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FM 352 Electronic Cam Controller Installation and Parameter Assignment

Manual

This manual is part of the documentation package with the order number:

6ES7352-1AH00-8BG0

02/2000
C79000-G7076-C352
Edition 04

Notes on Safety

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

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.

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Preface

Validity of the Manual

This manual contains the description of the FM 352 electronic cam controller valid at the time the manual was printed. We reserve the right to describe modifications in the functionality of the FM 352 in a product information leaflet.

The manual with the number in the footer	is valid for the FM 352 with order number
EWA 4NEB 720 6004-02	6ES7 352-1AH00-0AE0
EWA 4NEB 720 6004-02 a	6ES7 352-1AH01-0AE0
C79000-G7076-C352-03	6ES7 352-1AH01-0AE0

Content of the manual

This manual describes the hardware and software of the FM 352 electronic cam controller.

It consists of the following:

- A section describing basic aspects (Chapters 1 to 7)
- A reference section (Chapters 8 to 12)
- An appendix (Chapters A, B and C)
- An index.

Further Support

If you have questions about using the products described in the manual and you cannot find the answers here, please contact your local Siemens representative. You will find the addresses, for example, in the appendix ”SIEMENS Worldwide” in the installation manual *S7-300/M7-300 Programmable Controllers, Hardware and Installation, CPU Data*.

If you have any questions or comments on this manual, please fill out the remarks form at the end of the manual and return it to the address shown on the form. We would be grateful if you could take the time to answer the questions giving your own personal opinion of the manual.

To help you to become familiar with working with SIMATIC S7 PLCs,
we offer a range of courses.
Please contact your regional training center or the central training center in
D-90027 Nuremberg, Tel. +49 911/895-3200 for more information.

CE Mark

Our products meet the requirements of the EU directive 89/336/EEC ”Electromagnetic Compatibility” and the harmonized European standards (EN) listed in the directive.

in compliance with the above mentioned EU directive, Article 10, the conformity declarations are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A&D AS E48
Postfach 1963
D-92209 Amberg

Contents

1 Product Overview

Chapter Overview

1.1 What is the FM 352?

The FM 352 function module is a single-channel, electronic cam controller and is used in the S7-300 programmable controller. It supports both rotary and linear axes. When used for position sensing, you can connect initiators, incremental, or absolute encoders (SSI). As a slave, the FM 352 can listen in on the SSI frame of an absolute encoder.

You can use up to a maximum of 128 distance or time cams that you can assign to 32 cam tracks as required. The first 13 cam tracks are output via the digital outputs on the module. For information about the functions and settings of the cam controller, please refer to the following chapters.

You can operate several FM 352 modules at the same time. Combinations with other FM/CP modules are also possible. One typical combination is to use the module in conjunction with an FM 351 positioning module.

You can operate an FM 352 both in a central rack or in a distributed rack via PROFIBUS-DP.

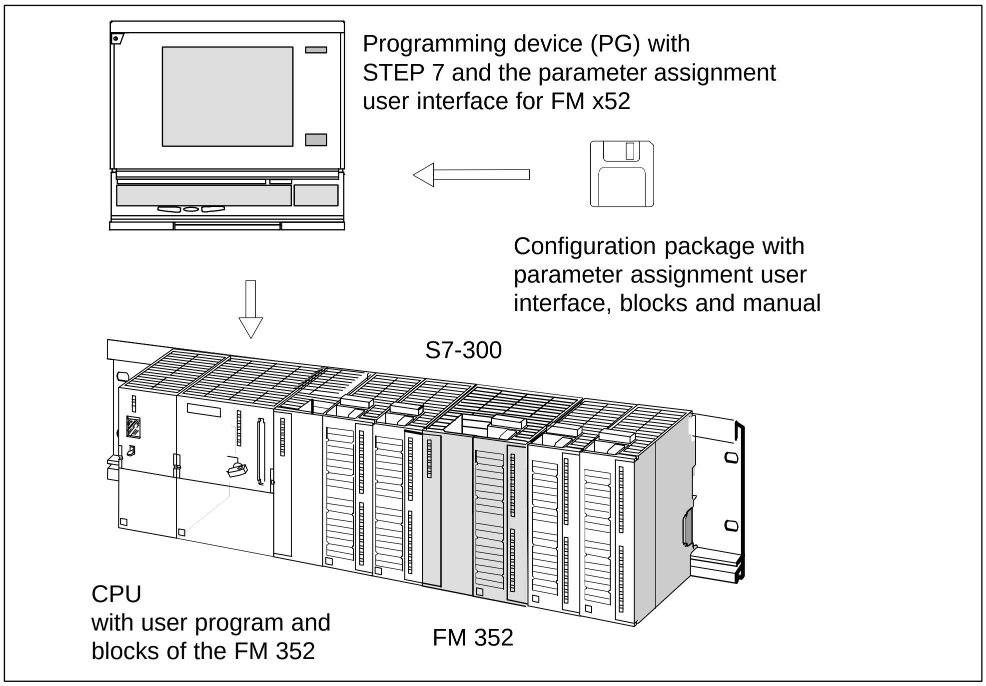


Figure 1-1 Structure of a SIMATIC S7-300 PLC with an FM 352

1.2 Areas of Application of the FM 352

Example: Applying Glue Tracks

In the following example, glue tracks are applied to wooden boards. Each cam track controls one glue gun via a digital output.

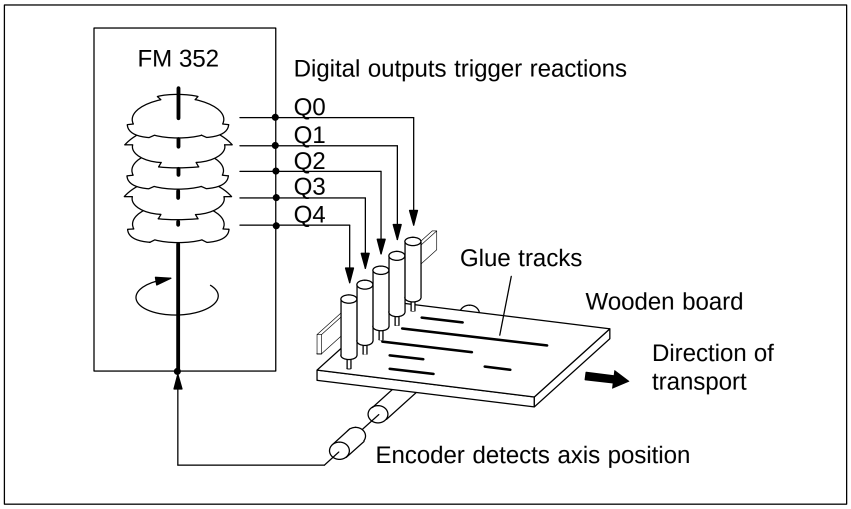


Figure 1-2 Example of an Electronic Cam Control Application

Example: Controlling a Press

Another typical application is the automation of an eccentric press with a cam controller.

This is a rotational process; in other words, after one revolution of the rotary axis, the function starts again at the beginning.

Typical electronic cam controller tasks in this application include:

- Turning the lubricant supply on and off
- Triggering material feed and removal (for example controlling a gripper)
- Stopping the press at the “upper dead point”

Example: Packaging System

Preserves are packed on a turntable. The electronic cam controller triggers actions at specific angular positions:

- Placing and folding of cartons on the turntable
- Placing the preserves in the cartons
- Closing the cartons
- Placing the cartons on a conveyor belt

1.3 Structure of an Electronic Cam Controller with an FM 352

Electronic Cam Controller

Figure 1-3 shows the components of an electronic cam controller. The schematic is explained briefly below.

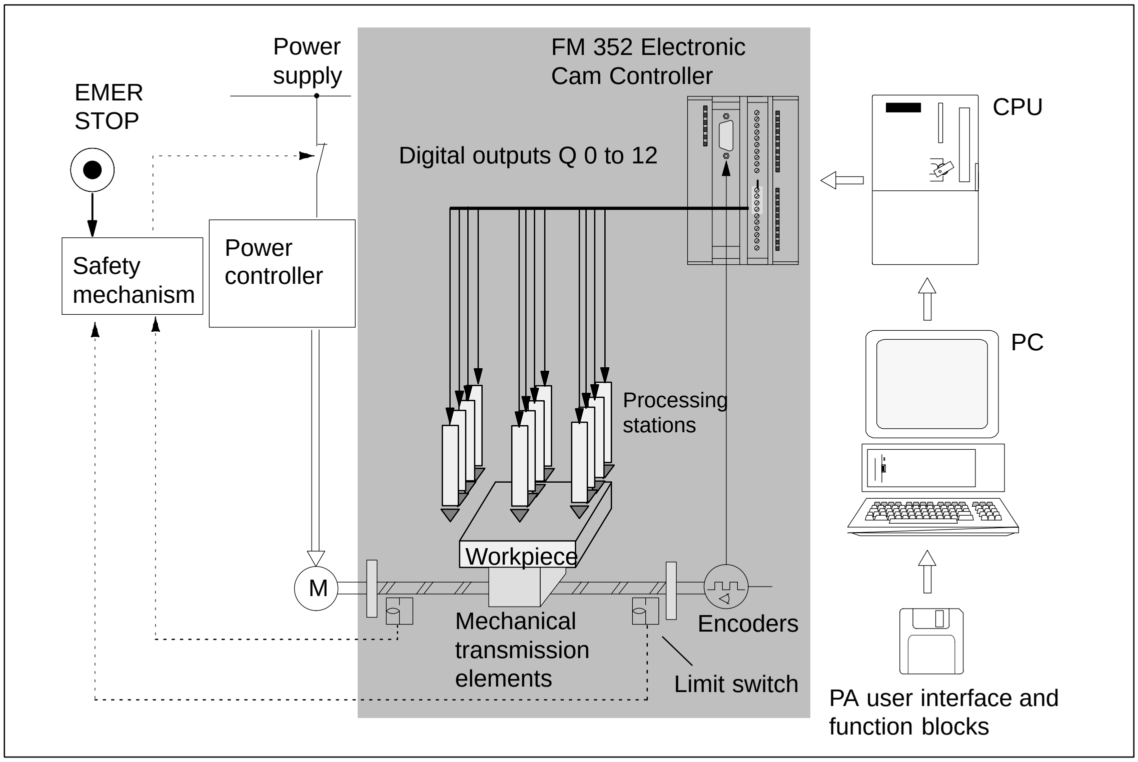


Figure 1-3 Electronic Cam Controller

Power Controller and Safety System

The motor is controlled by the power controller. The power controller can consist of a contactor circuit, for example, controlled by an FM 351 positioning module.

If the safety system responds (EMER STOP or limit switch), the power controller turns off the motor.

Motor

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

FM 352 Electronic Cam Controller

The electronic cam controller detects the current position of the axis using the information from an encoder. The encoder signals are evaluated (for example pulses counted) that are proportional to the distances traveled. Depending on the actual position, the digital outputs are activated or deactivated (“cams”). The processing stations are controlled via the digital outputs.

Encoders

The encoder supplies information both about position and direction.

CPU

The CPU executes the user program. Data and signals are exchanged between the user program and the module using function calls.

PG/PC

You assign the required parameters and program the electronic cam controller on a programming device or PC.

- Parameter assignment: You set parameters for the FM 352 either using the parameter assignment user interface or using the parameter DB.
- Programming: You program the FM 352 with functions that you incorporate directly in your user program.
- Testing and putting into operation: You test the FM 352 using the parameter assignment user interface with which you also finally put the system into operation.

2

Basics of Cam Control

Chapter Overview

2.1 Cams

Types of Cam

With the appropriate parameter settings, each cam can be either a distance cam or time cam.

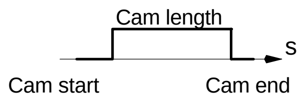
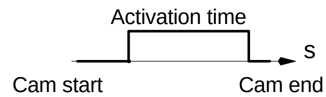
Table 2-1 compares the characteristics of both types of cam.

Direction Detection

The direction of movement of the axis is determined as follows:

- With each pulse of an incremental encoder.
- With each error-free frame of an SSI encoder.

Table 2-1 Definition and Switching of the Two Cam Types

	Distance Cam	**Time Cam**
Representation		
Parameter Settings	The following parameters are required: • Cam start • Cam end • Activation direction • Lead time	The following parameters are required: • Cam start • Activation time • Activation direction • Lead time
Activation direction	Two activation directions are possible: • Positive: The cam is activated at the cam start when the axis is moving in the direction of increasing actual values. • Negative: The cam is activated at the cam end when the axis is moving in the direction of decreasing actual values. You can set both activation directions at the same time.	Two activation directions are possible: • Positive: The cam is activated at the cam start when the axis is moving in the direction of increasing actual values. • Negative: The cam is activated at the cam start when the axis is moving in the direction of decreasing actual values. You can set both activation directions at the same time.
Activation	The cam is activated: • At the cam start when the axis is moving in a positive direction and the positive activation direction is set. • At the cam end when the axis is moving in a negative direction and the negative activation direction is set. • The actual value is within the range of the cam.	The cam is activated: • At the cam start when the axis is moving in a positive direction and the positive activation direction is set. The full cam activation time runs when the cam is activated. This also applies when the direction of movement of the cam is changed after the cam is activated. If the cam start is passed again during this time, the cam is **not** retriggered.
Deactivation	The cam is deactivated when: • The selected distance has been traveled, • The activation direction is opposite to the direction of movement of the axis and no hysteresis is set, • The actual value is no longer within the range of the cam.	The cam is deactivated when the selected time has expired.
Active length	The active length of the cam is defined by the cam start and cam end. Cam start and cam end belong to the active section of the cam.	The active length of the cam depends on the speed at which the axis travels while the cam is active.
On Time	The on time of the cam depends on the speed at which the axis travels the active length of the cam.	The on time of the cam is selected with the activation time.

2.2 Tracks

2.2.1 Tracks and Track Result

Cam Tracks

With the 32 tracks, you can control a maximum of 32 different switching actions. You can evaluate the tracks with the return signals.

Each of the first 13 tracks (track 0 to 12) has a digital output (Q0 to Q12) of the FM 352 assigned to it that can, for example, control a connected contactor directly.

Track Result

You have a maximum of 128 cams available that can be assigned to any track.

Several cams can be assigned to each track. The track result is the result of logically ORing all the cam values of this track.

Example of a Track Result

During parameter assignment, you specify the following cams for track 3:

Cam	Cam start	Cam end
1	101 μm	106 μm
2	100 μm	104 μm

This results in the following track result:

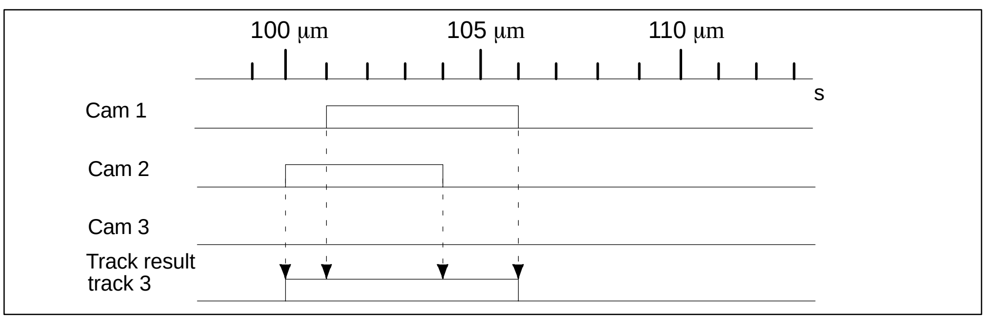


Figure 2-1 Calculating the Track Result

Track Enable

To allow the track results of tracks 0 to 12 to be applied as track signals to the digital outputs Q0 to Q12 of the FM 352, the tracks you are using must be enabled.

External Enable of Track 3

You can set an external enable for track 3 in the machine data. The track signal 3 is then ANDed with digital input I3, before it can switch digital output Q3 of the FM 352.

The digital output Q3 is switched when the following conditions are met:

- The relevant track is enabled
- At least one cam on this track is active (track result = 1).
- The corresponding digital input I3 was set by an external event.

Setting the Track Signals

The track signals 0 to 12 (corresponding to digital outputs Q0 to Q12) can be set via the cam controller or the CPU.

2.2.2 Special Tracks

Definition

By setting the relevant parameters, you can set tracks 0 to 2 as special tracks, as follows:

- Track 0 or 1: Counter cam track
- Track 2: Brake cam track
  To allow the track to be activated, input I0 is evaluated.

Requirements

The following requirements must be met to allow the use of the special tracks:

- Cams are assigned to the track
- Cam processing is active
- The relevant track is enabled
- The track is selected as a special track

Counter Cam Track

A counter cam track counts the status changes of the track results on this track.

You must specify a value for the counter and start the counter function.

Each rising edge of the track result decrements the counter value of the relevant track by 1.

As long as the counter value for the counter cam track is higher than 0, the track flag bit remains 0.

Once the counter value reaches the value 0, the track flag bit is set and, if selected in the parameter settings, the track signal is set (see Figure 2-4, page 2-11).

At the next falling edge of the track result (all cams on this track are off), the track flag bit is cleared again and the counter is reset to the specified value.

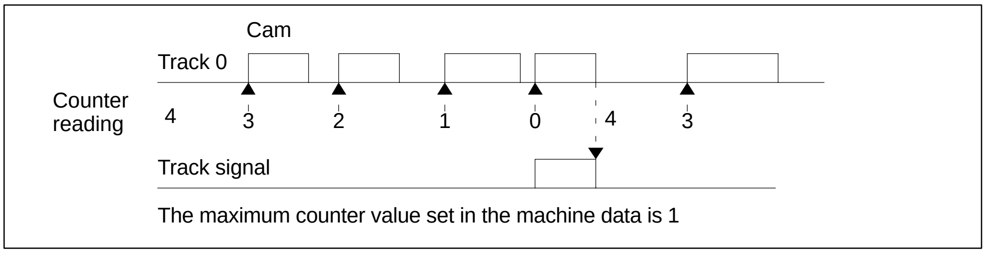


Figure 2-2 Switching a Counter Cam Track

Brake Cam Track

To use track 2 as a brake cam track, digital input I0 must be connected.

A rising signal edge at I0 sets the track flag bit.

The track flag bit is reset again when:

- There is no longer a “1” signal at I0 **and** afterwards
- the falling edge of the track result of track 2 is detected.

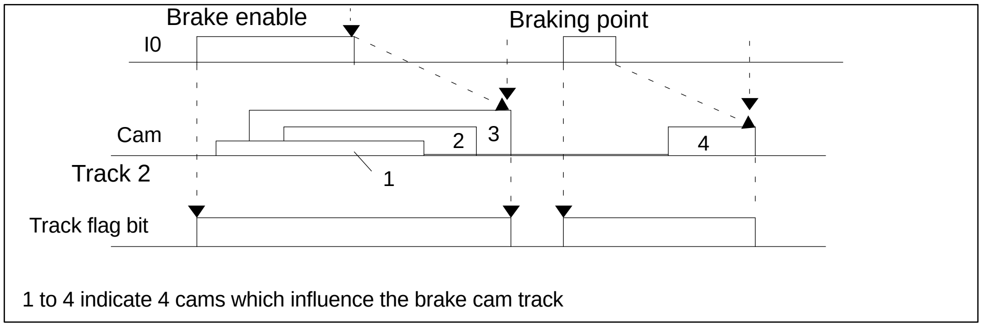


Figure 2-3 Response of a Brake Cam Track

In the example (Figure 2-3), the track flag bit is deactivated by the falling edges of cams 3 and 4.

2.3 Hysteresis

Definition

Mechanical disturbances on the axis can cause changes in the actual position value. If the actual position value fluctuates around the edge of a cam or within an active cam with only one activation direction, this cam would be continuously activated and deactivated. Hysteresis prevents this switching.

A hysteresis is dependent on the actual value and applies to all cams. It becomes active as soon as a change of direction is detected. Hysteresis also takes effect even if no cam is set at the current axis position.

Rules for the Hysteresis Range

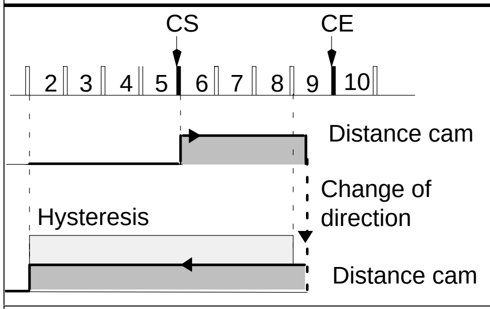
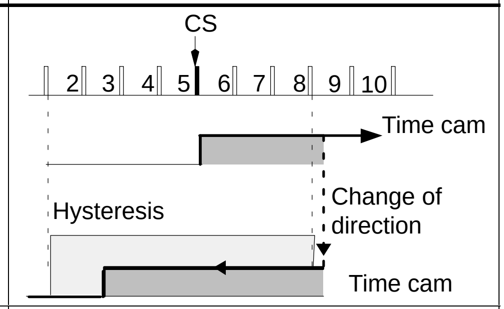
The following rules apply to the hysteresis range:

- Hysteresis is always activated when there is a change in direction.
- Within the hysteresis, the indication of the actual value remains constant.
- The direction is not changed within the hysteresis.
- Within the hysteresis, a distance cam is neither activated nor deactivated.
- Within the hysteresis, a time cam is not activated; an active time cam is deactivated when the set activation time elapses (even within the hysteresis range).
- After leaving the hysteresis range, the FM 352 determines the following:
  - the actual position value,
  - The current direction of motion of the axis
  - the current states of all cams
- The hysteresis range applies to all cams.

Effects of a Change of Direction on a Cam with Hysteresis

The following table illustrates the response of a cam when there is a change of direction. A distinction must be made between the behavior of a distance cam and a time cam. The activation direction of the cam is **positive**.

Table 2-2 Change of Direction on a Cam

<table>
<tr><th>Distance cam</th><th>Time cam</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>The hysteresis becomes active after change of direction is detected.
The cam is deactivated once the hysteresis range is exited.</td><td>The cam always remains active for the selected activation time.</td></tr>
</table>

2.4 Dynamic Adjustment

Task

The dynamic adjustment is used to compensate delays resulting from the connected switching elements.

Lead Time

This delay can be specified as a lead time that you specify separately for each cam. You can assign a lead time for each cam. The lead time applies to the cam start and cam end.

Lead Distance

The lead distance of a cam is recalculated depending on the current feedrate and the lead time. The entire cam is shifted in the direction of the actual value by this distance. The range set is known as the “static range” and the range calculated based on the lead time is known as the “dynamic range”.

$$\textit{Lead distance} = \textit{lead time} \cdot \textit{current feedrate of the axis}$$

Calculation of the lead distance of all cams is made within 1/4 of the longest set lead time on the FM 352.

If you set a very large lead time for a cam, you reduce the dynamics of the cam processing.

2.5 Interfaces of the Cam Controller

Overview

The schematic below shows the most important interfaces to illustrate the relationship between data, inputs and outputs.

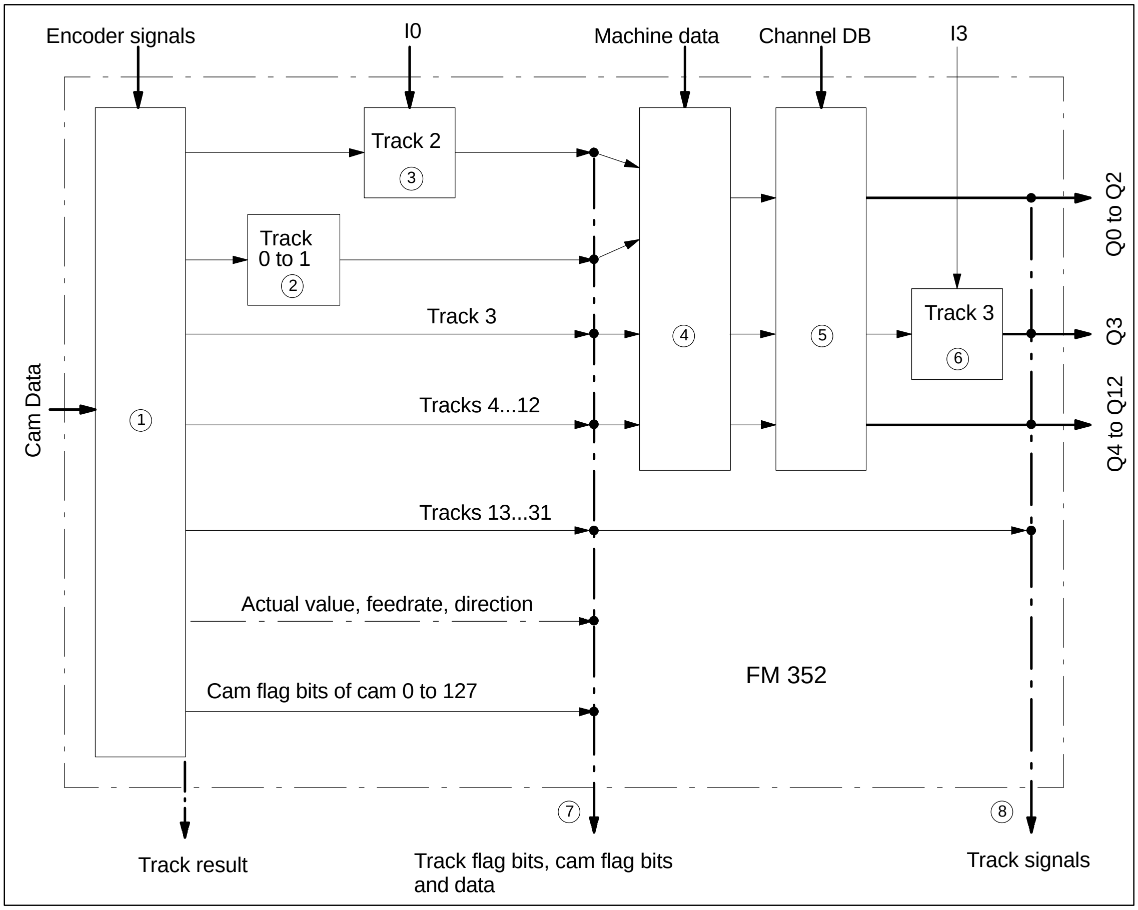


Figure 2-4 Interfaces of the FM 352

The schematic is explained in the table below.

No.	Description	Section
①	When the FM 352 processes the cams, the cam flag bits are calculated from the switching conditions and the current actual value. The track results based on the assignment of the cams to the tracks are also calculated.	2.1 (page 2-2)
②	If you have set track 0 or track 1 as a counter cam track, the track result of the cam controller (point 1) is logically combined with the counter result to produce the track flag bit. Otherwise, the track flag bit is the same as the track result.	2.2.2 (page 2-6)
③	If you have set track 2 as a brake cam track, the track result of the cam controller (point 1) is logically combined with input I0 to produce the track flag bit. Otherwise, the track flag bit is the same as the track result.	2.2.2 (page 2-7)
④	Using machine data, you can control whether the previously detected track flag bits of tracks 0 to 12 of the cam controller are passed on or whether they are set directly by the track enable (TRACK_EN).	8.7 (page 8-23), 9.15 (page 9-29)
⑤	You enable the track signals of tracks 0 to 12 with TRACK_EN and the count function with CNTC0_EN / CNTC1_EN.	9.11 (page 9-25)
⑥	The track signal of track 3 can be ANDed with digital input I3 if you have enabled this option in the machine data (EN_IN_I3).	8.7 (Page 8-23)
⑦	You can read out all the track and cam flag bits at this point (in other words before they are logically combined with machine and channel data) using the job ACTPOS_EN or CAMOUT_EN. For tracks 3 to 31, the track flag bit is the same as the track result (point 1).	9.12 (page 9-26) 9.14 (page 9-28)
⑧	After being logically combined with the machine and channel data, the track signals of tracks 0 to 12 are available in the return signals. The track signals of tracks 13 to 31 are identical to the track flag bits of point 7. The track signals of tracks 0 to 12 are available at digital outputs Q0 to Q12.	

Installing and Removing the FM 352 3

Important Safety Rules

When integrating an S7-300 with an FM 352 in a plant or system, there are important rules and regulations that are described in the installation manual *S7-300 Programmable Controller, Hardware and Installation*.

Installation of the Rail

Horizontal installation of the rail is preferable.

If you install the rail vertically, remember the restrictions regarding the ambient temperature (max. 40 °C).

Selecting Slots

The FM 352 can be installed in any slot for signal modules on the rail.

Configuring the Mechanical Layout

The following rules apply to the arrangement of the modules in a rack:

1. A maximum of 8 FMs are permitted per tier.
2. The maximum number of modules is restricted by the length of the rail and the width of the modules installed.

   The FM 352 takes up a width of 80 mm.
3. The number of modules that can be installed (SM, FM, CP) is limited by their current consumption from the S7-300 backplane bus.

   The total current consumption from the S7-300 backplane bus of all modules installed in a rack must not exceed 1.2 A with the CPU 313/314/314 IFM/315/315-2-DP/316-2 DP/318-2 and 0.8 A with the CPU 312 IFM.

   The current consumption from the backplane bus of the FM 352 is 100 mA.

Tools Required for Installation and Removal

To install or remove the FM 352, you require a 4.5 mm screwdriver.

Installing the FM 352 Electronic Cam Controller

1. The FM 352 is supplied with a bus interconnector. Plug this onto the bus connector of the module to the left of the FM 352. (The bus connector is on the back of the module and you may need to loosen the module again first).
2. If further modules are installed to the right, first plug the bus interconnector of the next module onto the right bus connector of the FM 352.

   If the FM 352 is the last module in the tier, do not attach a bus interconnector!
3. Secure the FM 352 with screws (torque approximately 0.8 to 1.1 Nm).
4. After installation, you can assign a slot number to the FM 352. Slot labels are supplied with the CPU.

   The numbering scheme and numbering of slots and how to insert the slot labels is described in the installation manual *S7-300 Programmable Controller, Hardware and Installation*.
5. Fit the shield contact element.

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

Removing the FM 352 Electronic Cam Controller

1. Switch off the power controller.
2. Turn off the 24 V supply for the FM 352.
3. Switch the CPU to STOP.
4. Open the front hinged panels.

   Remove any labeling strips.
5. Unlock the front connector and remove it.
6. Remove the D sub connector to the encoder.
7. Undo the securing screw on the module.
8. Tilt the module upwards and remove it from the rail.

Wiring the FM 352 Electronic Cam Controller

4

Chapter Overview

Important Safety Rule

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

- EMERGENCY STOP switch with which you can turn off the entire system.
- EMERGENCY STOP limit switches connected directly to the power units of all drives.
- Motor circuit-breaker.

4.1 Description of the Encoder Interface

Location of the Sub D Connector

Figure 4-1 shows the location and labeling of the female connector on the module. You can connect an initiator, incremental or absolute encoder (SSI) to the sub D connector.

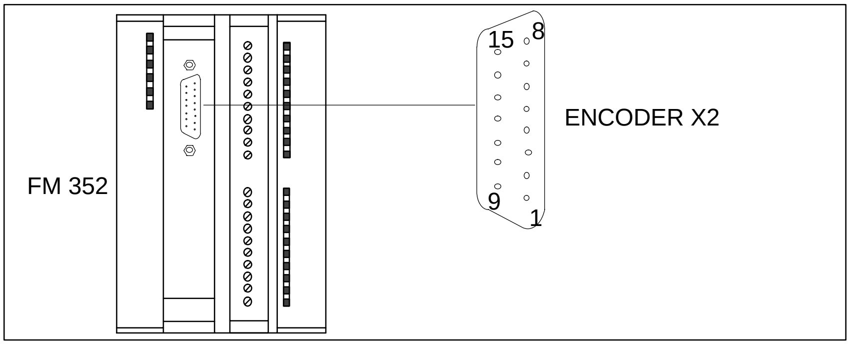


Figure 4-1 Location of the Sub D Connector X2

Pinout of the Encoder Interface

Pin	Name	Initiator	Incremental Encoders	Absolute Encoders
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 V DC	24 V encoder supply		
6	5.2 V DC	---	Encoder supply 5.2 V	
7	M	Ground		
8	N*	---	Zero mark signal (24 V)	---
9	RE	---	Sourcing/sinking (see Section B.3)	---
10	N	---	Zero mark signal (5 V)	---
11	$\overline{N}$	---	Zero mark signal inverse (5 V)	---
12	$\overline{B}/\overline{CLI}$ [1]	---	Encoder signal B inverse (5 V)	SSI shift clock inverse
13	B/CLI [1]	---	Encoder signal B (5 V)	SSI shift clock
14	$\overline{A}/\overline{DAT}$	---	Encoder signal A inverse (5 V)	SSI data inverse
15	A / DAT	---	Encoder signal A (5 V)	SSI data

1 In listen-in mode

4.2 Connecting the Encoder

Shield Contact Element

Using the shield contact element, you can connect all shielded cables with ground simply and easily making use of the direct connection between the shield contact element and the rail.

For more detailed information, refer to the manual *S7-300 Programmable Controller, Hardware and Installation*.

Procedure

Follow the steps outlined below to connect the encoder:

1. Connect the cable to the encoder.

   With absolute encoders, it may be necessary to prepare the cable and fit a connector to the encoder cable end according to the manufacturer’s instructions.
2. Open the front panel and plug the sub D connector into the FM 352.
3. Secure the connector with the knurled screws. Close the front panel.
4. Remove the insulation from the cable and clamp the cable shield into the shield contact element. Use shield clamps.

4.3 Pinout of the Front Connector

Front Connector

You connect the power supply and the switching elements via the front connector.

Pinout of the Front Connector

Terminal	Name	Meaning
1	L+	24 V DC encoder power supply and digital outputs
2	M	Encoder power supply and digital outputs ground
3	I0	Brake enable
4	I1	Length measurement/ edge detection/ setting actual value on-the-fly
5	I2	Reference point switch
6	I3	Enable track signal 3
7	Q0	Digital output 0
8	Q1	Digital output 1
9	Q2	Digital output 2
10	Q3	Digital output 3
11	Q4	Digital output 4
12	Q5	Digital output 5
13	Q6	Digital output 6
14	Q7	Digital output 7
15	Q8	Digital output 8
16	Q9	Digital output 9
17	Q10	Digital output 10
18	Q11	Digital output 11
19	Q12	Digital output 12
20	---	---

Auxiliary power for encoder and digital outputs (L+, M)

The 24 V DC auxiliary voltage of the encoders and digital outputs is monitored

- for wirebreak of the 24 V feed line
- for power failure

The 24 V DC auxiliary supply is converted internally to 5 V DC. This means that 24 V DC and 5 V DC are available on the encoder interface (sub D female connector X2) for the different types of encoders.

The general technical specifications and requirements of the DC power supplies are described in the installation manual *S7-300 Programmable Controller, Hardware and Installation, CPU Data*.

4 digital inputs (I0 to I3)

You can connect bounce-free switches (24 V current sourcing) or non-contact sensors (2 or 3-wire proximity switches) to the 4 digital inputs.

The digital inputs are not monitored for short-circuits or wire break and are connected to module chassis.

13 digital outputs (Q0 to Q12)

The state (on/off) of tracks 0 to 12 is output via 13 digital outputs. The digital outputs are connected to module chassis.

The following loads directions are possible:

- Operating voltage 24 V
- Current load 0.5 A/short-circuit proof

A separate LED indicates the state of each output.

4.4 Wiring the Front Connector

Connecting Cords

- The cords for digital inputs and digital outputs must be shielded if they exceed certain lengths, as follows:
  - digital inputs: cord length of more than 32 m
  - digital ouputs: cord length of more than 100 m
- The encoder cables must be shielded.
- The shields of the encoder cables must make contact with the shield/protective earth bar and the peripheral connector.
- The wires A/DAT, $\overline{\mathrm{A}}$/$\overline{\mathrm{DAT}}$, B/CLI, $\overline{\mathrm{B}}$/$\overline{\mathrm{CLI}}$, CLS, $\overline{\mathrm{CLS}}$ and N, $\overline{\mathrm{N}}$ of the incremental encoder must be twisted in pairs.
- For the connecting cords, use flexible cord, cross-sectional area 0.25 to 1.5 mm^2
- Ferrules are not necessary. If, however, you prefer to use them, you can use ferrules without an insulation collar (DIN 46228, form A, short version) and two cords each with 0.25 to 0.75 mm^2 in a ferrule.

Note

If you connect momentary-contact switches or proximity switches, you must use shielded cords to achieve the optimum noise immunity.

Note on Wiring 24 V DC

Caution

The module can be damaged.

If you connect the encoder supply with the incorrect polarity, the module will be damaged and must be replaced!

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

Required Tools

3.5 mm screwdriver or motorized screwdriver

Procedure

Warning

Injury to persons or damage to equipment if the power supply is not turned off.

If you wire the front connector of the FM 352 while it is live, you risk injury from electric shock.

Wire the FM 352 only when it is not live!

If no emergency stop switch is installed, damage can result from the connected units.

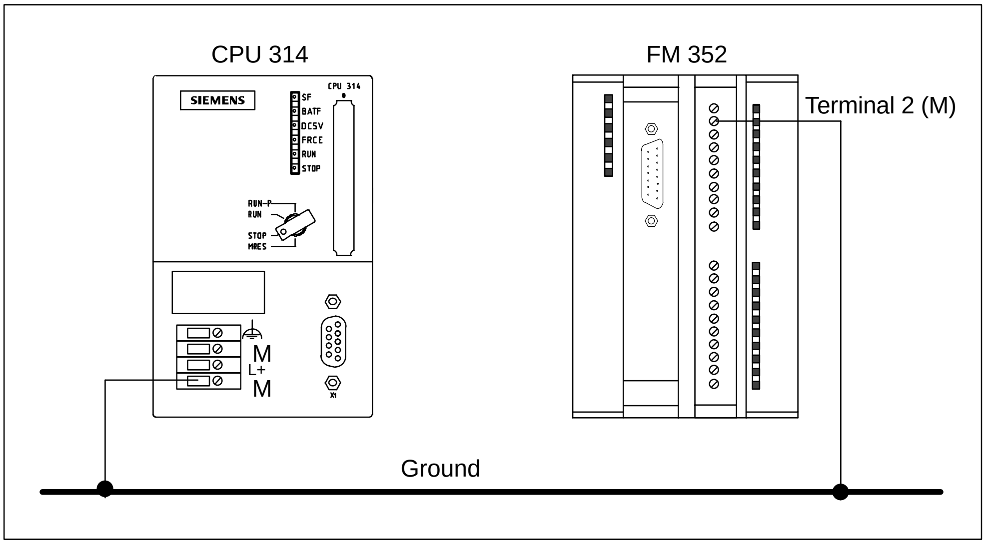
Install an emergency stop switch with which you can turn off the connected drives when you are controlling the FM 352 using the *Parameter Assignment User Interface*.

To wire up the front connector, follow the steps outlined below:

1. Remove 6 mm of insulation from the wire and, if required, crimp a ferrule onto the wire.
2. Open the front panel and position the front connector for wiring.
3. Fit the strain relief to the connector.
4. If you want to lead the wires out at the bottom, start at the bottom, otherwise at the top. Screw down unused terminals as well.
   Use a torque of 0.6 ... 0.8 Nm.
5. Secure the cable with the strain relief.
6. Put the front connector into the operating position (pressing the securing element).
7. You can complete the supplied label and insert it in the front panel.

Ground Connection

The ground of the encoder supply is electrically connected to the ground of the CPU; in other words, connect terminal 2 (1M) with the ground of the CPU or the IM 153 with a low-resistance connection.



Installing the Software

5

Introduction

You make the required settings for the FM 352 using the *Parameter Assignment User Interface.* This user interface is intended for both the FM 352 and the FM 452. You will find a description of the *Parameter Assignment User Interface* in the online help.

Requirements

Before you start to assign parameters for the FM 352 electronic cam controller, you should check that the following requirements are met:

- STEP 7, Version V4.02 or higher is correctly installed on your programming device/PC.

Installation

The entire software is on the supplied CD. It is installed as follows:

1. Insert the CD in the drive on your programming device/PC.
2. Start the software installation dialog in Windows 95/Windows NT by clicking the ”Add/Remove Programs” icon in the ”Control Panel”.
3. In this dialog, select the CD drive and the folder **FMx52\Disk1**, then select the file **Setup.exe** and start the installation.
4. Follow the instructions displayed by the installation program.

   Result: The software is installed in the following folders:

   – **SIEMENS\STEP7\S7LIBS\FMx52LIB**: FCs and UDTs

   – **SIEMENS\STEP7\S7FCAM**: parameter assignment user interface, readme, online help

   – **SIEMENS\STEP7\EXAMPLES\zEn19_01**: Example

   – **SIEMENS\STEP7\MANUAL**: manual

Note

If you installed STEP 7 in a folder other than SIEMENS\STEP7, this folder is entered.

Configuration and Parameter Assignment

These topics are described in Chapter 7.

Programming the FM 352

6

Chapter Overview

6.1 Basics of Programming an FM 352

Task

You can assign parameters, control and start up the FM 352 module in a user program. To exchange data between the user program and module, you use the functions (FCs) and data blocks (DBs) described below.

Preparations

- Open the block library FMx52LIB in the SIMATIC Manager and copy the required functions (FCs) and block templates (UDTs) to the block folder of your project. If the block numbers are already being used, assign new numbers. The block names are entered unchanged in the symbol table of your S7 program.
  - CAM_INIT (FC 0):
    This is required to initialize the channel DB following a module startup.
  - CAM_CTRL (FC 1):
    This is required for data exchange with the module.
  - CAM_DIAG (FC 2):
    This is required when you process detailed diagnostic information in the program or want to make this information available to an operator control and monitoring system.
  - CAM_MSRM (FC 3):
    can only be used with the FM 452
  - CAM_CHANTYPE (UDT1):
    This is required to generate a channel DB; this is used by FC CAM_INIT, CAM_CTRL and CAM_MSRM.
  - CAM_DIAGTYPE (UDT2):
    This is required to generate a diagnostic DB; this is used by FC CAM_DIAG.
  - CAM_P016TYPE (UDT3):
    This is required to generate a parameter DB with machine data and data for 16 cams; this is used by FC CAM_CTRL to write or read machine or cam data.
  - CAM_P032TYPE (UDT4):
    Same as CAM_P016TYPE, however for 32 cams.
  - CAM_P064TYPE (UDT5):
    Same as CAM_P016TYPE, however for 64 cams.
  - CAM_P128TYPE (UDT6):
    Same as CAM_P016TYPE, however for 128 cams.

- Create data blocks using the UDTs in the block folder of your S7 program. If you use several modules, you require a separate set of data blocks for each module.
- Enter the module address in the channel DB and, if used in the diagnostic DB, also at the address MOD_ADDR. You can also have the address entered automatically by selecting the module in HW Config and then selecting a data block in the “Properties” dialog with the “Mod Addr” button.
- If your programming device/PC is connected to a CPU, you can now download the FCs and DBs to the CPU.

6.2 FC CAM_INIT (FC 0)

Tasks

FC CAM_INIT initializes the following data in the channel DB:

- The control signals
- The return signals
- The trigger, done, error bits of the jobs
- The function switches and their done and error bits
- The job management and the internal buffers for FC CAM_CTRL and FC CAM_MSRM

Call

The function must be run through following a startup (power supply on) on the module or CPU. You should therefore install it, for example in the warm restart OB (OB100) and the remove/insert OB (OB83) or call it in the initialization phase of your user program. This ensures that your user program does not access old data following a CPU restart or a module startup.

Call Parameters

Name	Data Type	I/O	Meaning
DB_NO	INT	I	Number of the Channel DB

Return Values

This function does not return a value.

6.3 FC CAM_CTRL (FC 1)

Tasks

With FC CAM_CTRL, you can read the operating data from the module, initialize the module, and control it during operation. For these tasks, you use the control signals, return signals and write and read jobs.

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

- Read return signals:
  FC CAM_CTRL reads all return signals from the module and enters them in the channel DB. Since the control signals and jobs are only executed following this, the return signals reflect the status of the module before the block was called.
- Write control signals:
  The control signals entered in the channel DB are transferred to the module. The enabling of the cam processing is, however, delayed as long as the trigger for a “set reference point” or “write cam data” job is set. The activation (or reactivation) of cam processing is delayed for this time.
- Execute job:
  The next job is executed based on the trigger bits for jobs entered in the channel DB.

Call

This function must be called cyclically.

Before you call the function, enter all the data in the channel DB that are required to execute the intended functions.

Data Used

- Channel DB:
  The module address must be entered in the channel DB.
- Parameter DB:
  If you want to write or read machine or cam data using jobs, you require a parameter DB whose number must be entered in the channel DB. The size of the parameter DB must be adequate for the number of cams.

Jobs

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

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

If you use the FM 352 centrally, a read job is executed immediately. If you use the FM 352 decentrally, a read job may take several cycles.

Due to the required confirmations from the module, a write job requires at least three calls (or OB cycles).

You can send several jobs at the same time, if necessary, along with control signals. Apart from the job for writing the function switch, the jobs are executed in the order of the trigger bits as specified in the channel DB. Once a job has been completed, the trigger bit is reset. The next time the block is called, the next job is located and executed.

For each job there is not only a trigger bit but also a done bit and an error bit. In their names, instead of the ending _EN (for “enable“), they have the ending _D (for “done“) or _ERR (for “error”). Done and error bits of the job should be set to 0 after they have been evaluated or before the job is started.

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

Function Switches

The function switches activate and deactivate module states. A job for writing the function switches is only executed when there is a change in a switch setting. It is always executed between the jobs “set reference point” (REFPT_EN) and “set actual value” (AVAL_EN). The setting of the function switch is latched after the job has been executed.

Length measurements and edge detection must not be activated at the same time. FC CAM_CTRL makes sure that when one of the function switches is activated, the other is deactivated. If you do switch both function switches at the same time (0 -> 1), the length measurement is activated.

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

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

To be able to evaluate the done and error bits, you should set these bits to 0 when you change a function switch.

Startup

When the module or CPU starts up, call FC CAM_INIT (see Section 6.2, Page 6-4). Among other things, the function switches are reset.
FC CAM_CTRL acknowledges the module startup. During this time, RET_VAL and JOBBUSY are set to 1.

Call Parameters

Name	Data Type	I/O	Meaning
DB_NO	INT	I	Number of the Channel DB
RET_VAL	INT	O	Return value

Return Values

The function provides the following return values:

RET_VAL	BR	Description
1	1	At least one job active
0	1	No job active, no error
-1	0	Error: Data error (DAT_ERR) or Communication error (JOB_ERR) occurred

Job Status

You can check the status of job execution using the return value RET_VAL and the JOBBUSY activity bit in the channel DB. You can evaluate the status of a single job based on the trigger, done, and error bits of the job.

- Job active:
  - RET_VAL = 1
  - JOBBUSY = 1
  - Trigger bit = 1
  - Done bit = 0
  - Error bit = 0
- Job completed without error:
  - RET_VAL = 0
  - JOBBUSY = 0
  - Trigger bit = 0
  - Done bit = 1
  - Error bit = 0
- Job completed with error in this job:
  - RET_VAL = -1
  - JOBBUSY = 0
  - Trigger bit = 0
  - Done bit = 1
  - Error bit = 1
- Write job aborted:
  - RET_VAL = -1
  - JOBBUSY = 0
  - Trigger bit = 0
  - Done bit = 0
  - Error bit = 1

Response to Errors

If bad data were written by a write job, the module returns the message DATA_ERR = 1. If an error occurs in communication with the module during a write or read job, the cause of the error is entered in the JOB_ERR parameter in the channel DB.

- Error in a write job:

  If an error occurs in a job, the trigger bit is reset and the error bit (_ERR) and the done bit (_D) are set. The trigger bit is reset and the error bit (_ERR) is set for all write jobs still pending.

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

- Error in a read job:

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

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

For more detailed information on the errors, refer to the parameters JOB_ERR and DATA_ERR (see Chapter 11, Diagnostics and Appendix C.3, Page C-12**)**

6.4 FC CAM_DIAG (FC 2)

Tasks

Using FC CAM_DIAG, you read out the diagnostic buffer of the module and can make it available for display in an operator control and monitoring system or for programmed evaluation.

Call

This function must be called cyclically. A further job in an interrupt OB is not permitted. For complete execution of this function, at least two calls (cycles) are required.

The function reads the diagnostic buffer when a new entry is indicated in the diagnostic buffer by the return signal DIAG = 1. After reading the diagnostic buffer, DIAG is set to 0 by the module.

Data Used

- Diagnostic DB:
  The module address must be entered in the diagnostic DB. The latest entry in the diagnostic buffer is entered in the DIAG[1] structure and the oldest entry in the DIAG[4] structure.

Jobs

You can read the diagnostic buffer whether or not there is a new entry by setting the DIAGRD_EN trigger bit. After reading the diagnostic buffer, the trigger bit is set to 0.

Startup

There is no startup processing associated with the function.

Call Parameters

Name	Data Type	I/O	Meaning
DB_NO	INT	I	Number of the diagnostic DB
RET_VAL	INT	O	Return value

Return Values

The function provides the following return values:

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

Response to Errors

If an error occurs in a job, the cause of the error can be found in the diagnostic DB in the JOB_ERR parameter (see Chapter 11, Diagnostics and Appendix C.3, Page C-12).

6.5 Data Blocks

6.5.1 Templates for Data Blocks

The supplied library (FMx52LIB) contains a block template (UDT) for each data block. Based on this UDT, you can create data blocks with any numbers and names.

Optimizing the UDT

To save memory, you can delete unused data areas at the end of the UDT CAM_CHANTYPE. You can then save the modified UDT under a different name.

You can then generate a channel DB based on this UDT that is optimized for your application.

Functions that access deleted data areas can no longer be used.

The supplied UDT for the machine and cam data are matched already to the possible numbers of cams. They can be optimized in steps of 16 cams.

6.5.2 Channel DB

Task

The channel DB is the data interface between the user program and the FM 352 electronic cam controller. All the data required for controlling and operating the module is entered in this data block.

Structure

The channel DB is subdivided into various areas:

Channel DB
Address *)/version switch
Control signals
Return signals
Function switches
Trigger bits for write jobs
Trigger bits for read jobs
Done bits
Error bits
Job management for functions
Data for jobs

*) You can enter the address in the parameter assignment user interface.

6.5.3 Diagnostic DB

Task

The diagnostic DB provides the data storage for FC CAM_DIAG and contains the diagnostic buffer of the module created by this function.

Structure

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

6.5.4 Parameter DB

Task

The machine and cam data are stored in the parameter DB. The parameters can be modified by the user program or by an operator control and monitoring system. The modified data can be imported into the parameter assignment user interface and displayed there. You can export the data displayed in the parameter assignment user interface to a parameter DB.

There can be several sets of parameter assignment data for a module (for example, for various recipes) that you can activate program-controlled.

Structure

Parameter DB
CAM_P016TYPE (UDT3) *Machine data* *Cam data of cams 0 to 15*
CAM_P032TYPE (UDT4) *Machine data* Cam data of cams 0 to 31
CAM_P064TYPE (UDT5) *Machine data* Cam data of cams 0 to 63
CAM_P0128TYPE (UDT6) *Machine data* Cam data of cams 0 to 127

6.6 Interrupts

Interrupt Handling

The FM 352 can trigger hardware interrupts and diagnostic interrupts. You service these interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU changes to STOP (refer to the manual *Programming with STEP* 7).

You can enable interrupt servicing at the following levels:

1. Enabling general interrupts for the entire module:
   – Select the module in HW Config
   – Using the menu command **Edit > Object Properties > Basic Parameters**, enable diagnostic and/or hardware interrupts.
   – Select the OB number for the hardware interrupt using **Edit > Object Properties > Addresses**.
   – Save and compile the hardware configuration.
   – Download the hardware configuration to the CPU.
2. Enabling events for hardware interrupts in the machine data.
3. Setting parameters for hardware interrupts in the cam data for cams 0 to 7.

Evaluation of a Hardware Interrupt

If a hardware interrupt is triggered by the FM 352, the following information is available in the variable OB40_POINT_ADDR (or in the corresponding variable of a different hardware interrupt OB):

Table 6-1 Content of the Double Word OB40_POINT_ADDR

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	Cam	0	0
2	Cam 7 on	Cam 7 off	Cam 6 on	Cam 6 off	Cam 5 on	Cam 5 off	Cam 4 on	Cam 4 off
3	Cam 3 on	Cam 3 off	Cam 2 on	Cam 2 off	Cam 1 on	Cam 1 off	Cam 0 on	Cam 0 off

You can see the cause of the interrupt in Byte 1:

Cam: Evaluate byte 2 and byte 3 according to the table.

Lost Hardware Interrupts

If the processing of a hardware interrupt is not yet completed in the hardware interrupt OB, the module registers all subsequent hardware interrupt events. If an event occurs again before the hardware interrupt could be triggered, the module triggers the “hardware interrupt lost” diagnostic interrupt.

Evaluating a Diagnostic Interrupt

Following a diagnostic interrupt, the diagnostic information is available in the variables of OB82 and can be used for fast analysis. Call the CAM_DIAG function to find out the exact cause of the problem as entered in the diagnostic buffer.

The local data of the diagnostic interrupt OB that are supported are listed below.

Variable	Data Type	Description
OB82_MDL_DEFECT	BOOL	Module fault
OB82_INT_FAULT	BOOL	Internal error
OB82_EXT_FAULT	BOOL	External error
OB82_PNT_INFO	BOOL	Channel error
OB82_EXT_VOLTAGE	BOOL	External auxiliary voltage missing
OB82_FLD_CONNCTR	BOOL	No front connector
OB82_WTCH_DOG_F	BOOL	Watchdog monitoring has responded
OB82_INT_PS_FLT	BOOL	Internal module power supply failed
OB82_HW_INTR_FLT	BOOL	Hardware interrupt lost

6.7 Technical Specifications

The following table provides an overview of the technical specifications of the functions.

Table 6-2 Technical Specifications for the FM 352 Functions

No.	Block Name	Version	Space Occupied in Load Memory (bytes)	Space Occupied in Main Memory (bytes)	Space Occupied in Local Data Area (bytes)	MC7 Code/Data (bytes)	Called System Functions
FC0	FC CAM_INIT	1.0	192	138	2	102	
FC 1	FC CAM_CTRL	1.0	5232	4754	32	4718	SFC 58: WR_REC, SFC 59: RD_REC
FC2	FC CAM_DIAG	1.0	1758	1614	42	1578	SFC 59: RD_REC
	Channel DB	-	986	804	-	372	
	Parameter DB 16 Parameter DB 32 Parameter DB 64 Parameter DB 128	- - - -	616 808 1192 1960	336 528 912 1680	- - - -	300 492 876 1644	
	Diagnostic DB	-	460	338	-	302	

Module Cycle

The module updates the return data (except in the pulses measuring system) every 4 ms.

In the pulses measuring system, the data for the actual position value and the track signals are available after 1 ms.

Execution Times

The following table provides you with an overview of the execution times of the functions for the FM 352. The run time from the first function call to the done message (trigger bit reset) is shown. The cycle is extended by calling a function by between 8 and 12 ms for write jobs and by the length of the execution time for read jobs.

Table 6-3 Execution Times of the Functions for the FM 352

Block	Block Name/Job	CPU 315-2 (6ES7 315-2AF01-0AB0)
		Run time in ms
FC0	FC CAM_INIT	0.14
FC 1	FC CAM_CTRL	
	Control/return	0.55
	MDWR_EN	123.8
	MDWR_EN and MD_EN	132.1
	CAM1WR_EN (0 cam enabled)	26.3
	CAM1WR_EN (16 cams enabled)	92.9
	REFPT_EN	13.4
	SIM_ON	12.3
	AVAL_EN	15.1
	FVAL_EN	13.8
	ZOFF_EN	14.2
	CH01CAM_EN	15.7
	CH16CAM_EN (1 cam with check)	18.0
	CH16CAM_EN (1 cam without check)	17.6
	CH16CAM_EN (16 cams with check)	104.5
	CH16CAM_EN (16 cams without check)	94.1
	MDRD_EN	13.4
	CAM1RD_EN	18.1
	MSRRD_EN	8.8
	CNTTRC_EN	8.2
	ACTPOS_EN	8.8
	ENCVAL_EN	8.8
	CAMOUT_EN (FM_TYPE = 0, 16 bytes)	8.9
	CAMOUT_EN (FM_TYPE = 1, 24 bytes)	9.5
FC2	FC CAM_DIAG	
	Idle run	0.27
	Read diagnostic buffer	14.4
FC 3	FC CAM_MSRM	2.5

6.8 Fast Access to Module Data

Application

In special applications or in an interrupt level, particularly fast access to return and control signals is necessary. You can obtain this data directly via the input and output areas of the module.

To coordinate startup following each module startup (for example after inserting the module, CPU STOP → RUN), FC CAM_CTRL must be called continuously until the end of the startup is indicated by RET_VAL = 0.

Note

If you access data on the FM 352 directly, you must only use the non-internal data described here using the method described here. Otherwise, your user program will encounter difficulties accessing the module.

Direct Access for Reading Return Signals

The byte addresses are specified relative to the output address of the module. The names of the bits correspond to the names in the channel DB.

In STL, you access the data with the commands PIB (read 1 byte) and PID (read 4 bytes).

Address	**Bit number**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte 0	PARA	internal	internal	DATA_ERR	internal	DIAG	internal	internal
Byte 1	0	0	0	CAM_ACT	0	0	0	0
Byte 2	internal							
Byte 3	0	0	FVAL_ DONE	HYS	GO_P	GO_M	MSR_D ONE	SYNC
Byte 4	ACT_POS							
Byte 5								
Byte 6								
Byte 7								
Byte 8	TRACK_OUT							
Byte 9								
Byte 10								
Byte 11								

Direct Access for Writing Control Signals

The byte addresses are specified relative to the input address of the module. The names of the bits correspond to the names in the channel DB.

In STL, you access the data with the commands PQB (write 1 byte) and PQW (write 2 bytes).

Address	Bit number							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte 0	internal							
Byte 1	0	CNTC1_EN	CNTC0_EN	CAM_EN	DIR_P	DIR_M	0	0
Byte 2	TRACK_EN							
Byte 3								

Example: Actual position value (ACT_POS)

STL	Explanation
Example	**The base address of the module is 512**
L PID 516	Read the current actual position value (ACT_POS) with direct access: Base address of the module + 4

6.9 Parameter Transfer Routes

The term parameter includes the following machine and cam data.

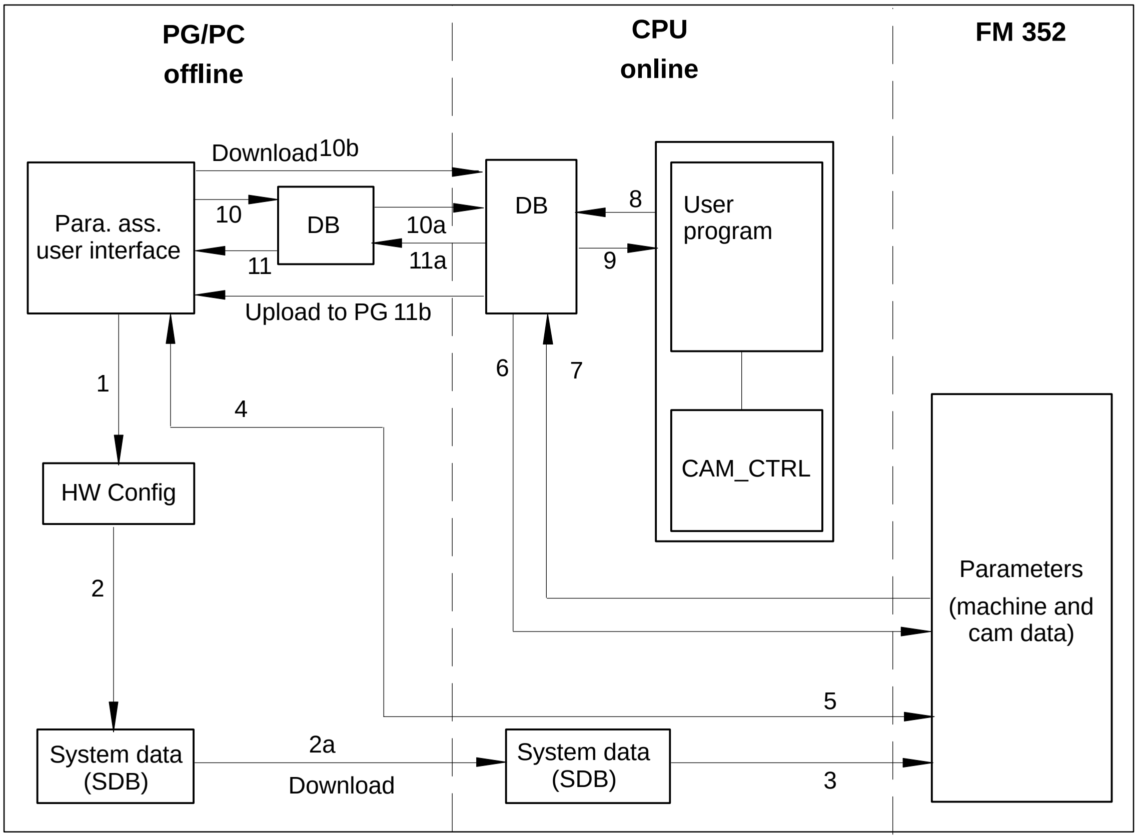


Figure 6-1 Parameter Transfer Routes

1	Save parameters in the parameter assignment user interface.
2	Save HW configuration, compile, and download to CPU.
3	The CPU writes the parameters to the module during system parameter assignment.
4	Upload the parameters of the module to the PG with the “Upload” command.
5	Download parameters from the parameter assignment user interface to the module with the “Download” command.
6	Write parameters to the module using jobs in the user program.
7	Read parameters from the module using jobs in the user program.
8	Store parameters from the user program in the online DB.
9	Read parameters into the user program from the online DB.
10	Export parameters from the parameter assignment user interface to the DB (offline or online DB); an offline DB must then also be downloaded to the CPU.
11	Import parameters from an online or offline DB into the parameter assignment user interface.

Typical Situations for the Transfer of Parameters:

1 You edit the parameters with the parameter assignment user interface. The module must then be assigned the parameters automatically during startup.
Action required: steps 1, 2, 3

2 You modify parameters during startup in the test mode in the parameter assignment user interface:
Action required: steps 4, 5

3 The parameters modified during installation should be downloaded automatically during startup:
Action required: steps 1, 2, 3

4 You set the parameters with the parameter assignment user interface. When it starts up, the module should be assigned parameters only by the user program using data blocks:
Action required: steps 10, 6

5 You want to create data for recipes:
Action required: step 10

6 You set the parameters with the parameter assignment user interface. These should be available to the user program for temporary modifications.
Action required: steps 1, 2, 3 for automatic parameter assignment.
Action required: steps 10, 7 for access by the user program.

7 You modify parameters (exclusively) using the user program:
Action required: steps 7, 9, 8, 6

8 You want to see the data modified by the user program in the parameter assignment user interface.
Action required: step 11

9 The parameters modified by the user program should be downloaded automatically during startup:
Action required: steps 6, 11, 1, 2, 3

Putting the FM 352 into Operation

7

Important Note

Please read the points in the following warning carefully.

Warning

To prevent injury to personnel and damage to equipment, please note the following points:

- Install an EMERGENCY STOP switch in the vicinity of the computer. This is the only way to ensure that the system can be switched off safely in the event of a computer or software failure.
- Install an EMERGENCY STOP limit switch directly connected to the power units of all drives.
- Make sure that nobody can obtain access to the area of the system that contains moving parts.
- Controlling and monitoring the FM 352 from within your program and from the **Test > Commission dialog** at the same time can lead to conflicts with unforeseeable effects. For this reason, always switch the CPU to STOP when you work in the Test dialog or deactivate your program.

Hardware Installation and Wiring

In the first section, you will install the FM 352 in your S7-300 and wire up the front connector.

Step	What Needs to Be Done?	✓
1	**Install the FM 352** (see Chapter 3) Fit the module in a suitable location.	 ❐
2	**Wire the FM 352** (see chapter 4) • Digital inputs on the front connector • Digital outputs on the front connector • Encoder connection • Power supply to the FM 352	 ❐ ❐ ❐ ❐
3	**Check the limit switches relevant for safety** Check that the following are functioning correctly: • The limit switches • The emergency stop circuits	 ❐ ❐
4	**Front connector** The front connector must sit firmly.	 ❐
5	Check the shielding of each individual cable.	❐
6	**Turn on the power supply** Switch the CPU to STOP (safe state). Turn on the 24 V supply for the FM 352.	 ❐ ❐

Creating a Project

Now set up a project in *STEP 7*.

The steps required to set up a project in the SIMATIC Manager are described below (without using a wizard).

Step	What Needs to Be Done?	✓
1	If you have not already done so, install the parameter assignment user interface.	❐
2	Create a new project in the SIMATIC Manager (**File > New**).	❐
3	Insert a station in your project (**Insert > Station**).	❐
4	Select the station and start the configuration user interface ”HW Config” by double-clicking ”Hardware”.	❐
5	Insert a rack in your hardware configuration with the following: • A power supply (PS) • CPU/IM 153 • Function module (FM)	❐
6	Save this hardware configuration in HW Config (**Station > Save**).	❐

Assigning Parameters with the Parameter Assignment User Interface.

If you are putting the module into operation for the first time, assign the parameters for the module using the parameter assignment user interface. Keep to the sequence below:

Step	What Needs to Be Done?	✓
1	Select the tier in the rack containing the FM 352 module.	❐
2	Now double-click to start the parameter assignment user interface for the FM 352.	❐
3	Using the menu command **File > Properties**, you can modify the following settings: • General You can modify the name and enter a comment. • Addresses You can modify the base address and assign the address area to a part process image. (**Note down the module address displayed.**) • Basic Parameters You can set the interrupt type and the reaction to a CPU stop.	❐
4	In the block diagram displayed, you can select the dialogs for **Axis, Encoders, Cams, Tracks** and **Interrupt Enable** and set the required parameters.	❐
5	Save the parameter settings with the menu command **File > Save.**	❐
6	Close the parameter assignment user interface with **File > Exit**.	❐
7	Save the hardware configuration in HW Config with **Station > Save and Compile**.	❐
8	Set up an online connection to the CPU and download the hardware configuration to the CPU. At each change from STOP to RUN, this data is transferred to the FM 352.	❐
9	Select **Test > Commission**.	❐

Test and Commissioning

You can now test the entries and modifications you have made.

Step	What Needs to Be Done?	✓
1	Check your data with the dialogs **Test > Commission**, **Test > Service** and **Test > Error Evaluation**.	❐
2	You can modify incorrect machine data in the **Test > Commission** dialog. These modifications remain valid until the next STOP-RUN change on the CPU.	❐
3	You can save the corrected machine data on the CPU by repeating steps 7 to 9 of the previous table.	❐

Note

If you use the FM 352 via PROFIBUS-DP; the CPU must be set to RUN or RUN-P during testing and commissioning. Otherwise, you cannot control the FM 352.

Tests for Axis Synchronization and Switching Behavior

Using the following tests you can check the correct assignment of parameters for the FM 352.

<table>
<tr><th>Step</th><th colspan="2">What Needs to Be Done?</th><th>✓</th></tr>
<tr><td rowspan="3">1</td><td colspan="2">Synchronize the axis</td><td></td></tr>
<tr><td>• Incremental Encoders
– Select ”set reference point”. Enter the required value (see Section 9.4).
or
– Set the function switch “retrigger reference point” (see Section 9.8).</td><td>• Absolute Encoders
– The FM 352 is synchronized immediately after parameter assignment.
– Make an absolute encoder adjustment (see Section 8.4)
You may first have to calculate the exact value with ”set reference point”.</td><td>❐</td></tr>
<tr><td colspan="2">Check the actual status of the axis. The actual position must agree with the position indicated.</td><td>❐</td></tr>
<tr><td>2</td><td colspan="2">Check the switching behavior of the cams and tracks being used.
• Activate the test enable.
• Run ”set reference point”.
• Activate cam processing.
• Enable the track signals.
• Rotate the encoder or
• Set the simulation function switch.</td><td>❐</td></tr>
<tr><td>3</td><td colspan="2">Test the other settings according to your application
• Set reference point
• Set actual value</td><td>❐</td></tr>
</table>

Preparations for Programming

You still need to create the blocks required in your project.

Step	What Needs to Be Done?	✓
1	Select the library FMX52LIB in the SIMATIC Manager (**File > Open > Libraries**).	❐
2	Copy the functions FC0, FC1 and the channel DB template UDT1 to your blocks folder.	❐
3	Create a channel DB based on the UDT1 template for each module.	❐
4	If you want to use a programmed diagnostic evaluation, copy FC2 and UDT2 and create a diagnostic DB for each module.	❐
5	If you want to write and read machine data in the user program, you require UDT3 for 16 cams, UDT4 for 32 cams, UDT5 for 64 cams, or UDT6 for 128 cams.	❐

Preparing the Channel DB

Step	What Needs to Be Done?	✓
1	Open the channel DB.	❐
2	Check whether the module address has already been entered in the MOD_ADDR parameter. If it is not there, it must be entered now.	❐
3	Save the channel DB (**File > Save**).	❐

Preparing the Diagnostic DB

Step	What Needs to Be Done?	✓
1	Open the diagnostic DB	❐
2	Check whether the module address has already been entered in the MOD_ADDR parameter. If it is not there, it must be entered now.	❐
3	Save the diagnostic DB (**File > Save**).	❐

Linking the Functions

Step	What Needs to Be Done?	✓
1	Link the required functions in your user program.	❐

Downloading the Blocks to the CPU

Step	What Needs to Be Done?	✓
1	Select the blocks in the SIMATIC Manager and download them with **PLC > Download.**	❐

Machine Data and Cam Data

8

Chapter Overview

8.1 Writing and Reading the Machine and Cam Data

This chapter is relevant if you want to write the parameters directly to the module using instructions in the user program without using the parameter assignment user interface.

All the machine and cam data are stored in the parameter DB. You must enter the number of the parameter DB in the appropriate channel DB.

You can write the parameter DB while working in the parameter assignment user interface with “Export” and read it with “Import”.

Writing and Activating Machine Data

With the machine data, you adapt the FM 352 to the axis and the encoder.

The machine data are in the parameter DB at addresses 3.1 to 104.0.

Initial Parameter Assignment

If the module does not yet contain machine data (return signal PARA = 0), follow the steps outlined below to set initial parameters without the parameter assignment user interface:

- Enter the new values in the parameter DB.
- Download the parameter DB to the CPU.
- Set the following trigger bit in the channel DB:
  - Write machine data (MDWR_EN)
- Call the FC CAM_CTRL function in the cyclic user program.

Changing Machine Data

To change existing machine data (return signal PARA = 1) from the user program, follow the steps below:

- Enter the new values in the parameter DB.
- Set the trigger bits in the channel DB:
  - Write machine data (MDWR_EN)
  - Activate machine data (MD_EN)
- Call the FC CAM_CTRL function in the cyclic user program.
- Check whether the previous cam data are compatible with the modified machine data.
- Always write the cam data of the set cams again whether they have been changed or not (CAM1WR_EN...CAM8WR_EN)

Note

If parameters that are relevant for synchronization were modified, the synchronization is deleted when the machine data are activated. The settings are also reset and all the machine and cam data are deleted on the module. Parameters relevant for synchronization are as follows:

- Axis type
- End of rotary axis
- Encoder type
- Distance per encoder revolution
- Increments per encoder revolution
- Number of revolutions
- Reference point coordinate
- Absolute Encoder Adjustment
- Type of retrigger reference point
- Direction adaptation
- Number of Cams
- Start and end software limit switch

Reading Machine Data

To read the current machine data from the module, follow the steps outlined below:

- Set the following trigger bit in the channel DB:
  - Read machine data (MDRD_EN)
- Call the FC CAM_CTRL function in the cyclic user program.

  This enters the current machine data in the parameter DB on the CPU.

Excerpt from the Channel DB

Address	Name	Type	Initial Value	Comment
35.0	MDWR_EN	BOOL	FALSE	1 = write machine data
35.1	MD_EN	BOOL	FALSE	1 = activate machine data
37.1	MDRD_EN	BOOL	FALSE	1 = read machine data

Writing Cam Data

With the cam data, you specify the type and action of the cams and their assignment to the tracks.

Cam data are located in the parameter DB from address 108.0 onwards. They are grouped in packages each with 16 cams.

Cam data are active immediately after writing.

To write cam data without the parameter assignment user interface, follow the steps outlined below:

- Enter the new values in the parameter DB.
- Download the parameter DB to the CPU.
- Set the trigger bits in the channel DB (CAM1WR_EN...CAM8WR_EN)
- Call the FC CAM_CTRL function in the cyclic user program.

Reading Cam Data

To read the current cam data from the module, follow the steps outlined below:

- Set the following trigger bit in the channel DB:
  - Read cam data (CAM1RD_EN ... CAM8RD_EN)
- Call the FC CAM_CTRL function in the cyclic user program.

  This writes the current cam data to the parameter DB on the CPU.

Excerpt from the Channel DB

Address	Name	Type	Initial Value	Comment
35.3	CAM1WR_EN	BOOL	FALSE	1 = Write cam data 1 (cams 0 to 15)
35.4	CAM2WR_EN	BOOL	FALSE	1 = Write cam data 2 (cams 16 to 31)
35.5	CAM3WR_EN	BOOL	FALSE	1 = Write cam data 3 (cams 32 to 47)
35.6	CAM4WR_EN	BOOL	FALSE	1 = Write cam data 4 (cams 48 to 63)
35.7	CAM5WR_EN	BOOL	FALSE	1 = Write cam data 5 (cams 64 to 79)
36.0	CAM6WR_EN	BOOL	FALSE	1 = Write cam data 6 (cams 80 to 95)
36.1	CAM7WR_EN	BOOL	FALSE	1 = Write cam data 7 (cams 96 to 111)
36.2	CAM8WR_EN	BOOL	FALSE	1 = Write cam data 8 (cams 112 to 127)
37.2	CAM1RD_EN	BOOL	FALSE	1 = Read cam data 1 (cams 0 to 15)
37.3	CAM2RD_EN	BOOL	FALSE	1 = Read cam data 2 (cams 16 to 31)
37.4	CAM3RD_EN	BOOL	FALSE	1 = Read cam data 3 (cams 32 to 47)
37.5	CAM4RD_EN	BOOL	FALSE	1 = Read cam data 4 (cams 48 to 63)
37.6	CAM5RD_EN	BOOL	FALSE	1 = Read cam data 5 (cams 64 to 79)
37.7	CAM6RD_EN	BOOL	FALSE	1 = Read cam data 6 (cams 80 to 95)

Address	Name	Type	Initial Value	Comment
38.0	CAM7RD_EN	BOOL	FALSE	1 = Read cam data 7 (cams 96 to 111)
38.1	CAM8RD_EN	BOOL	FALSE	1 = Read cam data 8 (cams 112 to 127)

Order when Writing Machine and Cam Data

Always modify machine and cam data in the following order:

- Write machine data
- Activate machine data
- Write cam data

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

8.2 System of Units

Selecting a Unit

In the parameter assignment user interface of the cam controller, you can select a specific unit for inputting and outputting data (default: mm).

You can also select the following units:

- Millimeters, inches, degrees and pulses.

Note

If you change the unit in the parameter assignment user interface, the values are calculated in the new system. This can lead to rounding errors.

If you change the unit using the machine data, the values are **not** recalculated automatically.

If the unit is changed from or to "pulses", the cam processing is deactivated and the axis is no longer synchronized.

Units in the Parameter DB

Address	Name	Type	Initial Value	Comment
8.0	UNITS	DINT	L#0	**Units** 1 = 10^{-3} mm 2 = 10^{-4} inches 3 = 10^{-4} degrees 4 = 10^{-2} degrees 5 = pulses 6 = 10^{-3} degrees

Standard Units

In this manual, limit values are always specified in the **unit mm**. To define the limits in other systems of units, please make the following calculation:

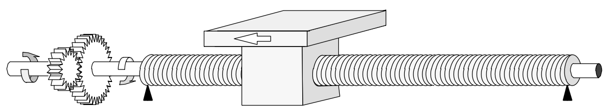
To convert....		Calculate...
mm → inches		Limit value (inches) = limit value (mm) · 0.1
mm → deg	10^{-4} (4 decimal places)	Limit value (degrees) = limit value (mm) · 0.1
	10^{-3} (3 decimal places)	Limit value (degrees) = limit value (mm) · 1
	10^{-2} (2 decimal places)	Limit value (degrees) = limit value (mm) · 10
mm → pulses		Limit value (pulses) = limit value (mm) · 1000

8.3 Machine Data of the Axis

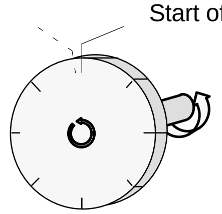
Axis Data

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

A **linear axis** is an axis with a limited physical travel range.



A **rotary axis** is an axis whose travel range is not restricted by mechanical limit stops.



Address	Name	Type	Initial Value	Comment
16.0	ENDROTAX	DINT	L#100000	**End of rotary axis** Range: 1 µm to +1 000 000 000 µm

The value “end of rotary axis” is the highest theoretical value that the actual value can reach. The highest theoretical value is however never displayed since it is physically the same position as the start of the rotary axis (0).

The highest value that can be displayed by a rotary axis is as follows:

End of the rotary axis [µm] – resolution [µm / pulse]·1 **[pulse]**

Example: End of rotary axis 1000 mm

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.

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 of the absolute encoder.

$$\text{End of rotary axis}[\mu m] = \text{number of revolutions(encoder)} \cdot \frac{\text{steps(encoder)[pul]}}{\text{revolution}} \cdot \text{RES}\left[\frac{\mu m}{\text{pul}}\right]$$

Address	Name	Type	Initial Value	Comment
44.0	REFPT	DINT	L#0	**Reference point coordinate** Range: – 1 000 000 000 μm to + 1 000 000 000 μm

Incremental encoder and initiator:
Using the “Retrigger Reference Point” function switch and a synchronization event specified by the “Type of Reference Point Retriggering”, the reference point coordinate is assigned to this event.

Absolute encoder (SSI)
An axis with an absolute encoder is always synchronized provided no error is detected (after transfer of the first error-free SSI frame).
Read the description of absolute encoder adjustment in Section 8.4 (Page 8-12), explaining the interaction of absolute encoder adjustment with other data.

Linear axis
The value of the reference point coordinate must be within the working range (including the start software limit switch and end software limit switch).

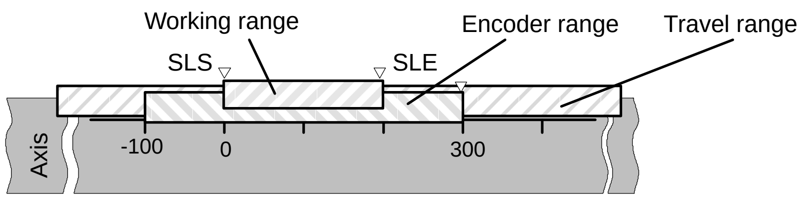
Rotary axis
The value of the reference point coordinate must be greater than or equal to 0 and must be less than the value “end of rotary axis” “ (0 ≤ reference point coordinate < “end of rotary axis”).

Address	Name	Type	Initial Value	Comment
52.0	RETR_TYPE	DINT	L#0	**Type of reference point retriggering**: Ranges: 0 = Ref. point switch and zero marker direction + 1 = Ref. point switch and zero marker direction – 6 = Only ref. point switch 7 = Only zero marker

With “type of reference point retriggering”, you specify the conditions for synchronizing the axis when working with an incremental encoder or an initiator (see also Section 9.8, Page 9-19)

Address	Name	Type	Initial Value	Comment
64.0 68.0	SSW_STRT SSW_END	DINT DINT	L# –100 000 000 L# 100 000 000	**Start software limit switch** **End software limit switch** Range: – 1 000 000 000 µm to 1 000 000 000 µm

This axis data is only of significance with a linear axis.
The software limit switches are active when the FM 352 is synchronized. The range set by the software end limit switch is known as the **working range**. The limits of the working range can be monitored by the FM 352.
The start software limit switch (SLS) must always be less than the end software limit switch (SLE).



Absolute encoder (SSI)
The FM 352 is synchronized after you have received a complete error-free frame. 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).

Incremental encoder and initiator
After starting up the FM 352, the axis is initially not synchronized. The software limit switches are only monitored after synchronization.

Relationship: working range, encoder range, travel range

- The “working range” is the range you specify for your task using the software limit switches.
- The “encoder range” is the range covered by the encoder. With a linear axis, this is placed symmetrically over the working range by the module; in other words, the module shifts the encoder range so that the distances between the software limit switches and the ends of the encoder range are the same (see figure).
- The “travel range” is the range of values that can be processed by the FM 352. It is dependent on the resolution.

The following rule applies:
Travel range ≥ encoder range ≥ working range

Address	Name	Type	Initial Value	Comment
80.0	HYS	DINT	L#0	**Hysteresis** Ranges: 0...65.535 [pul] · resolution [$^{\mu m}/_{pul}$]

The range of values depends on the resolution:
The maximum value that can be input is as follows:

– For linear axes: maximum input value < ¼ of the working range

– For rotary axes: maximum input value < ¼ of the rotary axis range

Distance Cams and Hysteresis

A distance cam is activated in the following situation:

- the detected actual value is within the distance cam and
- no hysteresis is active.

The switching point can vary depending on to the position of the direction change.

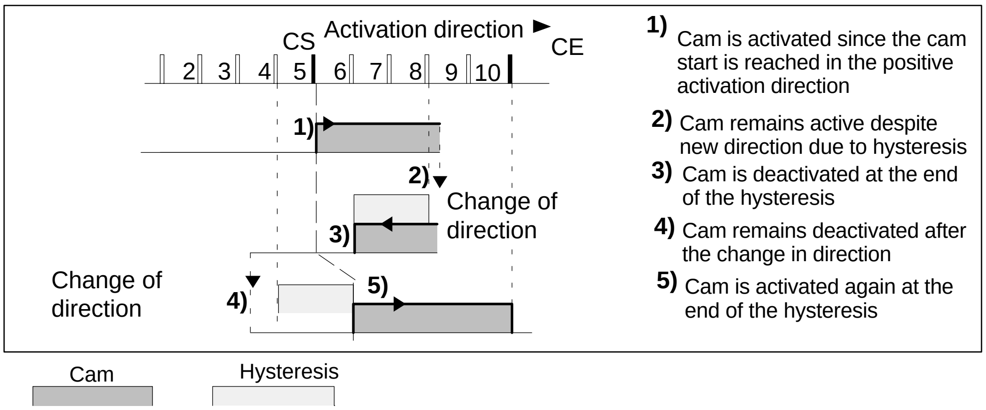


Figure 8-1 Activation of a Distance Cam with Hysteresis

Note

Distance cams that are shorter than the hysteresis can be hidden by the hysteresis when there is a change in direction.

Time Cams with Hysteresis

A time cam is activated in the following situation:

- the cam start is reached in the activation direction and
- no hysteresis is active.

Note

If the range between the reversal point and the start of the time cam is less than the hysteresis, the time cam will be “hidden” by the hysteresis.

Figure 8-2 illustrates a time cam that is **not** activated again.

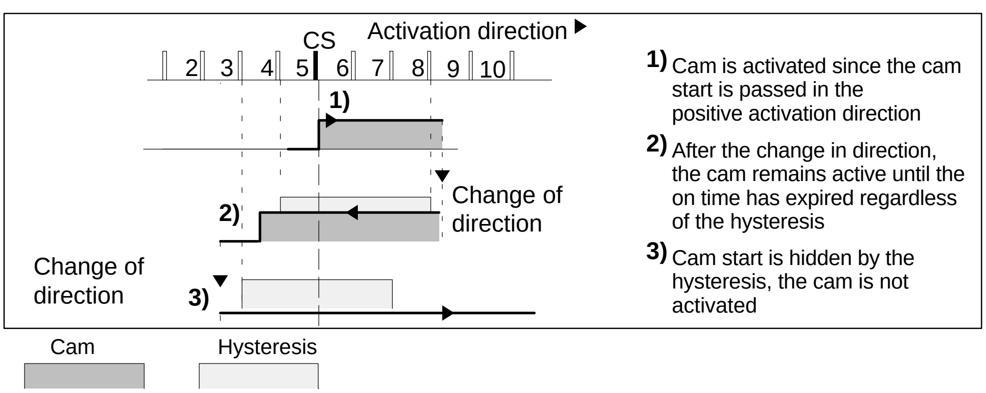


Figure 8-2 Activation of a Time Cam with Hysteresis

Address	Name	Type	Initial Value	Comment
84.0	SIM_SPD	DINT	L#0	**Simulation Speed** The simulation speed depends on the resolution. 0 = stationary $5 \cdot 10^8$ = Highest possible setting of the module Within this range, the simulation speed depends on the resolution: 1000 · resolution ≤ simulation speed ≤ 3 · 10^7 · resolution
This machine data specifies the simulation speed for simulation (see Chapter 9). The actual simulation speed V_{sim} can deviate from the entered simulation speed $V_{sim, V}$ and is calculated according to the following formula:				

$$V_{sim} = \frac{6 \cdot 10^7 \cdot RES}{\text{integer}\left(\frac{6 \cdot 10^7 \cdot RES}{V_{sim,V}}\right)}$$

In this formula

- V_{sim}: Simulation speed set by the FM 352, unit: $^{\mu m}/_{min}$.
- $V_{sim,V}$: Simulation speed specified in the machine data, unit: $^{\mu m}/_{min}$.
- RES: Resolution calculated from the encoder data, unit: $^{\mu m}/_{pulse}$
- Integer (): from this expression, only the value before the decimal point is used for further calculation. This expression must be within the range 2 ... 65536 for all calculations.

As a result of the relationships (see formula), the actual simulation speed changes abruptly.

Address	Name	Type	Initial Value	Comment
4.0	EDGEDIST	DINT	L#0	**Minimum edge-to-edge distance** Range: 0 ... 1 000 000 000 μm
With this machine data, you define a range after detection of the start of measurement when using edge detection. If the end of the measurement is within this range, the measurement is rejected. The start of the measurement is signaled only after the minimum edge-to-edge distance has been traveled.				

8.4 Absolute Encoder Adjustment

Definition

With absolute encoder adjustment and the reference point coordinate, there is a defined correlation between the encoder range of values and the axis coordinate system.

Address	Name	Type	Initial Value	Comment
48.0	ENC_ADJ	DINT	L#0	**Absolute encoder adjustment** Range: 0 to (2^{25}–1)
“Absolute encoder adjustment” finds the encoder value corresponding to the reference point coordinate on the axis. The value must be less than the total number of steps of the absolute encoder.				

Establishing the Correct Absolute Encoder Adjustment

After initial parameter assignment, further steps are necessary to establish the correct relationship between encoder and coordinate system. The sequence shown below is the sequence when using the parameter assignment user interface.

1. Move the axis to a defined reproducible point that you know and that is physically unique.

   This could be, for example,the “end software limit switch”.

2. Start “set reference point” with the coordinate of the point defined in step 1.

   The FM 452 now determines an encoder value, the absolute encoder adjustment, for the reference-point coordinate entered in the machine data. You can read out this value with the user interface in the service dialog.

3. Enter the read-out value in the machine data “absolute encoder adjustment“.
4. Save the machine data.
5. Download the data in HW Config to the CPU.
6. To activate the data, run a warm restart on the CPU.

Note

You make this adjustment once during installation and startup. The FM 452 is synchronized following parameter assignment during startup as soon as a complete, error-free frame is received from the encoder following startup.

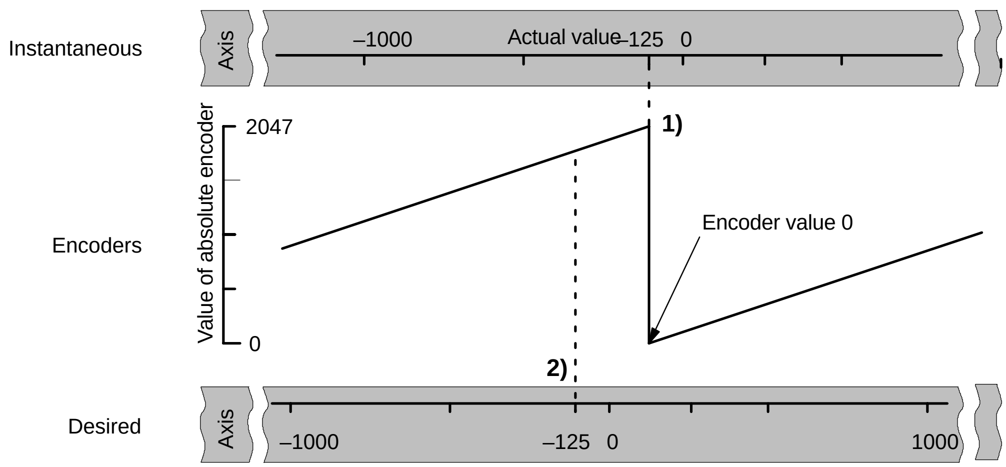
Data in the Parameter DB

Address	Name	Type	Initial Value	Comment
44.0	REFPT	DINT	L#0	**Reference point coordinate** Range: – 1 000 000 000 μm to + 1 000 000 000 μm

Example of Absolute Encoder Adjustment

In the example, the following is assumed:

- Reference-point coordinate = -125 mm
- Working range of SSW_STRT = – 1000 mm to SSW_END = 1000 mm
- Absolute encoder adjustment = 0
- Encoder range = 2048 increments (= pulses) with a resolution of 1 mm/pulse
- The absolute encoder used cannot be exactly adjusted mechanically and also does not have the option of setting the actual value.



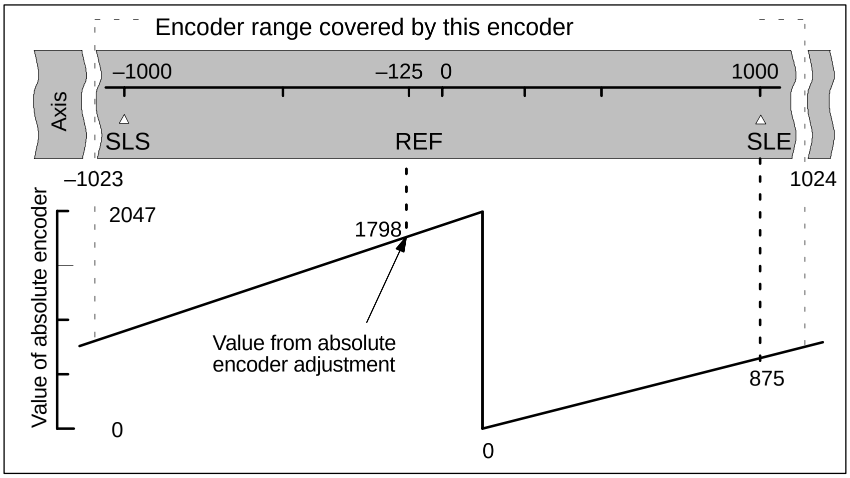
1) Correlation between the coordinate system and the encoder values with the set absolute encoder adjustment. The encoder value 0 corresponds to the actual value -125.

2) Required correlation of the coordinate system with the encoder. At this position the coordinate should be -125.

Result After Setting the Reference Point

After setting the reference point, the relationship between the encoder and coordinate system is as follows:

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



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

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

Alternative: Mechanical Adjustment of an Encoder

You can obtain a correct relationship between the coordinate system and the encoder as follows:

1. Move the axis to a reproducible position (for example the start software limit switch).
2. Enter this coordinate value in the machine data as the reference point coordinate.
3. Read the encoder value displayed at this position in the service dialog of the user interface.
4. Enter this value as the absolute encoder adjustment in the machine data.

A correct actual value is then always displayed after parameter assignment.

Instead of steps 3. and 4., you can also set the encoder to zero with “Reset” (if this exists) and enter the value “0” as the absolute encoder adjustment in the machine data.

8.5 Machine Data of the Encoder

Definition

The encoder supplies position information to the module; the module evaluates this information taking into account the resolution and calculates an actual value.

You can only be sure that the calculated actual value of the axis position matches the actual axis position when the information in the machine data of the encoder is correct.

Data in the Parameter DB

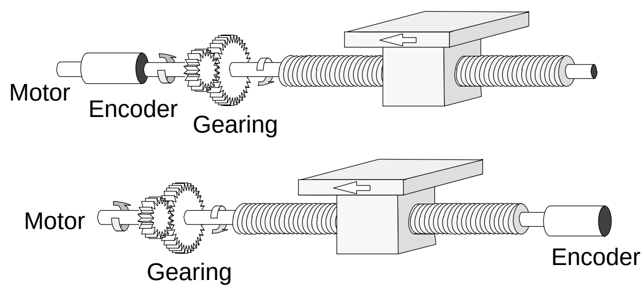
Address	Name	Type	Initial Value	Comment
20.0	ENC_TYPE	DINT	L#1	**Encoder type and frame length** Range of values: 1 = 5 V incremental 2 = 24 V incremental 3 = SSI 13-bit frame length 4 = SSI 25-bit frame length 5 = listen in 6 = 24 V initiator forwards 7 = 24 V initiator backwards 8 = SSI 13-bit (right-justified) 9 = SSI 25-bit (right-justified) 10 = listen in (right-justified)
With the “frame length”, you specify the clock frame output by the FM 352. If you select “listen in”, you turn off the clock of the FM 352. The FM 352 can then listen in on other SSI frames with a 13 or 25-bit frame length. The transmission rate depends on the cycle rate of the master module.				

Address	Name	Type	Initial Value	Comment
24.0	DISP_REV	DINT	L#80000	**Distance per encoder revolution** Range of values: 1 µm to 1.000.000.000 µm

With the machine data “distance per encoder revolution” you inform the FM 352 of the distance covered by the drive system per encoder revolution.

The value “distance per encoder revolution” depends on how the axis is set up and how the encoder is installed. You must take into account all transmission components such as couplings or gearing.

Section 8.6 (Page 8-20) describes the relationship between the machine data “distance per Encoder Revolution” and “increments per encoder revolution”.



Address	Name	Type	Initial Value	Comment
32.0	INC_REV	DINT	L#500	**Increments per encoder revolution** Range of values: 1 to 2^{25} **Note:** If you are using pulses as the unit, this entry has no significance.

The “increments per encoder revolution” machine data specifies the number of increments output by an encoder per revolution. Based on this value and the machine data “distance per encoder revolution”, the FM 352 can calculate the resolution.

Incremental encoder

Any value from the range shown can be entered. One increment involves quadruple evaluation by the module (see also Section 10.1, Page 10-2).

Initiator

Any value from the range shown can be entered.

Absolute encoder

The limits vary according to the type of encoder.

Encoder Type	Frame Length / Type	Value Range	Can be used as linear axis
Single-turn	13-bit half fir tree	64 ... 8192 in powers of 2	
Single-turn	13-bit right-justified	64 ... 8192 all values	X
Single-turn	25-bit right-justified	64 ... 2^{25} all values	X
Multi-turn	25-bit fir tree	64 ... 8192 in powers of 2	
Multi-turn	25-bit right-justified	64 ... 2^{24} all values	
Listen-in	Fir tree	64 ... 8192 in powers of 2	
Listen-in	right-justified	64 ... 2^{25} all values	X
Special setting: Multi-turn as Single-turn	25-bit half fir tree	64 ... 8192 in powers of 2	

Note:

The number of pulses of an encoder is calculated from the machine data “increments per encoder revolution” multiplied by “number of revolutions” (see page 8-20).

Address	Name	Type	Initial Value	Comment
36.0	NO_REV	DINT	L#1024	**Number of encoder revolutions** Range of values: 1 (single-turn encoder) 2 to 2^{19} (multi-turn encoder)

The machine data "number of encoder revolutions" is only necessary for absolute encoders. You use it to define the number of revolutions possible with this encoder. For more information on absolute encoders, read Chapter 10.3 in this manual.

Single-turn encoders

Only the value 1 is possible.

Multi-turn encoders

Multi-turn / Listen-in (fir tree): 2 ... 4096 in powers of 2.

Multi-turn / listen-in (right-justified): 2 ... 2^{19} All values with the following restriction:

Increment/encoder revolution · number of encoder revolutions $\leq 2^{25}$.

Linear measure

You can also connect a linear measure by entering the value 1.

Total number of steps of the encoder

The total number of steps is not part of the machine data.

Total no. of steps = increments per encoder revolution · no. of revolutions

Address	Name	Type	Initial Value	Comment
40.0	BAUDRATE	DINT	L#0	**Baud rate** Range of values: 0 = 125 kHz 1 = 250 kHz 2 = 500 kHz 3 = 1000 kHz

With the baud rate machine data, you define the speed of the data transfer from SSI encoders to the FM 352.

This entry has no significance for incremental encoders.

The maximum cable length depends on the baudrate:

- 125 kHz → 320 m
- 250 kHz → 160 m
- 500 kHz → 63 m
- 1000 kHz → 20 m

Address	Name	Type	Initial Value	Comment
59.0	CNT_DIR	BOOL	FALSE	**Count direction** 0 = normal 1 = inverted

With the machine data “count direction”, you match the direction of the position detection to the direction of axis movement.

You must also take into account all the directions of rotation of the transmission elements (for example coupling and gearing).

- Normal = ascending count pulses (incremental encoder) or encoder values (absolute encoder) correspond to ascending actual position values
- Inverted = ascending count pulses (incremental encoder) or encoder values (absolute encoder) correspond to descending actual position values.

A lead time in conjunction with an absolute encoder (SSI) and inverted count direction is not permitted.

Address	Name	Type	Initial Value	Comment
				Monitoring
63.0	MON_WIRE	BOOL	TRUE	1 = wire break
63.1	MON_FRAME	BOOL	TRUE	1 = frame error (must always be 1)
63.2	MON_PULSE	BOOL	TRUE	1 = missing pulses

Wire break

When monitoring is activated, the FM 352 monitors the signals A, $\overline{A}$, B, $\overline{B}$, N and $\overline{N}$ of an incremental encoder. The monitoring detects:

- Wire break
- Short circuit on individual lines.

  With incremental encoders without a zero marker, you must either
  - deactivate the wire break monitoring or
  - connect the signals N and $\overline{N}$ externally (see Section 10.1)
- Edge-to-edge distance between the edges of the counted pulses.
- Failure of the encoder power supply.

Frame error

The frame error monitoring for absolute encoders (SSI) cannot be deactivated. It monitors the frame as follows:

- Start and stop bit errors
- Monitoring of the monostable flip-flop period of the connected encoder

Missing pulses (incremental encoder)

An incremental encoder must always supply the same number of increments between two consecutive zero markers.

The FM 352 checks whether the zero marker of an incremental encoder occurs at the correct encoder status.

For encoders without zero markers, you must deactivate error pulse monitoring. You must also deactivate wire break monitoring or connect the zero marker inputs N and $\overline{N}$ externally.

8.6 Resolution

Definition

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

The resolution (RES) is calculated as shown in the following table:

	Incremental Encoders	Absolute Encoders/Initiators
Input values	• Distance per encoder revolution • Increments per encoder revolution • Pulse evaluation: quadruple • 1 increment = 4 pulses	• Distance per encoder revolution • Increments per encoder revolution • 1 increment = 1 pulse
Calculation	$\mathrm{RES} = \frac{\frac{\text{distance}}{\text{encoder rev}}}{\frac{\text{pulses}}{\text{encoder rev}}}$	

Note

In the pulses system of units, the resolution always has the value 1.

All position information is rounded up to the integral multiple of the resolution. This allows you to distinguish between the entered and the used values.

Range of Values of the Resolution

The range for the resolution must be converted to the basic system of units. The resolution must be kept within this range by selecting the values “distance per encoder revolution” and “increments per encoder revolution”.

Based on the systems of units, the ranges for the resolution are as follows:

System of Units	Specifications in...	Range for the Resolution
mm	10^{-3} mm	$0.1 \cdot 10^{-3}$ mm .... $1000 \cdot 10^{-3}$ mm/pulse
inches	10^{-4} inches	$0.1 \cdot 10^{-4}$ inch .... $1000 \cdot 10^{-4}$ inches/pulse
degrees	10^{-4} degrees 10^{-3} degrees 10^{-2} degrees	$0.1 \cdot 10^{-4}$ degrees .... $1000 \cdot 10^{-4}$ degrees/pulse $0.1 \cdot 10^{-3}$ degrees .... $1000 \cdot 10^{-3}$ degrees/pulse $0.1 \cdot 10^{-2}$ degrees .... $1000 \cdot 10^{-2}$ degrees/pulse
Pulses	1 pulse	1

Example

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

  This results in the following resolution (quadruple evaluation):

$$\text{Resolution} = \frac{1000\ \text{mm}}{5000\ \text{increments}} = 0.2000\ \frac{\text{mm}}{\text{increment}} = 0.2000\ \frac{\text{mm}}{4\ \text{pulses}} = 0.0500\ \frac{\text{mm}}{\text{pulse}}$$

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

  This results in the following resolution:

$$\text{Resolution} = \frac{1000\ \text{mm}}{4096\ \text{increments}} = 0.2441\ \frac{\text{mm}}{\text{increment}} = 0.2441\ \frac{\text{mm}}{\text{pulse}}$$

Relationship Between Travel Range and Resolution

The travel range is limited by the numeric representation in the FM 352. The number representation varies depending on the resolution. Therefore, make sure that you are always within the permitted limits when specifying values.

The maximum travel range is represented in the table below:

Resolution (RES) is in the range	Maximum travel range
0.1 $^{\mu m}/_{pulse} \leq$ RES < 1 $^{\mu m}/_{pulse}$	-10^8 µm to 10^8 µm (–100 m to + 100 m)
1 $^{\mu m}/_{pulse} \leq$ RES $\leq$ 1000 $^{\mu m}/_{pulse}$	-10^9 µm to 10^9 µm (–1000 m to + 1000 m)

Relationship Between Feedrate and Resolution

The feedrate displayed can be within the following limits depending on the resolution (this information relates to units of millimeters):

- from 1 $^{\mu m}/_{min}$ to 90 $^{m}/_{min}$ at a resolution of $<$ 1 $^{\mu m}/_{pulse}$
- from 1 $^{\mu m}/_{min}$ to 900 $^{m}/_{min}$ at a resolution of $\geq$ 1 $^{\mu m}/_{pulse}$

The speed is calculated and filtered by the module every 4 ms.

It has at least an inaccuracy of one pulse/4 ms and is not suitable for closed-loop control.

8.7 Number of Cams and Track Data

Number of Cams

The number of cams determines the cam cycle time and the maximum number of cams that can be set.

Number of Cams	Cam Cycle Time
16 cams	20.48 µs
32 cams	40.96 µs
64 cams	81.92 µs
128 cams	163.84 µs

Number of Cams in the Parameter DB:

Address	Name	Type	Initial Value	Comment
76.0	C_QTY	DINT	UDT3: L#0 UDT4: L#1 UDT5: L#2 UDT6: L#3	Number of cams: 0 = max. 16 cams 1 = max. 32 cams 2 = max. 64 cams 3 = max. 128 cams

Track Data in the Parameter DB

Address	Name	Type	Initial Value	Comment
90.0	TRACK_OUT	WORD	W#16#0	**Activation of the track outputs** Range: 0 = cam controller 1 = CPU Bit number = track number Bits 13 to 15 must be 0.

With the machine data “activation of the track outputs”, you specify how the track signals of tracks 0 to 12 are activated. Activation is possible via:

- **Cam controller:** The track signals are activated and deactivated by the cam processing of the FM 352.
- **CPU:** The track signals represent the corresponding values of the track enables in the channel DB.

  This means that the track outputs can be activated specifically from within your program.

Address	Name	Type	Initial Value	Comment
				Enable input
95.0	EN_IN_I3	BOOL	FALSE	1 = track signal track 3 is ANDed with enable input I3
				Bits 95.1 to 95.7 must be 0.
The track signal Q3 is activated in the following situation: • the track is enabled with TRACK_EN **and** • the appropriate external enable input I3 is set **and** • the track result of the track is 1.				

Address	Name	Type	Initial Value	Comment
				Special tracks
99.0	SPEC_TRC0	BOOL	FALSE	1 = track 0 is counter cam track
99.1	SPEC_TRC1	BOOL	FALSE	1 = track 1 is counter cam track
99.2	SPEC_TRC2	BOOL	FALSE	1 = track 2 is brake cam track
You can set tracks 0, 1 and 2 as special tracks.				

Address	Name	Type	Initial Value	Comment
100.0	CNT_LIM0	DINT	L#2	**Upper counter value counter cam track** (track 0)
104.0	CNT_LIM1	DINT	L#2	**Upper counter value counter cam track** (track 1)
				Range: 2 ... 65535
With this machine data, you specify the upper counter value for the set counter cam track.				

8.8 Interrupt Enable

Definition

In the cam data, you can specify where the hardware interrupts are generated when cams 0 to 7 are activated and/or deactivated (see Section 8.9, Page 8-26).

Machine Data for Interrupt Enable in the Parameter DB

Address (abs)	Name	Type	Initial Value	Comment
3.2	PI_CAM	BOOL	FALSE	1 = enable hardware interrupt: cam on/off

Cam Data for Interrupt Enable in the Parameter DB

Address (rel)	Name	Type	Initial Value	Comment
+0.4	PI_SW_ON	BOOL	FALSE	1 = hardware interrupt on activation
+0.5	PI_SW_OFF	BOOL	FALSE	1 = hardware interrupt on deactivation

8.9 Cam Data

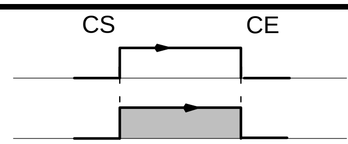
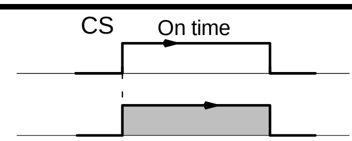
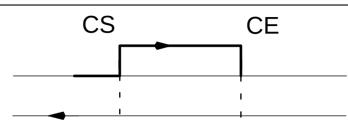
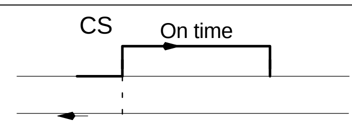
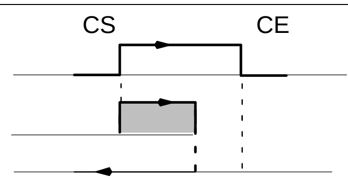
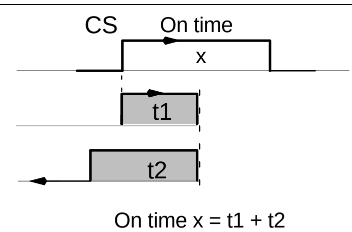
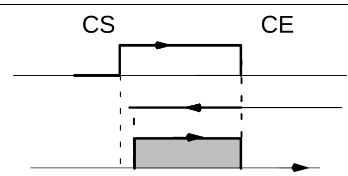
Definition

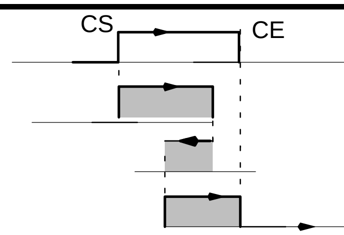
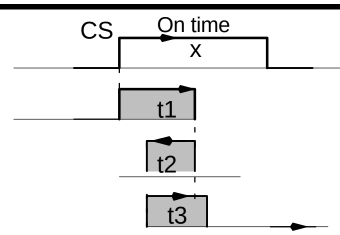
Cam data describe the characteristics of a cam, the assignment of each cam to a track, and the switching behavior of the cam. The cam data listed below are set for each individual cam.

- Only the cams you set as “true” will be interpreted and processed by the module.
- Cams 0 to 7 have process interrupt capability.
- The number of cams that can be set depends the number available.

Switching Response of Cams Dependent on the Activation Direction.

With the exception of example 5, the positive activation direction is assumed.

No.	Description	Distance cam	Time cam
1	A cam is passed in the activation direction		
2	A cam is passed in the direction opposite to the activation direction		
3	A cam is approached in the activation direction; while the cam is active, the direction of the axis is changed.		
4	A cam is approached in the direction opposite to the activation direction; the direction of travel of the axis changes to the activation direction at the cam		Cam not switched

No.	Description	Distance cam	Time cam
5	A cam is approached and left in any direction; **both directions** are set as the activation direction.		 On time x = t1 + t2 + t3

Set cam — Switched cam

Cam Data in the Parameter DB

Address (relative)	Name	Type	Initial Value	Comment
+0.0	CAMVALID	BOOL	FALSE	1 = cam valid
+0.1	EFFDIR_P	BOOL	TRUE	1 = activation direction positive (plus)
+0.2	EFFDIR_M	BOOL	TRUE	1 = activation direction negative (minus)
+0.3	CAM_TYPE	BOOL	FALSE	0 = distance cam 1 = time cam
+0.4	PI_SW_ON	BOOL	FALSE	1 = hardware interrupt on activation
+0.5	PI_SW_OFF	BOOL	FALSE	1 = hardware interrupt on deactivation
+1.0	TRACK_NO	BYTE	B#16#0	**Track number** Range: 0 to 31

Activation direction

Two activation directions are possible:

positive: The cam is activated at the cam start when the axis is moving in the direction of ascending actual values.

negative: The cam is activated at the cam end when the axis is moving in the direction of descending actual values.

You can also set both activation directions at the same time.

Track number

With the track number, you define the track with which each cam is effective.

Note:

Unused cams should always be set to “invalid” (CAMVALID = FALSE).

Address (relative)	Name	Type	Initial Value	Comment For distance cams
+2.0 +6.0	CBEGIN CEND	DINT DINT	L#–100000000 L#100000000	**Cam start (CS)** **Cam end (CE)** Range: – 1 000 000 000 µm to 1 000 000 000 µm

Minimum Length of a Distance Cam

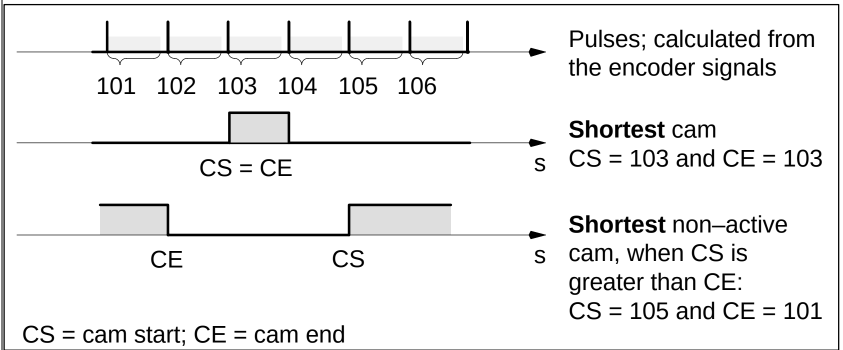


Figure 8-3 Shortest Cam with the Axis Moving in the Positive Direction

The inactive part of a cam must always have a minimum clearance of four pulses between the cam end (CE) and cam start (CS).

If CE = CS, the cam is activated for one pulse.

Address (relative)	Name	Type	Initial Value	Comment For time cams
+2.0	CBEGIN	DINT	L#–100000000	**Cam start (CS)**
+6.0	CEND	DINT	L#100000000	**Cam end (CE)** **On Time** Range: (0 to 13421) · 100 µs with a maximum of 16 cams (0 to 26843) · 100 µs with a maximum of 32 cams (0 to 53686) · 100 µs with a maximum of 64 cams (0 to 65535) · 100 µs with a maximum of 128 cams

With a time cam, you specify a cam start and an "on time" instead of a cam end. You can specify the on time in increments of 100 µs. The time starts to run when the cam is activated.

The following conditions apply for specifying the times

- 0 µs: A cam with the on time 0 µs is never activated.
- 0 µs < t ≤ 400 µs: The FM 352 sets a minimum cam time of approximately 330 µs.
- t > 400 µs: The FM 352 calculates the actual on time t_{act} from the specified on time t_{spec} according to the following formula:

$$t_{act} = \text{integer} \left(\frac{t_{spec}}{\text{cam cycle}} \right) * \text{Cam cycle time}$$

The maximum error is always less than one cam cycle period.

Address (relative)	Name	Type	Initial Value	Comment
+10.0	LTIME	INT	0	**Lead Time** Range: (0 to 53686) · 100 μs with a maximum of 16 cams (0 to 65535) · 100 μs with a maximum of 32, 64 or 128 cams

Delays in the connected switching elements can be compensated by specifying a lead time. You enter the lead time in steps of 100 μs. You can assign a lead time for each cam. The lead time applies to the cam start and cam end.

Lead Distance

The lead distance of a cam is recalculated depending on the current feedrate and the lead time. The entire cam is shifted in the direction of the actual value by this distance. The range set is known as the “static range” and the range calculated based on the lead time is known as the “dynamic range”.

Lead distance = lead time · current feedrate.

Calculation of the lead distance of all cams is made within 1/4 of the longest set lead time on the FM 352. If you set a very high lead time for a cam, the dynamic adjustment is calculated less often.

Actual Lead Time

You can calculate the actual lead time as follows:

Calculate the cam cycle time: This is the time in which the FM 352 has completely processed all cams and depends on the number of cams in use (see table Page 8-23).

Calculate the actual lead time with the following formula:

$$\text{Lead time}_{act} = \text{integer}\left(\frac{\text{Lead time}_{l}}{\text{Cam cycle time} \cdot 4}\right) \cdot \text{Cam cycle time} \cdot 4$$

Where:

Lead time $_{act}$ is the lead time set by the FM 352

Lead time $_{L}$ is the lead time you specified.

Integer () means that in the calculation inside the brackets, only the value before the decimal point is taken into account.

The maximum error of the lead time$_{act}$ is always less than the cam cycle time · 4.

Example:

The following values are specified:

Number of cams: maximum of 32 cams
cam cycle time: 40.96 μs
lead time $_{l}$ = 1000 μs

Result: You obtain an actual lead time of 983 μs.

A lead time in conjunction with an absolute encoder (SSI) and inverted count direction is not permitted.

Note

The actual lead time is always less than the set lead time. It can be 0 even though the set lead time is $\geq$ 100 μs.

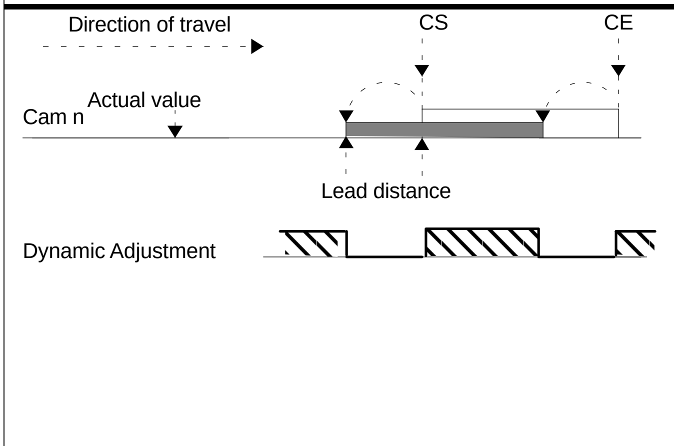
The lead distance on a rotary axis must be less than the rotary axis range and the non-active part of the cam. This must be guaranteed for all speeds.

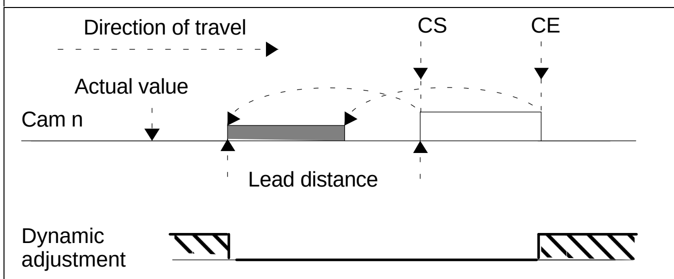
Dynamic Adjustment on a Cam

There are two distinct situations relating to the range of the cam:

1. The static and dynamic range of the cam overlap.
2. The static and dynamic range of the cam do not overlap.

Table 8-1 Dynamic Adjustment on a Cam (Different Cases)

<table>
<tr><th>Dynamic Adjustment</th><th>Description</th></tr>
<tr><td>
</td><td>If the dynamic range of the cam overlaps the static range of the cam, the following applies:

If the dynamic range of the cam has been reached, the cam is activated. At the same time, calculation of a new dynamic adjustment is disabled.
If the actual value reaches the static range of the cam, the calculation of a new dynamic adjustment is enabled again, a change in feedrate affects the cam end.
If the cam is deactivated at the end of the dynamic range, dynamic adjustment is disabled again until the end of the static range of the cam.
</td></tr>
<tr><td>
</td><td>If the dynamic range of the cam does not overlap the static range of the cam, the following applies:

If the dynamic range of the cam has been reached, the cam is activated. At the same time, calculation of a new dynamic adjustment is disabled.
At the end of the static range of the cam, dynamic adjustment is enabled again.
</td></tr>
</table>

Dynamic range   Static range   A **new** dynamic adjustment is possible

Settings

9

Chapter Overview

9.1 Influence of Settings on the Switching Response of Time Cams

Actual Value Changes

A time cam can be skipped by the following settings that change the actual value:

- Set actual value
- Set actual value on-the-fly
- Zero Offset
- Retrigger Reference Point

Switching a Time Cam

If you skip the start of a time cam due to one of the settings listed above, this cam is activated as long as the actual direction in which the axis is moving matches the activation direction set for the cam. The set on time runs until it expires.

Note

If the axis is stationary, the direction of movement depends on fluctuations in the actual value.

If you want the direction of movement to be taken into account when the axis is stationary, you must set a hysteresis that is greater than the fluctuations in the actual value when the axis is stationary.

If the axis is not moving, the last detected direction of movement is retained.

Warning

Injury to persons or damage to equipment can occur.

With a rotary axis, settings that modify the actual value can led to accidental activation of time cams.

You should always set the time cams of a rotary axis to “invalid” if you want to modify the actual value using the settings listed above.

9.2 Set Actual Value / Set Actual Value on-the-fly / Cancel Set Actual Value

Definition

With the settings “Set actual value/Set actual value on-the-fly”, you assign a new coordinate to the current encoder reading. The coordinate system is shifted as a result by the value: ACT_{new} - $ACT_{current}$

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

Calculating the New Coordinates

All the positions you specify in the modified coordinate system can be calculated according to the following formula:

$$\mathbf{coordinate_{new} = coordinate_{old} + (ACT_{new} - ACT_{current})}$$

Requirements

- The axis must be synchronized.
- With “set actual value on-the-fly”: Digital input I1 must be connected.

Sequence of the Setting

1. Enter the coordinate for the actual value or for the flying actual value in the channel DB.
   – Linear axis:

     You must select an actual value so that the software limit switch is still within the range of movement after the setting has been read.

     The value of the offset resulting from $\mathbf{(ACT_{new} - ACT_{current})}$ must be less than or equal to the value of the permitted travel range (maximum 100 m or 1000 m).

   – Rotary axis

     The following rule must apply to the specified actual value:

     0 ≤ actual value < end of rotary axis
2. Set the appropriate trigger bits in the channel DB.
3. Call FC CAM_CTRL.

   “Set actual values” is executed immediately.

   “Set actual value on-the-fly” is executed at the next rising edge at digital input I1. The FVAL_DONE bit is set.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
36.4	AVAL_EN	BOOL	FALSE	1 = Set actual value
36.5	FVAL_EN	BOOL	FALSE	1 = Set actual value on-the-fly
90.0	AVAL	DINT	L#0	Coordinate for actual value
94.0	FVAL	DINT	L#0	Coordinate for flying actual value
25.5	FVAL_DONE	BOOL	FALSE	1 = set actual value on-the-fly executed

Effects of the Setting

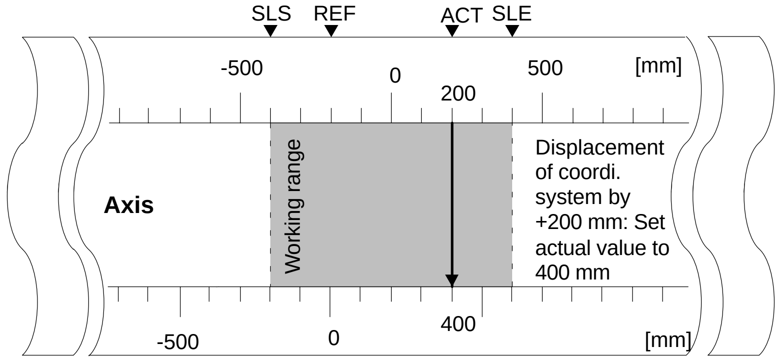
Based on the example “set actual value” to 400 mm (at position 200 mm), you can see how this setting shifts the coordinate system. The following effects result:

- The location of the working range is **not** physically shifted.
- The individual points (such as the software limit switches) are assigned new coordinate values.
- The cams retain their coordinate values and are therefore located at a different physical position.
- When the axis is synchronized and the cam processing is enabled, the actual position can skip cam edges or complete cams as a result of this setting.
- Status changes of the cam which would normally trigger an interrupt can be lost.

Note

Note the switching response of time cams in Section 9.1, page 9-2.

Table 9-1 Displacement of the Coordinate System by “Set Actual Value” / “Set Actual Value on-the-Fly”



Set Actual Value	SLS [mm]	REF [mm]	ACT [mm]	SLE [mm]
Old coordinate system	-400	-200	200	400
New coordinate system	-200	0	400	600

Canceling the Setting

With the setting ”Cancel set actual value”, you reset the coordinate displacement that resulted from “set actual value” or “set actual value on-the-fly”.

Once “set actual value on-the-fly” has been triggered, it can no longer be deleted before execution by a rising edge at input I1. However, it can be overwritten by a new “set actual value on-the-fly”.

During a module start up, these settings are reset.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
35.2	AVALREM_EN	BOOL	FALSE	1: Cancel actual value setting

Possible Sources of Error

“Set actual value on-the-fly” and “Retrigger reference point” must not be executed at the same time.

With the setting “set actual value on-the-fly”, an error can be signaled if the setting means that a software limit switch would be exceeded with the rising edge at I1. This operating error is signaled by a diagnostic interrupt and entered in the diagnostic buffer.

9.3 Zero Offset

Definition

With the “zero offset” setting, you shift the zero point in the coordinate system by the specified value. The sign determines the direction of the shift.

Calculating the New Coordinate

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

$$\mathbf{coordinate_{new} = coordinate_{old} - (ZPO_{new} - ZPO_{old})}$$

$\mathbf{ZPO_{old}}$ is any existing old zero point offset. If no zero offset was active before the call, set the value 0 for $\mathbf{ZPO_{old}}$.

With this formula, you can calculate which coordinate values are adopted, for example,by the software limit switches.

Sequence of the Setting

1. Enter the value for the zero offset in the channel DB.
   – Linear axis:

     The zero offset must be selected so that the software limit switch is still within the permissible range after the setting is read.

   – Rotary axis

     The following rule must apply to the zero offset:

     amount of zero offset ≤ end of the rotary axis.
2. Set the appropriate trigger bit.

Data Used in the Channel DB

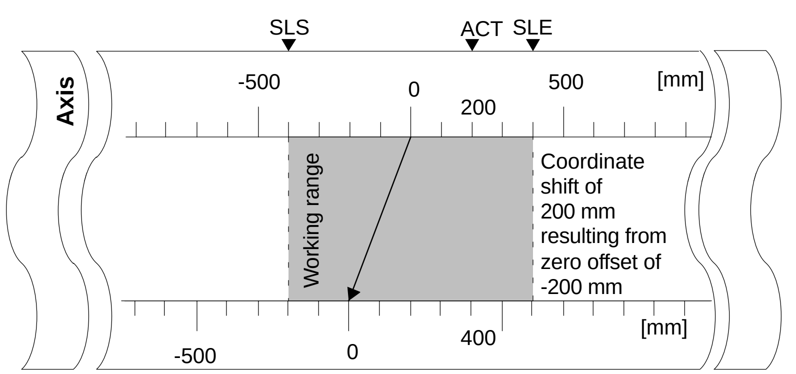
Address	Name	Type	Initial Value	Comment
36.6	ZOFF_EN	BOOL	FALSE	1 = set zero offset
86.0	ZOFF	DINT	L#0	Zero Offset

Effects on a Linear Axis

Based on the example of a zero offset of -200 mm you can see that this setting shifts the coordinate system in a positive direction. The following effects result:

- The working range is **not** physically shifted.
- The individual points (such as the software limit switches) are assigned new coordinate values.
- The cams retain their coordinate values and are therefore located at a different physical position.
- When the axis is synchronized and the cam processing is enabled, the actual position can skip cam edges or complete cams as a result of this setting.
- Status changes of the cam which would normally trigger an interrupt can be lost.

Table 9-2 Coordinate System Shift Resulting from Zero Offset

Zero Offset	**SLS** [mm]	**REF** [mm]	**ACT** [mm]	**SLE** [mm]
Old coordinate system 	-400	-200	200	400
New coordinate system	-200	0	400	600

Note

Note the switching response of time cams in Section 9.1, page 9-2.

Effects on a Rotary Axis

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

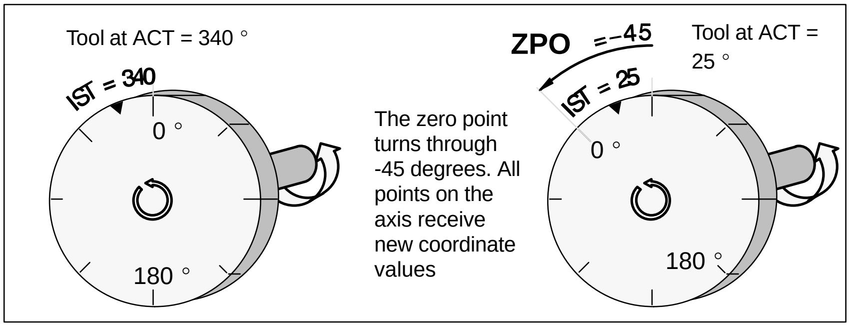


Figure 9-1 Rotation of the Coordinate System Resulting from a Zero Offset

Taking into account a **ZPO_{old} = 0** a new value of 385° results.

The actual value beings again at 0 at the end of the rotary axis when this is turning in a positive direction so that the value actually calculated is 25°:

$coordinate_{new} = coordinate_{old} - (ZPO_{new} - ZPO_{old})$ -end of rotary axis

The value **end of rotary axis** only needs to be subtracted when **$coordinate_{old} - (ZPO_{new} - ZPO_{old})$** will be higher than the end of the rotary axis.

Loss of Synchronization

If synchronization is lost due to an error or is reset due to “retrigger reference point”, a zero offset is **retained**.

Canceling the Setting

By setting a zero offset of 0, you reset an existing offset.

9.4 Set Reference Point

Definition

With the “set reference point” setting, you synchronize the axis. The setting shifts the working area. All shifts resulting from a zero offset or from “set actual value” remain in force.

Requirements

Cam processing must be switched off.

Sequence of the Setting

1. Enter the value for the reference point coordinate in the channel DB.
   – Linear axis:

     The reference-point coordinate must not be located outside the software limit switches. This also applies to the reference point coordinate in a shifted coordinate system.

   – Rotary axis

     The following rule applies to the reference point coordinate:

     0 ≤ reference point coordinate < end of rotary axis
2. Set the appropriate trigger bit.

Date Used in the Channel DB

Address	Name	Type	Initial Value	Comment
36.3	REFPT_EN	BOOL	FALSE	1 = set reference point coordinate
98.0	REFPT	DINT	L#0	Reference point coordinate
25.0	SYNC	BOOL	FALSE	1 = axis synchronized

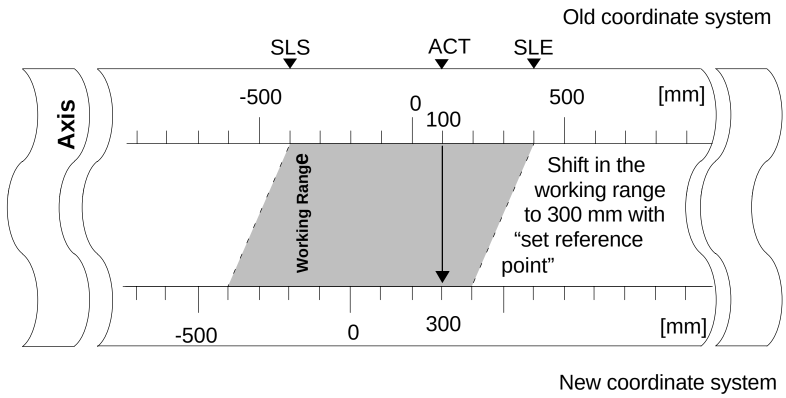
Effects of the Setting

Based on the example “set reference point” to 300 mm, you can see how this setting shifts the working range of the axis.

This has the following effects:

- The actual position is set to the value of the reference-point coordinate.
- The working range is physically shifted on the axis.
- The individual points retain their original coordinates but are located at new physical locations.
- The SYNC bit is set in the return signals.

Table 9-3 Shifting the Working Range on the Axis Using “Set Reference Point””

<table>
<tr><th>Set reference point</th><th>SLS [mm]</th><th>REF [mm]</th><th>ACT [mm]</th><th>SLE [mm]</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>

Note on Absolute Encoders

This setting is necessary for an absolute encoder adjustment (see section 8.4, page 8-12).

9.5 Changing the Cam Edges

Definition

With the “change cam edges” setting, you can change the cam start and, with distance cams, also the cam end of a single cam.

Requirements

The cam you want to change must be valid.

Sequence of the Setting

1. Enter the cam number in the channel DB.
2. For a distance cam:

   Enter the cam start and cam end in the channel DB.

   With a time cam:

   Enter the value for the cam start in the channel DB.
3. Set the appropriate trigger bit.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
36.7	CH01CAM_EN	BOOL	FALSE	1 = write setting for cam edges (one cam)
102.0	CAM_NO	INT	0	Cam number
104.0	CAM_START	DINT	L#0	Cam start
108.0	CAM_END	DINT	L#0	Cam end

Effects of the Setting

The FM 352 first shifts the on edge and then the off edge of the cam. This sequence does not depend on the direction in which the cam is shifted.

Special situation:

Due to the sequence explained above, an inverse cam can result briefly if the new cam start is higher than the old cam end.

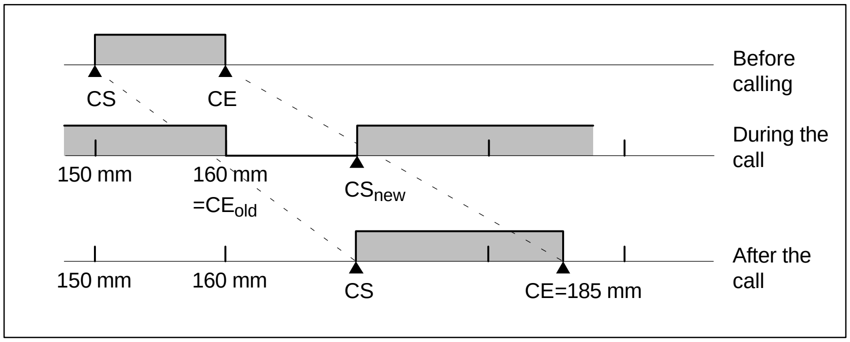


Figure 9-2 Changes in the Cam Edges in Individual Steps

Note

If a hardware interrupt has been enabled for this cam, the FM 352 can trigger one or two hardware interrupts depending on parameter settings, when the inverse cam is detected.

Changing the on and/or off edge can result in a cam edge or the entire cam being skipped.

Note the switching response of time cams in Section 9.1, page 9-2.

Cam status changes that would normally trigger a hardware interrupt can be lost.

Reading Out Modified Values

You can read out modified values with one of the jobs CAM1RD_EN to CAM8RD_EN.

Canceling the Setting

The modified values are lost when you restart the module.

9.6 Fast Cam Parameter Change

Definition

With the “fast cam parameter change” setting, you can modify up to 16 cams at the same time during operation.

Requirements

The cams you want to modify must be valid.

Sequence of the Setting

1. Enter the number of cams to be modified in the channel DB.
2. Enter the number of the first cam to be modified in the channel DB.
3. Set the trigger bits for the required modifications.
4. Enter the new values in the channel DB.
5. Repeat steps 2 - 4 for each cam to be modified.
6. Set the appropriate trigger bit in the channel DB.

Data Used in the Channel DB

Address (abs)	Name	Type	Initial Value	Comment
37.0	CH16CAM_EN	BOOL	FALSE	1 = settings for fast cam parameter change (16 cams)
176.0	C_QTY	BYTE	B#16#0	Number of cams to be modified
177.0	DIS_CHECK	BOOL	FALSE	1 =deactivate data check

Address (rel)	Name	Type	Initial Value	Comment
+0.0	CAM_NO	BYTE	B#16#0	Number of the cam to be modified
+1.0	C_EFFDIR	BOOL	FALSE	1 = change the cam activation direction
+1.1	C_CBEGIN	BOOL	FALSE	1 = change the cam start to the value CBEGIN
+1.2	C_CEND	BOOL	FALSE	1 = change the cam end / on time to the value CEND
+1.3	C_LTIME	BOOL	FALSE	1 = change the lead time to the value LTIME
+1.4	CAM_OFF	BOOL	FALSE	1 = deactivate the cam during the cam modification
+1.5	EFFDIR_P	BOOL	FALSE	1 = activation direction positive (plus)
+1.6	EFFDIR_M	BOOL	FALSE	1 = activation direction negative (minus)
+2.0	CBEGIN	DINT	L#0	New cam start
+6.0	CEND	DINT	L#0	New cam end / new on time
+10.0	LTIME	INT	0	New lead time

Deactivating a Cam During Modification

A consistent modification of the cam start and the cam end is only possible if you deactivate the cam during the modification (CAM_OFF).

Data Check by the Module

With the DIS_CHECK (channel DB) parameter, you activate or deactivate the checking of the transferred data by the FM 352. If you disable the data check, you yourself must make sure that only permitted values are transferred. If you transfer illegal values without a check, the module may react unexpectedly.

- FALSE: The module checks all data to be transferred
- TRUE: The data check for the cam parameters is deactivated. This means that the data to be changed can be processed faster on the FM 352.

  Regardless of this setting, a check is always made to determine the following:

  - Has the axis had parameters assigned?
  - Is the number of cams to be modified (C_QTY) permitted?
  - Is the cam (cam number) to be modified valid?

Only when all data have been checked and are error-free are they activated on the module.

In the event of an error, all data are rejected.

Effects of the Setting

Note

Note the switching response of time cams in Section 9.1, page 9-2.

Reading Out Modified Values

You can read out the modified values with one of the jobs CAM1RD_EN to CAM8RD_EN .

Canceling the Setting

The modified values are lost when you restart the module.

9.7 Length Measurement/Edge Acquisition

Definition

With the settings “length measurement” and “edge detection”, you can find out the length of a workpiece.

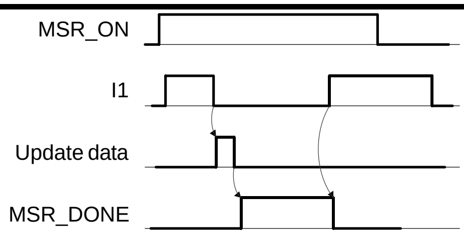
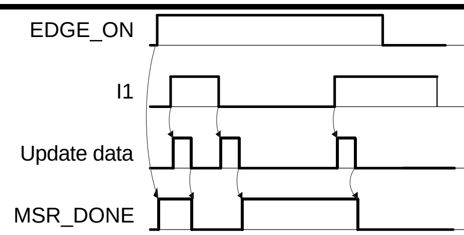
The length measurement and edge detection are and remain active until you deactivate them again or until you select a different measuring method. If you select both methods at the same time, FC CAM_CTRL activates the length measurement.

Requirements

A **bounce-free** switch must be connected at input I1.

Sequence of the Settings

Depending on the type of measurement, the FM 352 updates the data on the module at different times. The FM 352 signals every update in a parameter on the return interface.

Length Measurement	Edge Detection
	
1. Set the function switch for “length measurement”. 2. The rising edge of input I1 starts the length measurement. 3. The falling edge of input I1 terminates a measurement in progress. The FM 352 updates the data start value, end value, and length. 4. With the MSR_DONE parameter set, the FM 352 signals the updating of the data. The parameter indicates that the measurement is completed. The results of the measurement can be read out. 5. The start of another measurement with the rising edge of I1 resets the MSR_DONE parameter.	1. If necessary, enter a value for the minimum edge-to-edge distance in the parameter DB. Write and activate the machine data. 2. Set the function switch for “edge detection”. The MSR_DONE parameter is set. 3. The rising edge of input I1 starts the edge acquisition. The results of the measurement are updated and can be read out, the start of the measurement is entered; the end value and length become -1. 4. After the update, the FM 352 signals the change by resetting the MSR_DONE parameter. 5. The falling edge of input I1 terminates a measurement in progress. The FM 352 updates the data for end value of the measurement and length. 6. After the update, the FM 352 signals the change by setting the MSR_DONE parameter. The results of the measurement can be read out. 7. The start of another measurement with the rising edge of I1 resets the MSR_DONE parameter.
If the setting is switched off during a length measurement, the FM 352 does not update the data. The MSR_DONE parameter remains reset.	If the setting is switched off during edge acquisition, the FM 352 does not update the data. The MSR_DONE parameter remains reset.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
25.1	MSR_DONE	BOOL	FALSE	1 = length measurement completed
34.0	EDGE_ON	BOOL	FALSE	1 = edge detection on
34.2	MSR_ON	BOOL	FALSE	1 = length measurement on
38.2	MSRRD_EN	BOOL	FALSE	1 = read measured values
112.0	BEG_VAL	DINT	L#0	Start value
116.0	END_VAL	DINT	L#0	End value
120.0	LEN_VAL	DINT	L#0	Length

Data Used in the Parameter DB

Address	Name	Type	Initial Value	Comment
4.0	EDGEDIST	DINT	L#0	Minimum edge-to-edge distance for edge detection Range: 0 ... 1 000 000 000 μm
With the minimum edge-to-edge distance, you define a range after detection of the start of measurement when using edge acquisition. If the end of the measurement is within this range, the measurement is rejected. The start of the measurement is signaled only after the minimum edge-to-edge distance has been traveled.				

Conditions for Length Measurement

- The distance between the off edge and on edge at input I1 must be large enough so that your program on the CPU can evaluate the measurement result correctly before a new measurement begins.
- The minimum interval between the rising and the falling edge at input I1 as well as between the falling and the next rising edge at input I1 must be greater than 2 ms.

Incorrect Measurement

If a length measurement / edge detection is incorrect, the FM 352 returns the value -1 for the length.

A “length measurement” or “edge detection” can pass through zero a maximum of 126 times[1] in one direction. As soon as more than 126 zero passes in one direction are recognized by the FM 352, an incorrect “length measurement” or “edge detection” is signaled even when zero passes in the other direction were detected afterwards.

A length measurement error also occurs when:

- The measured length of a rotary axis is greater than 2^{31}.
- The on and off edges are detected simultaneously by the FM 352 (for example, caused by switch bounce).

Adjustment of the Coordinate System During Length Measurements

Adjustments in the coordinate system influence the measured length in the following situations:

- You are using an incremental encoder or an initiator and you are operating the FM 352 in the simulation mode.
- You are running “set reference point” or “retrigger reference point” during an active length measurement.

Example

You can use the influences on the measured length listed above as follows:

You have, for example, a system in which a slip always occurs during length measurement.

With retrigger reference point, you can correct this slip so that correct length measurement values are then output.

1 Zero pass = rotary axis pass from the “end of rotary axis” value to 0 and vice versa

9.8 Retrigger Reference Point

Definition

With the “retrigger reference point” setting, you can synchronize the axis in response to a recurrent external event.

The setting remains active until you switch it off again.

Requirements

- You are using an incremental encoder or initiator.
- The external event can be a zero marker of an incremental encoder or a reference point switch at input I2.

Sequence of a Setting

1. Enter the value for the reference point coordinate in the parameter DB.
2. Enter the type of “retrigger reference point” in the parameter DB.

   Here, you have the following options:

   - Only the zero marker of the encoder is evaluated (RETR_TYPE = 7).
   - Only the reference point switch is evaluated (RETR_TYPE = 6).
   - The zero marker is evaluated
     – in the positive direction: the first rising edge of the zero marker after leaving the reference point switch in a positive direction is evaluated (RETR_TYPE = 0).
     – in negative direction: the first falling edge of the zero marker after leaving the reference point switch in a negative direction is evaluated (RETR_TYPE = 1).
3. Write and activate the machine data.
4. Set the function switch in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
34.3	REFTR_ON	BOOL	FALSE	1 = retrigger reference point
25.0	SYNC	BOOL	FALSE	1 = axis is synchronized

Data Used in the Parameter DB

Address	Name	Type	Initial Value	Comment
44.0	REFPT	DINT	L#0	Reference point coordinate
52.0	RETR_TYPE	DINT	L#0	Type of retrigger reference point

Effects of the Setting

- The FM 352 evaluates the zero marker and the reference point switch depending on the direction of movement of the axis.
  - If movement is in a positive direction, the rising edges are evaluated.
  - If movement is in a negative direction, the falling edges are evaluated.
- The actual position is set to the value of the reference point coordinate.
- The working range is physically shifted on the axis.
- The individual points retain their original value, but are now located at new physical positions.
- Cam status changes that would normally trigger an interrupt can be lost.
- The SYNC bit is set in the return signals.

Note

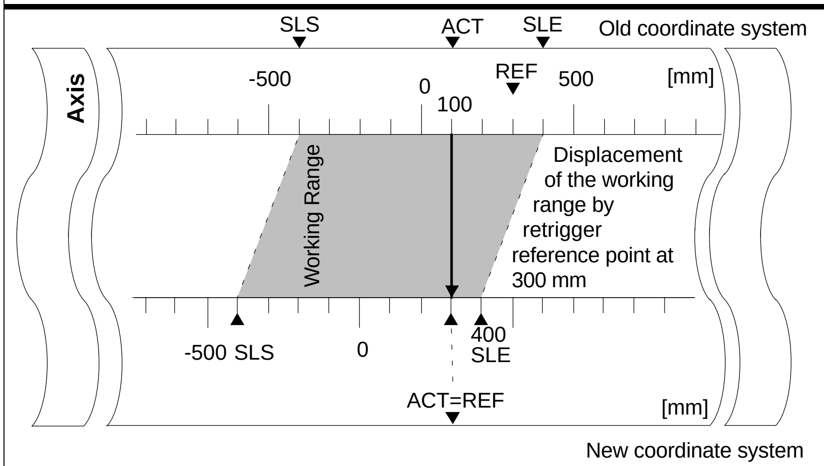
Note the switching response of time cams in Section 9.1, page 9-2.

Example

The following applies to the example:

- The rising edges of the reference point switch and zero marker are evaluated (axis moving in a positive direction).
- The reference point coordinate has a value 300 mm.
- No zero offset is active at the time of execution.

Table 9-4 Displacement of the Working Range on the Axis by Retrigger Reference Point

Retrigger reference point	**SLS** [mm]	**REF** [mm]	**ACT** [mm]	**SLE** [mm]
	-400	300	100	400
	-400	300	300	400

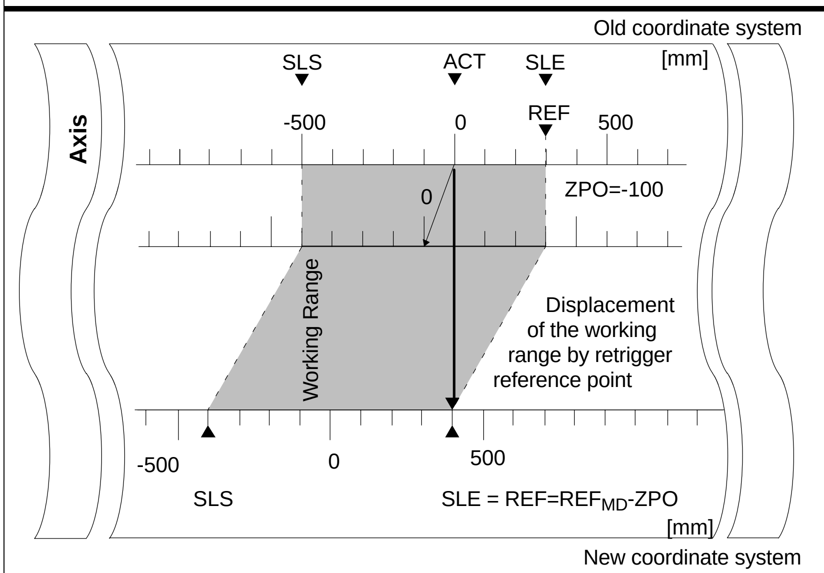
Including a Zero Offset

If a zero offset is active, this is taken into account in the retrigger reference point setting. This means that the reference point coordinate set is calculated according to the following formula:

Ref = Ref$_{MD}$ - zero offset

Ref$_{MD}$ is the value stored as the reference point coordinate in the machine data.

Table 9-5 Displacement of the Working Range on the Axis by Retrigger Reference Point with Zero Offset

Retrigger Reference Point	**SLS** [mm]	**REF** [mm]	**ACT** [mm]	**SLE** [mm]
	-500	300	0	300
	-400	400	100	400
	-400	400	400	400

9.9 Deactivating Software Limit Switches

Definition

With the “deactivate software limit switch” setting, you deactivate the monitoring of the software limit switches of the linear axis.

The setting remains active until you switch it off again. The software limit switches originally set then become active again.

Sequence of the Setting

Set the function switch in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
34.4	SSW_OFF	BOOL	FALSE	1 = software limit switch off

Data Used in the Parameter DB

Address	Name	Type	Initial Value	Comment
64.0	SSW_STRT	DINT	L#-1000000000	Start of software limit switch
68.0	SSW_END	DINT	L#1000000000	End of software limit switch

Effects of the Setting

- Simulation
  - If a software limit switch is passed in the simulation mode, the simulation mode is stopped.
  - If you then deactivate the monitoring of the software limit switches, the simulation mode is resumed. The axis moves in the specified direction.
- Zero offset when monitoring is switched off.

  If a zero offset is specified in which the software limit switches are still within the traverse range limits, the actual value can still be outside the permissible number range.
- Cams lying outside the set software limit switches can be activated.

Caution

Damage to equipment is possible.

If you restrict the travel range with the software limit switches as a safety measure, deactivating the limit switches can result in serious damage to equipment.

Please ensure when planning your plant and system that the drive can travel within the entire physical range.

9.10 Simulation

Definition

The “simulation” setting allows you to activate the cam controller without connected encoders.

Sequence of the Setting

1. Enter the simulation speed in the parameter DB.
2. Write and activate the machine data.
3. Select either the positive or negative direction in the channel DB as the simulation direction.
4. Set the function switch in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
15.2	DIR_M	BOOL	FALSE	1 = simulation in negative direction
15.3	DIR_P	BOOL	FALSE	1 = simulation in positive direction
34.1	SIM_ON	BOOL	FALSE	1 = simulation on

Data Used in the Parameter DB

Address	Name	Type	Initial Value	Comment
84.0	SIM_SPD	DINT	L#0	Simulation Speed

Effects of Activating Simulation

- The encoder signals are no longer evaluated.
- All monitoring relevant to the encoder input is deactivated.
- Any errors signaled with reference to the encoder are reset.
- The FM 352 simulates the movement of an axis at the constant simulation speed.
- Cam processing is switched off when simulation is switched on. However, you can then switch it back on again. The synchronization is retained.
- The actual position changes from the current actual value depending on the simulation speed and the simulation direction.

Effects of Deactivating Simulation

- Cam processing is stopped
- The synchronization is deleted for an incremental encoder or an initiator. The value of the reference point coordinate is then set as the actual value.
- With an absolute encoder, the actual position is signaled that corresponds to the current encoder status. The encoder signals are again evaluated according to the parameter settings in the machine data.

Limit Values

The maximum and minimum limits of the simulation speed depend on the resolution (see Section 8.3, page 8-7).

Feedrate

There may be a difference between the set and actual feedrate at which the module works (see Section 8.3. page 8-7).

9.11 Counted Values of the Counter Cam Tracks

Definition

With the “counted values of the counter cam tracks” setting, you read out the current counted values.

Sequence of the Setting

1. Specify the counter cam tracks and the upper counted values in the machine data.
2. Write and activate the machine data.
3. Enable the counter function.
4. The counted value is set to the upper counted value.
5. At each rising edge of the track result, the counted value is decremented by 1.
6. Set the trigger bit in the channel DB to read the counted values.
7. The counted values for both tracks are written to the channel DB. If the track is not set as a counter cam track, 0 is output.
8. If the counted value reaches the value 0, the track flag bit of the counter cam track is set to 1.
9. With the next falling edge at the track result, the track flag bit is set back to 0 and the counter is set to the upper counted value.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
15.5	CNTC0_EN	BOOL	FALSE	1 = enable count function of counter cam track 0
15.6	CNTC1_EN	BOOL	FALSE	1 = enable count function of counter cam track 1
38.3	CNTTRC_EN	BOOL	FALSE	1 = read count values of counter cam tracks
124.0	CNT_TRC0	INT	0	Current counter value for counter cam track 0
126.0	CNT_TRC1	INT	0	Current counter value for counter cam track 1

Data Used in the Parameter DB

Address	Name	Type	Initial Value	Comment
99.0	SPEC_TRC0	BOOL	FALSE	1 = track 0 is counter cam track
99.1	SPEC_TRC1	BOOL	FALSE	1 = track 1 is counter cam track
100.0	CNT_LIM0	DINT	L#2	Upper counter value for counter cam track 0
104.0	CNT_LIM1	DINT	L#2	Upper counter value for counter cam track 1

9.12 Position and Track Data

Definition

With the setting “position and track data”, you read the current actual position, the feedrate and the track flag bits. The track flag bits are acquired before they are logically combined with machine and channel data.

The calculation algorithm implemented on the FM 352 calculates speed changes greater than 1 pulse per 4 ms with a slight inaccuracy. The displayed speed therefore includes this inaccuracy and is unsuited, in particular, for closed-loop control. The internal speed used the dynamic values of the cam is more accurate.

Sequence of the Setting

1. Set the trigger bit in the channel DB.
2. The data are stored in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
38.4	ACTPOS_EN	BOOL	FALSE	1 = read position and track data
128.0	ACTPOS	DINT	L#0	Current position
132.0	ACTSPD	DINT	L#0	Current feedrate
136.0	TRACK_ID	DWORD	DW#16#0	Track flag bits of tracks 0 to 31

9.13 Encoder Data

Definition

With the “encoder data” setting, you read the current data of the encoder and the value of the absolute encoder adjustment.

Requirements

You can read out the value for the absolute encoder adjustment after making the setting “set reference point” (see Section 8.4, page 8-12).

Sequence of the Setting

1. Set the trigger bit in the channel DB.
2. The data are stored in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
38.5	ENCVAL_EN	BOOL	FALSE	1 = read encoder values
140.0	ENCVAL	DINT	L#0	Encoder value / counter value (internal representation)
144.0	ZEROVAL	DINT	L#0	Counter value at the last zero marker (internal representation)
148.0	ENC_ADJ	DINT	L#0	Absolute encoder adjustment

9.14 Cam and Track Data

Definition

With the setting “cam and track data”, you read the current cam and track flag bits and the position. The track flag bits are acquired before they are logically combined with machine and channel data.

Sequence of the Setting

1. Enter a 1 in the FM_TYPE parameter of the channel DB as the type identifier. This allows you to read 24 bytes of cam and track data.
   If you enter 0 as the type identifier, only the cam flag bits (16 bytes) are read.
2. The data are stored in the channel DB.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
12.0	FM_TYPE	BOOL	FALSE	0 = FM 352 up to V4.0 1 = FM 352 / FM 452 V5.0 or higher
38.6	CAMOUT_EN	BOOL	FALSE	1 = read cam and track data
152.0	CAM_00_31	DWORD	DW#16#0	Cam flag bits for cams 0 to 31
156.0	CAM_32_63	DWORD	DW#16#0	Cam flag bits for cams 32 to 63
160.0	CAM_64_95	DWORD	DW#16#0	Cam flag bits for cams 64 to 95
164.0	CAM_96_127	DWORD	DW#16#0	Cam flag bits for cams 96 to 127
168.0	TRACK_ID1	DWORD	DW#16#0	Track flag bits of tracks 0 to 31
172.0	ACTPOS1	DINT	L#0	Current position

9.15 Control Signals for the Cam Controller

Definition

With the “control signals for the cam controller” setting, you enable cam processing and the tracks.

Sequence of the Setting

1. Set the trigger bit in the channel DB.
2. The data are transferred to the module whenever FC CAM_CTRL is called.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
15.4	CAM_EN	BOOL	FALSE	1 = enable cam processing
16.0	TRACK_EN	WORD	W#16#0	Enable cam tracks 0 to 12 Bit 0 = track 0

Effects

The cam processing is started or stopped depending on the enable.

The track flag bits of the enabled tracks are passed on to the track signals and the digital outputs.

9.16 Return Signals for the Cam Controller

Definition

The “return signals for the cam controller” setting informs you about the current state of the cam controller and the track signals. Consistency between the signaled position and the track signals is not guaranteed.

Sequence of the Setting

1. Set the trigger bit in the channel DB.
2. The data are stored in the channel DB whenever FC CAM_CTRL is called.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
23.4	CAM_ACT	BOOL	FALSE	1 = cam processing active
26.0	ACT_POS	DINT	L#0	Current position of the axis
30.0	TRACK_OUT	DWORD	DW#16#0	Current track signals tracks 0 to 31 Bit 0 = track 0

9.17 Return Signals for Diagnostics

Definition

The “return signals for diagnostics” setting informs you of diagnostic events that have occurred.

Sequence of the Setting

1. When the module makes a new entry in the diagnostic buffer, it sets the DIAG bit. Whenever an error occurs belonging to any of the error classes listed in Appendix C, an entry is made in the diagnostic buffer.
2. If the module recognizes a write job with incorrect data, it sets the DATA_ERR bit. The cause of the error is entered in the diagnostic buffer.
3. The data are stored in the channel DB.
4. If the diagnostic buffer is read by FC DIAG or by the error evaluation of the parameter assignment user interface, the module sets the DIAG bit back to 0.

Data Used in the Channel DB

Address	Name	Type	Initial Value	Comment
22.2	DIAG	BOOL	FALSE	1 = diagnostic buffer modified
22.4	DATA_ERR	BOOL	FALSE	1 = data error

Encoders

10

Chapter Overview

10.1 Incremental Encoders

Connectable Incremental Encoders

Incremental encoders with two pulses electrically offset by 90° with or without zero markers are supported:

- Encoders with asymmetrical output signals with 24 V level
  - Cut-off frequency = 50 kHz:
  - max. 100 m line length.
- Encoders with symmetrical output signals with 5 V differential interfaces conforming to RS-422
  - Cut-off frequency = 1 MHz
  - At 5 V supply voltage: max. 32 m line length.
  - At 24 V supply voltage: max. 100 m line length.

Note

If the encoder (5 V) does not output a zero marker signal and you have activated the wire-break monitoring, you must switch the zero marker inputs N and $\overline{N}$ externally so that these inputs have a different level (for example, N on 5 V, $\overline{N}$ on ground).

Signal Shapes

Figure 10-1 illustrates the signal shapes from encoders with asymmetrical and and symmetrical output signals.

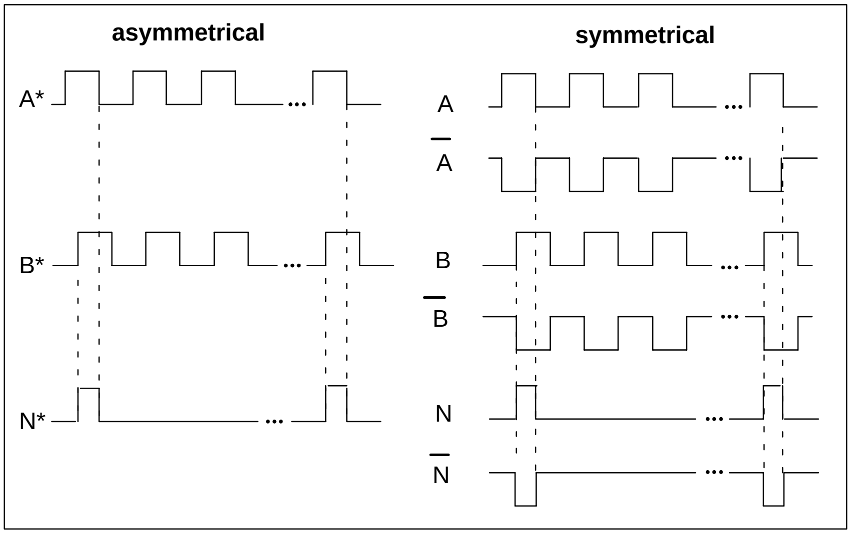


Figure 10-1 Signal Shapes from Incremental Encoders

Signal evaluation

Increments

An increment identifies a signal period of the two signals A and B of an encoder. This value is given in the technical specifications of an encoder and/or on its type label.

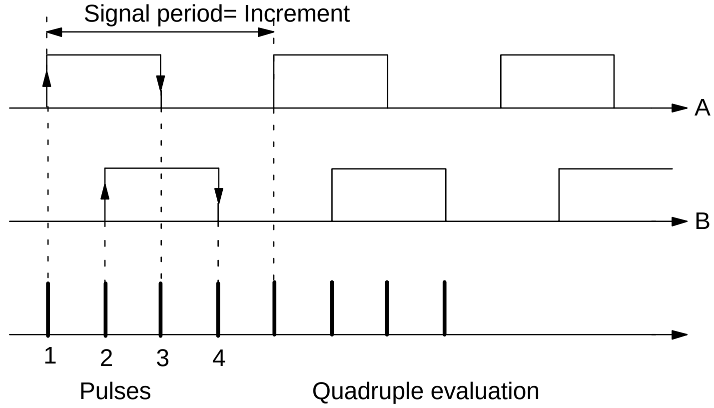


Figure 10-2 Increments and Pulses

Pulses

The FM 352 evaluates all 4 edges of the signals A and B (see figure) in each increment.

1 increment (from encoder) = 4 pulses (FM evaluation)

Reaction Times

With incremental encoders connected, the FM 352 has the following reaction times:

Minimum reaction time = cam cycle + switching time of the connected switching elements
Maximum reaction time = 2 · cam cycle + switching time of the connected switching elements

Example

An example for the minimum and maximum reaction time when using 16 cams:

- Cam cycle: approx. 20 µs
- Switching time of the hardware: approx. 150 µs

Minimum reaction time = 20 µs + 150 µs = 170 µs

Maximum reaction time = 2 · 20 µs + 150 µs = 190 µs

Note

You can compensate the reaction time with appropriate parameter settings for the cams or using dynamic adjustment.

Unsharpness

Unsharpness is the difference between the maximum and minimum reaction time. In the case of incremental encoders it is:

Unsharpness = 1 cam cycle

Note

If the switching time of the hardware on the FM 352 and the switching time of the connected switching elements can be ignored, then reliable switching of the cam is guaranteed if the cam is longer than the distance traveled within one cam cycle.

10.2 Initiators

Initiators are simple switches without direction information that output pulses. You specify the direction with the machine data for selecting the initiator.

Caution

Damage to equipment is possible.

Specifying a direction incorrectly can lead to serious errors in the system (for example as a result of incorrectly activating units.

Check the direction information each time you install and start up a system and whenever you replace an initiator.

Connectable Initiators

You can connect the following initiators to the FM 352:

- Initiators with 24 V level (proximity switches)
  limit frequency = 50 kHz
- max. 100 m cable length

Signal Evaluation

With an initiator, the rising edge of Signal A* is counted.

10.3 Absolute Encoders

Single-turn and Multi-turn Encoders

Absolute encoders are grouped as follows:

- Single-Turn Encoders

  Single-Turn Encoders form the total encoder range on one encoder revolution.
- Multi-Turn Encoders

  Multi-Turn Encoders form the total encoder range over a number of encoder revolutions.

Connectable Absolute Encoders

Absolute encoders with a serial interface are supported. Position information is transferred synchronously using the SSI protocol (**s**ynchronous **s**erial **i**nterface). The FM 352 supports only GRAY code. Due to the arrangement of the data bits in the transferred frames, the data formats ”fir tree”, ”half fir tree” and ”right-justified” are used.

Encoder Type	Frame Length / Type
Single-turn	13-bit half fir tree
Single-turn	13-bit right-justified
Single-turn	25-bit right-justified
Multi-turn	25-bit fir tree
Multi-turn	25-bit right-justified
Listen-in	fir tree
Listen-in	right-justified
Special setting: Multi-turn as single-turn	25-bit half fir tree

Data Transfer

The data rate for data transmission depends on the cable length (see Appendix, Technical Specifications).

Pulse Evaluation with Absolute Encoders

1 increment (from encoder) = 1 pulse (FM evaluation)

Listen-In

”Listen-In” means the following: An absolute encoder is operated in parallel on two modules (for example FM 351 and FM 352). The FM 351 positioning module is the master and the clocks the absolute encoder, and the FM 352 electronic cam controller is the slave and listens in to the signals of the SSI frame.

Set ”Increments/Encoder Revolution” and “Number of Revolutions” to the master setting. The **transmission rate** is irrelevant. Depending on the encoder type select ”Listen-In” or ”Listen-In Right-Justified” for ”Frame Length”.

Wiring Listen-In

Figure 10-3 based on the example of an FM 351 and FM 352 illustrates how to connect the absolute encoder so that the FM 352 listens in.

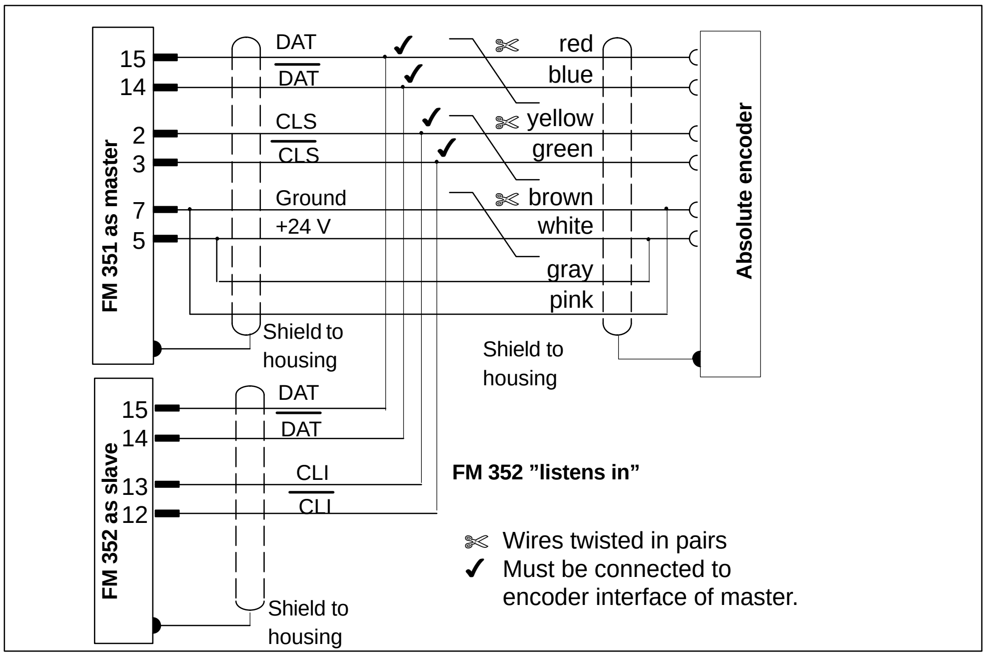


Figure 10-3 Connection of Absolute Encoders (SSI)

Note

If you want the FM 352 to listen in, you must connect the ground (M) of the encoder power supply of the master (for example FM 351: front connector, pin 48) and of the slave (FM 352: front connector, Pin 48) making low-resistance connection with the ground of the CPU.

Reaction Times

With absolute encoders, the FM 352 has the following reaction times:

Minimum reaction time = frame run time + cam cycle + switching time of the connected switching elements

Maximum reaction time = frame run time + monostable flip-flop time + 2 · cam cycle + switching time of the connected switching elements

With programmable absolute encoders:

Maximum reaction time = frame run time + monostable flip-flop time + 2 · cam cycle + switching time of the connected switching elements +1/max. step train sequence

Monostable flip-flop time

The following limit values apply to the monostable flip-flop time:

- Minimum monostable flip-flop period: > 15 µs
- Maximum monostable flip-flop time: < 64 µs

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

Frame run times

The frame run times depend on the baud rate:

Baud Rate	Frame Run Time for 13 bits	Frame Run Time for 25 bits
0.125 MHz	112 µs	208 µs
0.250 MHz	56 µs	104 µs
0.500 MHz	28 µs	52 µs
1.000 MHz	14 µs	26 µs

Example of Reaction Times

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

- Cam cycle: approx. 20 µs for max. 16 cams
- Switching time of the hardware: approx. 150 µs
- Frame run time: 26 µs at 1 MHz baud rate (25-bit frame)
- Monostable flip-flop period: 20 µs (depends on the encoder: typical 20 to 40 µs)

Minimum reaction time = 26 µs + 20 µs + 150 µs = 196 µs

Maximum reaction time = 2 · 26 µs + 20 µs + 2 · 20 µs + 150 µs = 262 µs

Note

You can compensate the reaction time with appropriate parameter settings for the cams or using dynamic adjustment.

Unsharpness

Unsharpness is the difference between the maximum and minimum reaction time. With an Absolute encoder it is as follows:

Unsharpness =	1 cam cycle + frame run time + monostable flip-flop time
With programmable absolute encoders:	
Unsharpness =	1 cam cycle + frame run time + monostable flip-flop time + 1/max. step train frequency

Note

If the switching time of the hardware on the FM 352 and the switching time of the connected switching elements can be ignored, then reliable switching of the cam is guaranteed if the cam is longer than the distance traveled within one cam cycle.

Diagnostics 11

Chapter Overview

11.1 Possibilities for Error Evaluation

- With the programming device/PC, you can read out the diagnostic buffer with the parameter assignment user interface using **Test > Error Evaluation**.
  - You will see the error class and error number along with plain text.
- You can evaluate errors in your program based on the following information:
  - The return values (RET_VAL) of the linked FC as a group display for errors that occurred while the FC was being executed.
  - The error bits of the jobs as a group display for errors that occurred while executing a job.
  - The error bit DATA_ERR as a group display for an error detected by the FM 352 during a write job.
  - The error flag in JOB_ERR for the cause of the error in communication between the FC and FM 352.
  - FC CAM_DIAG for reading out the diagnostic buffer of the FM 352. Here, you can find out the causes of errors in jobs and asynchronous events (operating errors, diagnostic errors).
  - Diagnostic interrupts for fast reaction to events.

11.2 Meaning of the Error LEDs

The status and error displays indicate various error states. The LED is lit, even with errors that occur briefly, for at least 3 seconds.

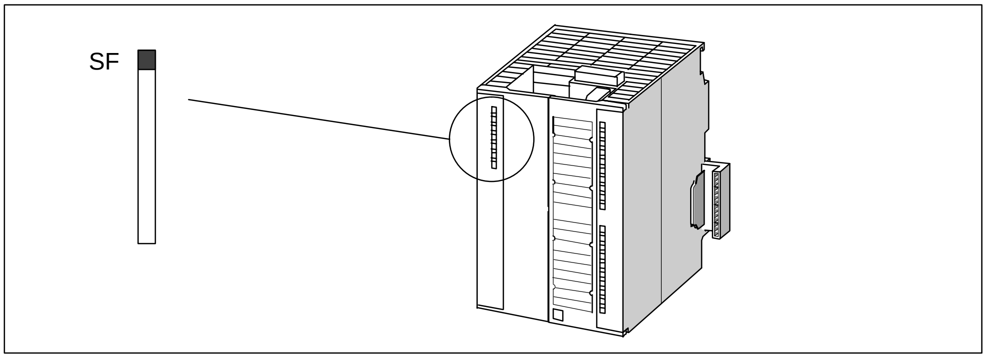


Figure 11-1 Status and Fault/Error Indicator of the FM 352

Indicator	Meaning	Explanation
SF (red) LED – ON	Group error for internal and external errors	This LED indicates the following error states on the FM 352: • Hardware interrupt lost • Watchdog expired • The FM 352 not configured. • Incorrect FM 352 parameter assignment (only when parameters assigned with SDB) • No external 24 V auxiliary supply • No front connector • Encoder wire break • Operating error • Absolute encoder frame error • Incremental encoder pulse missing or zero marker missing

11.3 Diagnostic Interrupts

Interrupt Servicing

The FM 352 can trigger hardware interrupts and diagnostic interrupts. You service these interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU changes to STOP (refer to the manual *Programming with STEP* 7).

You enable the servicing of diagnostic interrupts as follows:

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

Overview of the Diagnostic Interrupts

The following events and errors trigger a diagnostic interrupt:

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

These errors are explained in detail in Appendix C.4, page C-14 onwards.

Reaction of the FM 352 to an Error with a Diagnostic Interrupt

- Cam processing is stopped
- The synchronization is deleted with the following diagnostic interrupts:
  - Front connector missing, external power supply missing
  - A zero marker error was detected, cable fault (5 V encoder signals)
  - The travel range was exceeded (indicated by an operating error)
  - Set actual value cannot be executed (indicated by an operating error).
- With one exception, control signals are no longer processed

  Exception:

  If the software limit switch is passed, a change in direction is still possible in the simulation mode.
- Function switches and jobs continue to be processed.

The FM 352 Detects an Error ("entering state")

A diagnostic interrupt is "entering state" when at least one error is pending. If only some of the errors are eliminated, the remaining pending errors are signaled again as "entering state".

Sequence:

1. The FM 352 detects one or more errors and initiates a diagnostic interrupt. The "SF" LED is lit. The error is entered in the diagnostic buffer.
2. The CPU operating system calls OB82.
3. You can evaluate the start information of OB82.
4. With the OB82_MOD_ADDR parameter, you can see which module triggered the interrupt.
5. You can obtain further information by calling FC CAM_DIAG.

The FM 352 Detects that an Error State is Cleared ("leaving state")

A diagnostic interrupt is only "leaving state" when the last error on the module has been rectified.

Sequence:

1. The FM 352 detects that all errors have been rectified and initiates a diagnostic interrupt. The "SF" LED is no longer lit. The diagnostic buffer is not modified.
2. The CPU operating system calls OB82.
3. With the OB82_MOD_ADDR parameter, you can see which module triggered the interrupt.
4. Evaluate the OB82_MDL_DEFECT bit.

   If this bit is "0", then no errors are present on the module. You can stop evaluation here.

Diagnostic Interrupts Depending on the CPU Status

- When the CPU is in the STOP state, diagnostic interrupts from the FM 352 are disabled.
- If none of the pending errors are eliminated while the CPU is in the STOP mode, the FM 352 signals the errors that have not yet been eliminated as "entering state" again when the CPU changes to RUN.
- If all existing errors have been eliminated in the CPU STOP state, then the error-free FM 352 state is **not** signaled with a diagnostic interrupt after the CPU changes to RUN.

Samples 12

Chapter Overview

12.1 Introduction

When you install the FM 352/FM 452 software package, a sample project is also installed that illustrates several typical applications based on a number of selected functions.

The English sample project is in the following folder:

...\STEP7\EXAMPLES\zEn19_01

This contains several S7 programs of varying complexity and with different aims. The programs include comprehensive comments.

12.2 Requirements

The following requirements must be met:

- You have an S7 station consisting of a power supply module, a CPU and an FM 452 or FM 352 module (Version ≥ V5) that is installed and wired up. Earlier versions of the module may deviate from the behavior described.
- You have correctly installed STEP 7 and the configuration package for the FMx52 on your programming device/PC. The description of how to handle the programs is based on STEP 7 V5.0. If you use a different version of STEP 7, the procedures may differ slightly.
- The programming device is connected to the CPU.

You can operate an FM 452 or an FM 352 with these samples. All the samples can be executed with the FM 352 installed in a distributed configuration. To use the “MultiModules” sample, you require two modules.

12.3 Preparing the Samples

To be able work through the samples online, make the following preparations:

1. Open the sample project ...**\STEP7\EXAMPLES\zEn19_01_FMx52___Prog** with the SIMATIC Manager and copy it to your project folder giving it a suitable name.
2. Insert a station in this project to match your hardware configuration.
3. Configure the hardware completely with HW Config, save the configuration and download it to the CPU.
4. Assign parameters for the FM 352 or FM 452 based on the “Getting Started” manual.
5. Select a sample program and download its block folder to the CPU.
6. Select the FM 352 or FM 452 in the hardware configuration and display the object properties (**Edit > Object Properties)**.
7. Using the “Mod Addr…” dialog, enter the current module address in all offline channel DBs and diagnostic DBs that exist in the sample program. Open the dialog separately for each block.
   You can also enter the module address with the LAD/STL/FBD editor in the MOD_ADDR block parameter.
8. If you want to try out the next sample, go to step 5.

12.4 Code of the Samples

The samples are written in STL.

You can view them directly in the LAD/STL/FBD editor.

Select the view with “Symbolic Representation”, “Symbol Selection” and “Comments”. If you have enough space on your screen, you can also display “Symbol Information”.

12.5 Testing a Sample

When you have made all the necessary entries for the sample, download the complete block folder to the CPU.

The sample programs include variable tables (VATs) with which you can view and modify the data blocks online (in other words in the RUN-P mode on the CPU). In the variable table, select the views “Symbol” and “Symbol Comment”. Open a variable table, link it with the configured CPU and monitor the variables cyclically. This means that when the CPU is in the RUN-P or RUN mode, the displayed variables are updated constantly.

All the samples require that the machine and cam data were entered and saved with the parameter assignment user interface. This allows you to execute the samples one after the other.

12.6 Adapting a Sample

The code of the samples in neither optimized nor designed for all eventualities.

Error evaluation is not programmed in detail in the sample programs to avoid the programs becoming unwieldy.

12.7 Sample Program 1 “GettingStarted”

Aim:

With this sample, you can put your cam controller into operation once you have assigned parameters to it using the parameter assignment user interface based on the “Getting Started” manual.

The sample extends the program shown in the “Linking in the User Program” chapter of the primer by adding error evaluation.

Requirements:

You have assigned parameters for the cam controller as described in the “Getting Started” primer.

The address of your module is entered correctly at the address MOD_ADDR in the channel DB.

Startup:

In the startup OB (OB100) you call FC CAM_INIT that resets all the control and return signals and the job management in the channel DB.

Cyclic Operation:

Open the variable table, establish the connection to the configured CPU and monitor the variables. Transfer the prepared control values. The module changes to the simulation mode. You can see how the actual value (CAM.ACT_POS) and track signals (CAM.TRACK_OUT) change continuously.

Now change the simulation direction, specify different reference point coordinates, turn off the simulation etc. by modifying and transferring the control values.

Error Evaluation:

Produce a data error by entering a reference point coordinate greater than the end of the rotary axis (for example 10000000). The CPU changes to STOP. (In a sample, this is the simplest method of indicating an error. You can, of course, program a more elegant method.)

Open the hardware configuration and double-click the FM 352 or FM 452. The parameter assignment user interface is started. Display the cause of the error with Test > Error Evaluation.

To eliminate the error, follow the steps outlined below:

1. Enter a permitted value in the control value.
2. Switch the CPU to STOP.
3. Switch the CPU to RUN-P.
4. Activate the control values. If you activate the control values before the CPU restarts, they are reset by the initialization in OB100 and therefore have no effect.

12.8 Sample Program 2 “Commission”

Aim:

In this sample, you start up a cam controller without using the parameter assignment user interface. You control and monitor using variable tables (VATs).

Requirements:

You have assigned parameters for the cam controller as described in the “Getting Started” primer.

The address of your module has been entered in the block parameter MOD_ADDR in the channel DB and diagnostic DB.

The supplied channel DB already contains the DB number (3) of the parameter DB in the PARADBNO parameter.

The PARADB contained in the sample already has machine and cam data.

Startup:

In the startup OB (OB100), call FC CAM_INIT to initialize the channel DB. You then set the trigger bits for all jobs and all control signals that you require after the module starts.

Cyclic Operation:

Open the two variable tables (VAT1 and VAT2), establish the connection to the configured CPU and monitor the variables.

In VAT1, you can see the changes in the actual position and the track signals. The module is in operation.

In VAT2, you can see the most important entries of the diagnostic buffer of the module. The meaning of the error classes and error numbers is described in the manual in Appendix C.4, page C-14.

Change the machine and cam data in DB PARADB, download the DB to the CPU and activate the control values in VAT1. The new data are written to the module and activated. If the data contain errors, the error is indicated in VAT2. The machine and cam data are described in the manual in Chapter 8, Page 8-2 onwards.

Error Evaluation:

Attempt to create further errors:

- Specify a reference point coordinate that is higher than the end of the rotary axis.
- Turn off the external power supply.
- Delete PARADB on the CPU (online) and attempt to write machine data. (The error evaluation is once again programmed [spitefully] so that the CPU changes to STOP. If you update VAT1 again, the error code for this error is indicated in CAM.JOB_ERR.)

12.9 Sample Program 3 “OneModule”

Aim:

In this sample, you control a cam controller with a user program. The user program starts up the module following a CPU warm restart. Afterwards, it executes a series of steps that reacts to events.
Using the variable tables, you set the events, monitor the reactions of the module and evaluate the diagnostic buffer.

In this somewhat more complex sample, you can get to know the following options available with the blocks:

- Specifying several jobs at the same time
- Mixing write and read jobs
- Reading using a permanent job without waiting for the end of the job
- Evaluating the return signals of the block
- Evaluating the return signals of an individual job
- Resetting the done and error bits for individual or for all jobs
- Central CAM_CTRL call at the end of the user program
- Central error evaluation by CAM_DIAG at the end of the user program
- Evaluation of the diagnostic buffer in conjunction with DATA_ERR

Requirements:

You have assigned parameters for the cam controller as described in the “Getting Started” primer.

The address of your module has been entered in the block parameter MOD_ADDR in the channel DB and diagnostic DB.

The supplied channel DB already contains the DB number (3) of the parameter DB in the PARADBNO parameter.

The PARADB contained in the sample already has machine and cam data.

Startup:

In the startup OB (OB100) you set the startup flag (Step 0) for the user program in the corresponding instance DB.

Operation:

The CPU is in the STOP mode. Open the VAT1 variable table and transfer the control values.

Start the CPU (STOP > RUN-P). You can see how the actual position (CAM.ACT_POS), the cam data (CAM.CAM_00_31) and the track signals (CAM.TRACK_OUT) change. You should also observe the step number of the step sequence (PROGDB.STEPNO).

When cam 4 is set (130 degrees), cams 1 and 2 are assigned new parameter values that were specified in VAT1. You can see the modification in the VAT.

The program then waits for an external event. Transfer the prepared control values from the VAT again (this time PROGDB.SWITCH is evaluated). The cam data return to the previous values again.

After this run through, the step sequence has been processed, the step number is –2, and simulation is stopped.

If you want to repeat the entire sequence again, restart the CPU (STOP > RUN-P). (This procedure is, of course, only acceptable in a sample.)

If you have not activated the PROGDB.SWITCH switch before a CPU STOP, the parameters of the cam in the parameter DB are not set back to the original values. You must then download the parameter DB to the CPU again.

Error Evaluation:

If an error occurs in execution, the step sequence is stopped and simulation deactivated. The value –1 is entered as the step number.

Try to create cam errors that are entered in the PROGDB.CAM_ERR bit as group errors by the central error evaluation.

- Set cam positions in VAT1 that are higher than the end of the rotary axis.
- Enter negative cam positions in VAT1.

User Program (FB PROG):

The user program accesses the data in the module-specific data blocks with the form <blockname>.<symbolic name>. This means that the user program can operate exactly one module. The DB numbers specified when the user program is called are simply passed on to supply FC CAM_CTRL and FC CAM_DIAG. With this type of programming, you can access data in the data blocks using symbolic names. Indirect addressing of more than one module is part of the sample program 5 “MultiModules”.

The user program executes a sequence of steps made up as follows:

Step 0: The cam controller is initialized. The jobs with the corresponding data are set that will be executed when the module is started up. The restart of the module can, for example,be triggered by a CPU warm restart or the return of a rack after a rack failure.

Step 1: The program waits for the execution of the set jobs.

Step 2: The program reads the cam flag bits continuously and waits until cam 4 is set.

Step 3: Cams 0 and 1 are assigned new parameter values. To allow you to see the change, the cam data are read out before and after the change and displayed in VAT1.

Step 4: The program waits for the execution of the set jobs.

Step 5: Here, the program waits for the “external” event “switch on” (CAM.SWITCH = 1) that you can set with the VAT.

Step 6: When the event is recognized, cams 0 and 1 are set back to the value that was read out in the initialization step.

Step 7: The program waits for the execution of the set jobs.

At the end of the step sequence, FC CAM_CTRL and FC CAM_DIAG are called. If the diagnostics has detected a message about incorrect cam data, the output CAM_ERR is set.

12.10 Sample Program 4 “Interrupts”

Aim:

This sample contains a user program with the same task as in Sample program 3 “OneModule”. In this sample, we will show you how to evaluate a diagnostic interrupt for certain modules and how to process this in the user program to produce a general module error.

Requirements:

You have assigned parameters for the cam controller as described in the “Getting Started” primer.

The address of your module has been entered in the block parameter MOD_ADDR in the channel DB and diagnostic DB.

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

The supplied channel DB already contains the DB number (3) of the parameter DB in the PARADBNO parameter.

The PARADB contained in the sample already has machine and cam data.

Startup:

In the startup OB (OB100), the startup flag (step 0) for the user program is set in the instance DB.

Operation:

As in Sample program 3 “OneModule”.

Error Evaluation:

As in Sample program 3 “OneModule”.

Produce a diagnostic interrupt by disconnecting the power supply for the module or by removing the front connector. The module error MOD_ERR and the diagnostic error OB82_ERR are set to 1 and the step number becomes –1. When you eliminate the problem, the error flags are also reset. Cam processing and simulation, however, remain disabled.

User Program (FB PROG):

The task is the same as in the Sample program 3 “OneModule”. The block was, however, extended by adding evaluation of the diagnostic event.

In this sample, no special measures have been taken for restarting after eliminating the error. We have left this up to you as part of the exercise.

Diagnostic Interrupt (OB82)

Depending on the address of the module that triggered the interrupt (OB82_MDL_ADDR), the error ID in the corresponding instance DB of the user program is entered in the diagnostic interrupt.

12.11 Sample Program 5 “MultiModules”

Aim:

This sample contains the same user program as sample program 3 “OneModule”, however it is used to operate two modules with different cam parameters. The same copy of the user program is used for both modules. Naturally, each module has its own set of data blocks.

Requirements:

You have plugged in two FMx52 modules and configured them in HW Config.

You have assigned parameters for both cam controllers as described in the “Getting Started” primer.

The address of the relevant module has been entered in the block parameter MOD_ADDR in the channel DBs and diagnostic DBs.

The supplied channel DBs already contain the DB number (3 or 13) of the corresponding parameter DB in the PARADBNO parameter.

The parameter DBs DBs PARADB and PARADB2 contained in the sample contain machine and cam data for both modules.

A set of variable tables is also prepared for each module.

Startup:

In the start up OB (OB100), you set the start up flag (Step 0) for the user program in both instance DBs.

Operation:

The CPU is in the STOP mode. Open VAT1 and VAT11 and transfer their control values.

Start the CPU (STOP > RUN-P). You can see how the actual positions, the cam data, and the track signals of both modules change.

Error Evaluation:

As in Sample program 4 “Interrupts”, however separately for both modules.

User Program (FB PROG):

The aim and sequence of the user program are as in Sample program 4 “Interrupts” and in Sample program 3 “OneModule”.

The user program is designed for the operation of more than one module since it accesses the module-specific data blocks indirectly (channel DB, diagnostic DB, and parameter DB). The DB numbers specified in the call are not only passed on to supply FC CAM_CTRL and FC CAM_DIAG but are also used in the user program. With this type of programming, you cannot use symbolic names for the data in the data blocks.

Diagnostic Interrupt (OB82)

Depending on the address of the module that triggered the interrupt (OB82_MDL_ADDR), the error ID in the corresponding instance DB of the user program is entered in the diagnostic interrupt.

Technical Specifications

A

General Technical Data

The following technical specifications are described in the installation manual *S7-300 Programmable Controller, Installation and Hardware, CPU Specifications*.

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

UL/CSA Approvals

The following approvals exist for the S7-300:

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 following FM approval exists for the S7-300:
FM approval complying with 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 disconnect lines to S7-300 during 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 meet the requirements of the EU directive 89/336/EEC "Electromagnetic Compatibility" and the harmonized European standards (EN) listed in the directive.

In compliance with the above mentioned EU directive, Article 10, the conformity declarations are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A&D AS E148
Postfach 1963
D-92209 Amberg

Area of Application

SIMATIC products are designed for use in an industrial environment.

Area of Application	Requirements	
	Emitted Noise	**Noise Immunity**
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995

Adherence to Installation Instructions

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

Technical Data

Dimensions and weight	
Dimensions W × H × D (mm)	80 × 125 × 120
Weight	Approx. 530 g
Current, voltage and power	
Current consumption (from the backplane bus)	max. 100 mA
Power dissipation	Typ. 8.1 W
Current consumption for encoders, digital inputs and outputs from L+ (without load)	max. 200 mA (X1, terminal 1)
Supply of digital inputs and outputs	• Supply voltage: 24 VDC (permissible range: 20.4 to 28.8 V) • Permitted potential difference between input ground connection M (X1, terminal 2) • and the central grounding point (shield): 60 V AC; 75 V DC • Insulation tested with 500 VDC
Encoder supply	• Horizontal installation S7-300, 20° C: • 5.2 V/300 mA • 24 V/300 mA • Horizontal installation S7-300, 60° C: • 5.2 V/300 mA • 24 V/300 mA • Vertical installation S7-300, 40° C: • 5.2 V/300 mA • 24 V/300 mA • Encoder power supply 24 V, non-stabilized (X2, terminal 5) • L+ -0.8 V • Short-circuit protection: yes, thermic • Encoder power supply 5.2 V (X2, terminal 6) Short-circuit protection: yes, electronic • Permitted potential difference between input (ground) and central ground connection of the CPU: 1 V DC
Load voltage reverse polarity protection	No
Encoder inputs	
Position detection	• Incremental • Absolute
Signal voltages	• Symmetrical inputs: 5 V to RS 422 • Asymmetrical inputs: 24 V/typ. 9 mA
Input frequency and cable length for symmetrical incremental encoders with 5 V supply	Max. 1 MHz for 32 m shielded cable length
Input frequency and cable length for symmetrical incremental encoders with 24 V supply	Max. 1 MHz for 100 m shielded line length
Input frequency and cable length for asymmetrical incremental encoder with 24 V supply	• Max. 50 KHz for 25 m shielded cable length • Max. 25 KHz for 100 m shielded cable length

Encoder inputs	
Data transfer rate and cable length for absolute encoders	• Max. 125 KHz for 320 m shielded cable length • Max. 250 KHz for 160 m shielded cable length • Max. 500 KHz for 60 m shielded cable length • Max. 1 MHz for 20 m shielded cable length
Listen-in mode with absolute encoders	Yes
Input signals	• Incremental: 2 pulse trains, 90° offset, 1 zero pulse • Absolute: Absolute value
Digital inputs	
Number of digital inputs	4
Number of simultaneously controllable digital inputs	4
Electrical isolation	No
Status indication	Yes, green LED per channel
Input voltage	• 0 signal: –30 V to 5 V • 1 signal: 11 V to 30 V
Input current	• 0 signal: ≤ 2 mA (closed-circuit current) • 1 signal: 9 mA
Input delay	• 0 → 1 signal: max. 200 µs • 1 → 0 signal: max . 200 µs
Connection of a 2-wire BERO	Possible
Unshielded cable length	32 m
Shielded line length	600 m
Switching frequency	max. 500 Hz
Insulation test	VDE 0160
Digital outputs	
Number of outputs	13
Electrical isolation	No
Status indication	Yes, green LED per channel
Output current	• 0 signal: 0.5 mA • 1 signal: 0.5 A at 100 % simultaneity (permitted 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 missing pulse
Short-circuit protection:	Yes, thermically clocked Switching threshold 1.8 A
Limit on induct. cut-off voltage	Typ. L+ –48 V

Digital outputs	
Switching frequency	• Resistive load: max. 500 Hz • Inductive load: Max. 0.5 Hz
Total current of digital outputs with S7-300 horizontal installation	Simultaneity factor 100 %: • at 20° C: 6 A • at 60° C: 3 A
Total current of digital outputs with S7-300 vertical installation	Simultaneity factor 100 %: at 40° C: 3 A
Unshielded cable length	Max. 100 m
Shielded line length	600 m
Insulation test	VDE 0160

Note

When the 24 V power supply is turned on using a mechanical contact, the FM 352 applies a pulse to the outputs. Within the permitted output current range, the pulse may be 50 µs. You must take this into account when you use the FM 352 in conjunction with fast counters.

Connection Diagrams

B

Overview

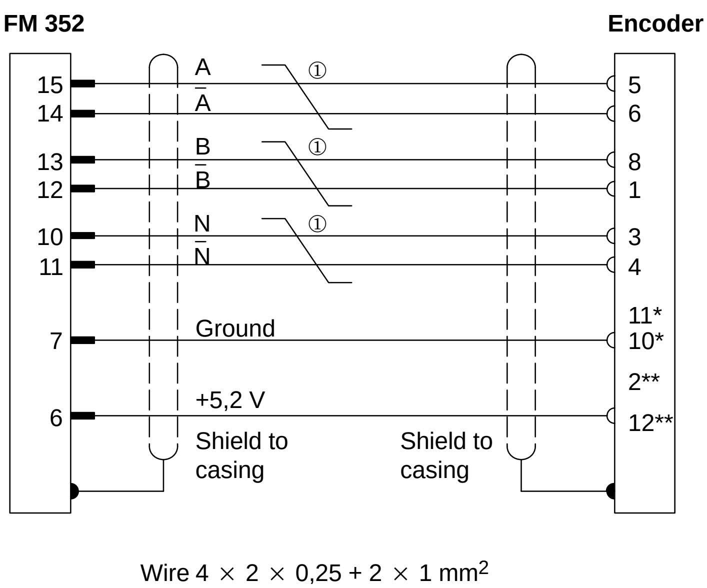
The following table describes encoders that you can connect to the FM 352. The connection diagrams for these encoders are described in this chapter.

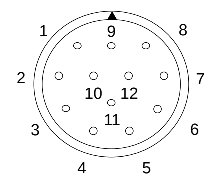
Section	Connection Diagram for	Connecting Cable	Remark	Page
B.1	**Incremental encoder** Siemens 6FX 2001-2□□□□	$4 \times 2 \times 0.25 + 2 \times 1$ mm^2	U_p=5V, RS–422	B-2
B.2	**Incremental encoder** Siemens 6FX 2001-2□□□□	$4 \times 2 \times 0.5$ mm^2	U_p=24V, RS–422	B-3
B.3	**Incremental encoder** Siemens 6FX 2001-4□□□□	$4 \times 2 \times 0.5$ mm^2	U_p=24V, HTL	B-4
B.4	**Absolute encoder** Siemens 6FX 2001-5□□□□	$4 \times 2 \times 0.5$ mm^2	U_p=24V, SSI	B-5

B.1 Connection Diagram for Incremental Encoder Siemens 6FX 2001-2 (U_p=5V; RS 422)

Connection Diagram

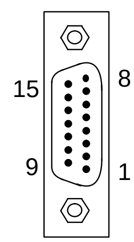
The following schematic shows the connection diagram for the incremental encoder Siemens 6FX 2001-2□□□□ (U_p=5 V: RS422):





12-pin circular socket
Siemens 6FX 2003-0CE12
Pin side (soldered side)

① Wires twisted in pairs



15-pin Cannon connector
Pin side (soldered side)
Metal housing with screw locks
6FC9 341-1HC

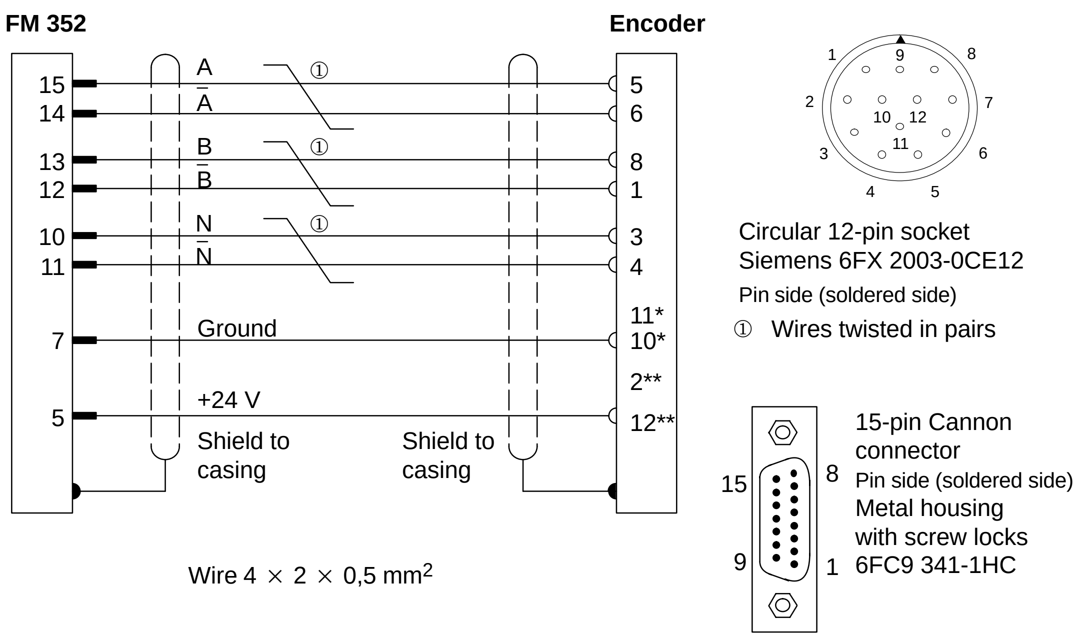
* Pins 10 and 11 are jumpered internally.

** Pins 2 and 12 are jumpered internally.

B.2 Connection Diagram for Incremental Encoder Siemens 6FX 2001-2 (Up=24V; RS 422)

Connection Diagram

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



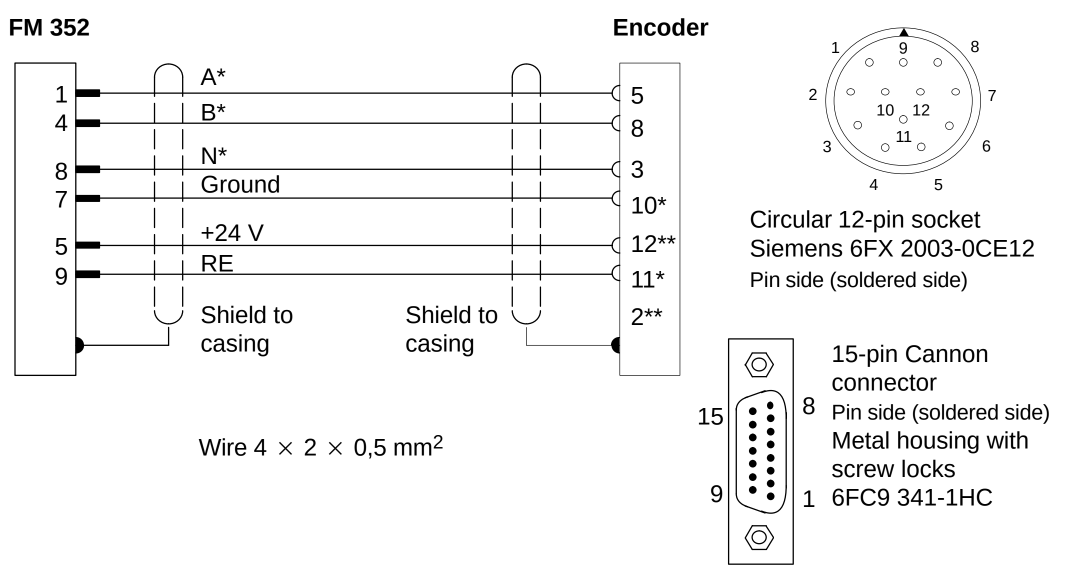
* Pins 10 and 11 are jumpered internally.

** Pins 2 and 12 are jumpered internally.

B.3 Connection Diagram for Incremental Encoder Siemens 6FX 2001-4 (Up=24V; HTL)

Connection Diagram

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



* Pins 10 and 11 are jumpered internally.

** Pins 2 and 12 are jumpered internally.

Note

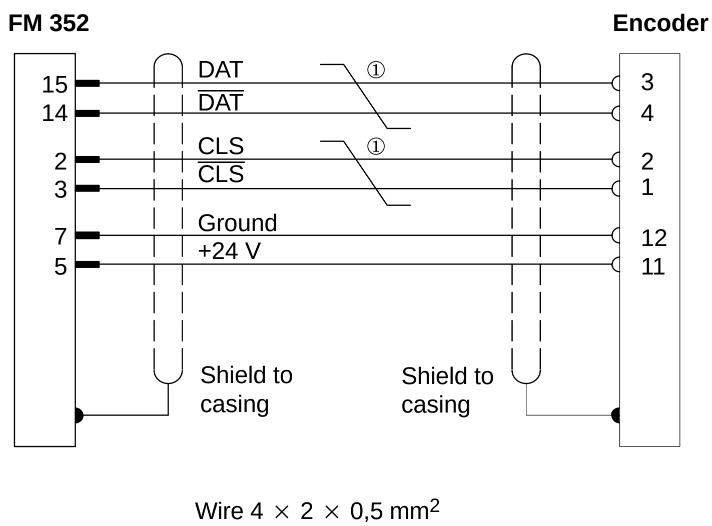
If you would like to connect an incremental encoder from another manufacturer in a push-pull configuration (current sourcing/sinking), then you must observe the following:

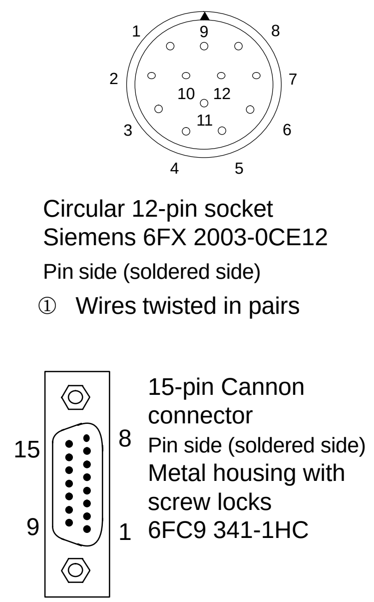
- Current sourcing: Connect RE (9) to ground (7).
- Current sinking: Connect RE (9) to +24 V (5).

B.4 Connection Diagram for Absolute Encoder Siemens 6FX 2001-5 (Up=24V; SSI)

Connection Diagram

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





Data Blocks/Error Lists

C

Chapter Overview

C.1 Content of the Channel DB

Note

Do not modify data that are not listed in this table.

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Addresses/Version Switch				
0.0	MOD_ADDR **(enter!)**	INT	0	Module address
2.0	CH_NO	INT	1	Channel number (always 1)
10.0	PARADBNO	INT	-1	Number of the parameter DB -1 = DB does not exist
12.0	FM_TYPE	BOOL	FALSE	0 = FM 352 up to V4.0 1 = FM 352 / FM 452 V5.0 or higher
Control signals				
15.2	DIR_M	BOOL	FALSE	1 = simulation in negative direction
15.3	DIR_P	BOOL	FALSE	1 = simulation in positive direction
15.4	CAM_EN	BOOL	FALSE	1 = enable cam processing
15.5	CNTC0_EN	BOOL	FALSE	1 = enable count function of counter cam track 0
15.6	CNTC1_EN	BOOL	FALSE	1 = enable count function of counter cam track 1
16.0	TRACK_EN	WORD	W#16#0	Enable cam tracks 0 to 15 Bit 0 = track 0
Return signals				
22.2	DIAG	BOOL	FALSE	1 = diagnostic buffer modified
22.4	DATA_ERR	BOOL	FALSE	1 = data error
22.7	PARA	BOOL	FALSE	1 = module has parameters assigned
23.4	CAM_ACT	BOOL	FALSE	1 = cam processing active
25.0	SYNC	BOOL	FALSE	1 = axis is synchronized
25.1	MSR_DONE	BOOL	FALSE	1= length measurement or edge detection completed
25.2	GO_M	BOOL	FALSE	1 = axis moving in negative direction
25.3	GO_P	BOOL	FALSE	1 = axis moving in positive direction
25.4	HYS	BOOL	FALSE	1 = axis within the hysteresis range
25.5	FVAL_DONE	BOOL	FALSE	1 = set actual value on-the-fly executed
26.0	ACT_POS	DINT	L#0	Current position of the axis

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Return signals				
30.0	TRACK_OUT	DWORD	DW#16#0	Current track signals tracks 0 to 31 Bit 0 = track 0
Function Switches				
34.0	EDGE_ON	BOOL	FALSE	1 = edge detection on
34.1	SIM_ON	BOOL	FALSE	1 = simulation on
34.2	MSR_ON	BOOL	FALSE	1 = length measurement on
34.3	REFTR_ON	BOOL	FALSE	1 = retrigger reference point
34.4	SSW_OFF	BOOL	FALSE	1 = software limit switch off
Trigger Bits for Write Jobs				
35.0	MDWR_EN	BOOL	FALSE	1 = write machine data
35.1	MD_EN	BOOL	FALSE	1 = activate machine data
35.2	AVALREM_EN	BOOL	FALSE	1 = cancel set actual value, set actual value on-the-fly
35.3	CAM1WR_EN	BOOL	FALSE	1 = write cam data 1 (cam 0 to 15)
35.4	CAM2WR_EN	BOOL	FALSE	1 = write cam data 2 (cam 16 to 31)
35.5	CAM3WR_EN	BOOL	FALSE	1 = write cam data 3 (cam 32 to 47)
35.6	CAM4WR_EN	BOOL	FALSE	1 = write cam data 4 (cam 48 to 63)
35.7	CAM5WR_EN	BOOL	FALSE	1 = write cam data 5 (cam 64 to 79)
36.0	CAM6WR_EN	BOOL	FALSE	1 = write cam data 6 (cam 80 to 95)
36.1	CAM7WR_EN	BOOL	FALSE	1 = write cam data 7 (cam 96 to 111)
36.2	CAM8WR_EN	BOOL	FALSE	1 = write cam data 8 (cam 112 to 127)
36.3	REFPT_EN	BOOL	FALSE	1 = set reference point coordinates
36.4	AVAL_EN	BOOL	FALSE	1 = set actual value
36.5	FVAL_EN	BOOL	FALSE	1 = set actual value on-the-fly
36.6	ZOFF_EN	BOOL	FALSE	1 = set zero offset
36.7	CH01CAM_EN	BOOL	FALSE	1 = write cam edge setting (1 cam)
37.0	CH16CAM_EN	BOOL	FALSE	1 = write settings for fast cam parameter change (16 cams)

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Trigger Bits for Read Jobs				
37.1	MDRD_EN	BOOL	FALSE	1 = read machine data
37.2	CAM1RD_EN	BOOL	FALSE	1 = read cam data 1 (cam 0 to 15)
37.3	CAM2RD_EN	BOOL	FALSE	1 = read cam data 2 (cam 16 to 31)
37.4	CAM3RD_EN	BOOL	FALSE	1 = read cam data 3 (cam 32 to 47)
37.5	CAM4RD_EN	BOOL	FALSE	1 = read cam data 4 (cam 48 to 63)
37.6	CAM5RD_EN	BOOL	FALSE	1 = read cam data 5 (cam 64 to 79)
37.7	CAM6RD_EN	BOOL	FALSE	1 = read cam data 6 (cam 80 to 95)
38.0	CAM7RD_EN	BOOL	FALSE	1 = read cam data 7 (cam 96 to 111)
38.1	CAM8RD_EN	BOOL	FALSE	1 = read cam data 8 (cam 112 to 127)
38.2	MSRRD_EN	BOOL	FALSE	1 = read measured values
38.3	CNTTRC_EN	BOOL	FALSE	1 = read count values of counter cam tracks
38.4	ACTPOS_EN	BOOL	FALSE	1 = read position and track data
38.5	ENCVAL_EN	BOOL	FALSE	1 = read encoder values
38.6	CAMOUT_EN	BOOL	FALSE	1 = read cam and track data
Done Bits for Function Switches				
40.0	EDGE_D	BOOL	FALSE	1 = “activate edge detection” or “deactivate edge detection” completed
40.1	SIM_D	BOOL	FALSE	1 = “activate simulation” or “deactivate simulation” completed
40.2	MSR_D	BOOL	FALSE	1 = “activate length measurement” or “deactivate length measurement” completed
40.3	REFTR_D	BOOL	FALSE	1 = “activate retrigger reference point” or “deactivate retrigger reference point” completed
40.4	SSW_D	BOOL	FALSE	1 = “activate software limit switch” or “Deactivate software limit switch” completed

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Done Bits for Write Jobs				
41.0	MDWR_D	BOOL	FALSE	1 = “write machine data” job completed
41.1	MD_D	BOOL	FALSE	1 = “enable machine data” job completed
41.2	AVALREM_D	BOOL	FALSE	1 = “cancel set actual value” or “cancel set actual value on-the-fly” completed
41.3	CAM1WR_D	BOOL	FALSE	1 = “write cam data 1” job completed
41.4	CAM2WR_D	BOOL	FALSE	1 = “write cam data 2” job completed
41.5	CAM3WR_D	BOOL	FALSE	1 = “write cam data 3” job completed
41.6	CAM4WR_D	BOOL	FALSE	1 = “write cam data 4” job completed
41.7	CAM5WR_D	BOOL	FALSE	1 = “write cam data 5” job completed
42.0	CAM6WR_D	BOOL	FALSE	1 = “write cam data 6” job completed
42.1	CAM7WR_D	BOOL	FALSE	1 = “write cam data 7” job completed
42.2	CAM8WR_D	BOOL	FALSE	1 = “write cam data 8” job completed
42.3	REFPT_D	BOOL	FALSE	1 = “set reference point” job completed
42.4	AVAL_D	BOOL	FALSE	1 = A “set actual value” job completed
42.5	FVAL_D	BOOL	FALSE	1 = A “set actual value on-the-fly” job completed
42.6	ZOFF_D	BOOL	FALSE	1 = “set zero offset” job completed
42.7	CH01CAM_D	BOOL	FALSE	1 = “change parameters for 1 cam” job completed
43.0	CH16CAM_D	BOOL	FALSE	1 = “change parameters for 16 cams” completed (fast cam parameter change)
Done Bits for Read Jobs				
43.1	MDRD_D	BOOL	FALSE	1 = “read machine data” job completed
43.2	CAM1RD_D	BOOL	FALSE	1 = “read cam data 1” job completed
43.3	CAM2RD_D	BOOL	FALSE	1 = “read cam data 2” job completed
43.4	CAM3RD_D	BOOL	FALSE	1 = “read cam data 3” job completed
43.5	CAM4RD_D	BOOL	FALSE	1 = “read cam data 4” job completed
43.6	CAM5RD_D	BOOL	FALSE	1 = “read cam data 5” job completed
43.7	CAM6RD_D	BOOL	FALSE	1 = “read cam data 6” job completed
44.0	CAM7RD_D	BOOL	FALSE	1 = “read cam data 7” job completed
44.1	CAM8RD_D	BOOL	FALSE	1 = “read cam data 8” job completed
44.2	MSRRD_D	BOOL	FALSE	1 = “read measured values” job completed
44.3	CNTTRC_D	BOOL	FALSE	1 = “read count values of counter cam tracks” job completed
44.4	ACTPOS_D	BOOL	FALSE	1 = “read position and track data” job completed

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Done Bits for Read Jobs				
44.5	ENCVAL_D	BOOL	FALSE	1 = “read current encoder value” job completed
44.6	CAMOUT_D	BOOL	FALSE	1 = “read cam and track data” job completed
Error Bits for Function Switches				
46.0	EDGE_ERR	BOOL	FALSE	1 = error in “activate edge detection” or “deactivate edge detection”
46.1	SIM_ERR	BOOL	FALSE	1 = error in “activate simulation” or “deactivate simulation”
46.2	MSR_ERR	BOOL	FALSE	1 = error in “activate length measurement” or “deactivate length measurement”
46.3	REFTR_ERR	BOOL	FALSE	1 = error in “activate retrigger reference point” or “deactivate retrigger reference point”
46.4	SSW_ERR	BOOL	FALSE	1 = error in “activate software limit switch” or “deactivate software limit switch”
Error Bits for Write Jobs				
47.0	MDWR_ERR	BOOL	FALSE	1 = error in “write machine data” job
47.1	MD_ERR	BOOL	FALSE	1 = error in “activate machine data” job
47.2	AVALREM_ERR	BOOL	FALSE	1 = error in “cancel set actual value” or “cancel set actual value on-the-fly”
47.3	CAM1WR_ERR	BOOL	FALSE	1 = error in “write cam data 1” job
47.4	CAM2WR_ERR	BOOL	FALSE	1 = error in “write cam data 2” job
47.5	CAM3WR_ERR	BOOL	FALSE	1 = error in “write cam data 3” job
47.6	CAM4WR_ERR	BOOL	FALSE	1 = error in “write cam data 4” job
47.7	CAM5WR_ERR	BOOL	FALSE	1 = error in “write cam data 5” job
48.0	CAM6WR_ERR	BOOL	FALSE	1 = error in “write cam data 6” job
48.1	CAM7WR_ERR	BOOL	FALSE	1 = error in “write cam data 7” job
48.2	CAM8WR_ERR	BOOL	FALSE	1 = error in “write cam data 8” job
48.3	REFPT_ERR	BOOL	FALSE	1 = error in “set reference point” job
48.4	AVAL_ERR	BOOL	FALSE	1 = error in “set actual value” job
48.5	FVAL_ERR	BOOL	FALSE	1 = error in “set actual value on-the-fly” job
48.6	ZOFF_ERR	BOOL	FALSE	1 = error in “set zero offset” job
48.7	CH01CAM_ERR	BOOL	FALSE	1 = error in “change parameters for 1 cam” job
49.0	CH16CAM_ERR	BOOL	FALSE	1 = error in “change parameters for 16 cams” (fast cam parameter change)
Error Bits for Read Jobs				

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Error Bits for Read Jobs				
49.1	MDRD_ERR	BOOL	FALSE	1 = error in “read machine data” job
49.2	CAM1RD_ERR	BOOL	FALSE	1 = error in “read cam data 1” job
49.3	CAM2RD_ERR	BOOL	FALSE	1 = error in “read cam data 2” job
49.4	CAM3RD_ERR	BOOL	FALSE	1 = error in “read cam data 3” job
49.5	CAM4RD_ERR	BOOL	FALSE	1 = error in “read cam data 4” job
49.6	CAM5RD_ERR	BOOL	FALSE	1 = error in “read cam data 5” job
9.7	CAM6RD_ERR	BOOL	FALSE	1 = error in “read cam data 6” job
50.0	CAM7RD_ERR	BOOL	FALSE	1 = error in “read cam data 7” job
50.1	CAM8RD_ERR	BOOL	FALSE	1 = error in “read cam data 8” job
50.2	MSRRD_ERR	BOOL	FALSE	1 = error in “read measured values” job
50.3	CNTTRC_ERR	BOOL	FALSE	1 = error in “read count values of counter cam tracks” job
50.4	ACTPOS_ERR	BOOL	FALSE	1 = error in “read position and track data” job
50.5	ENCVAL_ERR	BOOL	FALSE	1 = error in “read current encoder value” job
50.6	CAMOUT_ERR	BOOL	FALSE	1 = error in “read cam and track data” job
Job Management for FC CAM_CTRL				
52.0	JOB_ERR	INT	0	Communication error
54.0	JOBBUSY	BOOL	FALSE	1 = at least one job active
54.1	JOBRESET	BOOL	FALSE	1 = reset all error and done bits
Data for “Zero Offset” Job				
86.0	ZOFF	DINT	L#0	Zero Offset
Data for “Set Actual Value” Job				
90.0	AVAL	DINT	L#0	Coordinate for “set actual value”
Data for “Set Actual Value on-the-Fly” Job				
94.0	FVAL	DINT	L#0	Coordinate for “set actual value on-the-fly”
Data for “Set Reference Point” job				
98.0	REFPT	DINT	L#0	Coordinate for “set reference point”
Data for “Change Cam Edges” Job				
102.0	CAM_NO	INT	0	Cam number
104.0	CAM_START	DINT	L#0	Cam start
108.0	CAM_END	DINT	L#0	Cam end
Data for the “Length Measurement/Edge Detection” Job				
112.0	BEG_VAL	DINT	L#0	Initial Value

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Data for the "Length Measurement/Edge Detection" Job				
116.0	END_VAL	DINT	L#0	End value
120.0	LEN_VAL	DINT	L#0	Length
Data for the "Read Counted Values" Job				
124.0	CNT_TRC0	INT	0	Current counter value for counter cam track 0
126.0	CNT_TRC1	INT	0	Current counter value for counter cam track 1
Data for the "Read Position and Track Data" Job				
128.0	ACTPOS	DINT	L#0	Current position
132.0	ACTSPD	DINT	L#0	Current feedrate
136.0	TRACK_ID	DWORD	DW#16#0	Track flag bits of tracks 0 to 31
Data for the "Read Encoder Data" Job				
140.0	ENCVAL	DINT	L#0	Encoder value
144.0	ZEROVAL	DINT	L#0	Counter reading at last zero mark
148.0	ENC_ADJ	DINT	L#0	Absolute Encoder Adjustment
Data for the "Read Cam and Track Data" Job				
152.0	CAM_00_31	DWORD	DW#16#0	Cam flag bits for cams 0 to 31
156.0	CAM_32_63	DWORD	DW#16#0	Cam flag bits for cams 32 to 63
160.0	CAM_64_95	DWORD	DW#16#0	Cam flag bits for cams 64 to 95
164.0	CAM_96_127	DWORD	DW#16#0	Cam flag bits for cams 96 to 127
168.0	TRACK_ID1	DWORD	DW#16#0	Track flag bits of tracks 0 to 31
172.0	ACTPOS1	DINT	L#0	Current position
Data for the "Fast Cam Parameter Change" Job				
176.0	C_QTY	BYTE	B#16#0	Number of cams to be modified
177.0	DIS_CHECK	BOOL	FALSE	1 =deactivate data check
180.0	CAM	ARRAY [0...15] STRUCT		Note: The following structure must be completed for each cam to be modified
Relative Address				
+0.0	CAM_NO	BYTE	B#16#0	Number of the cam to be modified
+1.0	C_EFFDIR	BOOL	FALSE	1 = change the activation direction
+1.1	C_CBEGIN	BOOL	FALSE	1 = change the cam start to the value CBEGIN (new cam start)
+1.2	C_CEND	BOOL	FALSE	1 = change the cam end / on time to the value CEND (new cam end)

Table C-1 Content of the Channel DB

Address	Name	Type	Initial Value	Comment
Relative Address				
+1.3	C_LTIME	BOOL	FALSE	1 = change the lead time to the value LTIME (new lead time)
+1.4	CAM_OFF	BOOL	FALSE	1 = deactivate the cam during the cam data modification
+1.5	EFFDIR_P	BOOL	FALSE	1 = new activation direction positive (plus)
+1.6	EFFDIR_M	BOOL	FALSE	1 = new activation direction negative (minus)
+2.0	CBEGIN	DINT	L#0	New cam start
+6.0	CEND	DINT	L#0	New cam end / new on time
+10.0	LTIME	INT	0	New lead time

C.2 Content of the Parameter DB

Note

Do not modify data that are not listed in this table.

Table C-2 Content of the Parameter DB

Address	Name	Type	Initial Value	Comment
Machine data				
3.1	PI_MEND	BOOL	FALSE	0 for FM 352
3.2	PI_CAM	BOOL	FALSE	1: Enable hardware interrupt: Cam on/off
3.5	PI_MSTRT	BOOL	FALSE	0 for FM 352
4.0	EDGEDIST	DINT	L#0	Minimum edge-to-edge distance for edge detection
8.0	UNITS	DINT	L#1	System of Units
12.0	AXIS_TYPE	DINT	L#0	0: Linear axis, 1: Rotary axis
16.0	ENDROTAX	DINT	L#100000	End of rotary axis
20.0	ENC_TYPE	DINT	L#1	Encoder type, frame length
24.0	DISP_REV	DINT	L#80000	Distance per encoder revolution
32.0	INC_REV	DINT	L#500	Increments per encoder revolution
36.0	NO_REV	DINT	L#1024	Number of encoder revolutions
40.0	BAUDRATE	DINT	L#0	Baud rate
44.0	REFPT	DINT	L#0	Reference point coordinate
48.0	ENC_ADJ	DINT	L#0	Absolute Encoder Adjustment
52.0	RETR_TYPE	DINT	L#0	Type of retrigger reference point
56.0	CNT_DIR	DINT	L#0	Count direction: 0: normal, 1: inverted
63.0	MON_WIRE	BOOL	TRUE	1: Wire break monitoring
63.1	MON_FRAME	BOOL	TRUE	1: Frame error monitoring
63.2	MON_PULSE	BOOL	TRUE	1: Missing pulse monitoring
64.0	SSW_STRT	DINT	L#-100000000	Start of software limit switch
68.0	SSW_END	DINT	L#100000000	End of software limit switch
76.0	C_QTY	DINT	L#0	Number of cams: 0, 1, 2, 3 = max. 16, 32, 64, 128 cams
80.0	HYS	DINT	L#0	Hysteresis
84.0	SIM_SPD	DINT	L#0	Simulation speed
90.0	TRACK_OUT	WORD	W#16#0	Control of track outputs: 0 = cam controller, 1 = CPU; Bit number = track number
95.0	EN_IN_I3	BOOL	FALSE	Enable input I3

Table C-2 Content of the Parameter DB

Address	Name	Type	Initial Value	Comment
Machine data				
95.1	EN_IN_I4	BOOL	FALSE	0 for FM 352
95.2	EN_IN_I5	BOOL	FALSE	0 for FM 352
95.3	EN_IN_I6	BOOL	FALSE	0 for FM 352
95.4	EN_IN_I7	BOOL	FALSE	0 for FM 352
95.5	EN_IN_I8	BOOL	FALSE	0 for FM 352
95.6	EN_IN_I9	BOOL	FALSE	0 for FM 352
95.7	EN_IN_I10	BOOL	FALSE	0 for FM 352
99.0	SPEC_TRC0	BOOL	FALSE	1 = track 0 is counter cam track
99.1	SPEC_TRC1	BOOL	FALSE	1 = track 1 is counter cam track
99.2	SPEC_TRC2	BOOL	FALSE	1 = track 2 is brake cam track
100.0	CNT_LIM0	DINT	L#2	Upper counter value for counter cam track 0
104.0	CNT_LIM1	DINT	L#2	Upper counter value for counter cam track 1
Cam data for cams 0 to 15 / 0 to 31 / 0 to 63 / 0 to 127				
108.0		STRUCT		(12 bytes length per element)
Relative Address				
+0.0	CAMVALID	BOOL	FALSE	1: Cam valid
+0.1	EFFDIR_P	BOOL	TRUE	1: Activation direction positive (plus)
+0.2	EFFDIR_M	BOOL	TRUE	1: Activation direction negative (minus)
+0.3	CAM_TYPE	BOOL	FALSE	0: Distance cam, 1: Time cam
+0.4	PI_SW_ON	BOOL	FALSE	1: Hardware interrupt on activation
+0.5	PI_SW_OFF	BOOL	FALSE	1: Hardware interrupt on deactivation
+1.0	TRACK_NO	BYTE	B#16#0	Track number
+2.0	CBEGIN	DINT	L#-100000000	Cam start
+6.0	CEND	DINT	L#100000000	Cam end/activation time
+10.0	LTIME	INT	0	Lead time

C.3 Data and Structure of the Diagnostic DB

Note

Do not modify data that are not listed in this table.

Table C-3 Structure of the Diagnostic DB

Address	Name	Type	Initial Value	Comment
0.0	MOD_ADDR **(enter!)**	INT	0	Module address
256.0	JOB_ERR	INT	0	Communication error
258.0	JOBBUSY	BOOL	FALSE	1 = job active
258.1	DIAGRD_EN	BOOL	FALSE	1 = read diagnostic buffer unconditional
260.0	DIAG_CNT	INT	0	Number of valid entries in the list
262.0	DIAG[1]	STRUCT		Diagnostic data latest entry
272.0	DIAG[2]	STRUCT		Diagnostic data second entry
282.0	DIAG[3]	STRUCT		Diagnostic data third entry
292.0	DIAG[4]	STRUCT		Diagnostic data oldest entry

The diagnostic entry DIAG[n] is structured as follows:

Table C-4 Structure of the Diagnostic Entry

Address	Name	Type	Initial Value	Comment
+0.0	STATE	BOOL	FALSE	0 = event entering state 1 = event leaving state
+0.1	INTF	BOOL	FALSE	1 = internal error
+0.2	EXTF	BOOL	FALSE	1 = external error
+2.0	FCL	INT	0	Error class: 1: Operating errors 4: Data errors 5: Machine data errors 7: Cam data errors 15: Messages 128: Diagnostic errors
+4.0	FNO	INT	0	Error number 0 to 255
+6.0	CH_NO	INT	0	Channel number (always 1)
+8.0	CAMNO	INT	0	Cam number 0 to 127 for error class = cam data errors

List of JOB_ERR Messages

JOB_ERR (hex)	JOB_ERR (dec)	JOB_ERR (int)	Meaning
80A0	32928	-32608	Negative acknowledgment when reading from module. Module removed during read operation or module defective.
80A1	32929	-32607	Negative acknowledgment when writing to module. Module removed during write operation or module defective.
80A2	32930	-32606	DP protocol error at layer 2
80A3	32931	-32605	DP protocol error at user interface / user
80A4	32932	-32604	Communication problem on K bus
80B1	32945	-32591	Specified length wrong. Incorrectly set FM_TYPE parameter in the channel DB for the module in use.
80B2	32946	-32590	The configured slot is empty.
80B3	32947	-32589	Actual module type does not match configured module type.
80C0	32960	-32576	The module does not have the data to be read.
80C1	32961	-32575	The data of a write job of the same type have not yet been processed on the module.
80C2	32962	-32574	The module is currently processing the maximum number of jobs.
80C3	32963	-32573	Required resources (memory etc.) currently in use.
80C4	32964	-32572	Communication error
80C5	32965	-32571	Distributed I/Os not available.
80C6	32966	-32570	Priority class abort (warm restart or background)
8522	34082	-31454	Channel DB or parameter DB too short. The data cannot be read from the DB. (write job)
8532	34098	-31438	DB number of the parameter DB too high. (write job)
853A	34106	-31430	Parameter DB does not exist. (write job)
8544	34116	-31420	Error in nth (n > 1) read access to a DB after error occurred. (write job)
8723	34595	-30941	Channel DB or parameter DB too short. The data cannot be written to the DB. (read job)
8730	34608	-30928	Parameter DB on the CPU write-protected. The data cannot be written to the DB (read job).
8732	34610	-30926	DB number of the parameter DB too high. (read job)
873A	34618	-30918	Parameter DB does not exist. (read job)
8745	34629	-30907	Error in nth (n > 1) write access to a DB after error occurred. (read job)
The errors 80A2 to 80A4 and 80Cx are temporary; in other words, they can be cleared after a waiting time without you taking any action. Messages in the form 7xxx indicate temporary states in communication.			

C.4 Error Classes

Class 1: Operating Errors

Operating errors are detected asynchronous to operator input/commands.

No.	Meaning		Diagnostic Interrupt
1	**Software limit switch start passed**		Yes
2	**Software limit switch end passed**		Yes
3	**Travel range start passed**		Yes
4	**Travel range end passed**		Yes
13	**Set actual value on-the-fly cannot be executed**		Yes
	Cause	The software limit switches are outside the travel range (-100m...+100m or -1000m...+1000m) after the set actual value on-the-fly. The shift resulting from set actual value / set actual value on-the-fly is more than ± 100m or ± 1000m.	
	Effect	Axis not synchronized	

Class 4: Data Errors

Data errors are detected synchronous to operator input/commands.

No.	Meaning		Diagnostic Interrupt
10	**Bad zero offset**		No
	Cause	The zero offset is more than ± 100m or ± 1000m. The software limit switches are outside the travel range (-100m...+100m or -1000m...+1000m) after setting the zero offset. Rotary axis: The value of the zero offset is higher than the end of the rotary axis.	
11	**Bad actual value specified**		No
	Cause	Linear axis: the coordinate is outside the current (possibly shifted) software limit switch. Rotary axis: The coordinate is < 0 or higher than the end of the rotary axis.	
12	**Bad reference point**		No
	Cause	Linear axis: the coordinate is outside the current (possibly shifted) software limit switch. Rotary axis: The coordinate is < 0 or higher than the end of the rotary axis.	

No.	Meaning		Diagnostic Interrupt
20	**Activate machine data not permitted**		No
	Cause	There are no new (error-free) machine data on the module	
21	**Set actual value on-the-fly not permitted**		No
	Cause	An attempt was made to execute “set actual value on-the-fly” while “retrigger reference point” was active.	
27	**Illegal bit-coded setting**		No
	Cause	Unused and, in this case, unwritten bits are not 0. An attempt was made to select “length measurement” and “edge detection” at the same time.	
28	**Retrigger reference point is not permitted**		No
	Cause	An attempt was made to execute “retrigger reference point” while “set actual value on-the-fly” was active. An attempt was made to execute “retrigger reference point” with an SSI encoder.	
29	**Illegal bit-coded command**		No
	Cause	Unused and, in this case, unwritten bits are not 0.	
30	**Bad lead time**		No
31	**Bad cam number**		No
	Cause	The cam is not valid. The cam number is not in the range 0 to 127.	
32	**Bad cam start**		No
	Cause	The cam start is outside the travel range (-100m...+100m or -1000m...+1000m). Rotary axis: The cam start is < 0 or higher than the end of the rotary axis.	
33	**Bad cam end / bad activation time**		No
	Cause	The cam end is outside the travel range (-100m...+100m or -1000m...+1000m) . Rotary axis: The cam end is < 0 or higher than the end of the rotary axis. The cam is not active for at least the duration of a pulse.	
34	**Cancel set actual value not possible**		No
	Cause	The actual position value would be outside the working range with an SSI encoder and linear axis after making the setting.	

No.	Meaning		Diagnostic Interrupt
35	**Bad actual value specified for set actual value / set actual value on-the-fly**		No
	Cause	The specified actual value is outside the permitted numeric range of ± 100 m or ± 1000 m. The software limit switches would be outside the travel range (-100m...+100m or -1000m...+1000m) after making the setting. The shift resulting from set actual value / set actual value on-the-fly would be more than ± 100 m or ± 1000 m.	
107	**Parameters not set for the axis**		No
	Cause	There are no machine data on the axis. There are no machine data activated on the axis.	
108	**Axis not synchronized**		No
	Cause	One of the settings “set actual value”, “set actual value on-the-fly”, and “retrigger reference point” was started although the axis is not synchronized.	
109	**Cam processing running**		No
110	**Bad number of cams to be modified.**		No

Class 5: Machine Data Errors

The diagnostic interrupt is triggered only when there is an error in the system data block (SDB).

No.	Meaning		Diagnostic Interrupt
5	**Error in hardware interrupt setting**		Yes
	Cause	You have attempted to select a hardware interrupt that the module does not support.	
6	**Bad minimum edge-to-edge distance**		Yes
	Cause	You have entered a value < 0 or $> 10^9$ µm as the minimum edge-to-edge distance.	
8	**Bad axis type**		Yes
	Cause	You have specified neither 0 nor 1 as the axis type	
9	**Bad rotary axis end**		Yes
	Cause	The value for the end of the rotary axis is outside the permitted range of 1 to 10^9 µm or 1 to 10^8 µm (depending on the resolution).	
10	**Bad encoder type**		Yes
	Cause	The value for the encoder type is outside the permitted range of 1 to 10.	
11	**Bad distance /encoder revolution**		Yes
	Cause	The value for distance /encoder revolution is outside the permitted range of 1 to 10^9 µm (regardless of the resolution).	
13	**Bad number of increments /encoder revolution (see Section 8.5 page 8-15)**		Yes
14	**Bad number revolutions (see Section 8.5 page 8-15)**		Yes
15	**Bad baudrate**		Yes
	Cause	You have specified a baudrate outside the permitted range of 0 to 3.	
16	**Bad reference point coordinate**		Yes
	Cause	The coordinate is outside the range of -100m to +100m or -1000m to +1000m depending on the resolution. Linear axis: The coordinate is outside the working range. Rotary axis The coordinate is higher than the end of the rotary axis or < 0.	
17	**Bad absolute encoder adjustment**		Yes
	Cause	SSI encoder: The value of the absolute encoder adjustment is not in the encoder range (increments per encoder revolution * number of revolutions - 1).	
18	**Bad type of retrigger reference point**		Yes
	Cause	You have specified a value other than 0, 1, 6 and 7.	

No.	Meaning		Diagnostic Interrupt
19	**Bad direction adaptation**		Yes
	Cause	You have specified a value other than 0 and 1.	
20	**Hardware monitoring not possible**		Yes
	Cause		
21	**Bad software limit switch start**		Yes
	Cause	Linear axis: The software limit switch start is outside the travel range (-100m...+100m or -1000m...+1000m, depending on the resolution). Linear axis: software limit switch start and end including any existing zero offset) is less than -100 m or -1000 m (depending on the resolution).	
22	**Bad software limit switch end**		Yes
	Cause	Linear axis: The software limit switch end is outside the travel range (-100m...+100m or -1000m...+1000m, depending on the resolution) or is less than the software limit switch start. The software limit switch end (including any existing zero offset) is higher than +100 m or +1000 m (depending on the resolution).	
144	**Bad number of cams**		Yes
	Cause	You have specified a value other than 0 to 3 for the number of cams.	
145	**Bad hysteresis**		Yes
	Cause	The hysteresis is outside the range 0...65535*resolution. The hysteresis is higher than ¼*working range or ¼*rotary axis range.	
146	**Bad simulation speed**		Yes
	Cause	The simulation speed is outside the range 1000*RESO to $3*10^7$*RESO or is higher than $5* 10^8$ µm/min. The simulation speed cannot be set internally.	
147	**Bad track**		Yes
	Cause	Activation of a track outside 0 to 15 (bits 0 to 15) was selected.	
148	**Bad selection of the enable inputs**		Yes
	Cause	You wanted to enable a track outside 3 to 10 (bits 0 to 7) using an external signal.	
149	**Bad special track selection.**		Yes
	Cause	You wanted to define a track outside 0,1 and 2 (bits 0,1 and 2) as a special track	

No.	Meaning		Diagnostic Interrupt
150	**Bad upper counter value for track 0**		Yes
	Cause	You have specified a counter value < 2 or > 65535 as the upper counter value.	
151	**Bad upper counter value for track 1**		Yes
	Cause	You have specified a counter value < 2 or > 65535 as the upper counter value.	
200	**Bad resolution**		Yes
	Cause	You have specified a resolution < 0.1 µm/pulse or >1000 µm/pulse. You have specified a distance/encoder revolution and a number of pulses/encoder revolution, that results in a resolution of < 0.1 or > 1000.	
201	**Encoder does not match the working range / rotary axis range**		Yes
	Cause	SSI encoder and rotary axis: The encoder does not exactly cover the rotary axis range. Linear axis: The encoder does not cover at least the working range (including software limit switches).	

Class 7: Cam Data errors

The diagnostic interrupt is triggered only when there is an error in the system data block (SDB).

No.	Meaning		Diagnostic Interrupt
1	**Hardware interrupt not permitted**		Yes
	Cause	You want to specify a hardware interrupt for a cam with a cam number > 7.	
2	**Bad track number**		Yes
	Cause	The track number is outside the range 0 to 31.	
3	**Bad cam start**		Yes
	Cause	The cam start is outside the travel range (-100m...+100m or -1000m...+1000m). Rotary axis The cam start is < 0 and/or higher than the end of the rotary axis.	
4	**Bad cam end**		Yes
	Cause	The cam end is outside the travel range (-100m...+100m or -1000m...+1000m) . The cam is at least one pulse long. Rotary axis The cam end is < 0 and/or higher than the end of the rotary axis.	
5	**Bad activation time**		Yes
	Cause	The activation time is < 0µs. The maximum time depends on the number of cams: (see Section 8.9, page 8-26).	
6	**Bad lead time**		Yes
	Cause	The lead time is < 0µs or > 26000*100µs.	
50	**Too many cam records**		Yes
	Cause	You wanted to enter more cam records than is possible with this number of cams.	
51	**Axis in operation**		Yes
	Cause	You wanted to enter cam records while the cam controller is active.	
52	**Parameters not set for the axis**		Yes
	Cause	You want to enter cam data although not machine data are active yet.	

Class 15: Messages

No.	Meaning		Diagnostic Interrupt
1	**Start of parameter assignment**		No
	Cause	The module has detected a parameter assignment by a system data block.	
2	**End of parameter assignment**		No
	Cause	The module has processed the parameter assignment by a system data block error-free.	

Class 128: Diagnostic Errors

No.	Meaning		Diagnostic Interrupt
4	**External auxiliary voltage missing**		Yes
	Cause	External auxiliary 24 V voltage is not connected or has failed, front connector missing	
	Effect	See Page 11-4 • Cam processing switched off • Track outputs are switched off • With incremental encoders, synchronization is deleted. • The FM 352 has not had parameters assigned (return signal PARA = 0).	
	Rectification	Make sure that the 24 V connection is correct. (If 24 V connection is correct, then the module is defective.)	
51	**Watchdog expired**		Yes
	Cause	• Strong interference on the FM 352. • Error in the FM 352.	
	Effect	• Module is reset. • Provided that after resetting the module, no module defect is detected, the module is ready for operation again. • The module signals the expired WATCHDOG with “incoming” and “outgoing”.	
	Rectification	• Eliminate the interference. • Contact the relevant sales department who will require details of the circumstances leading to the error. • Replace the FM 352.	
52	**Internal module power supply failed**		Yes
	Cause	Error in the FM 352.	
	Effect	• Module is reset. • Provided that after resetting the module, no module defect is detected, the module is ready for operation again.	
	Rectification	Replace the FM 352.	

No.	Meaning		Diagnostic Interrupt
70	**Hardware interrupt lost**		Yes
	Cause	A hardware interrupt event has been detected by the FM 352 and cannot be signaled since the same event has not yet been processed by the user program/CPU.	
	Effect	• Cam processing switched off • Track outputs are switched off • With incremental encoders, synchronization is deleted.	
	Rectification	• Link OB40 into the user program • Check bus connection of the module • Deactivate process interrupt • Upgrade hardware and software to suit your process requirements (for example faster CPU, optimize user program)	
144	**Encoder wire break**		Yes
	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	• Cam processing switched off • Track outputs are switched off • With incremental encoders, synchronization is deleted.	
	Rectification	• Check encoder cable. • Keep within encoder specification. • Monitoring can be temporarily suppressed at the responsibility of the operator by setting appropriate parameters in the parameter assignment user interface. • Keep to the module technical data.	

No.	Meaning		Diagnostic Interrupt
145	**Frame error absolute encoder**		Yes
	Cause	The frame traffic between FM 352 and the absolute encoder (SSI) is incorrect or interrupted: • Encoder cable cut or not plugged in. • Incorrect encoder type • Encoder incorrectly set (programmable encoders) • Frame length incorrectly specified • Encoder supplies incorrect values (encoder defective) • Interference on measuring system cable • Baud rate selected too high	
	Effect	• Cam processing switched off • Track outputs are switched off • The last correct actual value remains unchanged till the end of the next correct SSI transfer	
	Rectification	• Check encoder cable. • Check the encoder. • Check the frame traffic between encoder and FM 352.	
146	**Missing pulses frame incremental encoder**		Yes
	Cause	• Encoder monitoring has detected missing pulses. • Number of increments per encoder revolution is incorrectly entered. • Encoder defective: Does not supply the specified number of pulses. • Bad or missing zero marker. • Interference affecting the encoder cable.	
	Effect	• Cam processing switched off • Track outputs are switched off • The synchronization is deleted.	
	Rectification	• Enter the number of increments/encoder revolution correctly. • Check the encoder and encoder cable. • Keep to shielding and grounding regulations. • Monitoring can be temporarily suppressed at the responsibility of the operator by setting appropriate parameters in the parameter assignment user interface.	

Index

D

E

F

G

H

I

J

L

M

N

O

T

U

V

W

Z

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