	SNG_COM	1.0	420 Bytes	286 Bytes	28 Bytes	1)	SFC 58: WR_REC
FC 8	DIAG_INF	1.0	300 Bytes	178 Bytes	28 Bytes	1)	SFC 59: RD_REC
FC 9	ACT_DAT	1.0	388 Bytes	254 Bytes	28 Bytes	1)	SFC 59: RD_REC
FC 10	JOG_MODE	1.0	364 Bytes	224 Bytes	10 Bytes	1)	None
FC 11	REF_MODE	1.0	396 Bytes	256 Bytes	10 Bytes	1)	None
FC 12	TG254	1.0	420 Bytes	286 Bytes	28 Bytes	1)	SFC 58: WR_REC
FC 13	TG253_5	1.0	456 Bytes	316 Bytes	28 Bytes	1)	SFC 58: WR_REC

1) Channel data block of FC0 (INC_MODE) with a length of 130 Bytes.

Processing Times

The following table gives you an overview of the processing times for the FM 351 technological functions.

Table 6-11 Processing Times for the FM 351 Technological Functions

Block Number	Block Name	CPU 314
FC 0	INC_MOD	0.5 ms
FC 1	REFPT	2.5 to 3.0 ms
FC 2	ACT_VAL	
FC 5	SNG_FCT	
FC 6	SNG_COM	
FC 8	DIAG_INF	3.2 to 3.7 ms
FC 9	ACT_DAT	
FC 10	JOG_MODE	0.5 ms
FC 11	REF_MODE	
FC 12	TG254	2.5 to 3.0 ms
FC 13	TG253_5	

Setting Up the FM 351

7

Introduction

In this chapter we would like to show in a few steps how you can set up the FM 351.

HW Installation and Wiring

To obtain a better overview, the procedure **Set-up** is subdivided into a number of small steps. In this first section you install the FM 351 in your S7-300 and wire the external peripheral components.

Step	What Must Be Done?	✔
1	**Installing the FM 351** Insert the module in one of the slots 4 to 11.	❐
2	**Wiring the FM 351** Wire the FM 351: • Digital inputs to the peripheral interface. • Digital outputs to the peripheral interface. • Encoder connections. • Power supply to the FM 351.	 ❐ ❐ ❐ ❐
3	**Checking the limit switches relevant for safety** Check for the correct function of: • The limit switches. • The emergency stop device.	 ❐ ❐
4	**Peripheral plugs** The peripheral plug must be latched in.	❐
5	Check the shielding of the separate cables.	❐
6	**Switch on the power supply** Switch the CPU to the STOP state (safe state). Switch on the 24 V supply for the FM 351.	 ❐ ❐

Configuring the Project

Now configure the project under *STEP 7* such that parameterization with the parameterization mask is possible.

Step	What Must Be Done?	✔
1	Configure a new project under *STEP 7*.	❐
2	Build up a new rack.	❐
3	Enter your hardware installation into the rack with the configuration interface.	❐
4	Select the FM 351 from the module catalog and drag it to the selected slot.	❐
5	Note the module address which is now displayed.	____
6	Now call the parameterization masks for the FM 351 by double clicking the order number.	❐

Parameterization

Parameterize the module.

Step	What Must Be Done?	✔
1	Fill in the masks in the basic parameterization.	❐
2	Click the **Parameter...** button.	❐
3	Fill in the dialog masks **Drive axis** and **Encoder.**	❐
4	Save the parameterization with the menu point **File** ▸ **Save**.	❐
5	Call **Test** ▸ **Set up.**	❐
6	• Load the machine data into the FM 351. To do this, select the **Load** button. • If the FM 351 contains valid data, select the button **Activate**. **Result:** • The **Start enable** LED must light. • The **Parameterized** LED in the service mask must light. **If an error occurs:** Evaluate the error messages in the mask Error evaluation and change the relevant machine data.	❐ ❐ ❐
7	Switch on the module enable in the mask Test: Set up.	❐

Setting Up the FM 351

Check for the correct parameterization of the FM 351 with the following table.

Step	What Must Be Done?	✔
1	Select the **Jog** operating mode.	❐
	• Check that the outputs are correctly wired (type of control). – Move forwards and backwards at creep speed. – Move forwards and backwards at rapid speed.	❐
	• Check the encoder resolution. – Move the drive over a defined distance in a defined direction. The actual traversed path must match the display in the mask **Test** ▸ **Set up.**	❐
2	Select the **seek-reference-point** operating mode. You check the correct synchronization of the module with the operating mode. Also, you can check whether the software limit switches are at the correct position. With **jog** move to the **software limit switches Start** and **Finish.** The actual position must match the specified values. The actual value must show the value of the software limit switches.	❐
3	Now enter the incremental dimension in the increment table. Note that only positive values are allowed for the **relative incremental mode.** Save the incremental dimension. Transfer the increment table to the FM 351.	❐ ❐ ❐
4	Select the operating mode **incremental mode**: • Absolute – Check positioning at the defined increment. – Check positioning at the Increments 254 and 255. • Relative – Check positioning at the defined increment. – Check positioning at the Increments 254 and 255.	 ❐ ❐
5	Test the other settings according to your application: • Set reference point. • Set actual value. • Loop mode.	❐

7

Saving the Project

Once you have successfully concluded all tests and the FM 351 parameterization has been optimized, you must save the data and prepare the system for the standard operating mode.

Step	What Must Be Done?	✔
1	Save all data in the parameterization interface with **File ▸ Save.**	❒
2	Terminate the parameterization interface.	❒
3	Save the project with **File ▸ Save.**	❒
4	Switch the CPU to the STOP state.	❒
5	Transfer the data to the CPU with **Load...** The data is transferred directly to the FM 351.	❒

Preparing the Channel DB

A channel DB must be prepared for each channel so that you can initiate the module functions via the FCs.

Step	What Must Be Done?	✔
1	In the channel DB enter: • Module address nnn in Parameter MOD_ADR of the channel DB. You noted the address during configuring the project in Point 5.	❒
	• Enter the channel address nnn.0 in Parameter CH_ADR. The channel address has the value nnn·8.	❒
	• Enter the data record offset in Parameter DS_OFF. – Always 0 for Channel 1. – Always 40 for Channel 2.	❒
	• Enter the values which the FCs require for operation.	❒
2	Only link the FCs into your project which you need for your work. **Important:** If you use a number of FMs in a project, note that you must where necessary change the numbers of the FCs.	❒
3	Test your program	❒

8 Machine Data and Increments

What is Machine Data For?

You adapt the FM 351 to the axes with the machine data.

Positioning with the FM 351 is only possible, if correct machine data exists on the module.

Increments

Increments are specified targets, the approach to which is controlled by the FM 351 with the relative or absolute **incremental mode.**

Structure

The data is subdivided in the parameterization interface and in this chapter into the following areas:

- Drive data and target data
- Axis data
- Encoder data
- Increments

Entering the Machine Data

Enter all the machine data, which you must transfer for the operation of the FM 351, into the entry masks in the parameterization interface.

Structure of this Chapter

Apart from the lists of data, in this chapter you will also find supplementary chapters which show the relationship between individual data items.

8.1 Basic Data

Starting Parameterizing

Before you parameterize your FM 351, you must

- select a special unit and
- create the required channels

for the entry of the data in the parameterization interface.

The selected system of units is then used both for the input as well as for the output of the data.

Possible Entry Selections

You set the desired system of units in the overview mask in the parameterization interface. You have the following possibilities:

Table 8-1 Basic Data

Machine Data and Assignment	Description
Dimensional system: • mm • inches • degrees	This data item determines the display of values in the course of your work. The system of units is used both for the input of values as well as for the output of values.
Channel • 1 • 2	The FM 351 offers two independent channels. By selecting the number you define the extent of the data which is transferred from the CPU to the FM 351 during starting.

Effect of the Units System Setting

The machine data item **Units System** enables you to enter values in a normal system of units.

Note

If you change the system of units, the original values are retained.

The values are not converted to the new system.

The maximum number of places before and after the decimal point in the value change depending on the system of units. For the value for the Software Limit Switch End, you can enter the following maximum values:

- 1,000,000.000 mm or
- 100,000.0000 inches or
- 100,000.0000 degrees

System of Units in this Chapter

In this chapter we use the **mm system of units** when stating the minimum and maximum values. For determining the limits in the other systems of units, apply the following calculation:

For the Conversion of	Calculate
mm → inches	Value (inch) = Value(mm) · 10^{-1}
mm → degrees	Value (degrees) = Value (mm) · 10^{-1}

Relationship between Increments and System of Units

The encoder signals from a connected encoder are evaluated by the FM 351 and converted to the momentary system of units. For the conversion, the following resolution (see Chapter 8.6) is used:

If the FM 351

- has counted 10 increments and
- a resolution of 100 µm per increment is set by the parameterized encoder data,

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

Speeds

The speed is displayed in the set system of units.

Travel Range of Incremental Encoders

The FM 351 can only process a certain number range. This number range determines the travel range. The travel range is dependent on the resolution and is:

- from –100 m to +100 m for a resolution < 1 $^{\mu m}/_{increment}$
- from –1000 m to +1000 m for a resolution $\geq$ 1 $^{\mu m}/_{increment}$

Note

For the rotary axis the following applies: The reproducibility of the reference point is only ensured if an integer ratio exists between the incremental values for the value **End of rotary axis** and the value **Displacement per encoder revolution.**

Travel Range of Absolute Encoders

With an absolute encoder the travel range is determined by the total number of encoder steps. In addition please note:

- With a linear axis the absolute encoder must at least cover the working range.
- With a rotary axis the absolute encoder must exactly cover the rotary axis range.

8

8.2 Machine Data for the Drive

Definition

The machine data for the drive describes:

- How the FM 351 can control a drive (power controller) using its outputs.
- How a target approach is executed and monitored.

Data List

All data for the Drive input range can be found in the following table:

Table 8-2 Drive Data

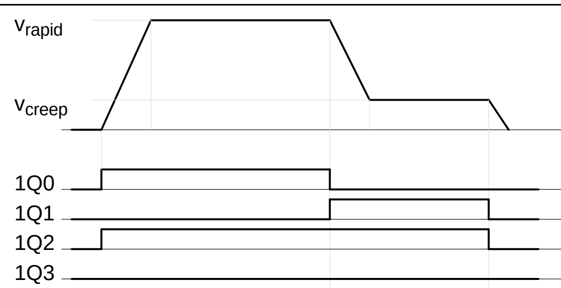
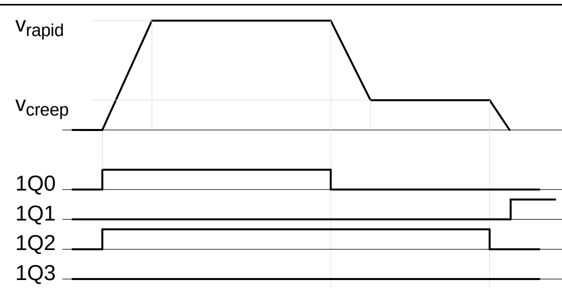
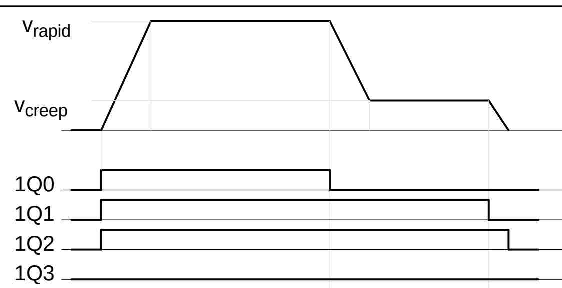
Machine Data and Assignment	Description
Control type • 1 • 2 • 3 • 4	The control type describes how the four digital outputs per channel operate a connected motor via the power controller. Channel 1 is displayed in each of the following diagrams.
Control type 1 • 1Q0/2Q0: Rapid speed • 1Q1/2Q1: Creep speed • 1Q2/2Q2: Positive approach • 1Q3/2Q3: Negative approach	
Control type 2 • 1Q0/2Q0: Rapid speed/ creep speed • 1Q1/2Q1: Position reached • 1Q2/2Q2: Positive approach • 1Q3/2Q3: Negative approach	
Control type 3 • 1Q0/2Q0: Rapid speed • 1Q1/2Q1: Creep speed • 1Q2/2Q2: Positive approach • 1Q3/2Q3: Negative approach	

Table 8-2 Drive Data, continued

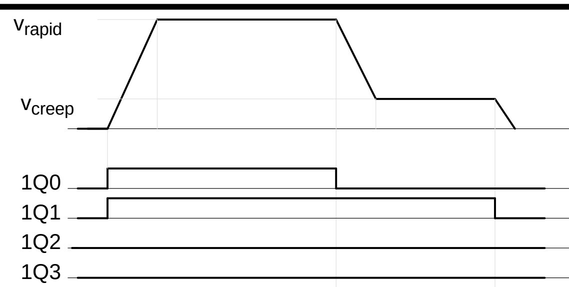
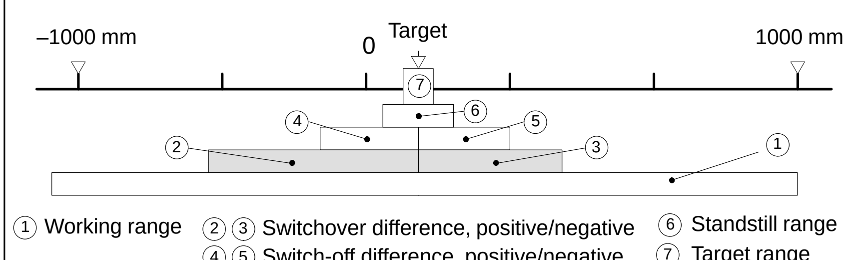
Machine Data and Assignment	Description
Control type 4 • 1Q0/2Q0: Rapid speed, positive • 1Q1/2Q1: Creep speed, positive • 1Q2/2Q2: Rapid speed, negative • 1Q3/2Q3: Creep speed, negative	
Switchover difference positive/negative und **Switch-off difference positive/negative** • 0.001 mm to 1 000 000,000 mm at a resolution $\geq$ 1 $\mu m/_{incr.}$ • 0.001 mm to 100 000,000 mm at a resolution $<$ 1 $\mu m/_{incr.}$	The switchover difference defines the switchover point in the travel range at which the drive switches over from rapid to creep speed. The switch-off difference defines the switch-off point in the travel range at which the drive at creep speed switches off. At this point the target run-in begins over which the drive has no further influence. The values apply for all targets which the FM 351 approaches; with the exception of the Increment 255. **Rules** Please take note of the following rules on entering the values. • The values for the positive and negative directions may be different. • The switchover difference must be larger than the switch-off difference. • The switchover difference must be smaller than the end of the rotary axis. • The switch-off difference must be larger than the half target range. • The distance between the switchover point and the switch-off point must be selected large enough that the drive can switch reliably from rapid to creep speed. • The distance to the target must be selected such that the drive comes to rest within the target range. Further information regarding the arrangement of the ranges can be found in Chapter 2.1. 
Target range • 0 mm to 1 000 000.000 mm	The FM 351 places a symmetrical range around each target. Within this range the actual value must come to rest during the target run-in. A value of 0 switches off the tolerance during the target run-in. The velocity on reaching the target position must then be lower than the parameterized standstill velocity. Pay attention to Chapter 2.3 regarding the topic of target run-in.

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Table 8-2 Drive Data, continued

Machine Data and Assignment	Description
Standstill range • 0 mm to 1 000 000.000 mm at a resolution $\geq$ 1 µm/incr. • 0 mm to 100 000.000 mm at a resolution $<$ 1 µm/incr.	The standstill range is used for monitoring for standstill. Whether the drive remains stationary at the approached position or drifts away is monitored. If the standstill range is left, an error is signaled. The standstill range is monitored: • For all targets which you approach with the FM 351. Monitoring starts after the FM 351 has signaled **Position reached.** • For traveling without a target if the momentary velocity is lower than the standstill velocity. For a value 0 the standstill monitoring is switched off. **Rules** During entry take note of the following rules: • The standstill range is placed symmetrically about the relevant target position. **Target position – 1/2** Standstill range $\leq$ Target position $\leq$ **Target position + 1/2** Standstill range Also, pay attention to Chapter 2.3 that shows the target run-in and the separate monitoring features and messages.
Standstill velocity • 0 mm to 100 000.000 mm/min	The standstill velocity acts as the reference velocity. If the actual value reaches the standstill velocity during a travel movement to a target and the drive is located in the target range, then **Position reached** is set. The positioning process is then terminated successfully. The accuracy of positioning increases when the value of the standstill velocity is reduced.
Monitoring time • 0 = No monitoring • 1 to 100 000 ms	The monitoring period monitors: • The axis movement. The actual value must have changed at least by one increment (resolution displacement) within the monitoring period. The monitoring period starts with the beginning of a positioning process. • The target run-in. The target range must be reached during the monitoring period. The monitoring period starts when the switch-off difference is reached. **Actual monitoring period** For the monitoring period you can specify all values from the defined range. • 0: The monitoring is switched off. • 1 to 100 000 ms: The FM 351 rounds the specified period up to a multiple of 8 ms. Note that a difference of a maximum of 7 ms between your specified value and the actual value used can occur. This difference is the more important the shorter the specified monitoring period is. Therefore, enter the monitoring period preferably on an 8 ms pitch.

8.3 Machine Data for the Axis

Definition

The axis has the input ranges:

- Axis type
- Entries for the reference point on the axis
- Axis limits

Data List

The description of all data for the axis input range can be found in Table 8-3.

Table 8-3 Machine Data for the Axis

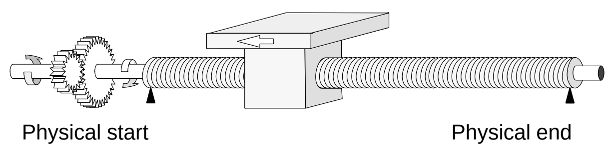
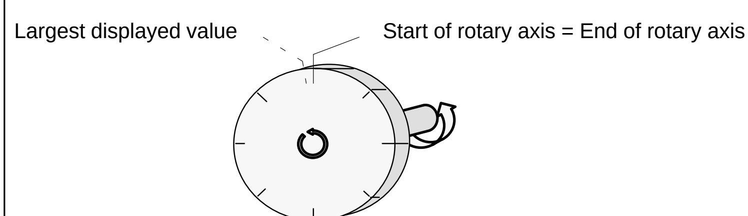
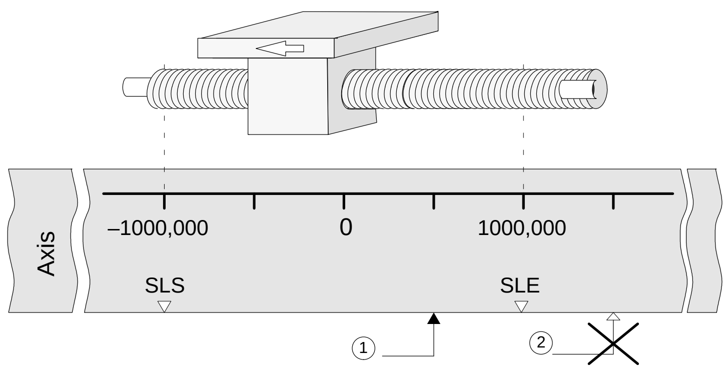
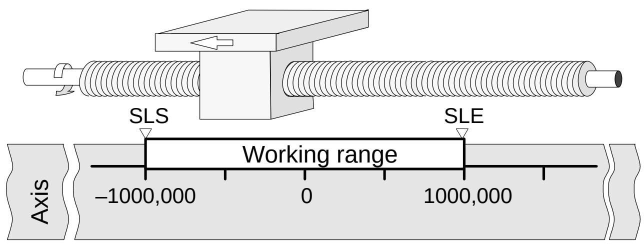
Machine Data and Assignment	Description
Axis type: • Linear axis • Rotary axis	The **linear axis** is an axis which has a physically limited travel range. 
	The **rotary axis** is an axis for which the travel range is not limited by mechanical end-stops. 
End of rotaty axis: 0.001 mm to +1,000,000.000 mm	The value, End of rotary axis, is theoretically the largest value which the actual value can attain. The theoretically highest value (in the example below: 1000 mm) is however never displayed, because it physically labels the same position as the start of the rotary axis (0). The display jumps: • With a positive direction of rotation from 999 mm to 0 mm. • With a negative direction of rotation from 0 mm to 999 mm. The largest value which is displayed for a rotary axis, has the value: **End of rotary axis [μm] - Resolution [μm/increment]· 1 [Increment]**
	Rotary axis with absolute encoders With a rotary axis with an absolute encoder the rotary axis range (0 to End of rotary axis) must exactly cover the total number of encoder steps. $\text{End of rotary axis} \doteq \text{Number of revolutions} \cdot \frac{\text{Steps}}{\text{Revs.}} \cdot \frac{1}{\text{RESOL}\left[\frac{\mu m}{\text{incr}}\right]}$

Table 8-3 Machine Data for the Axis, continued

<table>
<tr><th>Machine Data and Assignment</th><th>Description</th></tr>
<tr><td rowspan="2">Reference point coordinate
– 1,000,000.000 mm
to
+ 1,000,000.000 mm</td><td>Incremental encoder:
You determine the reference point by synchronization, that is, via the setting Set reference point or the Seek-reference-point mode. If the synchronization event is detected (for example, zero mark of the encoder during a seek-reference-point travel), the reference coordinate is allocated to this event.
During the selection of the value for the reference-point coordinate you must take into account that the value must be located within the working range, that is between the Software Limit Switch Start (SLS) and the Software Limit Switch End (SLE) (including the values of the limit switches).


① Reference-point coordinate 500.000 mm; the value lies within the accepted software limit switches.
② Reference-point coordinate 1500.000 mm; the value lies outside the software limit switches and is not allowed.</td></tr>
<tr><td>Absolute encoder (SSI)
A parameterized axis with an absolute encoder is always synchronized provided no error is detected.
In this respect, also read the description of the absolute encoder adjustment and Chapter 8.4 which describes the relationship of the absolute encoder adjustment and the other data.</td></tr>
<tr><td>Absolute encoder adjustment
0 to (2^{25}–1)</td><td>This entry is only significant for absolute encoders. It must be smaller or equal to the total number of steps on the absolute encoder.
Together with the value Reference-point coordinate, the value of the absolute encoder adjustment forms a pair of values. This pair of values determines the relationship between the encoder and the axis coordinate system. An unambiguous value of the coordinate system is allocated to each absolute encoder value.
Also read the Chapter Absolute Encoder Adjustment.</td></tr>
<tr><td>Type of seek–reference-point mode
• positive reference-point switch left
• negative reference-point switch left
• positive reference-point switch right
• negative reference-point switch right</td><td>With the type of seek-reference-point mode you determine the conditions for the axis synchronization for operation with an incremental encoder.
• The first statement defines the start direction in which the seek-reference-point travel starts.
• The second part defines the position of the zero mark leading to synchronization.
The reference point is located at the first zero mark after leaving the reference-point switch in the specified direction.
The application of this data is described in Chapter 9.4.</td></tr>
</table>

Table 8-3 Machine Data for the Axis, continued

Machine Data and Assignment	Description
Starting velocity for seek-reference-point travel: • Rapid speed • Creep speed	With this data you select the velocity for the start of a seek-reference-point travel: • Rapid speed • Creep speed
Software limit switch Start / Software limit switch End – 1,000,000.000 mm to 1,000,000.000 mm	This entry is only of significance with a linear axis. The software limit switches are active when the FM 351 is synchronized. We term the range set by the software limit switches the **working range**. The limits of the working range are monitored by the FM 351. The Software Limit Switch Start (SLS) must always be more negative than the Software Limit Switch End (SLE).  **Absolute encoder (SSI)** The FM 351 is synchronized directly after parameterization. The software limit switches are monitored from this point in time. The absolute encoder which you use must **at least** cover the working range (from Software Limit Switch Start to Software Limit Switch End). **Relationship: Encoder range, Travel range, Number range** • The working range is the range which you define for your task using the software limit switches. • The encoder range is the range unambiguously covered by the encoder. • The number range is the value range which the FM 351 can process. It is dependent on the resolution. • The travel range is determined by: – Encoder range if the encoder range is smaller than the number range. – Number range if the encoder range is larger or the equal to the number range.
	Incremental encoder The axis is initially not synchronized after each FM 351 start. The parameterized software limit switches are only monitored after synchronization.

8.4 Absolute Encoder Adjustment

Definition

The absolute encoder adjustment provides a permanent relationship between the coordinate system and the encoder.

What You Define

When you parameterize your FM 351 with the parameterization interface, the values that you define include the following:

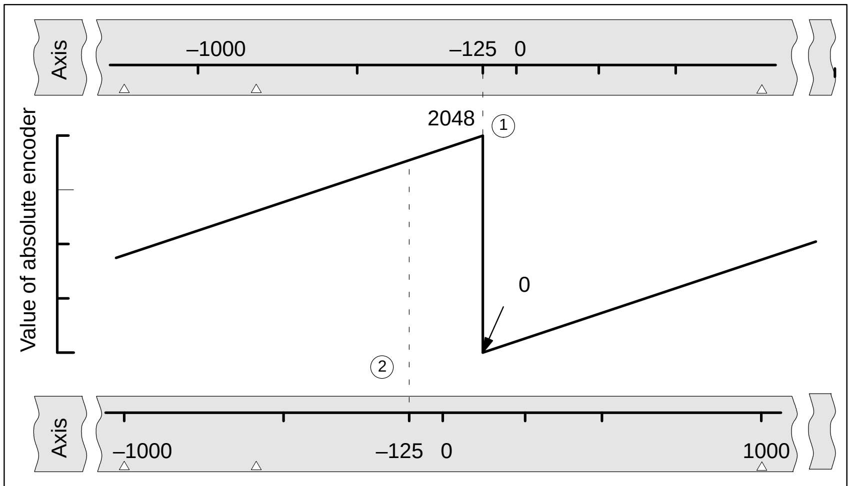
- Software Limit Switches Start (SLS) and End (SLE); these are the limits of the working range.
- Reference-point coordinate (REF); this is a value from the working range of the coordinate system.
- Absolute encoder adjustment; this is a value from the value range of the absolute encoder (0 to total number of steps - 1).

Assumption for an Absolute Encoder Adjustment

For the example which we want to show in this chapter, the following assumptions apply:

- Reference-point coordinate = -125 mm
- Working range of SLS = -1000 mm to SLE = 1000 mm
- Absolute encoder adjustment = 0
- Encoder range = 2048 steps
- The absolute encoder used cannot be exactly adjusted mechanically and also does not have the option of setting the encoder value.

The FM 351 forms pairs of values as shown in the illustration below from the relationship between the two values for the reference-point coordinate and the absolute encoder adjustment.



① Allocation of the coordinate system to the encoder values with the set encoder adjustment.
② Desired allocation of the coordinate system to the encoder.

Determining the Correct Absolute Encoder Adjustment

After the initial parameterization further steps are necessary to create a correct relationship between the encoder and the coordinate system.

1. Set the axis to a defined reproducible point with which you are familiar and which is physically unambiguous.
2. Call the setting Set reference point with the known coordinate.

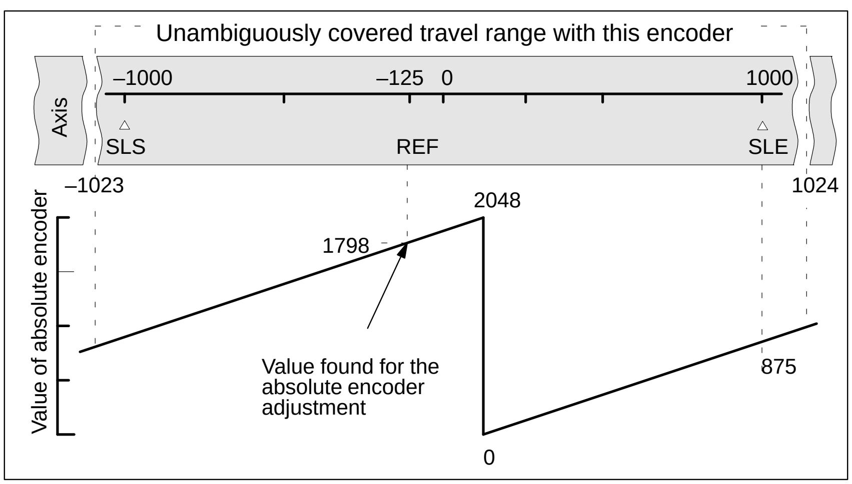
   The FM 351 now determines the correct absolute encoder adjustment (= 1798) for the reference-point coordinate entered in the machine data. You can read out this value with the parameterization interface in the service mask.
3. Enter the read-out value as a new value in the machine data **Absolute encoder adjustment.**
4. Save the machine data.
5. Load the data under the configuration interface to the CPU. The CPU must be in the STOP state for this. The FM 351 is then directly parameterized.

Note

You carry out this adjustment only once when you set up the FM 351. After parameterization, the FM 351 is now synchronized on starting.

Result after Set Reference Point

The relationship appears as follows after **Set reference point**:



Extended Travel Range

The encoder supplies 2048 unambiguous values. The working range is defined by the software limit switches. Due to the selected resolution of 1 mm per increment, the encoder can cover a larger working area.

With the set resolution the working range is already covered with 2001 values. Therefore, in the example there are 47 increments “left over” which lie symmetrically about the working range.

Therefore, the maximum possible range of the coordinate system is between -1023,000 mm and 1024,000 mm.

Mechanical Adjustment of an Encoder

A correct relationship between the coordinate system and the encoder can also be obtained if you:

1. Move the axis to a reproducible position.
2. Enter this coordinate value in the machine data as reference-point coordinate.
3. Read off the value of the absolute encoder adjustment in the service mask of the parameterization interface.
4. Enter the value of the absolute encoder adjustment in the machine data.

A correct actual value is then always displayed after parameterization.

Instead of steps 3 and 4, it is also possible to set the encoder to zero via “Reset” and to enter the value “0” as the absolute encoder adjustment in the machine data.

8.5 Machine Data for the Encoder

Definition

The encoder supplies the displacement information to the module which evaluates it and converts to an actual value using the resolution.

It is only by correctly specifying the machine data of the encoder that you can ensure that the determined actual value of the axis position matches the real axis position.

Data List

The following table describes all the data which you can parameterize in the Encoder dialog field on the parameterization interface.

Table 8-4 Machine Data for the Encoder

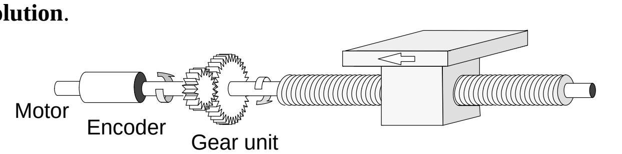
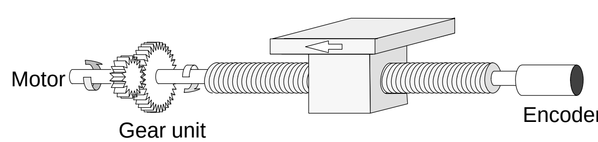
Machine Data and Assignment	Description
Encoder type: • 5 V incremental • 24 V incremental • Absolute (SSI)	You will find information about the working principle of encoders • In this manual – You will find information of a general nature about encoder systems in Chapter 10 (Encoders). – You will find special information on the connection of the encoders in Chapter 4.2 (Connecting the Encoders). • In the relevant data sheets.
Frame length • 13 bit • 25 bit	The machine data is only present with an absolute encoder. With the frame length you define the behavior of the FM 351 on receiving the encoder signal. You define the cycle frame which the FM 351 outputs.
Displacement per encoder revolution: 1 to 1,000,000.000 mm	With the machine data “Displacement per encoder revolution” you inform the FM 351 of the distance covered by the drive system per encoder revolution. The value **Displacement per encoder revolution** depends on how your axis is set up and the position of the encoder. With this value you must take into account all transmission components such as couplings or gear units (take note of the illustrations in this table). If you do not take into account all the transmission components, the determined resolution does **not** represent the resolution of the table or of the tool. Please take note also of Chapter 8.6 (Resolution). It describes the relationship between the machine data **Displacement per encoder revolution** and **Increments per encoder revolution**.  

Table 8-4 Machine Data for the Encoder, continued

Machine Data and Assignment	Description
Increments per encoder revolution 1 to 2^{25}	The machine data **Increments per encoder revolution** gives the number of increments which the encoder produces per revolution. The FM 351 determines the resolution from this value and the machine data **Displacement per encoder revolution.**
	Incremental encoder Any value from the input range shown opposite can be entered. The FM 351 counts each edge of the 90° displaced signals from the incremental encoder, that is, four increments per signal period are counted and processed by the FM 351 (see also Chapter 10.1).
	Absolute encoder The upper limit is limited by the total number of encoder steps. It is defined by the product of the **Number of revolutions** and the **Increments per encoder revolution**. Only values in steps of a power of two are allowed as input. For the limits there is a difference between the various encoder models: • Single-turn encoders (no. of revs = 1) with 13 bit frame length: – Minimum value = 4 – Maximum value = 8192 • Multiturn encoders (no. of revs. > 1) with 25 bit frame length: – Minimum value = 4 – Maximum value = 8192 • Single-turn encoders with 25 bit frame length, no. of revs. = 1 and no. of increments per encoder revolution > 8192: – Minimum value = 4 – Maximum value = 2^{25}
Baud rate • 0.125 MHz • 0.250 MHz • 0.500 MHz • 1.000 MHz	With the baud rate you define the speed of the data transfer from SSI encoders to the FM 351. This entry has no significance for incremental encoders. The maximum line length is dependent on the following four stages: • 0.125 MHz → 320 m • 0.250 MHz → 160 m • 0.500 MHz → 63 m • 1.000 MHz → 20 m Take note that with increasing line length the transfer rate must be set lower.
Counting direction • Normal • Inverted	With the machine data **Encoder counting direction** you match the direction of the displacement measurement to the direction of axis movement.

Table 8-4 Machine Data for the Encoder, continued

Machine Data and Assignment	Description
No. of revolutions • 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096	This machine data is only required for absolute encoders. You use it to define the number of revolutions possible with this encoder. If you would like to know more about absolute encoders, please read Chapter 10.3 of this manual.
	Single-turn encoders If you have set the 13 bit encoder, the value is permanently fixed at 1.
	Multiturn encoders If you have set a 25 bit absolute encoder, set the power-of-two value from 1 to 4096. Please ensure that the total number of encoder steps is not exceeded.
Total no. of encoder steps	The total number of steps is not an item of machine data. It is found from the two data items: • Increments per encoder revolution. • Number of revolutions. Total no. of steps = Increments per encoder rev. · No. of revs.
Monitoring • Wire breakage (5 V signals) • Error pulse from incremental encoders (zero mark monitoring)	In operation the FM 351 monitors the connected encoder for: • Wire breakage • Error pulse
	Wire breakage With the activation of the monitoring the FM 351 monitors for an incremental encoder the signals A, $\overline{A}$, B, $\overline{B}$, N and $\overline{N}$. The monitoring detects: • Wire breakage Short circuit on the separate lines. • Interval between the edges of the counting pulses. • Failure of the encoder supply.
	Error pulse from incremental encoders An incremental encoder must always supply the same number of increments between two following zero marks. The FM 351 checks whether the zero marks of an incremental encoder occur at the correct point in time.

8.6 Resolution

Definition

The resolution is not a direct item of machine data. It is however found by the FM 351 from the two items of machine data:

- Displacement per encoder revolution.
- Pulses per encoder revolution.

With incremental encoders the quadruple evaluation is also taken into account.

The resolution is a measure for the accuracy of the positioning. It also determines the maximum possible travel range.

Relationship between Travel Range and Resolution

The travel range is limited by the number representation in the FM 351. The number representation varies depending on the resolution. Therefore, make sure that you are always within the permissible limits when specifying values. Please take note of the following table:

Resolution Lies in the Range ...	..then Following Values are Possible...
0.1 $^{\mu m}/_{increment}$ to 1 $^{\mu m}/_{increment}$	–100 000.000 to 100 000.000 mm
1 $^{\mu m}/_{increment}$ (inclusive) to 1 000 $^{\mu m}/_{increment}$	–1 000 000.000 to 1 000 000.000 mm

Calculating the Resolution

The resolution is calculated as shown in the following table:

	Incremental Encoders	Absolute Encoders
Input values	• Displacement per encoder rev. • Increments per encoder rev. • Pulse evaluation: Quadruple	• Displacement per encoder rev. • Increments per encoder rev.
Calculation	$RES = \dfrac{\dfrac{\text{Displacement}}{\text{encoder rev.}}}{4 \cdot \dfrac{\text{Increments}}{\text{encoder rev.}}}$	$RES = \dfrac{\dfrac{\text{Displacement}}{\text{encoder rev.}}}{\dfrac{\text{Increments}}{\text{encoder rev.}}}$

RES = Resolution

Rounding of the Values

With the internal computations the results are rounded according to mathematical rules.

8.7 Incremental Dimensions

Definition

Incremental dimensions are specified target values which can be approached by the FM 351 with the relative or absolute **incremental** operating mode.

You have the possibility of entering a maximum of 100 incremental dimensions in a table.

Requirements for Incremental Dimensions

When entering the incremental dimensions, please note the following requirements:

- The target that is to be approached must:
  - Be more positive than the Software Limit Switch Start plus half the target range

    and

  - Be more negative than the Software Limit Switch End minus half the target range.

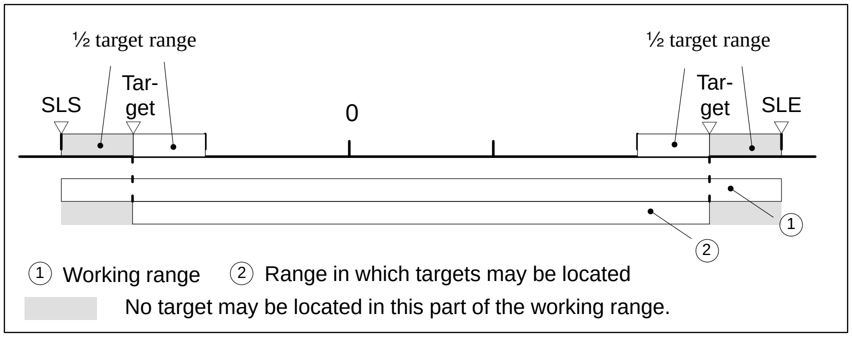


Figure 8-1 Limits for Entry of Incremental Dimensions

Interpretation of the Incremental Dimensions

Depending on which incremental mode you select, the FM 351 interprets the value differently.

- **Absolute incremental mode:** The incremental dimensions are interpreted as absolute target positions in the coordinate system.
- **Relative incremental mode:** The incremental dimensions are interpreted as differences in displacement from the start position.

Standard Increments 1 to 100

In the parameterization interface you must enter the incremental dimensions in an increment table. The list has space for a maximum of 100 increments which are valid for the **Relative incremental mode** as well as for the **Absolute incremental mode.**

Note

Note that the FM 351 does not allow any negative values for the **Relative incremental mode.**

Define separate areas for relative and absolute increments in the increment list.

Increment 254

You can use the setpoint value 254 as a further value for the displacement independently of the increment table. You enter the value:

- Either in the parameterization interface for transfer from the parameterization software.
- Or in the instance DB for transfer with the FC TG254.

Increment 255

Apart from Increment 254 another value is available with Increment 255. You enter the value:

- Either in the parameterization interface for transfer.
- Or in the channel DB for transfer with the FC TG253_5.

You transfer the switch-off difference and the switchover difference together with the increment. The entries from the machine data have no validity for this increment.

Switchover and Switch-off Difference for Increment 255

In contrast to the increments 1 to 100 and 254, for Increment 255 you specify only one value for each of the two ranges switch-off difference and switchover difference. These values are interpreted by the FM 351 depending on the direction of movement as positive or negative differences.

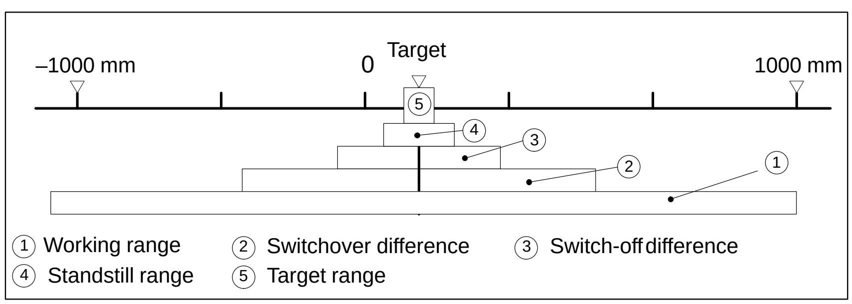


Figure 8-2 Symmetrical Position of the Switch-off and Switchover Points for Increment 255

Operating Modes and Settings 9

Operating Modes

The task of an FM 351 is the positioning of a drive at certain specified targets.

For these tasks the FM 351 has the following operating modes available:

- Jogging

  The drive is driven for the duration of the key depression.

- Incremental
  - Relative: The axis is traversed over a specified displacement.
  - Absolute: The axis is moved to an absolute target.
- Seek-reference-point

  The axis is synchronized.

Calling an operating mode is only possible with a parameterized channel.

Settings

Apart from the positioning of the drives using the operating modes, the FM 351 offers you settings. With these settings you have the possibility of:

- Synchronizing the axis.
- Displacing the coordinate system with the physical working range remaining the same.

The settings are executed once after calling. The effect is then retained after the call.

For example, a coordinate system remains in the displaced state after **Set actual value** until you set a further displacement or reset the displacement with a command.

Calling a setting is only possible with a parameterized channel.

Single Setting

With single settings you switch the FM 351 into a state in which you:

- Can define from which direction a target position is to be approached.
- Can position the drive independent of the enable input.

Single settings remain switched on until you terminate them with an FC call or by a call from the parameterization interface.

Calling Options

Basically, you have the option of conveniently calling all the settings. To do this, you select:

- The parameterization interface with which you comprehensively test and set up the FM 351.
- The FCs which you can link into your program.

In this chapter we only show you the calling of the single FCs. How you set the parameters, and which role the channel DB plays, you will find in the chapter Programming.

Note

Please note that the operating modes and (single) settings can only be called when correct machine data is present on the FM 351, that is, when the axis is parameterized.

Abbreviations in this Chapter

In this chapter we use abbreviations to describe individual actual positions or switches.

These are:

- SLS: Software Limit Switch Start
- SLE: Software Limit Switch End
- ACT: Actual value (momentary)
- REF: Reference point coordinate
- AEA: Absolute Encoder Adjustment

Chapter Overview

In this chapter you will find information as follows:

9.1 Generally Applicable Definitions

Travel Range

The maximum possible travel range is determined by the number representation in the FM 351.

Caution

The travel range of the FM 351 may be larger than the maximum range of the physical axis.

Therefore, secure your axis against the maximum possible limits being exceeded.

Starting an Operating Mode

Basically, an operating mode can only be started when all the starting conditions are satisfied. These are:

- The drive enable must be set.
- A “1” signal is applied to the enable input.
- A start command has been detected by the FM 351.

9.2 Jogging Operating Mode

Definition

In the **Jogging** operating mode you move the drive in one direction with the pressing of a key. You must install a key for each direction (positive and negative).

Requirements

The following requirements must be fulfilled for the start of the operating mode:

- The axis must be parameterized.
- No other operating mode must be currently started.
- The drive enable must be set.
- The enable input must be wired for each channel if the evaluation is not switched off (see Chapter 9.9).
- The operating mode must be started with a valid start command,
  - DIR_P for starting in the positive direction
  - DIR_M for starting in the negative direction.

Start Sequence

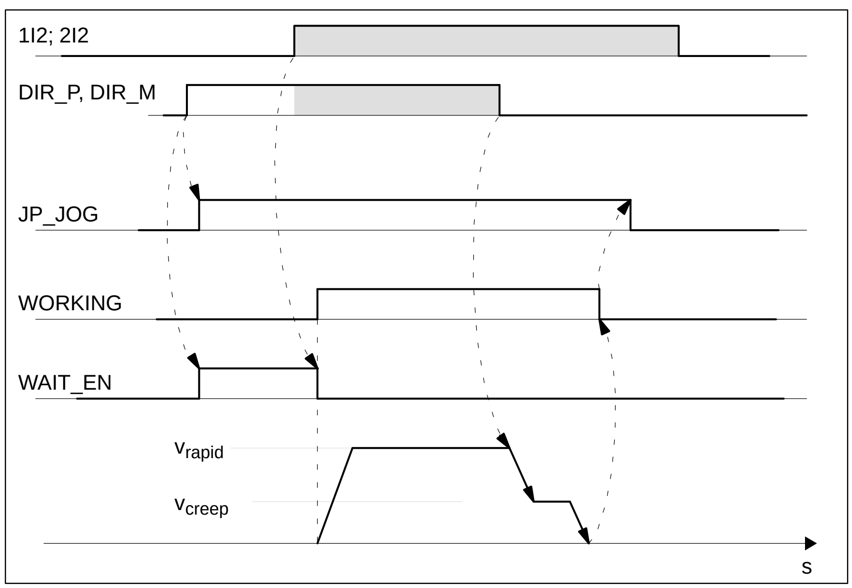


Figure 9-1 Starting the Jogging Operating Mode

Terminating Jogging

The **Jogging** operating mode is terminated when:

- You release the key with which you are "jogging" or
- The FM 351 receives a STOP signal or
- The actual value reaches the limit of the working range for a synchronized linear axis.

A change of direction is possible after the termination of the traverse.

Aborting Jogging

Aborting is a process with which the otherwise normal sequence of a target approach is not carried out (see Chapter 2.2)

“Jogging” is aborted when:

- The signal Drive enable is deleted.
- A traverse range limit is crossed with a linear axis.

Speeds

With the FM 351 jogging is possible at two speeds:

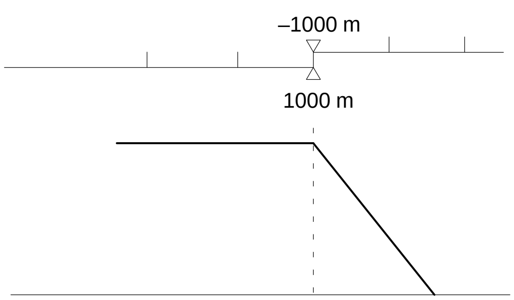
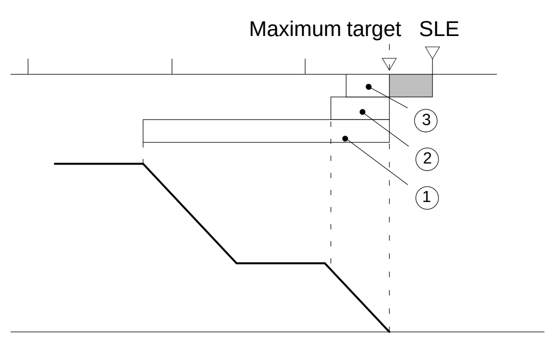
- Jogging at rapid speed.
- Jogging at creep speed.

You specify the speed on calling the operating mode either in the parameterization interface or in the FC JOG_MOD.

Limit for a Linear Axis

The limits for the **Jogging** operating mode differ for a synchronized and a non-synchronized axis.

Table 9-1 Jogging with a Synchronized and Non-Synchronized Axis

<table>
<tr><th>Axis is Not Synchronized</th><th>Axis is Synchronized</th></tr>
<tr><td>If the traverse range limit is crossed during jogging:
• The actual value display jumps to the opposite limit and
• The positioning is aborted.

</td><td>Jogging is positioning to target positions which are located at a distance of the half target range from the software limit switches.
The limits are determined from:
• SLE– ½ target range for the positive end of the linear axis
• SLS+ ½ target range for the negative end of the linear axis.
If you do not previously release the key, the FM 351 terminates at a target point which is located at the half target range in front of the corresponding software limit switch. All ranges, which are necessary for correct termination, are set by the FM 351 at this target point.


Part of the working range in which no target position may be located.</td></tr>
</table>

① Switchover difference positive ② Switch-off difference positive ③ ½ target range

9.3 Seek-Reference-Point Operating Mode

Definition

You synchronize the FM 351 with the Seek-reference-point mode.

Synchronization with a seek-reference-point traverse is only necessary with incremental encoders. A seek-reference-point traverse must be carried out for each channel.

The synchronization of pulse counters and the axis is necessary:

- So that your drive can approach an absolute target.
- So that your drive can traverse a relative displacement in a defined range.
- Because, for example, the reference point is lost after a POWER-ON.

Requirements

Please take note of the following requirements for the seek-reference-point mode:

- The channel for which a seek-reference-point mode is to be carried out, must be parameterized.
- You have defined in the machine data:
  - The type of seek-reference-point mode.
  - The start speed for a seek-reference-point mode.

Note

The following applies for a rotary axis: The reproducibility of the reference point is only guaranteed if an integer ratio exists between the increment values for the value **End of rotary axis** and the value **Displacement per encoder revolution**.

Connection	Channel 1	Channel 2
Reference-point switch	On digital input 1I0	On digital input 2I0
	The reference-point switch must be designed such that in the region of the switch the drive can brake reliably from rapid to creep speed.	
Reversing switch	On digital input 1I1	On digital input 2I1
	During parameterization ensure that the start of the seek-reference-point traverse is parameterized in the direction of the reversing switch. It is only by doing this that you can be sure that the reference-point switch is always found.	
Enable input	On digital input 1I2	On digital input 2I2

Speeds

You can define a speed for the start of a seek-reference-point traverse:

- Start with creep speed.
- Start with rapid speed.

Calling the Seek-Reference-Point Mode

You call the seek-reference-point mode:

- In the mask for setting up the parameterization interface.
- With the FC REF_MODE.

Start Commands for a Seek-Reference-Point Traverse

The following commands are selected by edge control for the operating mode **Seek-reference-point:**

Table 9-2 Start Commands for a Seek-Reference-Point Traverse

Start Command	Task	Remarks
DIR_P	The drive starts in the direction of positive values, that is, it moves in the direction of the end of the traverse range.	If a negative direction is entered in the machine data, the FM 351 signals an operating error. No seek-reference-point traverse is carried out.
DIR_M	The drive starts in the direction of negative values, that is, it moves in the direction of the start of the traverse range.	If a positive direction is entered in the machine data, the FM 351 signals an operating error. No seek-reference-point traverse is carried out.
START	The drive starts in the direction entered in the machine data.	

Type of Seek-Reference-Point Mode

For incremental encoders the machine data **Type of Seek-Reference-Point Mode** determines:

- The direction in which a seek-reference-point traverse must be started.
- The position of the encoder zero mark referred to the reference-point switch.

Take note of the following table. It shows you the four types of seek-reference-point mode.

Table 9-3 Types of Seek-Reference-Point Mode

Start Direction is...	For Synchronization use...
positive	The first zero mark after leaving the reference-point switch in **positive** direction.
positive	The first zero mark after leaving the reference-point switch in **negative** direction.
negative	The first zero mark after leaving the reference-point switch in **positive** direction.
negative	The first zero mark after leaving the reference-point switch in **negative** direction.

Starting Sequence

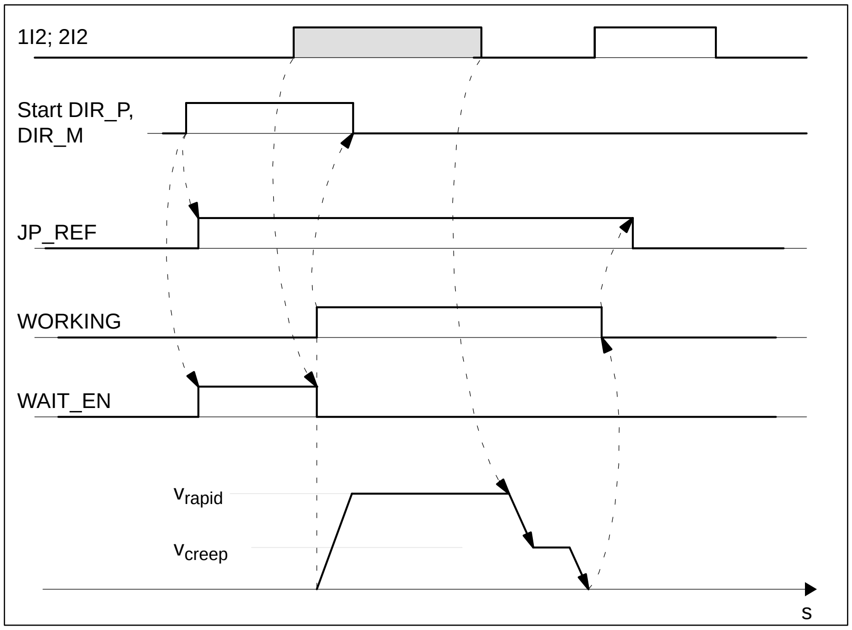


Figure 9-2 Starting a Seek-Reference-Point Traverse

9.4 Possibilities for the Seek-Reference-Point Mode

Seek-Reference-Point Traverse in Dependence of the Start Position

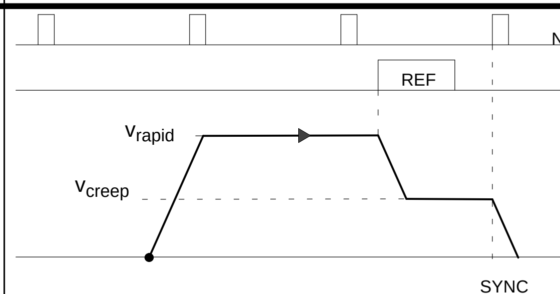
With a seek-reference-point traverse there are five different cases which are dependent:

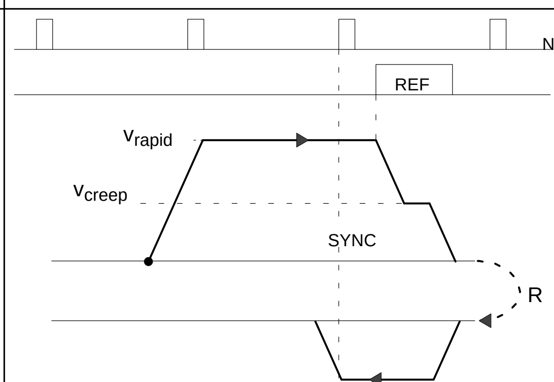
- On the position of the drive on starting a seek-reference-point traverse.
- On the parameterized start direction.
- On the parameterized position of the zero mark for the reference-point switch.

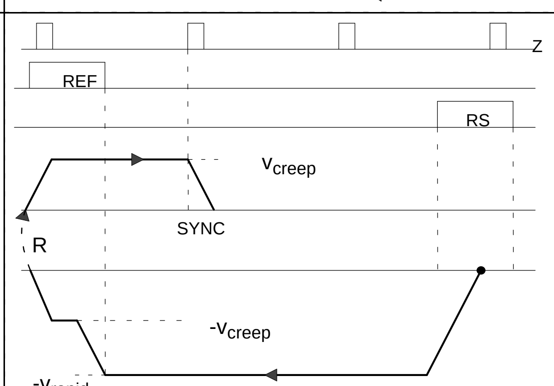
Please take note of the following table.

Table 9-4 All Possibilities for a Seek-Reference-Point Mode

<table>
<tr><th>Conditions for the Seek-Reference-Point Mode</th><th>Sequence of the Seek-Reference-Point Mode</th></tr>
<tr><td>On reaching the reference-point switch, the traverse direction is identical to the position of the zero mark from the reference-point switch:

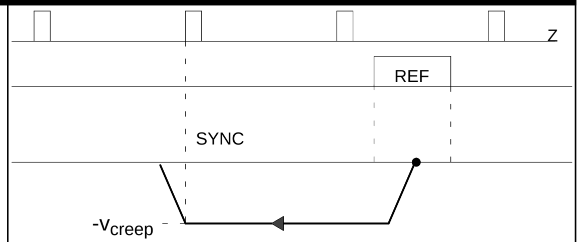
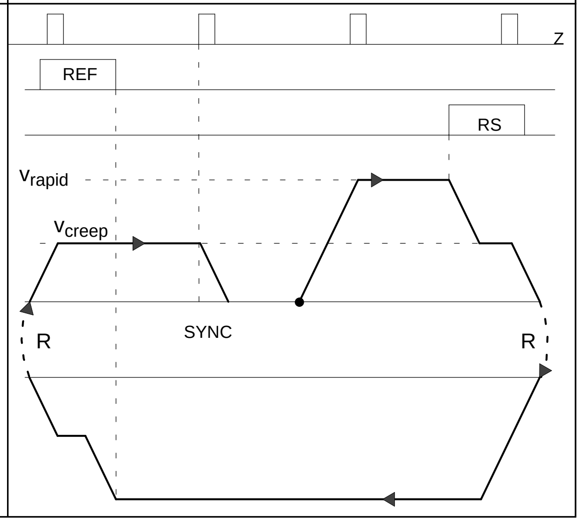
Current traverse direction on reaching the reference-point switch is positive.
Position of the zero mark from the reference-point switch is parameterized positively.
Start position of the seek-reference-point traverse is more negative than the reference-point switch.
Start direction is positive.
</td><td>
</td></tr>
<tr><td>On reaching the reference-point switch, the traverse direction is not equal to the position of the zero mark from the reference-point switch:

Current traverse direction on reaching the reference-point switch is positive.
Position of the zero mark from the reference-point switch is parameterized negatively.
Start position of the seek-reference-point traverse is more negative than the reference-point switch.
Start direction is positive.
</td><td>
</td></tr>
<tr><td>The drive is positioned at the reverse switch:

Position of the zero mark from the reference-point switch is parameterized positively.
Start position of the seek-reference-point traverse is at the reverse switch.
The reverse switch is more positive than the reference-point switch.
Start direction must be parameterized positively.
</td><td>
</td></tr>
</table>

9

Table 9-4 All Possibilities for a Seek-Reference-Point Mode, continued

Conditions for the Seek-Reference-Point Mode	Sequence of the Seek-Reference-Point Mode
At the start of the seek-reference-point mode the drive is located at the reference-point switch. • Position of the zero mark from the reference-point switch is parameterized **negatively.** • Start position for the seek-reference-point mode is at the reference-point switch. • Start direction is positive.	
On starting in the parameterized traverse direction the drive is located between the reference-point switch and the reversing switch. The start direction is in the direction of the reversing switch. • Position of the zero mark from the reference-point switch is parameterized **positively.** • The reversing switch is more positive than the reference-point switch. • Start direction is positive.	

R = Direction reversal REF = Reference-point switch RS = Reversing switch Z = Encoder zero mark
SYNC = Synchronization has been obtained.

9.5 Incremental Operating Mode

Definition

With the incremental mode the FM 351 can:

- Move the drive to **absolute** targets.
- Move the drive **relatively** by a displacement in a specified direction.

The target position or the relative displacements are specified for the FM 351 as incremental dimensions.

Requirements

Take note of the following requirements for the incremental mode:

- The channel which is to be operated in the **incremental** operating mode must be parameterized, that is, the machine data must be present.
- The incremental dimensions must be present on the module.
- The channel must be synchronized.
- A valid start signal must be received.
- The drive enable must be set.
- When positioning on the Increment 254, the value must be present in the relevant channel DB (TARGET_254) and on the FM 351.
- When positioning on the Increment 255, the value and switchover and switch-off differences must be entered in the relevant channel DB (TARGET_255) and must be present on the FM 351.

Note

Only positive specified values are permitted for the specified displacement for the incremental operating mode.

Starting Sequence

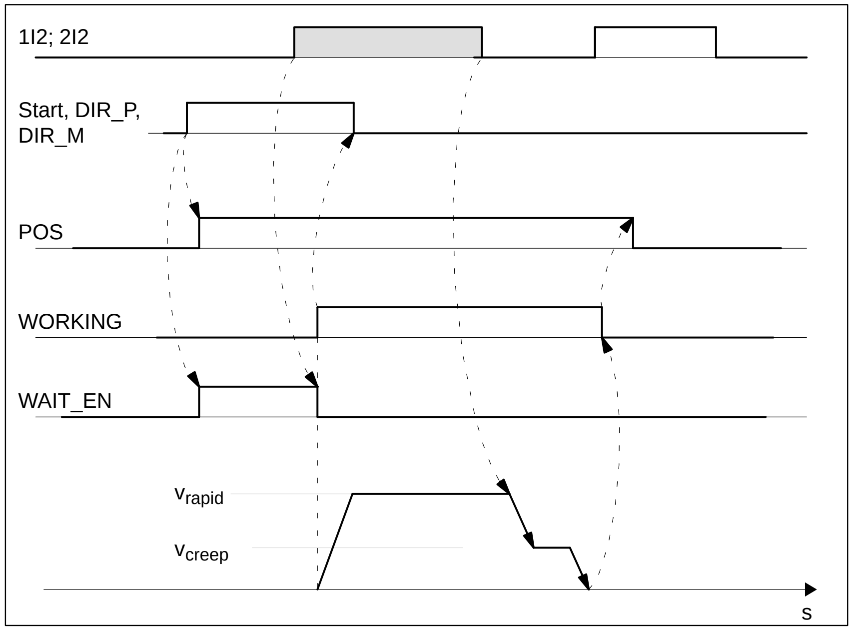


Figure 9-3 Starting the Incremental Mode

Start Command

The methods of starting an incremental mode are dependent on:

- The type of incremental mode (relative or absolute).
- The type of axis.

The FM 351 evaluates the rising edge of the start signal. In this respect, please take note of Chapter 9.9.

The FM 351 starts the positioning after detecting the start command and when all start conditions are fulfilled.

You have the following possibilities for the start:

Table 9-5 Start Commands for the Incremental Mode

Type of Axis	Start Command for Relative Incremental Mode	Start Command for Absolute Incremental Mode
Linear axis	**DIR_P**; Start in positive direction **DIR_M;** Start in negative direction	**START:** Start for the absolute target position. The direction is unambiguously defined by the target and the current actual value.
Rotary axis	**DIR_P**; Start in positive direction **DIR_M;** Start in negative direction	**START:** The target is approached along the shortest path. **DIR_P:** Start in positive direction. **DIR_M:** Start in negative direction.

Residual Distance with Relative Incremental Mode

With the **relative incremental** mode a residual distance remains, if the relative incremental mode was terminated by STOP.

The remaining residual distance can be traversed to the end if:

- The operating mode is unchanged,
- The incremental dimension number is unchanged,
- The direction is unchanged and
- The remaining residual distance is larger than the parameterized switch-off difference.

The residual distance is traversed by starting the relative incremental mode once again unchanged.

Deleting the Residual Distance

You delete an existing residual distance using the single command **Delete residual distance.**

You call the single command via the FC SNG_COM. You must have saved the parameters for the call in the instance DB.

By calling a different operating mode, or starting the operating mode in the other direction, you also delete the existing residual distance.

9.6 Setting Set Actual Value

Definition

With the setting **Set actual value** you allocate a new coordinate to the current encoder location. The working range is projected to a different physical range on the axis. Therefore, you do not change any coordinate values.

The displacement of the working range is determined by ACT_{new} - $ACT_{current}$.

- ACT_{new} is the specified value.
- $ACT_{current}$ is the actual value at the time of execution.

Requirements

Take note of the following requirements for this setting:

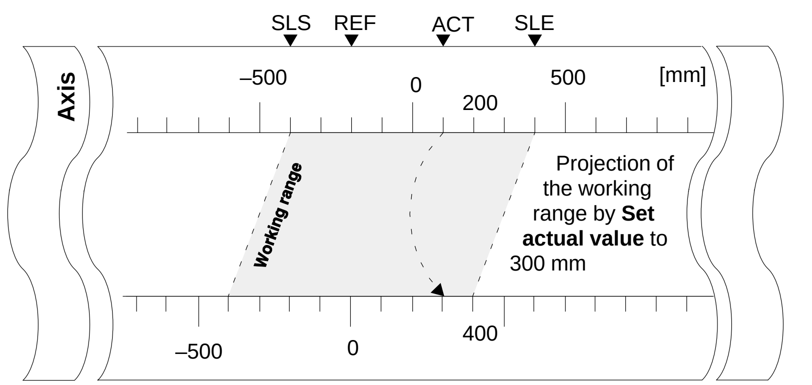
- The axis must be synchronized on calling the function.
- The specified actual value must be located within the working range.
- The value must be entered in the DB for calling the setting by an FC.
- Select the FC ACT_VAL for setting Set actual value.
- The following applies to a linear axis: The magnitude of the displacement produced from (**ACT_{new} - $ACT_{current}$**) must be less than or equal to the magnitude of the permissible number range.
- The following applies to a rotary axis: The specified actual value must be more negative (smaller) than the rotary axis end and greater than or equal to zero.

Effects of the Setting

Using an example of **Set actual value** to 300 mm you can see how this setting projects the travel range to a certain physical position on the axis. It produces the following effects:

- The actual position is set to the **new actual value.**
- The working range is displaced physically on the axis.
- The individual points retain their original value, but are located at new physical positions.

Table 9-6 Displacement of the Working Range on the Axis by **Set Actual Value**

<table>
<tr><th>Set Actual Value</th><th>SLS</th><th>REF</th><th>ACT</th><th>SLE</th></tr>
<tr><td rowspan="2">
</td><td>-400</td><td>-200</td><td>100</td><td>400</td></tr>
<tr><td>-400</td><td>-200</td><td>300</td><td>400</td></tr>
</table>

All numerical values are given in the units of mm.

Resetting the Setting

With the single command **Undo set actual value** you set the coordinate displacement created by Set actual value back again.

You call the single command with the FC SNG_COM. The channel DB must contain the appropriate values.

9.7 Setting Set Reference Point

Definition

With the setting **Set reference point** you synchronize the axis.

Requirements

Take note of the following requirements for this setting:

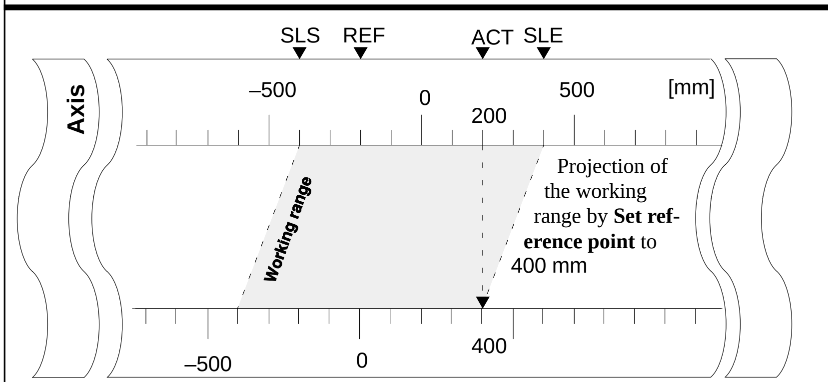
- The channel must be parameterized.
- Linear axis: The reference-point coordinate must not be located outside the software limit switches.
- For a rotary axis: The reference-point coordinate must be greater than or equal to zero and less than the value **End of rotary axis.**

Effects of the Setting

Using an example of **Set reference point** to 400 mm, you can see how this setting projects the traverse range to a certain physical position on the axis. It has the following effects:

- The actual position is set to the value of the reference-point coordinate.
- The working range is physically displaced on the axis.
- The individual points retain their original value, but are now located at new physical positions.

Table 9-7 Displacement of the Working Range on the Axis by **Set reference point**

<table>
<tr><th>Set reference point</th><th>SLS</th><th>REF</th><th>ACT</th><th>SLE</th></tr>
<tr><td rowspan="2">
</td><td>-400</td><td>-200</td><td>200</td><td>400</td></tr>
<tr><td>-400</td><td>-200</td><td>400</td><td>400</td></tr>
</table>

All numerical values are given in the units of mm.

Special Remarks for Absolute Encoders

With absolute encoders this setting is used to assign a coordinate system to the encoder range.

The FM 351 then determines an absolute encoder adjustment (see Chapter 8.4) which is assigned to the value of the reference-point coordinate. With this the absolute encoder is matched to the axis.

9.8 Single Setting Loop Traverse

Definition

With the single setting **Loop traverse** you define the direction in which a target is approached.

A target which is approached against the specified direction is first passed by. Then the FM 351 carries out a reversal of direction and approaches the target in the specified direction.

With this single setting you can ensure that a target is always approached with force contact.

The loop traverse can be simultaneously called with the following single settings:

- Do not evaluate enable input.

Use of the Loop Traverse

You can use the loop traverse when force contact between the motor and the axis can only be ensured in one direction.

Make sure that you select the correct loop traverse for the force contact. Specifying the wrong loop traverse may mean that the drive does not reach the target.

Fictitious Target

When you start positioning to a target, which is located against the direction of the parameterized loop traverse, the FM 351 determines a fictitious target for this target. At the fictitious target it executes a change of direction and then approaches the real target in the correct direction.

This fictitious target **must** be located within the permissible range for incremental dimensions.

The distance of the fictitious target from the parameterized target is found depending on the direction:

Table 9-8 Calculation of the Position of the Fictitious Target during a Loop Traverse

Specified Values	Position of the Fictitious Target
Parameterization: Loop + and traverse in negative direction.	The distance of the fictitious target is calculated from: • The positive switch-off difference and • The negative switch-over difference. The fictitious target (**Target$_f$**) has the value: **Target$_f$ = Target - Positive switch-off difference - Negative switchover difference**
Parameterization: Loop - and traverse in positive direction.	The distance of the fictitious target is calculated from: The negative switch-off difference, • The positive switch-over difference. The fictitious target (**Target$_f$**) has the value: **Target$_f$ = Target + Negative switch-off difference + Positive switchover difference**

Requirements

Take note of the following requirements for a loop traverse:

- If you have parameterized a loop traverse against the traverse direction to the target, the target position which can be approached at a maximum is located at:
  - With positive traverse direction

    Target < SLE - $^1/_2$ Target range - Negative switch-off difference - Positive switchover difference
  - With negative traverse direction

    Target > SLS + $^1/_2$ Target range + Positive switch-off difference + Positive switchover difference
- A loop traverse is **not** executed if the target is approached in the direction of the loop traverse.
- If you have parameterized a loop traverse in the traverse direction to the target, the target position which can be approached at a maximum is located at:
  - With positive traverse direction

    Target < SLE - $^1/_2$ Target range
  - With negative traverse direction

    Target > SLS + $^1/_2$ Target range

Example

The figure below shows you the position of the fictitious target based on positioning with loop traverse to the maximum target position in the positive direction.

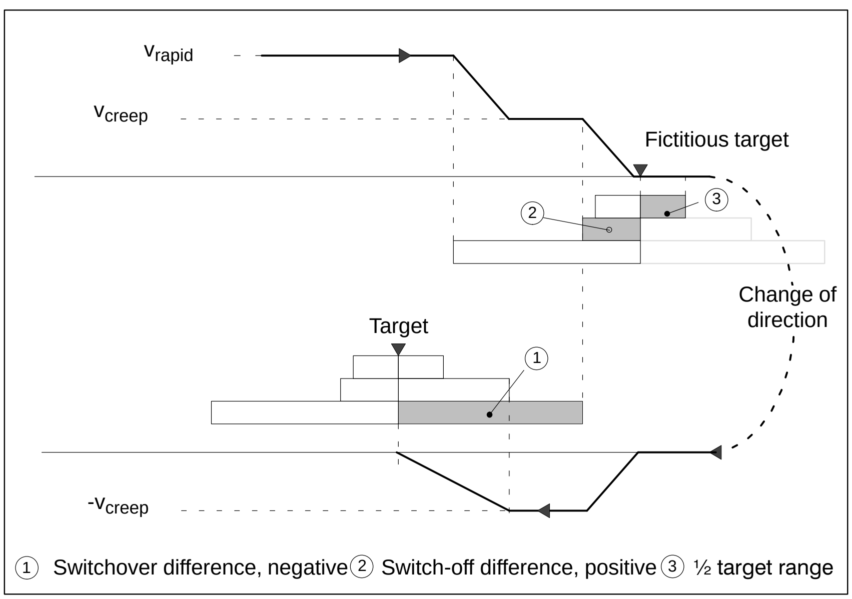


Figure 9-4 Loop Traverse to a Target at the Software Limit Switch End

9.9 Single Setting Do Not Evaluate Enable Input

Definition

The start of an operating mode for a channel is normally only possible, if the appropriate enable input is set:

- Digital input 1I2 for Channel 1
- Digital input 2I2 for Channel 2

You therefore have the possibility of preparing an operating mode for starting. The actual start is then independent of the program sequence in the your user program. You start the operating mode by applying a “1” on the enable input.

Switching the Evaluation Off

When you switch off the evaluation of the enable input, an operating mode starts immediately after detection of the start signal. It is then not possible to prepare an operating mode and to start it at a defined later point in time.

Start Enable in Dependence of the Start Signal

The operating modes are started differently in the FM 351. You must differentiate between:

- Edge-controlled start signals.
- Level-controlled start signals.

Table 9-9 shows you the start signals for the various operating modes:

Table 9-9 Behavior of the Start Signals during the Operating Modes

Operating Mode	Start Signal is Level-Controlled	Start Signal is Edge-Controlled
Jog	DIR_P, DIR_M	
Seek-reference-point		START, DIR_P, DIR_M
Absolute increment		START, DIR_P, DIR_M
Relative increment		DIR_P, DIR_M

Requirements for Starting an Operating Mode

In order that an operating mode actually starts, the following requirements must be fulfilled:

- The operating mode has been prepared with a set start command using an FC.
- The enable input must be switched on.

Encoders 10

Encoders which You Can Connect

You can connect the following encoders to the positioning function module:

- Incremental encoders
- Absolute encoders (SSI)

Chapter Overview

In this chapter you will find information in the following sub-chapters:

10.1 Incremental Encoders

Incremental Encoders

The FM 351 Positioning Function Module supports two types of incremental encoder:

- Incremental encoders (25 V) with asymmetrical output signals.
- Incremental encoders (5 V) with symmetrical output signals.

Signal Waveforms

The signal waveforms from encoders with asymmetrical and symmetrical output signals are illustrated in Figure 10-1.

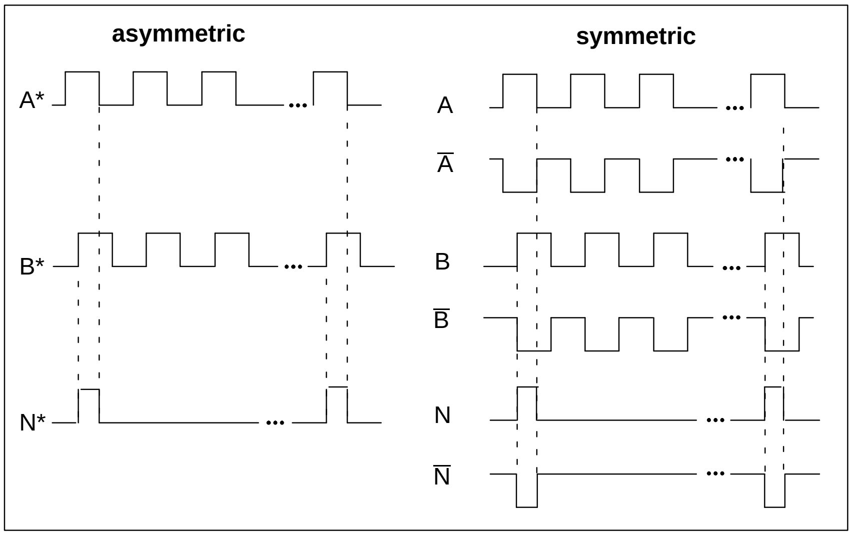


Figure 10-1 Signal Waveforms from Incremental Encoders

Pulse Evaluation

The FM 351 Positioning Function Module employs quadruple evaluation of the encoder pulses.

Quadruple evaluation means that both edges of the pulse trains A and B are evaluated.

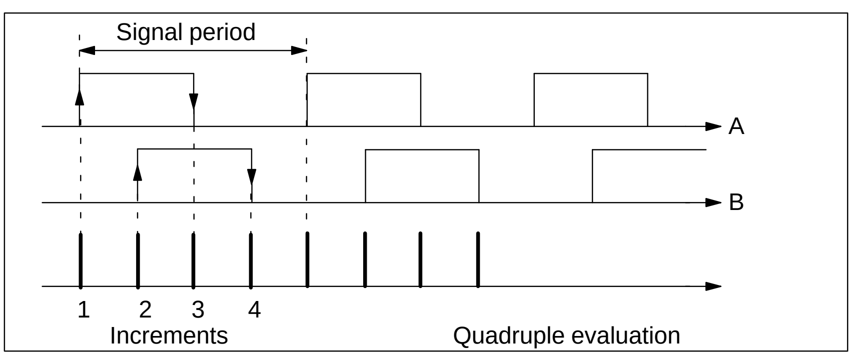


Figure 10-2 Quadruple Evaluation

10.2 Selecting an Incremental Encoder

Incremental Encoders

Only incremental encoders with two pulses having zero marks and offset by 90° are supported:

- Encoders with symmetrical output signals with 5 V differential interfaces conforming to RS422
  - Cut-off frequency = 500 kHz
  - At 5 V supply voltage: max. 32 m line length.
  - At 24 V supply voltage: max. 100 m line length.
- Encoders with asymmetrical output signals with 24 V level
  - Cut-off frequency = 50 kHz: max. 100 m line length.

Response Times

The following response time applies to incremental encoders:

Response time = Hardware switching time

Note

You can compensate the response time with appropriate parameterization of the switchover and switch-off differences.

Example: Response Times

An example of the response time:

Hardware switching time: approx. 150 µs

Response time = 150 µs

Blurring

Blurring affects the positioning accuracy. With incremental encoders the blurring is negligible.

Manufacturer

We recommend that you use incremental encoders from SIEMENS (see Appendix B).

10.3 Absolute Encoders

Single-Turn and Multi-Turn Encoders

There are the following absolute encoders:

- Single-turn encoders

  Single-turn encoders form the total encoder range on one encoder revolution. You can use single-turn encoders with the following steps per revolution:

  – With 13 bit frame length having 2^2 to 2^{13} steps.

  – With 25 bit frame length having 2^2 to 2^{25} steps.

- Multi-turn encoders

  Multi-turn encoders form the total encoder range over a number of encoder revolutions.

  Multi-turn encoders (25 bit: tree-type):

  – Steps per revolution: 2^2 to 2^{13}

  – Number of revolutions: 2^1 to 2^{12}

Data Processing

Only absolute encoders with a serial interface are supported. The transfer of the displacement information takes place synchronously according to the SSI protocol (Synchronous Serial Interface). The FM 351 supports the data format from the company Stegmann.

You can only use absolute encoders (SSI) with GRAY code. Due to the arrangement of the user bits within the 13 or 25 bit frame, data formats are produced which have the shape of a “tree” or “half tree”.

- Single-turn encoders: “half tree” with 13 or 25 bit frame length (left justified).
- Multi-turn encoders: Tree type with 25 bit frame (12 bits for number of revolutions and 13 bits for steps per revolution).

Data Transfer

The baud rate for the data transfer depends on the line length (see Appendix A, Technical Data).

10.4 Selecting an Absolute Encoder

Absolute Encoders

You can connect single-turn encoders (13 or 25 bit frame length) or multi-turn encoders (25 bit frame length) to the FM 351 Positioning Function Module (see Chapter 10.3).

Response Times

The following response times apply to absolute encoders (SSI):

> Min. response time = Frame transfer time + Hardware switching time
>
> Max. response time = 2 · Frame transfer time + monostable flipflop period + Hardware switching time
>
> With programmable absolute encoders:
>
> Max. response period = Frame transfer time + Monostable flipflop period + Hardware switching time + 1/max. step sequence frequency

Frame Transfer Times

The frame transfer times depend on the baud rate:

Baud Rate	Frame Transfer Time for 13 Bit	Frame Transfer Time for 25 Bit
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 you can calculate the minimum and maximum response times. In the example a programmable encoder is not used.

- Hardware switching time: approx. 150 µs
- Frame transfer time: 26 µs at 1MHz baud rate
- Monostable flipflop period: 64 µs

Min. response time = 26 µs + 150 µs = 176 µs

Max. response time = 2 · 26 µs + 64 µs + 150 µs = 266 µs

Note

You can compensate the minimum response time by appropriate parameterization of the switchover and switch-off differences.

Blurring

Blurring affects the accuracy of positioning. It is the difference between the maximum and minimum response times. With an absolute encoder (SSI) it's magnitude is:

> Blurring = Frame transfer time + Monostable flipflop period
>
> For programmed absolute encoders:
>
> Blurring = Frame transfer time + Monostable flipflop period +1/max. step sequence frequency

Manufacturer

We recommend that you use absolute encoders from SIEMENS (see Appendix B).

11 Error Handling

Preliminary Remarks

The FM 351 Positioning Function Module provides diagnostic possibilities for:

- Errors on the module and the connected peripherals.
- Errors which occur when controlling the module.

Purpose of this Chapter

This chapter describes the procedure during the error evaluation for the FM 351.

There are three different cases for diagnosis:

- Module defects

  Module defects are faults or defects on the module. The module must be replaced.
- Errors for which the FM 351 initiates a diagnostic interrupt.
- General errors which the module stores in its diagnostic buffer.

  These are the errors

  – which the FM 351 detects during parameterization and controlling and which do not initiate a diagnostic interrupt and

  – those which occur in operation asynchronously to the control and which initiate a diagnostic interrupt due to a group error bit.

Evaluating Errors with the Program

How you link modules which are capable of diagnosis into your user program and how you evaluate the diagnostic signals in a program is described in the following manuals:

- Programming Manual *System Software for S7-300 and S7-400, Program Design* (OB types, diagnostic interrupt OB 82).
- Reference Manual *System Software for S7-300 and S7-400, System and Standard Functions*.

The basic description of the S7-300 diagnostic system is described in the User Manual *Standard Software for S7 and M7, STEP 7*.

11.1 Module Defects

Purpose

When the FM 351 starts up, that is, the power supply is switched on (“Power on”), the FM 351 goes through a general module test (that is, RAM test and EPROM test).

Effect

If the module is faulty and not ready, then

- the FM 351 remains in a safe state,
- the LED “SF” (see following Fig. 11-1) does not go out and
- it is not possible to start the CPU.

It is **not** possible to communicate with the module using the user program and the operating interface.

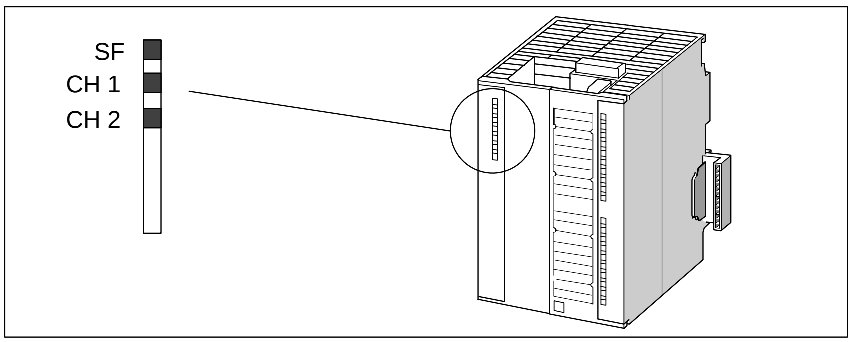


Figure 11-1 Status and Error Indicators on the FM 351

Status and Error Indicators

The status and error indicators are explained in the sequence in which they are arranged on the FM 351.

Indicator	Meaning	Explanation
SF (red) LED – ON	Group error	This LED indicates an error state with the FM 351. Diagnostic interrupt (internal or external (channel) error). See the error list in Appendix 11.2 for rectification of the error.
CH 1 (red) CH 2 (red)	Channel error 1 Channel error 2	These LEDs indicate a channel error on channel 1 or on channel 2. • Wire breakage on encoder 1 or encoder 2. • Error, absolute encoder 1 or absolute encoder 2. • Error pulse incl. encoder 1 and encoder 2. • Operating error. • Parameterization error for parameterization from the rack SDB.

Error Rectification

The module is defective and must be replaced.

11.2 Diagnostic Interrupts

Purpose

Errors leading to a diagnostic interrupt are monitored for their "incoming" and "outgoing".

The FM 351 signals "incoming" errors by:

- Lighting the LED "SF" (see Fig. 11-1).
- Maybe also lighting the LEDs "CH1" or "CH2".
- Setting the Bit **0.0** in OB 82 (OB82_MDL_DEFECT).

Note

A diagnostic interrupt is "incoming" if at least one error is present. If an error, but not all errors have been rectified, the rest of the existing errors are signaled again as "incoming".

A diagnostic interrupt is then only "outgoing" if the last error on the module has been rectified.

Requirements

A requirement for the evaluation of the cause of a diagnostic interrupt is that you have linked the interrupt OB (OB 82; see Programming Manual *System Software for S7-300 and S7-400, Program Design*) in your user program.

The diagnostic interrupts must be enabled in the basic parameterization.

Note

If the OB 82 is not linked, the CPU enters the STOP state for a diagnostic interrupt.

FM 351 Response to an Error with Diagnostic Interrupt

When a diagnostic interrupt occurs, the FM provides a defined system state due to the following actions:

- The positioning is aborted.
- The synchronization is deleted if:
  - The external auxiliary voltage is missing,
  - A zero-mark error has been detected, line fault (5 V encoder signals),
  - The traverse range and the working range have been left (an operating error is also signaled).
- The start of a new traverse is only possible when the error has been rectified. With an operating error jogging in the direction of the working range is still possible.

FM 351 Detects an Error (”Incoming”)

If the FM 351 signals an “incoming” error, you should note the following sequence:

1. The FM 351 detects one or more errors and initiates a diagnostic interrupt. The LED “SF” and, depending on the error, the LEDs “CH1”/“CH2” light.
2. The CPU operating system calls OB 82.
3. You can evaluate the four-byte start information of OB 82.
4. If this information is not enough, then you must read the module-specific diagnostic data.

   The FC DIAG_INF reads the diagnostic data and enters it in the channel DB in the parameter DIAGNOSTIC_INT_INFO. The first four bytes are identical to the start information of the OB 82. The rest of the bytes contain the additional information.
5. From a program point of view, the evaluation is finished.

   If you require still further information, that is, about the operating errors, then you must call the “FM Config” operating interface and read the error messages in the service mask.

FM 351 Detects the Transition to the Error-Free Status (”Outgoing”)

If the FM 351 signals an “outgoing” error, then you should take note of the following sequence:

1. The FM 351 detects that all errors have been rectified and initiates a diagnostic interrupt. The LED “SF” does not light any more.
2. The CPU operating system calls the OB 82.
3. First you should evaluate Bit **0** in the first byte (OB82_MDL_DEFECT).
   If this bit is “0”, then no errors are present on the module. Your evaluation can terminate here.

How Can the Diagnostic Interrupt Be Localized?

When the FM 351 initiates a diagnostic interrupt:

- The system makes four bytes of interrupt information available in the interrupt OB (OB 82) (see Table 6-3).
- Further diagnostic bytes are accessible via the FC DIAG_INF which are entered in the FC in the relevant channel DB.
- The Bit **0.0** on the faulty module is set (OB82_MDL_DEFECT) and
- The LED "SF" lights and "CH1"/"CH2" depending on the error.
- With the aid of the diagnostic chart shown in Figure 11-2 you can see the relationship between the separate bits.

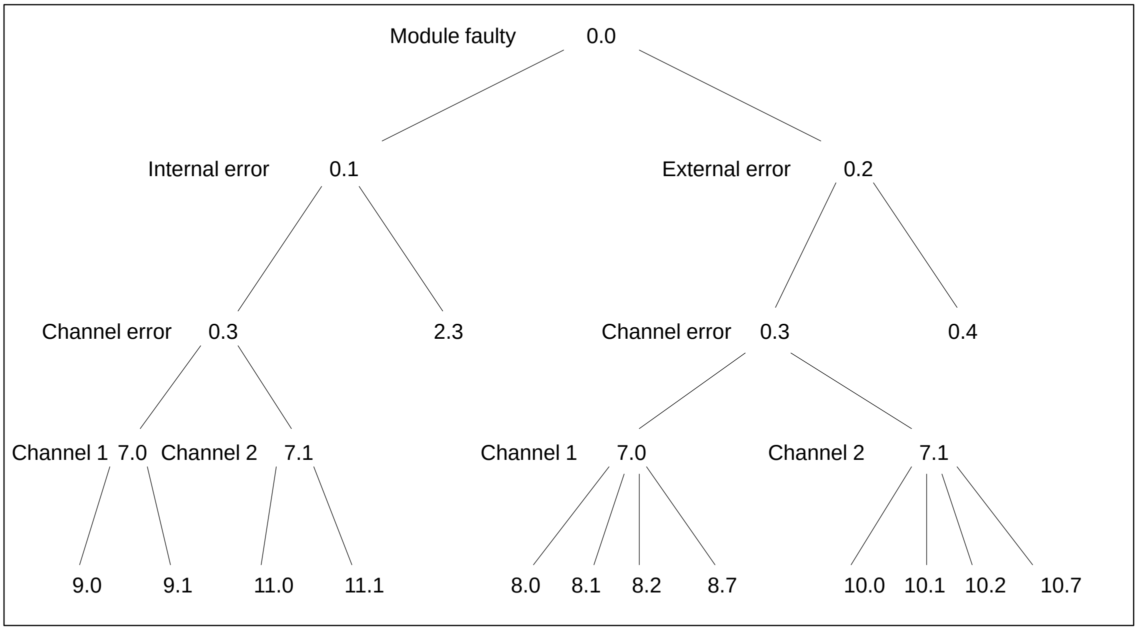


Figure 11-2 Diagnostic Chart: Bits in the Channel DBs from Byte 72 Onwards (DIAGNOSTIC_INT_INFO)

Diagnostic Interrupts in Dependence of the CPU Status

If you have allowed diagnostic interrupts in the basic FM 351 parameterization, then please take note of the following relationship:

- In the CPU STOP state the diagnostic interrupts from the FM 351 are inhibited.
- If with the CPU in the STOP state, none of or not all of the existing errors are rectified, the FM 351 signals the errors which have been already detected and not yet rectified again as "incoming" after the transition into the RUN state.
- If all existing errors have been rectified in the CPU STOP state, then the error-free FM 351 state is **not** signaled with a diagnostic interrupt after the transition to the RUN state.

Diagnostic Interrupts

The following table shows all diagnostic interrupts output by the FM 351. The byte details in the following table are relative to the Address 72.0 of the relevant channel DB.

Table 11-1 Diagnostic Interrupts for Internal Errors

Bit	Error Signal, Error Analysis and Rectification		Event Number
0.0	Module is faulty - more precise analysis is possible (see Figure 11-2)		0x8000
0.1	Internal error has occurred - more precise analysis is possible (see Figure 11-2)		0x8001
0.2	External error has occurred - more precise analysis is possible (see Figure 11-2)		0x8002
03	Channel error (internal or external) - more precise analysis is possible (see Figure 11-2)		0x8003
0.4	**External auxiliary voltage 24 V missing**		0x8004
	Cause	• External 24 V auxiliary voltage is not connected. • Fuse on the module is defective. • Low voltage. • Ground wire breakage.	
	Effect	See Page 11-3 • The processing is aborted. • The outputs are switched off. • With incremental encoders, synchronization is deleted. • Start enable is deleted.	
	Rectifica-tion	Make sure that the 24 V connection is correct. (If 24 V connection is correct, then the module is defective.)	
2.3	**Internal time monitoring (watchdog)**		0x8033
	Cause	• Strong interference on the FM 351. • Error in the FM 351.	
	Effect	• Module is reset. • Provided that after resetting the module, no module defect (see Chapter 11.1) is detected, the module is ready for operation again. • The module signals the expired WATCHDOG with “incoming” and “outgoing”.	
	Rectifica-tion	• Eliminate the interference. • If the manual instructions are followed, the errors should not occur. However, if this is the case, please contact the appropriate sales department. It is very important to state the exact circumstances leading to the error. • Replace the FM 351.	
7.0	Channel 1 faulty - more precise analysis is possible (see Figure 11-2)		
7.1	Channel 2 faulty - more precise analysis is possible (see Figure 11-2)		

Table 11-1 Diagnostic Interrupts for Internal Errors, continued

Bit	Error Signal, Error Analysis and Rectification		Event Number
8.0 or 10.0	**Encoder wire breakage**		0x8090
	Cause	• Encoder cable cut or not plugged in. • Encoder has no quadrature signals. • Incorrect pin assignment. • Cable length too long. • Encoder signals short circuited.	
	Effect	See Page 11-3 • The outputs are switched off. • With incremental encoders, synchronization is deleted. • Start enable is deleted.	
	Rectifica-tion	• Check encoder cable. • Keep within encoder specification. • Monitoring can be temporarily suppressed under the owner's responsibility by parameterization in the parameterization interface. • Keep to the module technical data.	
8.1 or 10.1	**Errors for absolute encoders**		0x8091
	Cause	The frame traffic between FM 351 and the absolute encoder (SSI) is erroneous or interrupted: • Encoder cable cut or not plugged in. • SSI frame error; Start/stop bit error detected during measurement data acquisi-tion. • Prefix and suffix bits (actual useful bits up to clock boundary) in frame not zero (encoder value outside encoder range). • Change in encoder value greater than 1/4 encoder range.	
	Effect	See Page 11-3 • The outputs are switched off. • Start enable is deleted.	
	Rectifica-tion	• Check the encoder cable. • Check the encoder. • Check the frame traffic between encoder and FM 351.	

Table 11-1 Diagnostic Interrupts for Internal Errors, continued

Bit	Error Signal, Error Analysis and Rectification		Event Number
8.2 or 10.2	**Error pulses in incremental encoders**		0x8092
	Cause	• Encoder monitoring has found error pulses. • Number of increments per encoder revolution is incorrectly entered. • Encoder defective: Does supply the specified number of pulses. • Faulty or missing zero mark. • Radiated interference on the encoder cable. • Incorrect number of pulses between two zero marks (monitored with a tolerance of +/- 7 increments). • No zero mark has occurred. The machine data Increments per encoder revolution is monitored with a tolerance of +/- 7 increments.	
	Effect	See Page 11-3 • The outputs are switched off. • The synchronization is deleted. • The start enable is deleted.	
	Rectifica-tion	• Correctly enter the number of increments/encoder revolution (parameterization interface). • Check the encoder and encoder cable. • Keep to shielding and grounding regulations. • Monitoring can be temporarily suppressed under the owner’s responsibility by parameterization in the parameterization interface.	

Table 11-1 Diagnostic Interrupts for Internal Errors, continued

Bit	Error Signal, Error Analysis and Rectification		Event Number
8.7 or 10.7	**Operating errors**		0x8097
	Cause	The following operating errors may occur: • Software limit switch passed. • Limit of traverse range passed. • Error on target run-in. • Standstill range left. • Positive feedback. • Missing / too slight change in actual value. • Target range passed. • Switchover point erroneously switched. • Switch-off point erroneously switched. • Start of target range erroneously switched. • Change is greater than half the round axis range. • Change is greater than the round axis range.	
	Effect	Software limit switch passed: • The outputs are switched off. Limits of traverse range passed: • The outputs are switched off. • The synchronization is deleted for incremental encoders. • Positional actual value undefined.	
	Rectification	You can obtain more precise information about this error with the parameterization interface.	
9.0 or 11.0	**Machine data erroneous**		0x8098
	Cause	Machine data from the rack SDB is incorrect.	
	Effect	See Page 11-3 • FM 351 not parameterized. • The processing is aborted. • The outputs are switched off. • Start enable not granted. You can obtain more precise information about this error with the parameterization interface.	
	Rectification	Enter correct machine data with parameterization interface and save it in SDB on the CPU.	
9.1 or 11.1	**Incremental dimension list erroneous**		0x8099
	Cause	Incremental dimension is located outside permissible value range.	
	Effect	The processing is aborted.	
	Rectification	Enter correct incremental dimensions with the parameterization interface and save them in SDB on the CPU.	

11

11.3 General Errors

Purpose

If there are no module defects or diagnostic interrupts present, then you can localize general errors on the module with the parameterization software.

General errors are:

- Parameterization errors during test and set-up with the parameterization software.
- Parameterization errors during parameterization on system start-up.
- Operating errors.
- Operating errors which have been signaled as group errors by diagnostic interrupt.
- Data errors which occur when controlling the module are signaled on the output DATA_ERR of the appropriate FC (see Chapter 6).

  You can read the error message in plain text using the parameterization software. In addition you can obtain tips on how to rectify the error in the integrated help.

Reading Error Messages

To view the general error messages in plain text, you must call the test masks in the parameterization software.

Structure of the Channel DB

12

Purpose of the Channel DB

The channel DB is the data interface between the user program and the FM 351 Positioning Function Module.

All data belonging to one channel of the FM 351 Positioning Function Module are located in the channel DB of the FC INC_MODE. Before you program the FM 351, you must specify in the DB the following valid data.

- Module address: MOD_ADR (WORD)
- Channel address: CH_ADR (DWORD)
- Record offset: DS_OFFS (BYTE)

You read out this data under STEP 7 during the basic parameterization and enter it in the channel DB with the program editor (see Chapter 5).

DB Structure

The channel DB is subdivided into various ranges:

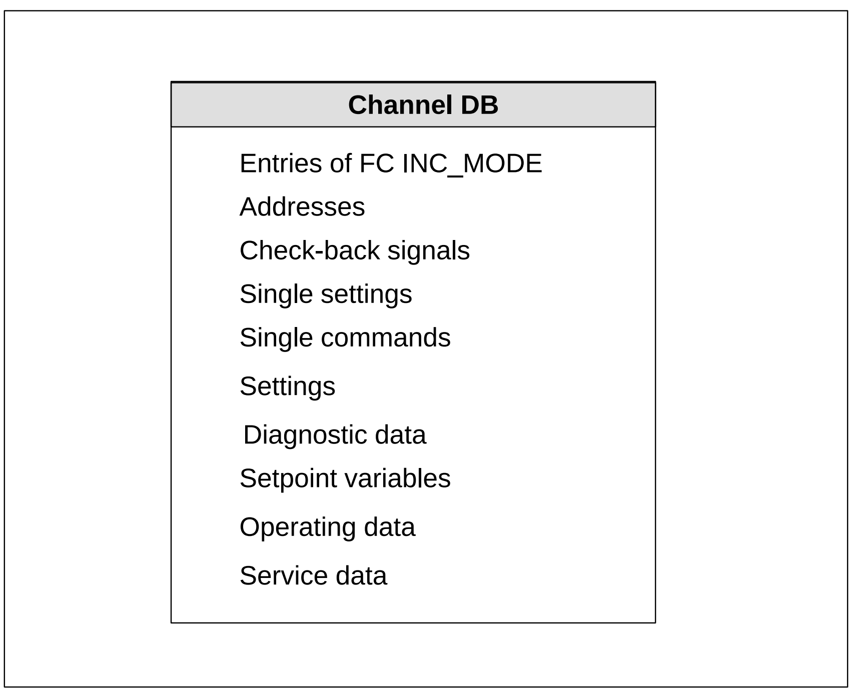


Figure 12-1   Channel DB Structure

Contents in the Channel DB

Table 12-1 below describes the contents of the channel DB with the associated absolute and symbolic addresses.

Table 12-1 Contents in the Channel DB

Address	Declaration	Variable	Data Type	Starting Value	Description
Entries of FC INC_MODE					
0.0	in	DRV_EN	BOOL	FALSE	• TRUE: Positioning enable • FALSE: Switches off a running positioning
0.1	in	REL_ABS	BOOL	FALSE	• TRUE: Absolute incremental mode • FALSE: Relative incremental mode
1.0	in	TRG_NO	BYTE	B#16#0	Incremental dimension number
2.0	in	OT_ERR_A	BOOL	FALSE	• TRUE: Acknowledge operating error • FALSE: No response
2.1	in	STOP	BOOL	FALSE	• TRUE: Stop running approach • FALSE: No response
4.0	out	OT_ERR	BOOL	FALSE	• TRUE: Operating error occurred • FALSE: No operating error occurred
4.1	out	INC_MD_A	BOOL	FALSE	• TRUE: Incremental operating mode active • FALSE: Not active
4.2	out	POS	BOOL	FALSE	• TRUE: Positioning running • FALSE: No response
4.3	out	POS_RCD	BOOL	FALSE	• TRUE: Position reached • FALSE: No response
6.0	in_out	START	BOOL	FALSE	• TRUE: Start positioning • FALSE: No response
6.1	in_out	DIR_P	BOOL	FALSE	• TRUE: Positive direction • FALSE: No response
6.2	in_out	DIR_M	BOOL	FALSE	• TRUE: Negative direction • FALSE: No response
Addresses					
12.0	stat	MOD_ADR **(Entries!)**	WORD	W#16#0	Module address
14.0	stat	CH_ADR **(Entries!)**	DWORD	DW#16#0	Channel address
18.0	stat	DS_OFFS **(Entries!)**	BYTE	B#16#0	Record offset

Table 12-1 Contents in the Channel DB, continued

Address	Declaration	Variable	Data Type	Starting Value	Description
Check-back signals					
28.0	stat	CHECKBACK_SIGNALS. ...	STRUCT	---	Check-back signals
28.7	stat	... PARA	BOOL	FALSE	• TRUE: Module is parameterized • FALSE: Module is not parameterized
29.0	stat	... START_EN	BOOL	FALSE	• TRUE: Start enable • FALSE: Start not enabled
29.1	stat	... WORKING	BOOL	FALSE	• TRUE: Positioning running • FALSE: Positioning not running
29.2	stat	... WAIT_EN	BOOL	FALSE	• TRUE: Axis waiting for ext. enable • FALSE: No function
29.4	stat	... SPEED_SL	BOOL	FALSE	• TRUE: Rapid speed • FALSE: Creep speed
29.5	stat	... ZS_RANGE	BOOL	FALSE	• TRUE: Axis is in standstill range • FALSE: Axis not in standstill range
29.6	stat	... CUTOFF	BOOL	FALSE	• TRUE: Axis is located in switch-off range • FALSE: Axis is not located in switch-off range
29.7	stat	... CHGOVER	BOOL	FALSE	• TRUE: Axis is located in switch-over range • FALSE: Axis is not located in switchover range
30.0	stat	... MODE	BYTE	B#16#0	Operating mode • Jogging • Seek-reference-point • Relative incremental • Absolute incremental
31.0	stat	... SYNC	BOOL	FALSE	• TRUE: Module is synchronized • FALSE: Module is not synchronized
31.1	stat	... MSR_DONE	BOOL	FALSE	Not used
31.2	stat	... GO_M	BOOL	FALSE	• TRUE: Approach in negative direction • FALSE: No function
31.3	stat	... GO_P	BOOL	FALSE	• TRUE: Approach in positive direction • FALSE: No function

Table 12-1 Contents in the Channel DB, continued

Address	Decla-ration	Variable	Data Type	Starting Value	Description
Check-back signals					
31.5	stat	... FAVAL	BOOL	FALSE	Not used
31.7	stat	... POS_RCD	BOOL	FALSE	• TRUE: Position reached • FALSE: Position not reached
32.0	stat	... ACT_POS	DINT	L#0	Momentary actual value
Single settings					
40.0	stat	SINGLE_FUNCTIONS. ...	STRUCT	---	Single settings
41.0	stat	... P_ROUND	BOOL	FALSE	• TRUE: Loop traverse in positive direction • FALSE: No function
41.1	stat	... M_ROUND	BOOL	FALSE	• TRUE: Loop traverse in negative direction • FALSE: No function
41.4	stat	... DI_EN	BOOL	FALSE	• TRUE: Evaluate enable input • FALSE: No function
41.6	stat	... SSW_DIS	BOOL	FALSE	Not used
Single commands					
42.0	stat	SINGLE_COMMANDS. ...	STRUCT	---	Single commands
43.1		... DEL_DIST			• TRUE: Delete residual distance • FALSE: No function
43.6	stat	... AVAL_REM	BOOL	FALSE	• TRUE: Undo set actual value • FALSE: No function
Settings					
48.0	stat	SETTING_ACT_VALUE	DINT	L#0	Set coordinate for actual value
56.0	stat	SETTING_REFE-RENCE_POINT	DINT	L#0	Reference-point coordinate
Diagnostic data					
72.0	stat	DIAGNOSTIC_INT_INFO. ...	STRUCT	---	Diagnostic data (see Chapter 11.2)
72.0	stat	... BYTE 0	BYTE	B#16#0	Module diagnosis: DS0/DS1
73.0	stat	... BYTE 1	BYTE	B#16#0	Module diagnosis: DS0/DS1
74.0	stat	... BYTE 2	BYTE	B#16#0	
75.0	stat	... BYTE 3	BYTE	B#16#0	

Table 12-1 Contents in the Channel DB, continued

Address	Decla-ration	Variable	Data Type	Starting Value	Description
Diagnostic data					
76.0	stat	... BYTE 4	BYTE	B#16#0	Channel diagnosis: DS1 (see Table 6-3)
77.0	stat	... BYTE 5	BYTE	B#16#0	
78.0	stat	... BYTE 6	BYTE	B#16#0	
79.0	stat	... BYTE 7	BYTE	B#16#0	
80.0	stat	... BYTE 8	BYTE	B#16#0	
81.0	stat	... BYTE 9	BYTE	B#16#0	
82.0	stat	... BYTE 10	BYTE	B#16#0	
83.0	stat	... BYTE 11	BYTE	B#16#0	
84.0	stat	... BYTE 12	BYTE	B#16#0	Not used
85.0	stat	... BYTE 13	BYTE	B#16#0	Not used
Incremental dimensions					
86.0	stat	TARGET_254	DINT	L#0	Increment 254 for incremental mode
90.0	stat	TARGET_255	STRUCT	---	Increment 255 for incremental mode
90.0	stat	POSITION	DINT	L#0	Increment 255
94.0	stat	CHANGEOVER_DIF-FERENCE	DINT	L#0	Switchover difference
98.0	stat	CUTOFF_DIFFERENCE	DINT	L#0	Switch-off difference
Operating data					
106.0	stat	OPERATING_DATA. ...	STRUCT	---	Operating data:
106.0	stat	... ACTUAL_SPEED	DWORD	DW#16#0	Actual speed
110.0	stat	... DISTANCE_TO_GO	DINT	L#0	Residual distance
114.0	stat	... LAST_TARGET	DINT	L#0	Setpoint variable
Service data					
118.0	stat	SERVICE_DATA. ...	STRUCT	---	Service data:
118.0	stat	... COUNTER_ENCO-DER_VALUE	DWORD	DW#16#0	Encoder value/Counter reading
122.0	stat	... ZEROMARK_VALUE	DWORD	DW#16#0	Counter reading at last zero mark
126.0	stat	... ABS_ENCODER_AD-JUSTMENT	DWORD	DW#16#0	Absolute encoder adjustment

Technical Specifications

A

Purpose of this Chapter

This chapter acts as a reference chapter. It describes the technical data for the FM 351 Positioning Function Module.

- General technical data
- Dimensions and weight
- Encoder inputs
- Digital inputs
- Digital outputs

Chapter Overview

A.1 General Technical Specifications

What are General Technical Specifications?

The general technical data contains the standards and test values which the S7-300 contains and fulfills, and also the test criteria to which the S7-300 has been tested.

UL/CSA Approvals

The S7-300 has obtained the following approvals:

UL-Recognition-Mark
Underwriters Laboratories (UL) conforming to
Standard UL 508, File E 116536

CSA-Certification-Mark
Canadian Standard Association (CSA) conforming to
Standard C 22.2 No. 142, File LR 48323

FM Approval

The S7-300 has the FM approval:
FM approval to Factory Mutual Approval Standard Class Number 3611, Class I, Division 2, Group A, B, C, D

Warning

Injury to persons and damage to property may occur.

In areas subject to explosion hazards persons may be injured and property damaged if you interrupt an S7-300 connection in running operation.

Electrically disconnect the S7-300 before separating plug connections in areas subject to explosion hazards.

Warning

WARNING - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS LOCATION IS KNOWN TO BE NON-HAZARDOUS

CE Marking

Our products satisfy the requirements of the EU Directive 89/336/EWG “Electromagnetic Compatibility” and the harmonized European standards (EN) listed therein.

The EU declarations of conformity are kept according to the above-mentioned EU Directive, Article 10 for the responsible authorities at:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
AUT E 148
Postfach 1963
D-92209 Amberg
Federal Republic of Germany

Area of Application

SIMATIC products have been designed for use in the industrial area.

SIMATIC products may also be used in the domestic environment (household, business and trade area, small plants) with individual approval which must be obtained from the respective national authority or testing body.

Area of Application	Requirements	
	Emitted interference	**Immunity**
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995
Domestic	Individual approval	EN 50082-1 : 1992

Observing the Installation Guidelines

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

A

A.2 Special Technical Data

General Technical Data

General technical data is:

- Electromagnetic compatibility
- Transport and storage conditions
- Mechanical and climatic ambient conditions
- Details on insulation tests, class and level of protection.

This general technical data contains standards and test values which the S7-300 maintains and fulfills, as well as to which test criteria the S7-300 was tested. The general technical data is described in the manual *S7-300 Programmable Controller, Hardware and Installation*.

Technical Data

The following table describes the FM 351 technical data:

Dimensions and Weight	
Dimensions W X H X D (mm)	80 × 125 × 120
Weight	Approx. 535 g
Current Consumption and Power	
Current consumption (from the backplane bus)	max. 200 mA
Power dissipation	Typ. 7.9 W
Encoder supply	• Horizontal installation S7-300, 20°C: – 5.2 V/500 mA (both channels) – 24 V/800 mA (both channels) • Horizontal installation S7-300, 60°C: – 5.2 V/500 mA (both channels) – 24 V/600 mA (both channels) • Vertical installation S7-300, 40°C: – 5.2 V/500 mA (both channels) – 24 V/600 mA (both channels) • Current consumption from 1L+ (without load): Max. 100 mA (X1, Terminal 1) • Encoder supply 24 V, unregulated – L+-2V (X2/X3 Terminal 5) – Short circuit protection: yes, thermal • Encoder supply 5.2 V (X2/X3, Terminal 6) Short circuit protection: yes, electronic • Permissible potential difference between input (ground) and central ground connection of CPU: 1 VDC.

Current Consumption and Power	
Supply of digital inputs and outputs	• Supply voltage: 24 VDC (permissible range: 20.4 to 28.8 V) • Current consumption from 2L+ (without load): Max. 50 mA (X1, Terminal 19) • Permissible potential difference between input ground connection 1M (X1, Terminal 2) – and the central grounding point (shield): 60 VAC; 75 VDC – Insulation tested with 500 VDC • Permissible potential difference between input ground connection 2M (X1, Terminal 20) – and the central grounding point (shield): 60 VAC; 75 VDC – Insulation tested with 500 VDC
Encoder Inputs	
Displacement measurement	• Incremental • Absolute
Signal voltages	• Symmetrical inputs: 5 V to RS 422 • Asymmetrical inputs: 24 V/typ. 4 mA
Input frequency and line length for symmetrical encoder with 5 V supply	Max. 500 KHz for 32 m shielded line length
Input frequency and line length for symmetrical encoder with 24 V supply	Max. 500 KHz for 100 m shielded line length
Input frequency and line length for asymmetrical encoder with 24 V supply	• Max. 50 KHz for 25 m shielded line length • Max. 25 KHz for 100 m shielded line length
Data transfer rate and line length for absolute encoders	• Max. 250 KHz for 160 m shielded line length • Max. 500 KHz for 60 m shielded line length • Max. 1 MHz for 20 m shielded line length
Monitoring possible for absolute encoders	No
Input signals	• Incremental: 2 pulse trains, 90° offset, 1 zero pulse • Absolute: Absolute value
Digital Inputs and Outputs	
Shielded line length	600 m
Load voltage reverse polarity protection	No
Status indication	Yes, green LED per channel
Digital Inputs	
Number of inputs	8
Number of simultaneously controllable digital inputs	8
Electrical isolation	Yes, optocoupler
Input voltage	• 0-signal: -3 V to 5 V • 1-signal: 11 V to 30 V

Digital Inputs	
Input current	• 0-signal: ≤ 2 mA (quiescent current) • 1-signal: 6 mA
Input delay (1Q0, 1Q1, 1Q2 and 2Q0, 2Q1, 2Q2)	• 0 → 1-signal: typ. 3 ms • 1 → 0-signal: typ. 3 ms
Input delay (1Q3 and 2Q3)	• 0 → 1-signal: typ. 300 µs • 1 → 0-signal: typ. 300 µs
Connection of a 2-wire BERO	Possible
Unshielded line length	100 m
Insulation test	VDE 0160
Digital Outputs	
Number of outputs	8
Electrical isolation	Yes, optocoupler
Output current	• 0-signal: 0.5 mA • 1-signal: 0.5 A (Permissible range: 5...600 mA) • Lamp load: 5 W
Output delay for output current 0.5 A	• 0 → 1 signal: Max. 300 µs • 1 → 0-signal: Max. 300 µs
Signal level for 1-signal	L+: –0.8 V
Control of a digital input	Yes
Control of a counter input	No, due to 50 µs error pulse[1]
Short circuit protection	Yes, thermally switching Switching threshold 1 A
Limit on induct. cut-off voltage	Typ. L+ -48 V
Switching frequency	• Resistive load: Max. 100 Hz • Inductive load: Max. 0.5 Hz
Summation current of digital outputs for horizontal installation of S7-300	Simultaneity factor 75%: at 20°C and 60°C: 3 A
Summation current of digital outputs for vertical installation of S7-300	Simultaneity factor 75%: at 40°C: 3 A
Unshielded line length	Max. 100 m
Insulation test	VDE 0160

1 When the 24 V power supply is switched on using a mechanical contact, the FM 351 gives a pulse on the outputs! Within the permissible output current range the pulse can be 50 µs long. You must take this into account when you use the FM 351 in conjunction with fast counters.

Connecting Cables

B

Overview

The following table gives you an overview of the cable sets to fit the matching encoders:

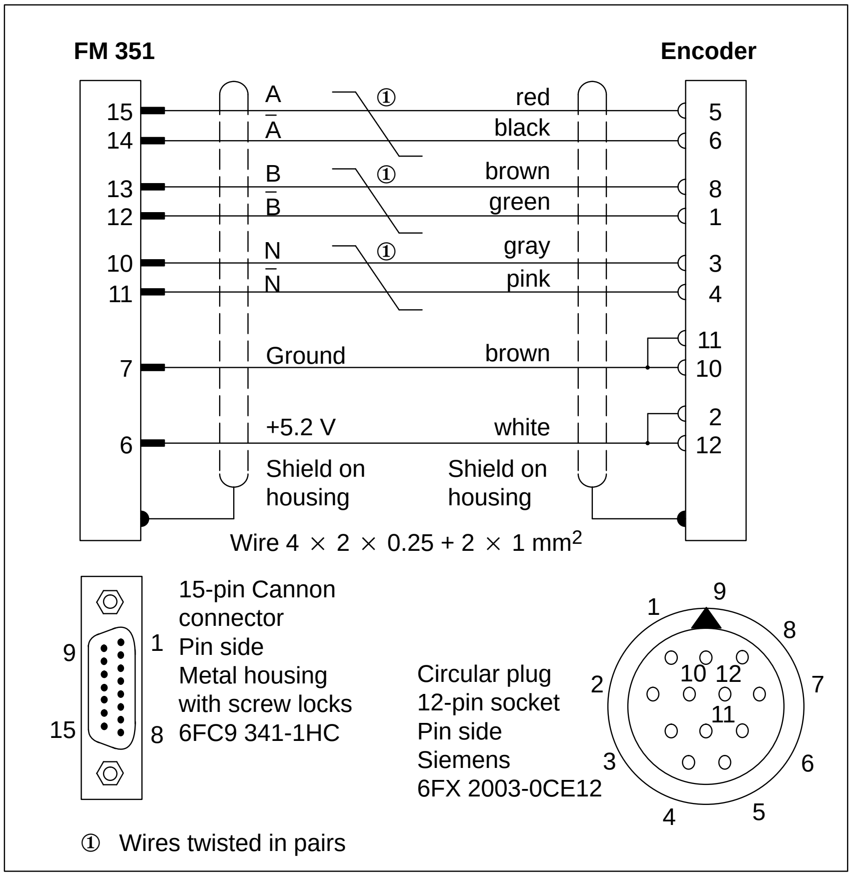
Encoder	Connecting Cable	Remark
6FX 2001-2	6ES5 703-1xxx0	Incremental encoder: V_p=5 V, RS 422
	6ES5 703-2xxx0	Encoder end of cable open
6FX 2001-2	6ES5 703-7xxx0	Incremental encoder: V_p=24 V, RS422
	6ES5 703-3xxx0	Encoder end of cable open
6FX 2001-4	6ES5 703-8xxx0	Incremental encoder: V_p=24 V, HTL
	6ES5 703-4xxx0	Encoder end of cable open
6FX 2001-5	6ES5 703-9xxx0	Absolute encoder: V_p=24 V, SSI
	6ES5 703-5xxx0	Encoder end of cable open

Chapter Overview

B.1 Connecting Cable for Incremental Encoder Siemens 6FX 2001-2 (V_p=5V; RS 422)

Connecting Diagram

The following illustration shows the connecting diagram for the incremental encoder Siemens 6FX 2001-2 (V_p=5 V: RS422):



Ordering Information

The cable cross-sectional areas are stated in the figure. The maximum length of the connecting cable, matching the incremental encoder Siemens 6FX 2001-2 (V_p=5 V; RS 422), is 32 m shielded. The relevant order number is:

6ES5 703-1xxx0 (xxx: Length code see catalog...)

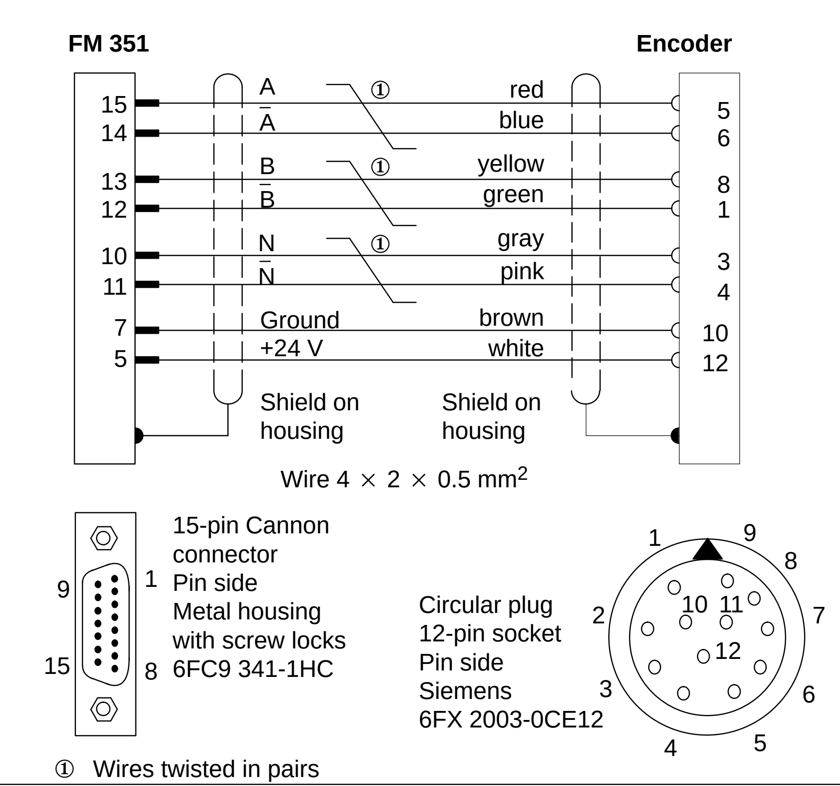
The connecting cable can also be obtained without an encoder connector (open cable end). The order number is:

6ES5 703-2xxx0 (xxx: Length code see catalog...)

B.2 Connecting Cable for Incremental Encoder Siemens 6FX 2001-2 (Vp=24V; RS 422)

Connecting Diagram

The following illustration shows the connecting diagram for the incremental encoder Siemens 6FX 2001-2 (V_p=24 V; RS 422):



Ordering Information

The cable cross-sectional areas are stated in the figure. The maximum length of the connecting cable, matching the incremental encoder Siemens 6FX 2001-2 (Vp=24 V; RS 422), is 100 m shielded. The relevant order number is:

6ES5 703-7xxx0 (xxx: Length code see catalog...)

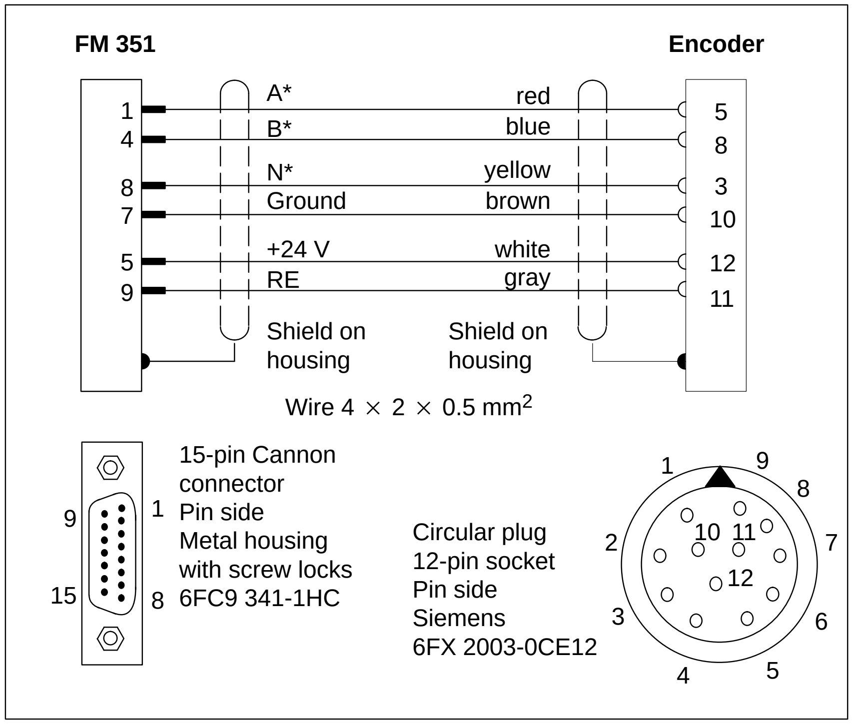
The connecting cable can also be obtained without an encoder connector (open cable end). The order number is:

6ES5 703-3xxx0 (xxx: Length code see catalog...)

B.3 Connecting Cable for Incremental Encoder Siemens 6FX 2001-4 (Vp=24V; HTL)

Connecting Diagram

The following illustration shows the connecting diagram for the incremental encoder Siemens 6FX 2001-4 (Vp=24 V; HTL):



Ordering Information

The cable cross-sectional areas are stated in the figure. The maximum length of the connecting cable, matching the incremental encoder Siemens 6FX 2001-4 (Vp=24 V; HTL), is 100 m shielded. The relevant order number is:

6ES5 703-8xxx0 (xxx: Length code see catalog...)

The connecting cable can also be obtained without an encoder connector (open cable end).

6ES5 703-4xxx0 (xxx: Length code see catalog...)

Note

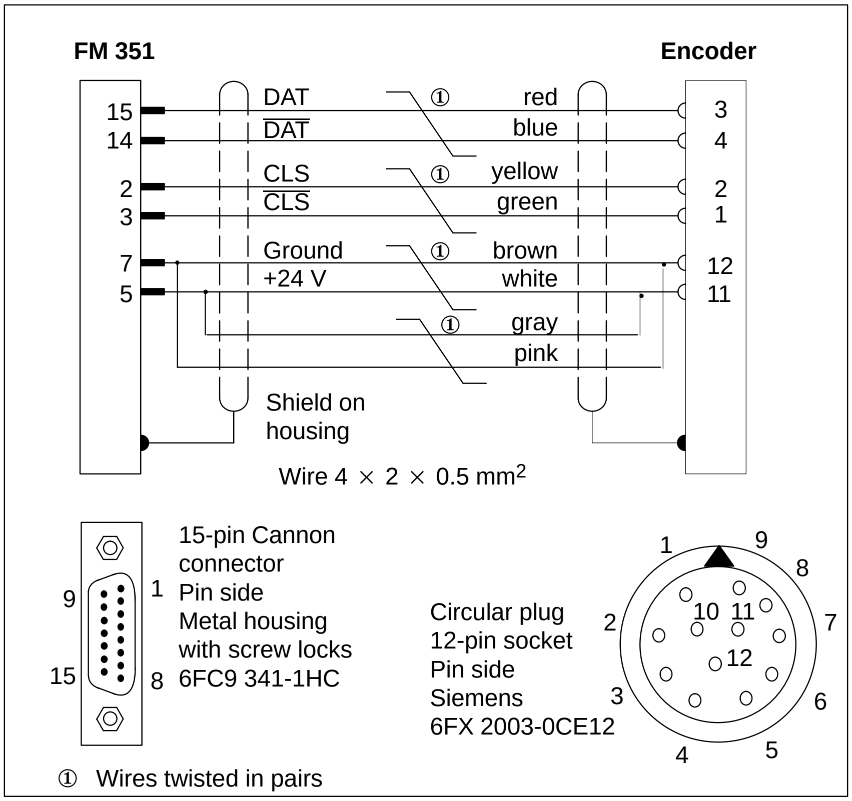
If you would like to connect an incremental encoder from another manufacturer in a push-pull configuration (current sourcing/sinking), then you must observe the following:

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

B.4 Connecting Cable for Absolute Encoder Siemens 6FX 2001-5 (Vp=24V; SSI)

Connecting Diagram

The following illustration shows the connecting diagram for the absolute encoder Siemens 6FX 2001-5 (Vp=24 V; SSI):



Ordering Information

The cable cross-sectional areas are stated in the figure. The maximum length of the connecting cable, matching the absolute encoder Siemens 6FX 2001-5, is 320 m shielded at a baud rate of 125 KHz. The relevant order number is:

6ES5 703-9xxx0 (xxx: Length code see catalog...)

The connecting cable can also be obtained without an encoder connector (open cable end).

6ES5 703-5xxx0 (xxx: Length code see catalog...)

Glossary

Absolute Encoder

An absolute encoder determines the displacement traveled by reading off a numerical value.

Absolute Encoder Adjustment

The absolute encoder adjustment provides a fixed relationship between the coordinate system and the encoder.

The following values are required for this:

- Absolute encoder adjustment: This is a value from the value range of the absolute encoder.
- Reference-point coordinate: This is a value from the coordinate system.

Absolute Incremental Mode

The drive approaches an absolute target with the absolute incremental operating mode.

Axis

The axis consists of toothed belt, spindle, toothed rack (pinion), hydraulic cylinder, gear unit and coupling system.

Controlled Positioning

During controlled positioning the axis traverses without actual-value feedback to the programmed target position in response to a specification of a target position.

Creep Speed/ Creep Mode

The creep speed is a relatively low speed. The purpose of the creep speed or creep mode is to achieve accurate positioning.

Delete Residual Distance

This single command deletes the remaining residual displacement after a job is aborted.

Displacement per Encoder Revolution

The displacement per encoder revolution gives the distance moved by the axis for each encoder revolution.

Drive

The drive consists of the power controller and the motor which drives the axis.

Enable Input
The enable input is a digital input per channel on the positioning module. A positioning process is started and stopped with the enable input.

Encoder
Encoders are used for the exact measurement of distances, positions and speeds.

Evaluate Enable Input
As standard the positioning module evaluates the enable input of the relevant channel before starting an operating mode. You can switch off this evaluation with this setting.

Fast Input
In contrast to standard input, a fast input has a shorter switch-on delay.

Increment Table
The drive traverses to setpoint values within the working range. These set points are held in the increment table.

Incremental Encoder
Incremental encoders measure distances, positions, speeds, revolutions, masses, etc. by counting small increments.

Increments per Encoder Revolution
Increments per encoder revolution indicates the number of increments which an encoder outputs per revolution.

Jogging
The “Jogging” operating mode moves the drive in the positive or negative direction. The operating mode runs while ever the relevant key for this operating mode is pressed.

Linear Axis
With a linear axis the axis moves between two range limits. Linear axes therefore have a limited traverse range.

Loop Traverse
The single setting “Loop traverse” determines the direction in which the target is approached.

Machine Data
The positioning module is adapted to the machines with the machine data.

Monitoring
The module continually monitors the connected axis. If a monitored feature responds, an error signal is output. Monitoring checks the working range, traversing range, etc.

Monitoring Time
The monitoring time determines in which time period increments from an encoder must be received.

Multi-Turn Encoder Multi-turn encoders are absolute encoders. The resolution is determined over a number of coded disks.

Positioning Positioning means to bring a load to a defined position in a certain time taking into account all the forces and moments acting.

Positioning Module for Rapid and Creep Speed Drives The positioning module for rapid and creep speed drives is a function module for controlled positioning.

Power Controller The power controller controls the motor and can, for example, consist of a simple contactor circuit.

Pulse Counter The pulse counter on a function module counts the edges from the connected encoder.

Quadruple Evaluation Quadruple evaluation means that in an incremental encoder all the edges of the A and B pulse trains are evaluated.

Rapid and Creep Speed Drive A rapid and creep speed drive is a drive which approaches a position on an axis first at rapid speed and then at creep speed. See also the definition: → Rapid speed and → Creep speed.

Rapid Speed/ Rapid Mode The target is first approached in the rapid mode, that is at rapid speed. The rapid speed is a relatively high speed and determines the speed of positioning.

Reference Point The reference point is the synchronization point between the pulse counter on the positioning module and the axis.

Reference-Point Coordinate The reference-point coordinate is a value which is assigned to the reference point.

Reference-Point Switch The reference-point switch is assigned to the Seek-reference-point operating mode. Together with the zero-mark signal from the connected encoder it determines the physical position of the reference point.

Relative Incremental Mode The drive is moved a specified distance in the positive or negative direction with the “Relative incremental operating mode”.

Resolution

The resolution is determined from the ratio of the machine data:

- Displacement per encoder revolution
- Pulses per encoder revolution.

The resolution is a measure of the accuracy of the positioning. It also determines the possible maximum traversing range.

Reversing Switch

When the drive reaches the reversing switch, the traversing direction is reversed.

Rotary Axis

The characteristic feature of a rotary axis is that after one revolution of the axis the actual value is again reset to “0” or to the value “End of rotary axis”.

Seek-Reference-Point Mode

The “Seek-reference-point mode” synchronizes the pulse counter in the positioning module to the axis.

Set Actual Value

The setting “Set actual value” allocates a new coordinate in the system of units to the current encoder value.

Set Reference Point

The setting “Set reference point” synchronizes the axis.

Settings

Settings are functions in the FM 351 Positioning Function Module for:

- Setting a reference point.
- Setting an actual value.

Single Settings

Single settings switch the FM 351 Positioning Function Module into a state in which you:

- Can start a loop traverse.
- Cannot evaluate the enable input.
- Can switch off the software limit switches.

Single-Turn Encoder

Single-turn encoders are absolute encoders. The resolution is determined by a coded disk.

Software Limit Switch

The working range on the axis is defined by the software limit switches.

Software Limit Switch End

The software limit switch End defines the end of the working range on the axis.

Software Limit Switch Start
The software limit switch Start defines the start of the working range on the axis.

SSI Encoders
The SSI encoder is a subset of the absolute encoders. With the SSI encoder the data is transferred serially.

Standstill Monitoring
The standstill monitoring reacts when the standstill range has been left without a traverse movement starting.

Standstill Range
The standstill range is a symmetrical range about the target.

Standstill Speed
The undercutting of the standstill speed indicates to the positioning module that the position being approached has been reached.

Switchover Difference
The switchover difference is the difference in displacement between the switchover point and the target.

Switchover Point
The drive switches over from rapid to creep speed at the switchover point.

Switch-Off Difference
The switch-off difference is the difference in distance between the switch-off point and the target.

Switch-Off Point
The drive is switched off a certain displacement interval (switch-off difference) before the target - at the switch-off point. This ensures exact positioning of the load.

Switch-Off Point Positioning
Switch-off point positioning is characterized by a target position, switch-off points, a traverse range and parameters which determine the sequence of positioning.

Synchronization
Synchronization means that the pulse counter in the positioning module is matched to the axis.

System of Units
The machine data ’system of units’ defines the units for the data input and output.

Target
The target is the absolute or the relative position on the axis which is to be approached during a positioning process. The target is located within the target range.

Target Range The target range is located symmetrically about the target. Within the target range the drive must reach the standstill speed, so that the signal “Position reached” is set.

Target Approach After reaching the switch-off point, the drive switches off. It then runs in - starting from the creep speed - to the target.

Termination On ending or interrupting an operating mode the drive is terminated. Termination means that the drive is switched off via the creep speed.

Traverse Range The traverse range is a range in a system of units which is limited by the resolution of a number representation or by the range covered by an absolute encoder.

Traverse Range Monitoring The traverse range monitoring is activated when the actual value becomes located outside of the traverse range or the range covered by the absolute encoder.

Type of Control The type of control determines the function of the digital outputs on the FM 351. The FM 351 has 4 types of control.

Undo Set Actual Value The single command “Undo set actual value” sets the system of units back in the original state.

Working Range The working range is the range between the parameterized software limit switches which have been defined in the machine data. The working range is always smaller than the traversing range.

Zero Mark The zero mark supplies a zero-mark signal after each revolution.

Zero-Mark Signal The zero-mark signal is output from an incremental encoder after each revolution.

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Federal Republic of Germany

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