SIEMENS

SIMATIC

# S7-300
# FM 352 electronic cam controller

Operating Instructions

05/2011
A5E01071724-03

## Legal information

### Warning notice system

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

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**⚠ WARNING**

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

Siemens AG
Industry Sector
Postfach 48 48
90026 NÜRNBERG
GERMANY

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# Table of contents

# Preface 1

## Purpose of the manual

This manual gives you a complete overview of the FM 352 function module. It helps you during installation and commissioning. The procedures involved in installation, wiring, parameter assignment, and programming are described.

This manual is intended for the programmers of STEP 7 programs and for those responsible for configuring, commissioning, and servicing automation systems.

## Basic knowledge required

This manual presumes general knowledge in the field of automation engineering.

In addition, you should know how to use computers or devices with similar functions (e.g., programming devices) under the Microsoft® Windows® operating systems and have a knowledge of STEP 7 programming.

## Scope of the manual

This manual contains the description of the FM 352 electronic cam controller as valid at the time it was published. We reserve the right to publish modifications of FM 352 functionality in a separate Product Information.

| The manual with the number in the footer | applies to the FM 352 with order number |
|---|---|
| EWA 4NEB 720 6004–01 | 6ES7 352-1AH00-0AE0 |
| EWA 4NEB 720 6004–01 a | 6ES7 352-1AH01-0AE0 |
| C79000–G7000–C352–03 | 6ES7 352-1AH01-0AE0 |
| A5E01071724-01 | 6ES7 352-1AH01-0AE0 |
| A5E01071724-02 | 6ES7 352-1AH02-0AE0 |
| A5E01071719-03 | 6ES7 352-1AH02-0AE0 |

## Content of this manual

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

It comprises the following sections:

- Fundamentals part (Chapters 1 to 8)
- Reference part (Chapters 9 to 13)
- Appendices (A, B, C, and D)
- Index

## Standards

The SIMATIC S7-300 product series is compliant with IEC 61131-2.

## Recycling and disposal

The FM 352 is low in contaminants and can therefore be recycled. For ecologically compatible recycling and disposal of your old device, contact a certificated disposal service for electronic scrap.

## Additional support

If you have any further questions about the use of products described in this manual and do not find the right answers here, contact your local Siemens representative (http://www.siemens.com/automation/partner):

A guide to the technical documentation for the various products and systems is available on the Internet:

- SIMATIC Guide manuals (http://www.siemens.com/simatic-tech-doku-portal)

The online catalog and online ordering systems are also available on the Internet:

- A&D Mall (http://www.siemens.com/automation/mall)

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- Internet: SITRAIN homepage (http://www.sitrain.com)

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## Service & Support on the Internet

In addition to our documentation, we offer a comprehensive online knowledge base on the Internet at:

Industry Automation and Drive Technologies - Homepage (http://www.siemens.com/automation/service&support)

There you will find the following information, for example:

- The newsletter that provides up-to-date information on your products.
- The documents you need via our Search function in Service & Support.
- A forum for global information exchange by users and specialists.
- Your local partner for Automation and Drives.
- Information about on-site service, repairs, and spare parts. Much more can be found under "Services".

# Product overview 2

## 2.1 The FM 352

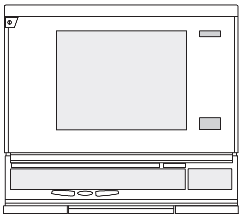
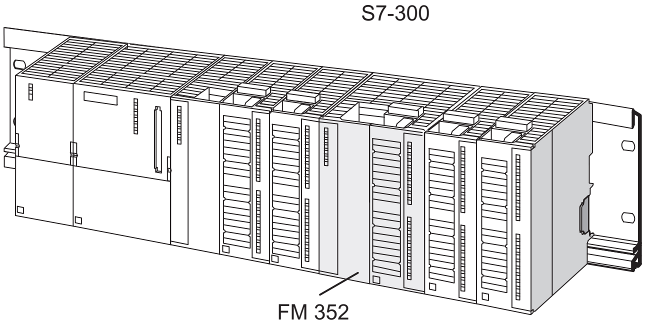
The FM 352 function module is a single-channel, electronic cam controller for integration in the S7-300 automation system. It supports rotary and linear axes. The module supports initiators and incremental or absolute encoders (SSI) for position feedback. When operating in slave mode, the FM 352 can listen in on the SSI frame of an absolute encoder.

You can specify up to 128 position-based or time-based 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 control, refer to the next chapters.

You can operate several FM 352 stations simultaneously. The module also supports combinations with other FM/CP modules. A typical application is the combination of the module with an FM 351 positioning module.

You can operate an FM 352 in a central and distributed configuration on PROFINET or PROFIBUS-DP.

Table 2- 1 Configuration of a SIMATIC S7-300 with FM 352

| Graphics | Description |
|---|---|
| | Configuration package containing the parameter assignment interface, the blocks, and the manual |
|  | Programming device (PG) with STEP 7, and the FM x52 parameter assignment interface |
|  | CPU with the user program and blocks of FM 352 |

## 2.2 Fields of application of FM 352

### Example: Applying glue tracks

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

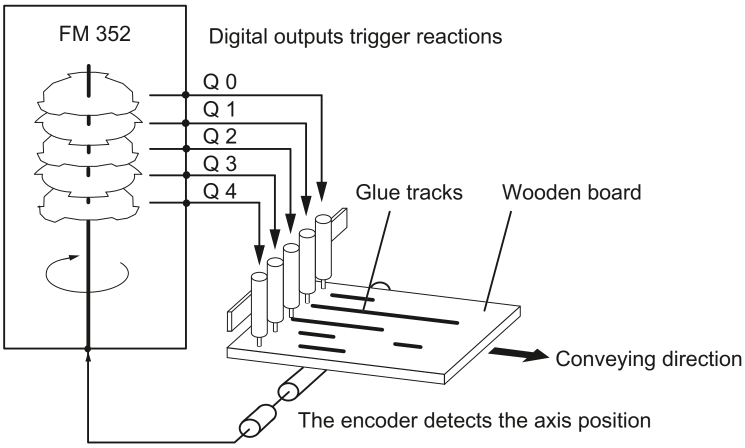

FM 352
Digital outputs trigger reactions
Q 0
Q 1
Q 2
Q 3
Q 4
Glue tracks
Wooden board
Conveying direction
The encoder detects the axis position

Figure 2-1 Example of an electronic cam control

### Example: Press control

The automation of an eccentric press using a cam controller is another typical application.

Press operation is based on a rotary motion, i.e. the rotary axis moves by 360 degrees, and then starts the next cycle at zero.

Typical tasks of an electronic cam controller:

- Switching a lubricating system on and off
- Enabling material feed and discharge (for example, gripper control)
- Stopping the press at the "upper dead center"

### Example: Packaging unit

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

- Inserting and unfolding the cardboard box on the automatic rotary turntable
- Filling the preserves into the cardboard boxes
- Closing the cardboard boxes
- Transfer of the cardboard boxes to a conveyor

## 2.3 Configuration of an electronic cam control with FM 352

### Components of the electronic cam control

The figure below shows the components of an electronic cam control. These are described briefly below.

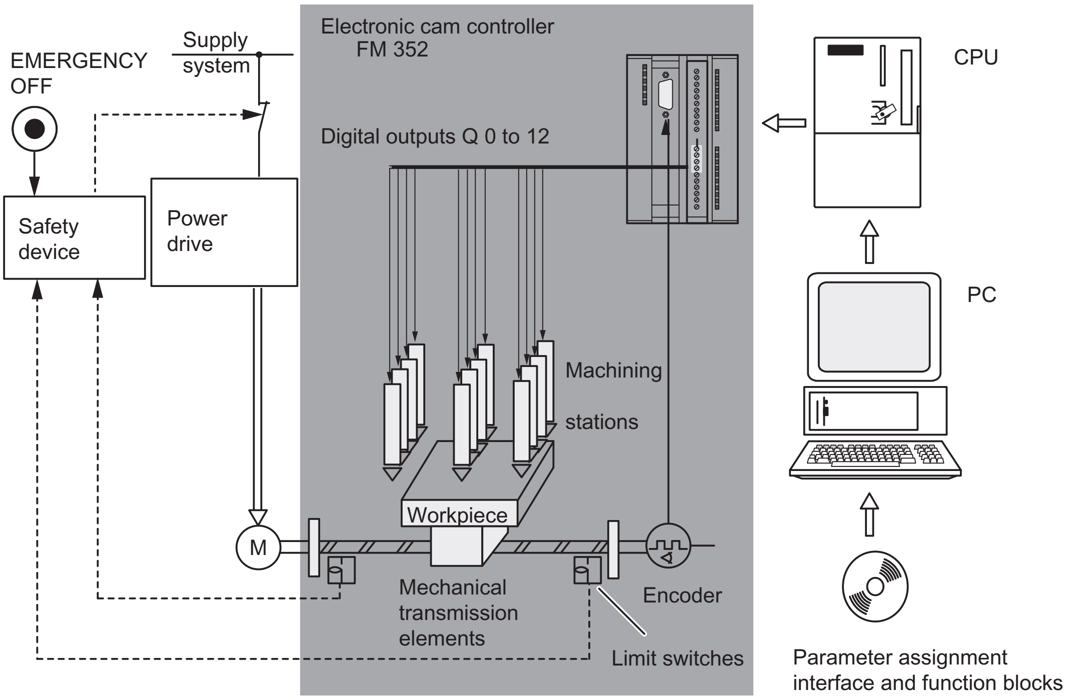


Figure 2-2 Electronic cam control

### Power drive and safety system

The motor is controlled by the power drive. The power drive may consist of a contactor circuit which is controlled by an FM 351 positioning module.

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

### Motor

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

## FM 352 electronic cam controller

The electronic cam controller determines the actual position value of the axis based on an encoder signal. It evaluates the encoder signals (for example, by counting the pulses) which are proportional to the distance traveled. Based on the actual position value, it sets or resets the digital outputs ("cams"). The processing stations are controlled by signals at the digital outputs.

## Encoder

The encoder returns position and direction data.

## CPU

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

## PG/PC

The electronic cam controller is programmed and assigned its parameters using a PG or PC.

- Assigning parameters: You assign parameters for the FM 352 using the parameter assignment interface or the parameter DB.
- Assigning parameters: You program FM 352 functions you can implement directly in the user program.
- Testing and commissioning: You test and commission the FM 352 with the help of the parameter assignment interface.

# Cam control basics 3

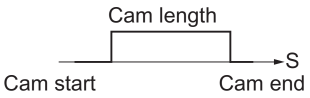
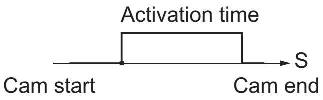
## 3.1 Properties of the cam types

### Cam types

You can assign each cam for operation as a position-based cam or time-based cam.

The table below shows a comparison of the properties of both cam types.

Table 3- 1 Definition and switching of the two cam types

| | Position-based cam | Time-based cam |
|---|---|---|
| **Representation** |  |  |
| **Parameter assignment** | The following parameters are assigned:<br>• Cam start<br>• Cam end<br>• Effective direction<br>• Lead time | The following parameters are assigned:<br>• Cam start<br>• Activation time<br>• Effective direction<br>• Lead time |
| **Effective direction** | Two effective directions are supported:<br>• positive: The cam is activated at the cam start, if the axis is moving in direction of increasing actual values.<br>• negative: The cam is activated at the cam end, if the axis is moving in direction of decreasing actual values.<br>You can set both effective directions in parallel. | Two effective directions are supported:<br>• positive: The cam is activated at the cam start, if the axis is moving in direction of increasing actual values.<br>• negative: The cam is activated at the cam start if the axis is moving in direction of decreasing actual values.<br>You can set both effective directions in parallel. |

| | Position-based cam | Time-based cam |
|---|---|---|
| Enabling | The cam is activated:<br>• at the cam start, if the axis is moving in positive direction and positive effective direction is set.<br>• at the cam end, if the axis is moving in negative direction and negative effective direction is set.<br>• when the actual value lies within the cam range. | The cam is activated:<br>• at the cam start, if the axis is moving in positive direction, and a positive effective direction is set.<br>• at the cam start, if the axis is moving in negative direction, and a negative effective direction is set.<br>After it has been activated, the full cam activation time elapses, even if the direction of motion of the axis changes after the cam is activated. The cam is **not** retriggered if its start position is passed once again within the cam activation time. |
| Deactivating | The cam is deactivated if:<br>• the assigned distance has been traveled<br>• axis motion in reversed effective direction is detected, and hysteresis is not assigned<br>• axis motion in reversed effective direction is detected, and the hysteresis is exited<br>• the actual value no longer lies within the cam range, e.g., "Set actual value"/"Set actual value on-the-fly". | The cam is deactivated on expiration of the assigned time, i.e., the activation time is not restarted. |
| Path length | The path length of the cam is defined by the cam start and cam end.<br>The cam start and cam end belong to the active section of the cam. | The path length of the cam is determined by the axis velocity within the cam activation time. |
| On period | The on period of the cam is determined by the speed at which the axis travels across the path length of the cam. | The on period of the cam is assigned with the activation time. |

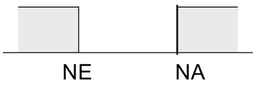
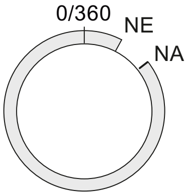
## Direction detection

The direction of the axis motion is determined as follows:

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

## Inverse cam

An inverse cam comes about if the cam start is greater than the cam end. The following table shows the effect of an inverse cam with a linear axis and a rotary axis.

| Inverse cam with a linear axis | Inverse cam with a rotary axis |
|---|---|
|  |  |
| The cam start (NA) is greater than the cam end (NE). | The cam start (NA) is more positive than the cam end (NE). |
| With both types of axes there must always be an interval of at least 4 pulses between the cam start and the cam end. | |

# 3.2 Tracks and track result

## 3.2.1 Standard tracks

### Cam tracks

The 32 tracks can be used to control up to 32 different switching actions. You can evaluate the tracks based on the checkback signals.

The first 13 tracks (track 0 to 12) are each assigned a digital output (Q0 to Q12) of FM 352. Those tracks can be used for the direct control of a connected contactor relay, for example.

### Track result

The system provides up to 128 cams which can be assigned to user-specific tracks.

Each track can be assigned several cams. The track result is a logic OR operation derived from all cam values of this track.

### Example of a track result

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

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

This leads to the following track result:

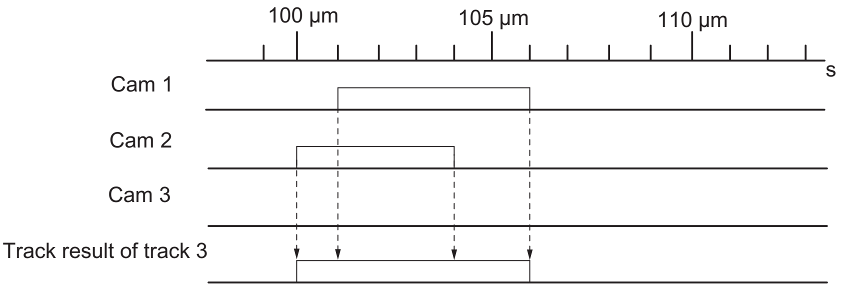


Figure 3-1 Calculating the track result

### Track enable

In order to transfer the track results of tracks 0 to 12 to as track signals to the digital outputs Q0 to Q12 of FM 352, enable the tracks used.

## External enable of track 3

You can assign an external enable signal for track 3 in the machine data. Track signal 3 is then logically linked to digital input I3 by an AND operation, before it can switch digital output Q3 of the FM 352.

Digital output Q3 is thus only set if the following conditions are satisfied:

- The corresponding 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 (according to digital outputs Q0 to Q12) can be set by the cam control system, or by the CPU.

### 3.2.2 Special tracks

#### Definition

You can program tracks 0 to 2 for operation as special tracks:

- Track 0 or 1: Counter cam track
- Track 2: Brake cam track

  Input I0 must be evaluated in order to enable the track.

#### Requirements

Requirements of working with special tracks:

- You programmed the cams for the track
- Cam processing is enabled
- The corresponding track is enabled
- The track is programmed as special track

#### Counter cam track

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

Define a counter value, and then start the counter function.

The counter value of the relevant track decrements by the count of 1 at each positive edge of the track result signal.

The track flag bit = 0 as long as the value of the counter cam track is not equal to zero.

When the counter value = 0, the controller sets the track flag bit and, if programmed accordingly, the track signal (see chapter "Interfaces of the cam controller (Page 25)").

It resets the track flag bit, and sets the default value of the counter at the next negative edge of the track result signal (all cams on this track are disabled).

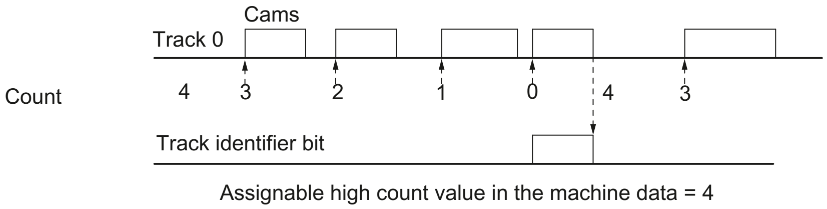


Figure 3-2 Setting a counter cam track

## Brake cam track

In order to use track 2 as a brake cam track, interconnect digital input I0.

A positive edge of the I0 signal 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 controller has detected a negative edge at the track 2 result signal.

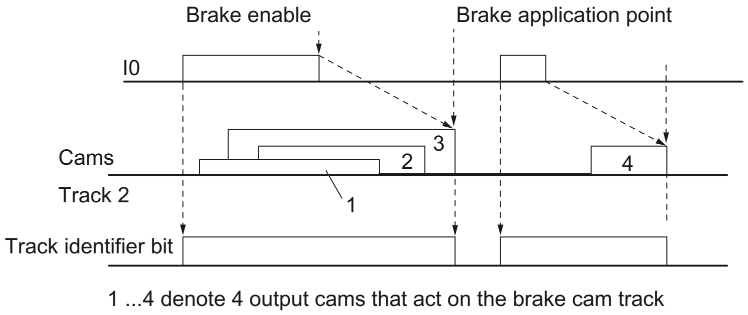


Figure 3-3 Setting a brake cam track

In the example, the track flag bit is reset by a negative edge at cam 3 or 4.

## 3.3 Hysteresis

### Definition

Mechanical imbalance at the axis may cause fluctuation of the actual position value. If the actual position value is offset by one edge of a cam, or within an active cam with only one effective direction, this cam's activation would be cycled on and off continuously. A hysteresis prevents this flutter.

A hysteresis setting is dependent on the actual value, and applies globally to all cams. It is enabled when a direction reversal is detected. A hysteresis will always take effect, regardless of whether or not a cam is set at the current axis position.

### Rules for the hysteresis range

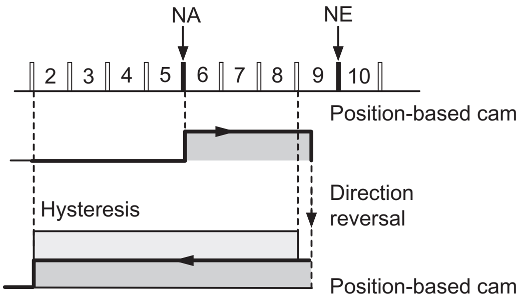
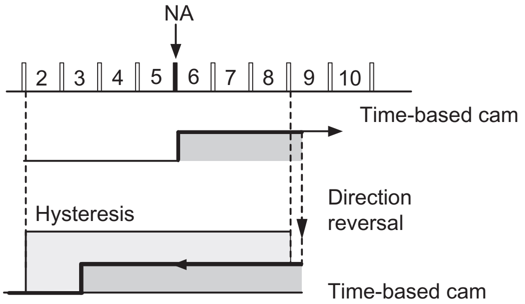
Rules applicable to the hysteresis range:

- The hysteresis will always be set when a directional reversal is detected.
- The indication of the actual value remains constant within the hysteresis.
- The direction is not redefined within the hysteresis.
- A position-based cam is neither activated nor deactivated within the hysteresis.
- A time-based cam is not activated within the hysteresis. An active time-based cam is deactivated on expiration of the assigned activation (not only on reaching the hysteresis limit).
- When the value is out of the hysteresis range, the FM 352 sets:
  - 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.

## Directional reversal of a cam with hysteresis

The table illustrates the reaction to directional reversal. A distinction must be made between the reaction of position- and time-based cams. The effective direction of the cam is **positive.**

Table 3- 2 Directional reversal of a cam

| Position-based cam | Time-based cam |
|---|---|
|  NA<br>NE<br>2 3 4 5 6 7 8 9 10<br>Position-based cam<br>Hysteresis<br>Direction reversal<br>Position-based cam |  NA<br>2 3 4 5 6 7 8 9 10<br>Time-based cam<br>Hysteresis<br>Direction reversal<br>Time-based cam |
| The hysteresis will be set when a directional reversal is detected. The cam is deactivated immediately when the hysteresis range is violated. | The cam always remains active for the duration of the assigned activation time. |
| ▨ Cam<br>□ Hysteresis | |

# 3.4 Dynamic adjustment

## Task

The dynamic adjustment is used to compensate delay times of the connected control elements.

## Derivative-action time

You can program a delay time and assign it as derivative-action time to each cam. You can assign one derivative-action time to each cam. The derivative-action time applies to the cam start and end position.

## Actuation distance

The actuation distance of a cam is calculated continuously based on the current velocity and derivative-action time. The entire cam is shifted in direction of the actual value by this value. The programmed range is the "static range," and the range calculated based on the derivative-action time represents the "dynamic range."

*Actuation distance = <derivative-action time> x <actual velocity of the axis>*

FM 352 calculates the actuation distance of all cams within 1/4 of the longest programmed derivative-action time.

An extremely high derivative-action time of a cam reduces the dynamic performance of cam processing.

# 3.5 Interfaces of the cam controller

## Overview

The graphic below contains a schematic diagram of the main interfaces to illustrate the relationship between data, inputs, and outputs.

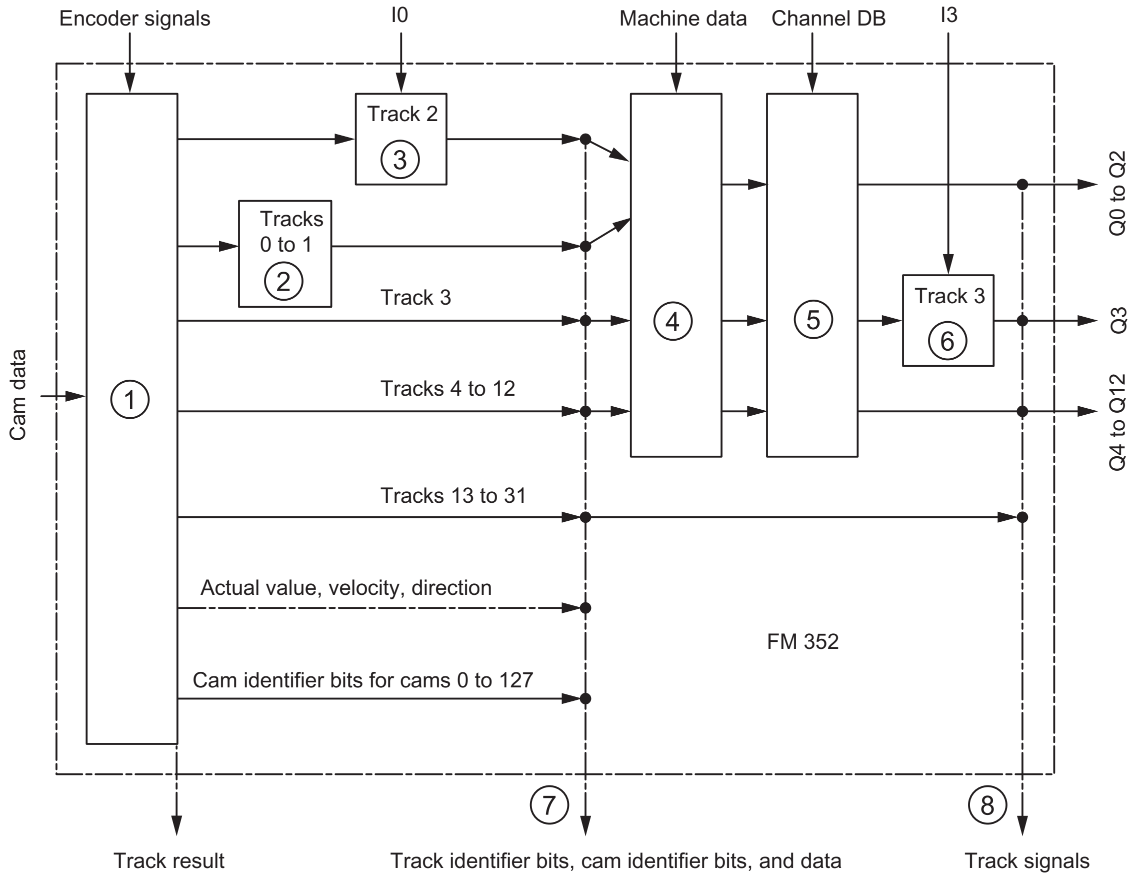


Figure 3-4 Interfaces of FM 352

| No. | Description |
|---|---|
| ① | The FM 352 cam processing functions calculate the cam identifier bits based on switching conditions and actual values. The module also determines the track results according to the assignment of the cams to the tracks. |
| ② | If you assigned track 0 or 1 as a counter cam track, the track result of the cam controller (point 1) is logically linked to the counter result in order to produce the track identifier bit. The track identifier bit is otherwise equivalent to the track result. |
| ③ | If you assigned track 2 as a brake cam track, the track result of the cam controller (point 1) is logically linked to input I0 to produce the track identifier bit. The track identifier bit is otherwise equivalent to the track result. |

| No. | Description |
|---|---|
| ④ | Using machine data, you can control whether the previously determined track identifier bits of tracks 0 to 12 of the cam controller are passed on, or whether they are set directly by the track enable signal (TRACK_EN). |
| ⑤ | You enable the track signals of tracks 0 to 12 by setting TRACK_EN, and the count function by setting CNTC0_EN / CNTC1_EN. |
| ⑥ | The track signal of track 3 and digital input I3 can be logically linked by an AND operation, provided you have set this option in the machine data (EN_IN_I3). |
| ⑦ | All track and cam identifier bits can be read at this location (i.e., before these are logically linked with machine and channel data) using the ACTPOS_EN or CAMOUT_EN job.<br>At tracks 3 to 31, the track identifier bit is equivalent to the track result (point 1). |
| ⑧ | After having been logically linked with the machine / channel data, the track signals of tracks 0 to 12 are available in the checkback signals. The track signals of tracks 13 to 31 and the track identifier bits of point 7 are identical. The track signals of tracks 0 to 12 are also available at the digital outputs Q0 to Q12. |

# Installing and removing the FM 352 4

## Important safety rules

Certain important rules and regulations govern the integrating of an S7-300 with FM 894.08 cm a plant or system. These are described in the Operating Instructions SIMATIC S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499).

## Rail mounting position

Horizontal installation of the rail is preferable.

For a vertical installation, make allowances for ambient temperature limits (max. 40 °C).

## Selecting slots

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

## Mechanical configuration

Rules for the layout of the modules on 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 by the mounting width of the modules.

   FM 352 requires a mounting width of 80 mm.
3. The number of installed modules (SM, FM, CP) is limited by the permitted current consumption on the S7-300 backplane bus. The current consumption in line 0 (CPU) must not exceed a total of 1.2 A; the value in the expansion lines 1 to 3 must not exceed 0.8 A each. The current consumption of the FM 352 from the backplane bus can be found in the Technical data (Page 166) in the appendix.

## Installation and removal tools

You require a 4.5 mm screwdriver to install or remove the FM 352.

## Installing the FM 352 electronic cam controller

1. The FM 352 is supplied with a bus connector. Plug this connector into the bus connector of module to the left of the FM 352. The bus connector is installed on the rear panel of the module; you may first have to loosen the module again.
2. If you install any further modules on the right side, start by plugging the bus connector of the next module into the right hand bus connector of FM 352.

   If the FM 352 is the last module in the tier, do not install a bus connector.
3. Screw-tighten the FM 352 (tightening torque approx. 0.8 N/m to 1.1 N/m).
4. After installation, you can assign a slot number to FM 352. For this purpose, the CPU comes with slot plates.

   The required numbering scheme and the procedure for inserting the slot plates can be found in the Operating Instructions SIMATIC S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499).
5. Install the shield connection element.

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

## Removing the electronic cam controller

1. Switch off the power drive.
2. Switch off the 24 V supply to FM 352.
3. Set the CPU to STOP.
4. Open the front panel covers.

   Remove the labeling strip.
5. Unlock and remove the front connector.
6. Remove the sub D connector of the encoder.
7. Loosen the fixing screw on the module.
8. Swivel the module up, and then remove it from the rail.

# Wiring the FM 352

# 5

## 5.1 Before you start wiring

### Important safety rule

It is imperative for system safety to install the switchgear listed below, and to adapt these to system conditions.

- EMERGENCY STOP switch to shut off the entire system.
- EMERGENCY STOP limit switches directly affecting the power components of all drives.
- Motor circuit-breakers.

# 5.2 Description of the encoder interface

## Location of the sub D socket

The figure shows the position and designation of the connector on the module. You can connect an initiator, incremental encoder or absolute encoder (SSI) to the sub D socket.

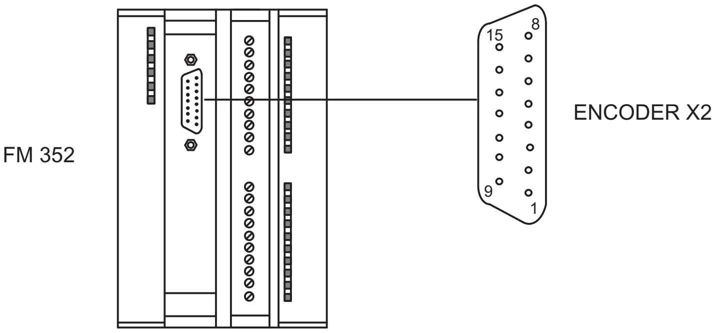


Figure 5-1 Location of the sub D socket X2

## Pin assignment of the encoder interface

| Pin | Name | Initiator | Incremental encoder | Absolute encoder |
|---|---|---|---|---|
| 1 | A* | Encoder signal A (24 V) | | --- |
| 2 | CLS | --- | --- | SSI shift clock |
| 3 | /CLS | --- | --- | SSI shift clock inverse |
| 4 | B* | --- | Encoder signal B (24 V) | --- |
| 5 | 24 V DC | Encoder supply 24 V | | |
| 6 | 5.2 V DC | --- | Encoder supply 5.2 V | |
| 7 | M | Ground | | |
| 8 | N* | --- | Zero mark signal (24 V) | --- |
| 9 | Computer Unit | --- | Current sourcing/current sinking[2] | --- |
| 10 | N | --- | Zero mark signal (5 V) | --- |
| 11 | /N | --- | Zero mark signal inverse (5 V) | --- |
| 12 | /B / /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 | /A / /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

[2] See chapter "Wiring Diagram of the Incremental Encoder Siemens 6FX 2001-4 (Up = 24 V; HTL) (Page 174)".

## 5.3 Connecting the encoder

### Shield connection element

The shield connection element is a comfortable means of bonding all shielded cables to ground, due to the direct connection between the shield connection element and the rack.

You will find detailed information in the Operating Instructions SIMATIC S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499).

### Procedure

1. Wire the cable to the encoder.

   The cables of absolute value encoders may have to be prepared (cable end to encoder) according to the manufacturer specifications.
2. Open the front panel cover and insert the d-sub connector into the FM 352.
3. Secure the connector by tightening the finger screws. Close the front cover.
4. Strip the cable, then clamp the shielding into the shield connection element. Use shield connection terminals.

## 5.4 Terminal assignment of the front connector

### Front connector

You connect the power supply and the switching elements by wiring these to the front connector.

### Terminal assignment of the front connector

| Terminal | Name | Meaning |
|---|---|---|
| 1 | L+ | 24 V DC encoder supply, and digital outputs |
| 2 | M | Ground of the encoder supply and digital outputs |
| 3 | I 0 | Brake enable |
| 4 | I 1 | Length measurement/ edge detection/ set actual value on-the-fly |
| 5 | I 2 | Home position switch |
| 6 | I 3 | Enable track signal 3 |
| 7 | Q 0 | Digital output 0 |
| 8 | Q 1 | Digital output 1 |
| 9 | Q 2 | Digital output 2 |
| 10 | Q 3 | Digital output 3 |
| 11 | Q 4 | Digital output 4 |
| 12 | Q 5 | Digital output 5 |
| 13 | Q 6 | Digital output 6 |
| 14 | Q 7 | Digital output 7 |
| 15 | Q 8 | Digital output 8 |
| 16 | Q 9 | Digital output 9 |
| 17 | Q 10 | Digital output 10 |
| 18 | Q 11 | Digital output 11 |
| 19 | Q 12 | Digital output 12 |
| 20 | - - - | - - - |

### Auxiliary voltage for encoders and digital outputs (L+, M)

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

- for wire-break of the 24 V feed line
- for power failure

The 24 V DC auxiliary supply is converted internally to 5.2 V DC. This supplies 24 V DC and 5 V DC at the encoder interface (sub D socket X2) to the various types of encoders.

The general technical data and requirements for the DC load power supplies are described in the Operating Instructions SIMATIC S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499).

## 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 have a non-isolated connection to the module chassis.

## 13 digital outputs (Q0 to Q12)

The state (on/off) of tracks 0 to 12 is output at 13 digital outputs. The digital outputs have a non-isolated connection to the module chassis.

Loads supported:

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

The state of each output can be read off from the respective LED.

## 5.5 Wiring the front connector

### Connecting cables

- The cables for digital IO must be shielded if they exceed a certain lengths:
  - Digital inputs: cable length > 32 m
  - Digital outputs: cable length > 100 m
- The encoder cables must be shielded.
- The shields of the encoder cables must be terminated at the shielding / ground conductor busbar, and on the IO connectors.
- Always use twisted-pair cables for the A/DAT, /A / /DAT, B/CLI, /B / /CLI, CLS, /CLS and N, and /N signals of the incremental encoder.
- Use flexible connecting cables with a conductor cross-section of 0.25 to 1.5 mm$^2$
- Wire end ferrules are not required. However, should you prefer to use these, you can crimp and wire two wires with a conductor cross-section of 0.25 to 0.75 mm$^2$ using a single ferrule without insulation collar (DIN 46228, design A, short version).

**Note**

If you connect measuring probes or proximity switches, you must use shielded cables to achieve optimum noise immunity.

### Note on wiring 24 V DC

⚠ CAUTION

The module can be damaged.

If you reverse the polarity of the encoder supply, the module will be destroyed and must be replaced!

Verify the correct polarity of the encoder supply (1L+, 1M)

### Tools required

3.5-mm screwdriver or power screwdriver

## Procedure

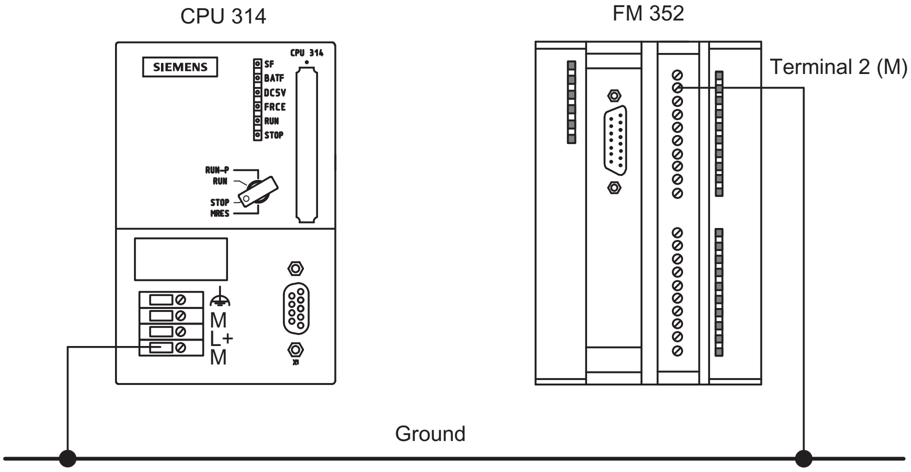
> **WARNING**
>
> Personal injury and damage to equipment on account of unshielded voltage.
>
> If you wire the FM 352 front connector while the system is in live state, you will risk injury from electric shock!
>
> Always switch off power before you wire the FM 352!
>
> If no EMERGENCY OFF switch is installed, damage may be caused by connected aggregates.
>
> Install an EMERGENCY OFF switch to be able to shut down the connected drives while operating the FM 352 via the *Parameter assignment interface*.

To wire the front connector:

1. Strip the wires to length of 6 mm. Crimp on wire end ferrules as required.
2. Open the front panel cover, then position the front connector for wiring.
3. install the cable strain relief in the connector.
4. To exit the cables at the bottom, terminate the wires starting at the bottom, otherwise at the top. Screw-tighten any unused terminals. Tightening torque = 0.6 N/m to 0.8 N/m.
5. Tighten the strain relief for the cable harness.
6. Move the front connector into operating position (press the interlocking element while doing so).
7. You can fill out the included label and insert it into the front panel cover.

## Non-isolation

The chassis of the encoder supply has a non-isolated connection to the chassis of the CPU; i.e., you have to connect terminal 2 (1M) to the chassis of the CPU or the IM 153 using a low-impedance connection.



# Installing the software 6

### Introduction

You assign parameters for the FM 352 using the *Parameter assignment interface.* This interface is designed for FM 352 and FM 452. A description of the *Programming interface* is available in the *Online Help*.

### Requirements

Before starting to assign parameters for the FM 352 Electronic Cam Controller, note the requirements in the readme.rtf file, in particular, the required version of STEP 7. The readme.rtf file is available on the CD included in your shipment.

### Installation

To install the configuration package:

1. Place the supplied CD in the CD drive of your programming device / PC.
2. Start the Setup.exe program.
3. Follow the operating instructions provided by the installation program.

### Result

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

- SIEMENS\STEP7\S7LIBS\FMx52LIB: FBs, FCs, and UDTs
- SIEMENS\STEP7\S7FCAM: Parameter assignment interface, Readme, Online Help
- SIEMENS\STEP7\EXAMPLES\zEn19_01andzEn19_02: Examples for FM 452 and FM 352
- SIEMENS\STEP7\MANUAL: Getting Started, Manuals

**Note**

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

### Configuring and assigning parameters

For further information, refer to the chapter "Commissioning the FM 352 (Page 61)".

# Programming the FM 352 7

### If your CPU supports the system blocks SFB 52 and SFB 53 with DPV1 functionality

Then use the blocks from the program folder "FM 352 CAM V2" to program the FM 352.

In addition to centralized use in the S7-300, these blocks also support distributed use with PROFINET and PROFIBUS DP.

You will find a description in this section.

### If your CPU does not support the system blocks SFB 52 and SFB 53 with DPV1 functionality

Then use the blocks from the program folder "FM 352,452 CAM V1" to program the FM 352.

For a description, please refer to Appendix D "Programming without SFB 52 and SFB 53 (Page 199)".

# 7.1 Basics of Programming an FM 352

## Task

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

## Preparation

- Open the block library FM352LIB in SIMATIC Manager, then copy the required functions (FCs), function blocks (FBs), and block templates (UDTs) to the block container of your project. If the block numbers are already being used, assign new numbers. The block names are entered unchanged in the symbol table of your S7 program.
  - CAM_INIT (FC 0):

    You need this FC to initialize the channel DB following a module startup.
  - CAM_CTRL (FB 1):

    You need this FB for data exchange with the module. The instance DB for this block is called "channel DB".
  - CAM_DIAG (FB 2):

    You need this FB when you process detailed diagnostic information in the program or want to make this information available to an operator control and monitoring system. The instance DB for this block is referred to as a "diagnostic DB".
  - CAM_P016TYPE (UDT3):

    You need this UDT to generate a parameter DB with machine data and data for 16 cams. The parameter DB is used by the FB 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 are using multiple modules, you require a separate set of data blocks for each module used.

- Enter the module address in the channel DB and, if necessary, also in the diagnostic DB in the MOD_ADDR parameter.

  Proceed as follows to enter the module address:

  – Recommended procedure:

    Assign the module address to the channel DB/diagnostic DB in the user program so that the assignment of the module address takes place when you call the user program in OB 100.

  – Alternative procedure:

    You can have the module address entered automatically if you select the module in HW Config, open the "Properties" dialog with the menu command **Edit > Object Properties**, and use the "Mod_Adr" button there to select a channel DB and diagnostic DB, if necessary. But in this case the values entered in the channel DB/diagnostic DB (including the module address) are reset to their initial values in the event of a consistency check (menu command **Edit > Check block consistency** opens the "Check block consistency" dialog) followed by a compilation (menu command **Program > Compile All** in the "Check block consistency" dialog box).

    The values are not changed if there is only a consistency check without compilation.

    The menu command **Edit > Compile All** is only required within the consistency check if the project was last edited with STEP 7 V5.0 Service Pack 2 or later.

- If your PG/PC is connected to a CPU, you can now download the blocks to the CPU.

## 7.2 FC CAM_INIT (FC 0)

### Tasks

FC CAM_INIT initializes the following data in the channel DB:

- The control signals
- The checkback signals
- The trigger, done and error bits of the jobs
- The function switches and their done and error bits
- Job management and the internal buffers for FB CAM_CTRL

### Call

The function must be executed after a startup, i.e., after the power supply to the module or CPU is switched on. You should therefore insert it, for example, in the restart OB (OB100) and the removal/insertion OB (OB83) or call it in the initialization phase of your user program. This ensures that your user program does not access obsolete data after a CPU or module restart.

### Call parameters

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

### Return values

This function does not return a return value.

## 7.3 FB CAM_CTRL (FB 1)

### Tasks

You can use FB CAM_CTRL to read operating data from the module, initialize the module, and control it during operation. For these tasks, you use the control signals, checkback signals, and write and read jobs.

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

- Read checkback signals:

  The FB CAM_CTRL reads all checkback signals from the module and enters these in the channel DB. The control signals and jobs are not executed until this task is completed, and thus the checkback signals reflect the module status prior to the block call.

- Write control signals:

  The control signals written to the channel DB are transferred to the module. Enabling of cam processing, however, is delayed as long as the trigger for a "Set reference point" job or "Write cam data" job is set. The activation (or reactivation) of cam processing is delayed by this time.

- Execute job:

  The next job is executed based on the trigger bits for jobs entered in the channel DB.

### Call

The function block must be called cyclically.

Before you call the block, 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.

### Parameters

| Parameter | Declaration | Data type | Description |
|---|---|---|---|
| DB_NO | INPUT | INT | Number of the channel DB |
| RETVAL | OUTPUT | INT | Return value |

## Jobs

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

To start a job, set the corresponding trigger bit in the channel DB and provide the relevant data for write jobs. You then call FB 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 in a distributed system, a read job may take several cycles.

Due to the required confirmations from the module, a write job requires at least 3 calls (or OB cycles). If you use the FM 352 in a distributed system, a write job may take more than 3 calls.

You can send several jobs at the same time, if necessary, along with control signals. With the exception of the job for writing the function switches, the jobs are executed in the order of the trigger bits specified in the channel DB. Once a job has been completed, the trigger bit is canceled. The next time the block is called, the subsequent job is identified 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 reset to 0.

## 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. 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. For this reason, FB CAM_CTRL makes sure that when one of the function switches is activated, the other is deactivated. If you do activate 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 FB 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

Call FC CAM_INIT at the startup of the module or CPU (see chapter "FC CAM_INIT (FC 0) (Page 42)"). Among other things, this resets the function switches.

FB CAM_CTRL acknowledges the module startup. During this time, RETVAL and JOBBUSY = 1.

## Return values

The block returns the following return values in the RETVAL parameter of the channel DB in word 372:

| RETVAL | BR | Description |
|---|---|---|
| 1 | 1 | At least 1 job active |
| 0 | 1 | No job active, no error |
| -1 | 0 | Error:<br>Data error (DAT_ERR) or<br>Communication error (JOB_ERR) occurred |

## Job status

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

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

## Reaction to errors

If faulty data were written by a write job, the module returns the message DATA_ERR = 1. If an error occurs during communication with the module for 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 canceled and error bit _ERR and done bit _D are set. The trigger bit is canceled and error bit _ERR is also set for all write jobs still pending.

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

- Error in a read job:

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

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

  For further error information, refer to the JOB_ERR and DATA_ERR parameters (see chapter "Diagnostics (Page 145)" and "Data and Structure of the Diagnostic DB (Page 187)").

## Application in the user program

The FB CAM_CTRL is indeed a multiple instance block, however cannot be used as a multiple instance in a user block.

## 7.4 FB CAM_DIAG (FB 2)

### Tasks

Use FB CAM_DIAG to read the diagnostic buffer of the module and make it available for display on an operator control and monitoring system or for a programmed evaluation.

### Call

The function block must be called cyclically. It is not permitted to initiate a second call in an interrupt OB. At least two calls (cycles) are required to completely execute this function.

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

### Data used

- Diagnostic DB:

  The module address must be entered in the diagnostic DB. The newest entry in the diagnostics buffer is written in the DIAG[1] structure and the oldest entry is written 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.

### Parameters

| Parameter | Declaration | Data type | Description |
|---|---|---|---|
| DB_NO | INPUT | INT | Number of the diagnostic DB |
| RETVAL | OUTPUT | INT | Return value |

### Startup

There is no startup processing associated with the function block.

## Return values

The block returns the following return values in the RETVAL parameter of the diagnostic DB in word 302:

| RETVAL | BR | Description |
|---|---|---|
| 1 | 1 | Job active |
| 0 | 1 | No job active, no error |
| -1 | 0 | Error |

## Reaction to errors

The cause of a job error can be found in the JOB_ERR parameter of the diagnostic DB (see chapter "Diagnostics (Page 145)" and "Data and Structure of the Diagnostic DB (Page 187)").

## Application in the user program

The FB CAM_DIAG is indeed a multiple instance block, however cannot be used as a multiple instance in a user block.

# 7.5 Data blocks

## 7.5.1 Templates for data blocks

The included FM352LIB library contains a block template (UDT) for the different variants of the machine data DB. Based on this UDT, you can create data blocks with user-specific numbers and names. You generate channel and diagnostic DBs as instances of FB 1 and FB 2.

## 7.5.2 Channel DB

### Task

The channel DB forms the data interface between the user program and the FM 352 electronic cam controller. It contains and accepts all data required for controlling and operating the module.

### Configuration

The channel DB is divided into various areas:

| Channel DB |
|---|
| Address* /version switch |
| Control signals |
| Checkback signals |
| Function switches |
| Trigger bits for write jobs |
| Trigger bits for read jobs |
| Done bits |
| Error bits |
| Job management for functions |
| Data for jobs |
| * You can enter the address in the parameter assignment interface. |

### 7.5.3 Diagnostic DB

#### Task

The diagnostic DB is the data storage for the FB CAM_DIAG and contains the diagnostic buffer of the module that has been prepared by this block.

#### Configuration

| Diagnostic DB |
|---|
| Module address |
| Internal data |
| Job status |
| Trigger bit |
| Prepared diagnostic buffer |

## 7.5.4 Parameter DB

### Task

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

A module may contain several parameter data sets (for example, for various recipes) that can be selected from the program.

### Configuration

| Parameter DB |
|---|
| CAM_P016TYPE (UDT3)<br>Machine data<br>Cam data of cams 0 to 15 |
| CAM_P032TYPE (UDT4)<br>Machine data<br>Cam data of cams 0 to 31 |
| CAM_P064TYPE (UDT5)<br>Machine data<br>Cam data of cams 0 to 63 |
| CAM_P0128TYPE (UDT6)<br>Machine data<br>Cam data of cams 0 to 127 |

# 7.6 Interrupts

## Interrupt processing

The FM 352 can trigger hardware and diagnostic interrupts. You process those interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU goes to STOP mode (refer to the *Programming with STEP 7* Manual).

You can enable interrupt processing in the following stages:

1. Global interrupt enable for the entire module
   - Select the module in HW Config

     Select **Edit > Object Properties > Basic Parameters**, then enable the diagnostic and/or hardware interrupt.
   - 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. Enable the hardware interrupt events in the machine data.
3. Assign the hardware interrupts in the cam data for cams 0 to 7.

## 7.7 Evaluation of a hardware interrupt

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

Table 7- 1 Content of 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 bytes 2 and 3 according to the table.

### Lost hardware interrupts

If the hardware interrupt OB is still busy processing a hardware interrupt, the module registers all subsequent hardware interrupt events. If an event occurs again before the hardware interrupt could be triggered, the module triggers a "hardware interrupt lost" diagnostic interrupt.

## 7.8 Evaluating a diagnostics interrupt

Following a diagnostic interrupt, the diagnostic information is available in the variables of OB 82 and can be used for a fast analysis. Call the CAM_DIAG block to find out the exact cause of the error by reading 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 fault |
| OB82_EXT_FAULT | BOOL | External fault |
| OB82_PNT_INFO | BOOL | Channel fault |
| OB82_EXT_VOLTAGE | BOOL | External auxiliary voltage missing |
| OB82_FLD_CONNCTR | BOOL | Front connector missing |
| OB82_WTCH_DOG_FLT | BOOL | Watchdog timeout |
| OB82_INT_PS_FLT | BOOL | Internal power supply of the module failed |
| OB82_HW_INTR_FLT | BOOL | Hardware interrupt lost |

## 7.9 Technical data

### Overview

The table below provides an overview of the technical specifications for the FM 352 blocks.

Table 7- 2 Technical specifications for FM 352 blocks

| No. | Block name | Version | Allocation in load memory (bytes) | Allocation in work memory (bytes) | Allocation in local data area (bytes) | MC7 code / data (bytes) | System functions called |
|---|---|---|---|---|---|---|---|
| FC 0 | FC CAM_INIT | 1.0 | 192 | 138 | 2 | 102 | |
| FB 1 | FB CAM_CTRL | 1.0 | 6940 | 5768 | 28 | 5768 | SFB 53: WR_REC,<br>SFB 52: RD_REC |
| FB 2 | FB CAM_DIAG | 1.0 | 2122 | 1874 | 36 | 1838 | SFB 52: RD_REC |
| | Channel DB | - | 1102 | 464 | - | 428 | |
| | Parameter DB 16<br>Parameter DB 32<br>Parameter DB 64<br>Parameter DB 128 | -<br>-<br>-<br>- | 616<br>808<br>1192<br>1960 | 336<br>528<br>912<br>1680 | -<br>-<br>-<br>- | 300<br>492<br>876<br>1644 | |
| | Diagnostic DB | - | 532 | 368 | - | 332 | |

### Module cycle

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

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

## 7.10 High-speed access to module data

### Application

Very fast access to checkback and control signals is required in special applications or in an alarm level. You can obtain those data directly by reading the IO areas of the module.

To coordinate startup following each module startup (for example, after inserting a module, CPU STOP → RUN), call FB CAM_CTRL continuously until the end of the startup is indicated by RETVAL = 0.

#### Note

For direct access to FM 352 data, always use the non-internal data and method described in this section. Otherwise, your user program will encounter difficulties accessing the module.

### Reading checkback signals via direct access

The byte addresses are defined with an offset to the output address of the module. The bit names correspond to the names in the channel DB.

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

| Address | Bit number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Byte 0 | PARA | Interna<br>l | 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_DONE | SYNC |
| Byte 4 | ACT_POS | | | | | | | |
| Byte 5 | | | | | | | | |
| Byte 6 | | | | | | | | |
| Byte 7 | | | | | | | | |
| Byte 8 | TRACK_OUT | | | | | | | |
| Byte 9 | | | | | | | | |
| Byte 10 | | | | | | | | |
| Byte 11 | | | | | | | | |

## Direct write access to control signals

The byte addresses are defined with an offset to the input address of the module. The bit names correspond to the names in the channel DB.

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

| 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)

The start address of the module is 512.

```
STL
L PID 516                                  Read the current actual position value
                                           (ACT_POS) with direct access:
                                           Module start address + 4
```

# 7.11 Parameter transmission paths

## Transmission paths

The term parameter refers to the following machine and cam data.

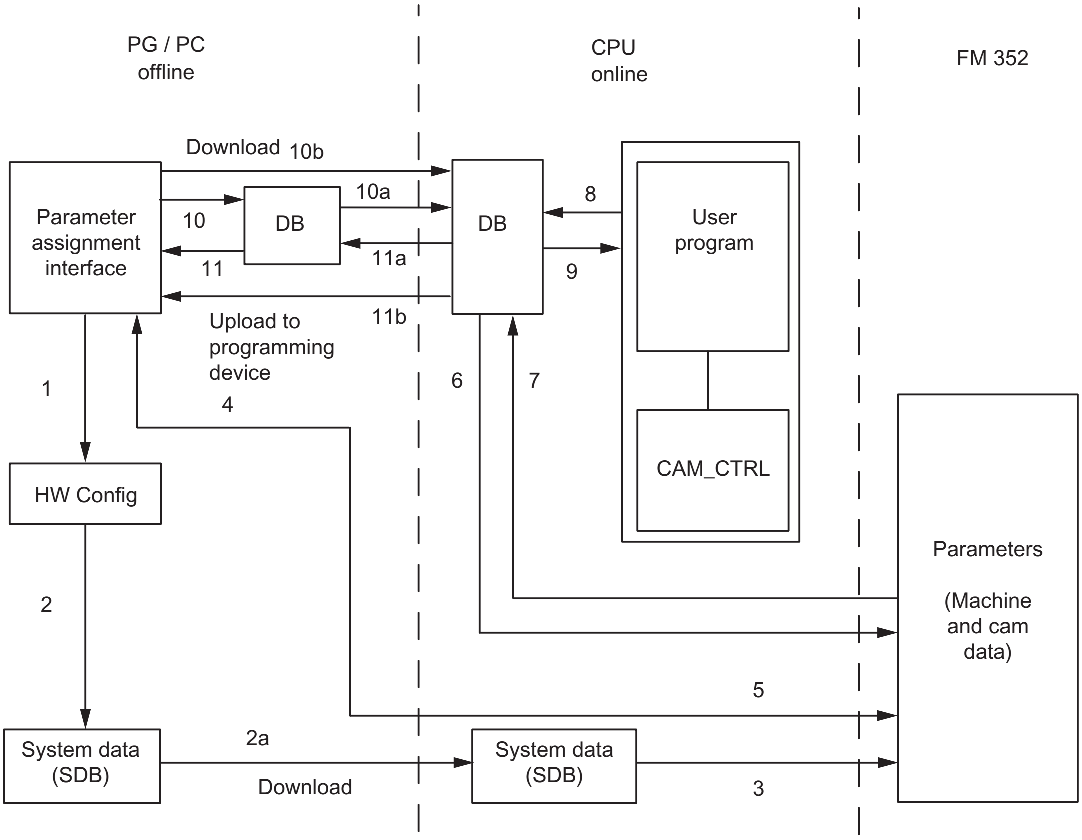


Figure 7-1 Parameter transmission paths

| | |
|---|---|
| 1 | Save the parameters in the parameter assignment interface. |
| 2 | Saving and compiling the HW configuration, and download to the CPU. |
| 3 | The CPU writes the parameters to the module during system parameter assignment. |
| 4 | Upload the module parameters to the PG by selecting the "PLC > Upload to PG" command. |
| 5 | Download the parameters from the parameter assignment interface to the module with the "PLC > 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 | Save parameters from the user program to the online DB. |
| 9 | Read in parameters from the online DB to the user program. |
| 10 | Export parameters from the parameter assignment interface to the DB (offline or online DB); an offline DB must then be downloaded to the CPU. |
| 11 | Import parameters from an online or offline DB into the parameter assignment interface. |

## Some use cases for the transfer of parameters

| Use case | Steps |
|---|---|
| You edit the parameters on the parameter assignment interface. The parameter should then be assigned automatically to the module during startup. | Perform steps 1, 2, and 3. |
| You edit parameters on the parameter assignment interface in the commissioning test mode: | Perform steps 4 and 5 |
| The parameters edited during commissioning should be downloaded automatically during startup. | Perform steps 1, 2, and 3. |
| Create the parameters using the parameter assignment interface. When it starts up, the module should be assigned parameters only by the user program using data blocks. | Perform steps 10 and 6. |
| You need a comfortable means of creating data records for recipes. | Perform step 10. |
| Create the parameters using the parameter assignment interface. These should be available to the user program for temporary modifications. | Perform steps 1, 2, and 3 for automatic parameter assignment. Perform steps 10, 7 to enable access by the user program. |
| You modify existing parameters (exclusively) using the user program. | Perform steps 7, 9, 8, and 6. |
| You want to view the data modified by the user program on the parameter assignment interface. | Perform step 11. |
| Parameters modified by the user program should also be loaded automatically during startup. | Perform steps 6, 11, 1, 2, and 3. |

# Commissioning the FM 352 8

## Important notes

Please observe the points listed in the following warnings.

⚠ WARNING

In order to prevent injury and material damage:

Install an EMERGENCY STOP switch in the area of the computer. This is the only way to ensure that the system can be switched off safely in the event of a computer or software failure.

Install an EMERGENCY STOP limit switch which directly affects the power units of all drives.

Always make sure to prevent access to the plant areas containing moving parts.

Concurrent controlling and monitoring of the FM 352 from your user program and on the Test > Commissioning screen form can lead to conflicts with unforeseeable effects. Hence, always set the CPU to STOP when working in the Test screen form, or disable the user program.

## Hardware installation and wiring

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

| Step | Description | ✓ |
|---|---|---|
| 1 | **Installing the FM 352** (see chapter "Installing and removing the FM 352 (Page 27)")<br>Insert the module in an available slot. | <br>❑ |
| 2 | **Wiring the FM 352** (see chapter "Wiring the FM 352 (Page 29)")<br>• Digital inputs at the front connector<br>• Digital outputs at the front connector<br>• Encoder connection<br>• Power supply to the FM 352 | <br>❑<br>❑<br>❑<br>❑ |
| 3 | **Check the limit switches relevant for safety**<br>Check the function of the following:<br>• Limit switches<br>• Emergency stop equipment | <br><br>❑<br>❑ |
| 4 | **Front connector**<br>The front connector must be engaged. | <br>❑ |
| 5 | Check the shielding of the various cables. | ❑ |
| 6 | **Switch on the power supply**<br>Switch the CPU to STOP (safe state).<br>Switch off the 24 V supply to FM 352. | <br>❑<br>❑ |

## Setting up a project

You now create a project in *STEP 7*.

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

| Step | Description | ✓ |
|---|---|---|
| 1 | If not already done, install the parameter assignment interface. | ❑ |
| 2 | Create a new project in SIMATIC Manager by selecting **File > New**. | ❑ |
| 3 | Add a station to your project (**Insert > Station**). | ❑ |
| 4 | Select the station, then run the configuration interface "HW Config" by double-clicking "Hardware". | ❑ |
| 5 | In your hardware configuration, insert a rack containing the:<br>• Power supply module (PS)<br>• CPU/IM 153<br>• Function module (FM) | <br>❑<br>❑<br>❑ |
| 6 | Save this hardware configuration in HW Config (**Station > Save**). | ❑ |

## Assigning parameters using the parameter assignment interface

For initial commissioning of the module, assign parameters for the module using the parameter assignment interface. Observe the following order:

| Step | Description | ✓ |
|---|---|---|
| 1 | Select the tier in the rack containing the FM 352 module. | ❑ |
| 2 | Next, double-click the entry to open the parameter assignment interface for FM 352. | ❑ |
| 3 | Select File > Properties to edit the following settings:<br>• General<br>You can edit the name and enter a comment.<br>• Addresses<br>You can edit the start address and assign the address area to a process image partition.<br>**Note the module address displayed.**<br>• Basic parameters<br>You can set the interrupt type and the reaction to a CPU STOP. | ❑ |
| 4 | In the block diagram shown, you can select the Axis, Encoders, Cams, Tracks **and** Interrupt Enable dialog boxes, and set the relevant parameters. | ❑ |
| 5 | Select File **>** Save to save the parameter assignment. | ❑ |
| 6 | Close the parameter assignment interface by selecting **File > Exit**. | ❑ |
| 7 | Backup the hardware configuration in HW Config by selecting **Station > Save and Compile**. | ❑ |
| 8 | Go online and download the hardware configuration to the CPU: The CPU transfers those data to the FM 352 at each STOP to RUN transition. | ❑ |
| 9 | Select Test > Commissioning. | ❑ |

## Test and Commissioning

You can now test your entries and changes.

| Step | Description | ✓ |
|---|---|---|
| 1 | To test your commissioning data, select the **Test > Commission**, **Test > Service** and **Test > Error Evaluation** screen forms. | ❑ |
| 2 | You can modify faulty machine data in the **Test > Commissioning** screen form. These changes remain valid until the next CPU STOP to RUN transition. | ❑ |
| 3 | You can save the corrected machine data to the CPU by repeating steps 7 to 9 of the sequence. | ❑ |

### Note

If you are using the FM 352 on PROFINET or PROFIBUS DP, the CPU must be in RUN mode for testing and commissioning. Otherwise, you cannot control the FM 352.

## Test steps for axis synchronization and switching characteristics

The tests described in the next section help you to validate FM 352 parameter assignment.

<table>
<tr><th>Step</th><th colspan="2">Description</th><th>✓</th></tr>
<tr><td rowspan="3">1</td><td colspan="2">Synchronize the axis</td><td></td></tr>
<tr><td>• Incremental encoder<br>– Select "set reference point". To do this enter the required value (see chapter "Set reference point (Page 110)").<br>**or**<br>– Set the "Retrigger reference point" function switch (see chapter "Retrigger reference point (Page 120)").</td><td>• Absolute encoder<br>– The FM 352 is always synchronized immediately following parameter assignment.<br>– Adjust the absolute encoder (see chapter "Determining the correct absolute encoder adjustment (Page 82)"). You may first have to determine the precise value using the "set reference point" function.</td><td>☐</td></tr>
<tr><td colspan="2">Check the actual status of the axis. The physical position must match the value output on the display.</td><td>☐</td></tr>
<tr><td>2</td><td colspan="2">Check the switching characteristics of the assigned cams and tracks.<br>• Enable testing.<br>• Execute the "set reference point" function.<br>• Activate cam processing.<br>• Enable the track signals.<br>• To do so, rotate the encoder **or**<br>• set the **simulation** function switch.</td><td>☐</td></tr>
<tr><td>3</td><td colspan="2">Test the other settings according to your application<br>• Set reference point<br>• Set actual value</td><td>☐</td></tr>
</table>

## Getting prepared for programming

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

| Step | Description | ✓ |
|---|---|---|
| 1 | Select the FMX52LIB library in SIMATIC Manager (**File > Open > Libraries**). | ☐ |
| 2 | From the program folder FM 352 CAM V2, copy the function FC 0 and the block FB 1 to the Blocks folder. | ☐ |
| 3 | Create a channel DB for each module (instance DB of FB CAM_CTRL). | ☐ |
| 4 | If you want to use a programmed diagnostic evaluation, copy FB 2 and create a diagnostic DB for each module. | ☐ |
| 5 | 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 | Description | ✓ |
|---|---|---|
| 1 | Open the channel DB. | ❑ |
| 2 | Make sure that the module address is entered in the MOD_ADDR parameter (refer to the section entitled Basics of Programming an FM 352 (Page 40)). | ❑ |
| 3 | Save the channel DB (**File > Save**). | ❑ |

## Preparing the diagnostic DB

| Step | Description | ✓ |
|---|---|---|
| 1 | Open the diagnostic DB. | ❑ |
| 2 | Make sure that the module address is entered in the MOD_ADDR parameter (refer to the section entitled Basics of Programming an FM 352 (Page 40)). | ❑ |
| 3 | Save the diagnostic DB (**File > Save**). | ❑ |

## Integrating blocks

| Step | Description | ✓ |
|---|---|---|
| 1 | Integrate the required functions and blocks in your user program. | ❑ |

## Downloading blocks to the CPU

| Step | Description | ✓ |
|---|---|---|
| 1 | Select the blocks in SIMATIC Manager, then download these with **PLC > Download to CPU.** | ❑ |

# Machine and cam data 9

## 9.1 Machine and cam data

### General information

This chapter is relevant if you want to write the parameters directly to the module in the user program, and without using the programming interface.

All machine and cam data are saved in the parameter DB. You must enter the parameter DB number in the associated channel DB in each case.

You can write to the parameter DB with "Export" and read the parameter DB with "Import" on the parameter assignment interface.

### Sequence when writing machine and cam data

Always edit machine and cam data in the following sequence:

1. Write machine data
2. Enable machine data
3. Writing cam data

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

## 9.2 Writing and enabling machine data

### General

Machine data are used to adapt the FM 352 to the axis and encoder.

Machine data are stored in the parameter DB at addresses 3.1 to 104.0.

### Initial parameter assignment

If the module does not yet contain machine data (checkback signal PARA = 0), follow these steps to initially assign parameters without the parameter assignment interface:

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

### Modifying machine data

To modify existing machine data (checkback signal PARA = 1) by means of the user program:

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

4. Check to see if the revised machine data were transmitted and enabled successfully by evaluating the done bit (_D ending) and error bit (_ERR ending) assigned to each job:

   – "Write machine data" job completed (MDWR_D)

   – "Enable machine data" job completed (MD_D)

   – Error during "Write machine data" job (MDWR_ERR)

   – Error during "Enable machine data" job (MD_ERR)

   A job was completed without errors if done bit = 1 and error bit = 0 (refer to the section entitled FB CAM_CTRL (FB 1) (Page 43)).

   Set the done and error bits of a job to 0 after evaluation.

   Note

   If any parameters relevant for synchronization were modified, the synchronization will be canceled when the machine data are activated. This operation also resets your settings and deletes all machine and cam data from the module.

   Parameters relevant to synchronization:

   - Axis type
   - End of rotary axis
   - Encoder type
   - Distance per encoder revolution
   - Increments per encoder revolution
   - Number of revolutions
   - Reference point coordinate
   - Absolute encoder adjustment
   - Type of reference point retriggering
   - Direction adaptation
   - Number of cams
   - Software limit switch start and end

5. Always rewrite the cam data of the assigned cams, regardless if they have been changed or not:

   – Write cam data n, n = 1...8 (CAM1WR_EN...CAM8WR_EN).

6. Check to see if the cam data were transmitted successfully by evaluating the done bit (_D ending) and error bit (_ERR ending) assigned to each job:

   – "Write cam data n" job completed, n = 1...8 (CAM1WR_D...CAM8WR_D).

   – Error in "Write cam data n" job, n = 1...8 (CAM1WR_ERR...CAM8WR_ERR).

   A job was completed without errors if done bit = 1 and error bit = 0 (refer to the section entitled FB CAM_CTRL (FB 1) (Page 43)).

   Set the done and error bits of a job to 0 after evaluation.

# 9.3 Read machine data

## Procedure

To read actual machine data from the module:

1. Set the following trigger bit in the channel DB:
   – Read machine data (MDRD_EN)
2. Call FB CAM_CTRL in the cyclic user program.

   This saves the current machine data to the parameter DB on the CPU.

## Excerpt from the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 35.0 | MDWR_EN | BOOL | FALSE | 1 = write machine data |
| 35.1 | MD_EN | BOOL | FALSE | 1 = enable machine data |
| 37.1 | MDRD_EN | BOOL | FALSE | 1 = read machine data |

# 9.4 Writing cam data

## Writing cam data

Cam data define the type and function principle of the cams and their assignment to the tracks.

Cam data are stored in the parameter DB, starting at address 108.0. These data are grouped in packets, each consisting of 16 cams.

Cam data are active immediately after having been written.

To write cam data without using the programming interface:

1. Enter the new values in the parameter DB.
2. Download the parameter DB to the CPU.
3. Set the trigger bits at the channel DB (CAM1WR_EN to CAM8WR_EN)
4. Call FB CAM_CTRL in the cyclic user program.

# 9.5 Reading cam data

## Reading cam data

To read actual cam data from the module:

1. Set the following trigger bit in the channel DB:
   – Read cam data (CAM1RD_EN to CAM8RD_EN)
2. Call FB CAM_CTRL in the cyclic user program.

   This saves the actual 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) |
| 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) |

## 9.6 Physical units system

### Selecting a system of units

You can choose a specific system of units for the input and output of data in the parameter assignment interface of the cam controller (default: mm).

You can set any of the following as the system of units:

- mm, inches, degrees, and pulse.

> **Note**
>
> If you change the system of units in the parameter assignment interface under STEP 7, the values are converted to the new system. This may lead to rounding errors.
>
> Values are **not** converted automatically if you change the system of units via the machine data.
>
> If the system of units is changed from or to "pulses", the cam processing is deactivated, and the axis is no longer synchronized.

### System of units in the parameter DB

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 8.0 | UNITS | DINT | L#1 | **System of units**<br>1 = $10^{-3}$ mm<br>2 = $10^{-4}$ inch<br>3 = $10^{-4}$ degrees<br>4 = $10^{-2}$ degrees<br>5 = pulses<br>6 = $10^{-3}$ degrees |

## Default system of units

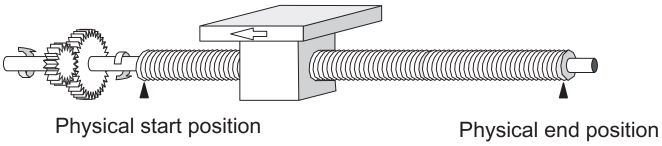
This manual always specifies limits using **mm as the system of units** To define the limits in another system of units, convert the values as shown below:

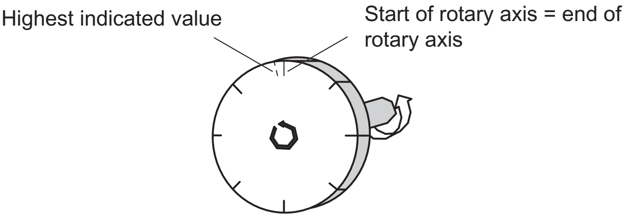
| To convert.... | | you calculate... |
|---|---|---|
| mm → inch | | Limit (inch) = limit (mm) × 0.1 [1] |
| mm → degrees | $10^{-4}$ (4 decimal places) | Limit (degrees) = limit (mm) × 0.1 |
| | $10^{-3}$ (3 decimal places) | Limit (degrees) = limit (mm) × 1 |
| | $10^{-2}$ (2 decimal places) | Limit (degrees) = limit (mm) × 10 |
| mm → pulses | | Limit (pulses) = limit (mm) × 1000 |

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

## 9.7 Machine data of the axis

### Axis type

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Start value</th><th>Comment</th></tr>
<tr><td>12.0</td><td>AXIS_TYPE</td><td>DINT</td><td>L#0</td><td><b>Axis type</b><br>0 = linear axis<br>1 = rotary axis</td></tr>
<tr><td colspan="5">A <b>linear axis</b> has a limited physical traversing range.


A <b>rotary axis</b> is not restricted in its motion range by mechanical limit stops.

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

## End of rotary axis

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 16.0 | ENDROTAX | DINT | L#100000 | **End of rotary axis**<br>Range: 1 µm to +1 000 000 000 µm |

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

The highest rotary axis value displayed is:

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

Example: End of rotary axis = 1000 mm

The displayed value jumps:

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

**Rotary axis with absolute encoders**

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

$$\text{Rotary axis end}[\mu\text{m}] = \text{Number of revolutions(encoder)} * \frac{\text{steps(encoder)[pulse]}}{\text{Revolution}} * \text{RES}[\frac{\mu\text{m}}{\text{Pulse}}]$$

## Reference point coordinate

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 44.0 | REFPT | DINT | L#0 | **Reference point coordinate**<br>Range:<br>- 1 000 000 000 µm to<br>+ 1 000 000 000 µm |

**Incremental encoder and initiator**

Using the "Retrigger reference point" function switch and a synchronization event defined by the "Type of reference point retriggering", the reference point coordinate is assigned to this event.

**Absolute encoder (SSI)**

An assigned axis with an absolute encoder is always synchronized, provided no error is detected (after transmission of the first error-free SSI frame).

For more information, refer to the absolute encoder adjustment description (see chapter "Determining the correct absolute encoder adjustment  (Page 82)"), which explains the interaction of the absolute encoder adjustment with the other data.

**Linear axis**

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

**Rotary axis**

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

## Retrigger reference point:

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment</th></tr>
<tr><td>52.0</td><td>RETR_TYPE</td><td>DINT</td><td>L#0</td><td>Type of reference point retriggering<br>Ranges:<br>0 = reference point switch and zero mark direction +<br>1 = reference point switch and zero mark direction -<br>6 = only reference point switch<br>7 = only zero mark</td></tr>
<tr><td colspan="5">By setting the "Type of reference point retriggering", you define the conditions for synchronizing the axis when working with an incremental encoder or an initiator (see chapter "Retrigger reference point (Page 120)").</td></tr>
</table>

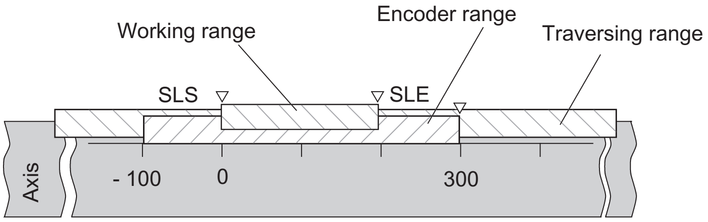
## Software limit switch start and end

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 64.0 | SSW_STRT | DINT | L# -100 000 000 | **Software limit switch start** |
| 68.0 | SSW_END | DINT | L# 100 000 000 | **Software limit switch end**<br>Range:<br>- 1 000 000 000 µm to 1 000 000 000 µm |

Those axis data are only of significance to a linear axis.

The software limit switches are enabled after the FM 352 is synchronized. The range set by the software limit switches represents the **working range**. The FM 352 can monitor the working range limits.

The software limit switch start (SLS) must always be less than the software limit switch end (SLE).



**Absolute encoder (SSI)**

The FM 352 is synchronized after it has received a complete frame without errors. It monitors the software limit switches as of this time. The absolute encoder used must cover at least the working range (from software limit switch start to software limit switch end, including the limits).

**Incremental encoder and initiator**

The axis is initially not synchronized after each restart of the FM 352. The assigned software limit switches are not monitored unless the module has completed a synchronization cycle.

**Relationship: working range, encoder range, traversing range**

- The "working range" is defined by your task-specific software limit switch settings.
- The "encoder range" represents the effective encoder range. For linear axes, the module imposes this range symmetrically across the working range, i.e., it shifts the encoder range in order to equalize the distances between the software limit switches and the ends of the encoder range (see the figure above).
- The "traversing range" represents the range of values the FM 352 is capable of processing. It is dependent on the resolution.

**The following applies: working range ≥ encoder range ≥ traversing range**

## Hysteresis

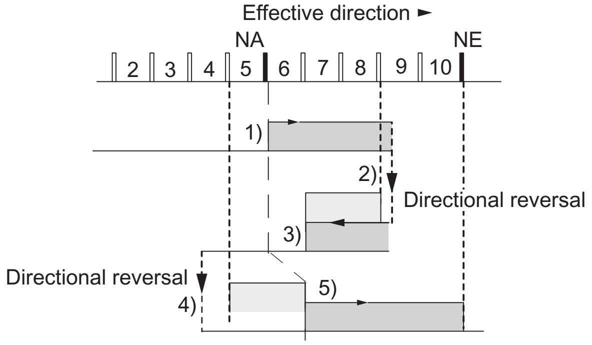
| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 80.0 | HYS | DINT | L#0 | **Hysteresis**<br>Ranges:<br>0 to 65 535 [Imp] x resolution [µm/Imp] |
| The range of values is determined by the resolution:<br>Maximum input value:<br>- to linear axes: max. input value < ¼ of the working range<br>- to rotary axes: max. input value < ¼ of the rotary axis range | | | | |

## Position-based cams and hysteresis

A position-based cam is activated if:

- the detected actual value lies within the position-based cam, and
- no hysteresis is set.

Switching points may vary, depending on the position of the direction reversal.



▨ Cam

□ Hysteresis

1) Cam is activated, as the cam start is crossed in the positive effective direction.
2) The cam remains active due to the hysteresis, irrespective of a direction reversal.
3) At the end of hysteresis, the cam is deactivated.
4) Cam remains deactivated after a direction reversal.
5) The cam is activated again at the end of the hysteresis.

Figure 9-1 Enabling position-based cams with hysteresis

### Note

When the direction is reversed, the hysteresis cannot reduce a cam actuation time shorter than the hysteresis.

## Time-based cam with hysteresis

A time-based cam is activated when:

- the cam start is crossed in the effective direction, and
- no hysteresis is set.

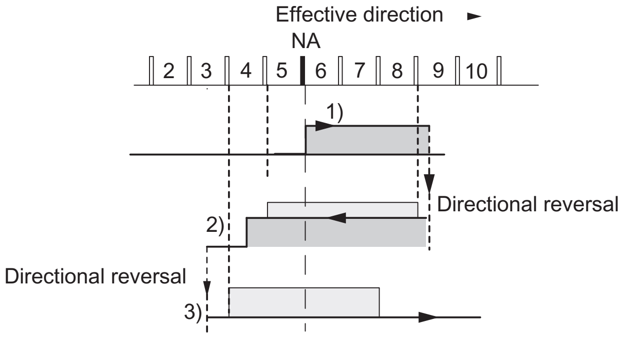
---

**Note**

The hysteresis will hide a time-based cam if its range between the reversal point and the cam start is less than the hysteresis.

---

The figure illustrates a time-based cam that is **not** activated again.



▨ Cams

□ Hysteresis

1) Cam is activated, as the cam start is crossed in the positive effective direction.

2) After the direction reversal, the cam remains active until the activation time has expired, regardless of the hysteresis.

3) Cam start is hidden by the hysteresis, the cam is not activated.

Figure 9-2 Activation of a time-based cam with hysteresis

## Simulation velocity

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 84.0 | SIM_SPD | DINT | L#0 | **Simulation velocity**<br>The simulation velocity depends on the resolution.<br>0 = standstill<br>$5 * 10^8$ = highest setting supported by the module<br>Within this range, the simulation velocity depends on the resolution:<br>1000 x resolution ≤ simulation velocity ≤ 3 x $10^7$ x resolution |

This machine data determines the simulation velocity (see chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)"). The physical simulation velocity $V_{sim}$ may deviate from the setting at $V_{sim,\,V}$, and is calculated according to the following formula:

$$V_{Sim} = \frac{6*10exp7*RES}{\text{Integer}\left(\frac{6*10exp7*RES}{V_{Sim,\,V}}\right)}$$

Meaning of this formula:

- $V_{sim:}$ Simulation velocity set by the FM 352. Unit: $^{µm}/_{min}$
- $V_{sim,\,V:}$ Default simulation velocity set in machine data.

  Unit: $^{µm}/_{min}$
- RES: Resolution derived from encoder data. Unit: $^{µm}/_{pulse}$
- Integer ( ): Of this expression, only the value before the decimal point is used for further calculation. In all calculations, this expression must lie within the range from 2 to 65536.

The actual simulation velocity changes abruptly as a result of the relationships (see the formula).

## Minimum edge interval

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 4.0 | EDGEDIST | DINT | L#0 | **Minimum edge interval**<br>Range:<br>0 ... 1 000 000 000 µm |

This machine data defines a range after detection of the start of a measurement for an edge detection. The measurement is discarded if the end of the measurement lies within this range.

The start of the measurement is not reported unless the minimum edge interval has been traveled.

# 9.8 Determining the correct absolute encoder adjustment

## Definition

The absolute encoder adjustment and reference point coordinate maps the encoder's range of values unambiguously to the axis coordinate system.

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 48.0 | ENC_ADJ | DINT | L#0 | **Absolute encoder adjustment**<br>Range: 0 to ($2^{25}$ -1) |
| The "Absolute encoder adjustment" is used to determine 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. | | | | |

## Procedure

After you completed the basic program, you need to define a balanced correlation between the encoder and the coordinate system. The procedure shown in the next section is based on the use of the programming interface.

1. Move the axis to a known and physically unambiguous, reproducible point.

   This could be the "Software limit switch end".
2. Call the "Set reference point" function, using the coordinate position defined in step 1.

   The FM 352 now calculates an encoder value for the reference point coordinate entered in the channel DB (REFPT in channel DB), namely the absolute encoder adjustment. You can view this value at the service screen for of the programming interface.
3. Enter the value from the service screen in the "Absolute encoder adjustment" field on the "Axis" tab of the parameter assignment interface.
4. Save your parameter assignment to the corresponding parameter DB using the export function.
5. Close the parameter assignment interface by selecting File and Exit.
6. In HW Config, download the data to the CPU.
7. Restart the CPU (cold restart) to apply the data.

**Note**

This adjustment is made once during commissioning. After parameters are assigned, the FM 352 is synchronized during startup as soon as it has received a complete, error-free encoder frame.

## Data in the channel DB

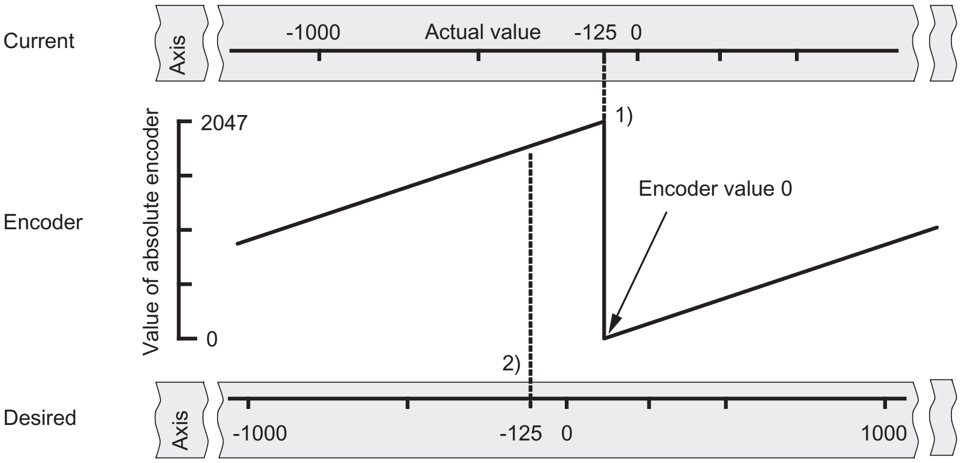
| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 98.0 | REFPT | DINT | L#0 | Reference point coordinate<br>Range:<br>- 1 000 000 000 µm to<br>+ 1 000 000 000 µm |

# 9.9 Example: Adjusting the absolute encoder

## Assumptions

For this example, let us presume:

- 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) at a resolution of 1 mm/pulse
- A precise mechanical adjustment of the absolute encoder is not possible, and there is no option for setting a selective actual value.



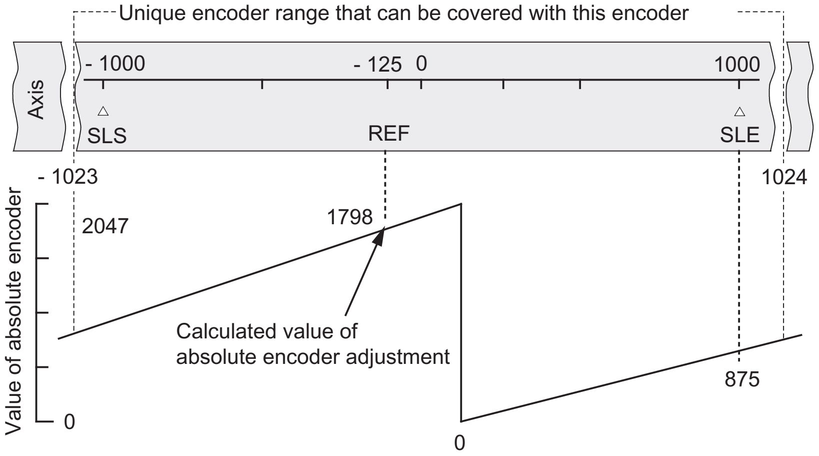
(1) Assignment of the coordinate system to encoder values, based on the absolute encoder adjustment. Encoder value 0 is equivalent to actual value -125.

(2) Required assignment of the coordinate system to the encoder. The coordinate value should be -125 at this position.

## Result of "Set reference point"

The Set reference point operation creates the following relationship between the encoder and coordinate system:

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


Unique encoder range that can be covered with this encoder
Axis
- 1000
- 125
0
1000
SLS
REF
SLE
- 1023
1024
Value of absolute encoder
2047
1798
Calculated value of absolute encoder adjustment
875
0
0

The encoder returns 2048 unambiguous values. The working range is determined by the software limit switches. However, due to the set resolution of 1 mm/pulse, the encoder's working area extends beyond the set software limit switch range.

At the set resolution, the working range is already covered by 2001 values. In the example, this produces a "remainder" of 47 pulses which symmetrically enclose the working range.

## Alternative: Mechanical encoder adjustment

To achieve a correct relationship between the coordinate system and the encoder, perform the following:

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

The parameters will thus always return the correct actual value.

As an alternative to steps 3 and 4, you can also set the encoder to zero by means of a "Reset" signal (if this exists), and then enter the value "0" as the absolute encoder adjustment in the machine data.

## 9.10 Machine data of the encoder

### Definition

The encoder returns position data to the module for evaluation and conversion to an actual value based on the resolution.

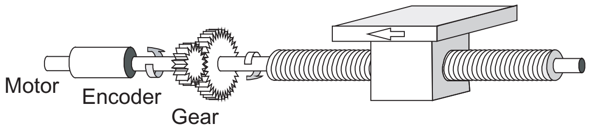
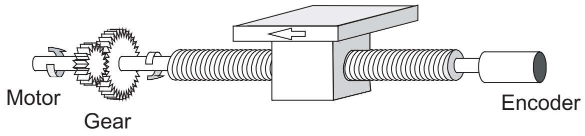
The correct definition of the encoder's machine data is essential for ensuring consistency between the calculated and physical actual position of the axis.

### Data in the parameter DB:

### Encoder type and frame length

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 20.0 | ENC_TYPE | DINT | L#1 | Encoder type and frame length<br>Range of values:<br>1 = 5 V, incremental<br>2 = 24 V, incremental<br>3 = SSI 13-bit frame length<br>4 = SSI 25-bit frame length<br>5 = listen in<br>6 = 24 V initiator positive direction<br>7 = 24 V initiator negative direction<br>8 = SSI 13-bit (right-justified)<br>9 = SSI 25-bit (right-justified)<br>10 = listen in (right-justified) |
| At the "frame length" you define the clock frame output by FM 352. The "listen in" selection disables the clock pulse of FM 352. The FM 352 can then listen in on other SSI frames with a 13 or 25-bit frame length. The transmission rate is determined by the cycle clock rate of the master module. | | | | |

## Distance per encoder revolution

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment</th></tr>
<tr><td>24.0</td><td>DISP_REV</td><td>DINT</td><td>L#80000</td><td>Distance per encoder revolution<br>1 µm to 1 000 000 000 µm</td></tr>
<tr><td colspan="5">With the "Distance per encoder revolution" machine data, you inform the FM 352 about the distance covered by the drive system per encoder revolution.<br>The "Distance per encoder revolution" value depends on the structure of the axis and the way in which the encoder is mounted. You must take all transmission elements, such as couplings or gears into account.<br>The chapter "Resolution (Page 91)" describes the connection between the machine data "Distance per encoder revolution" and "Increments per encoder revolution".<br> <br> </td></tr>
</table>

## Increments per encoder revolution

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment</th></tr>
<tr><td>32.0</td><td>INC_REV</td><td>DINT</td><td>L#500</td><td>Increments per encoder revolution<br>Range of values:<br>1 to $2^{25}$<br>Note:<br>This entry is irrelevant when using pulse units.</td></tr>
<tr><td colspan="5">The "Increments per encoder revolution" machine data element specifies the number of increments output by an encoder per revolution. FM 352 calculates he resolution based on this value and the "Distance per encoder revolution" machine data element.<br>• Incremental encoder<br>Any value within the range of values can be input. The module evaluates the increments in four operations (see chapter "Incremental encoders  (Page 137)").<br>• Initiator<br>Any value within the range of values.<br>• Absolute encoder<br>Limits differ between the various encoder types:</td></tr>
</table>

| Encoder type | Frame length / type | Range of values | can be used as linear axis |
|---|---|---|---|
| Single-turn encoder | 13-bit half fir tree | 64 ... 8192 in powers of 2 | |
| Single-turn encoder | 13-bit right-justified | 64 ... 8192 all values | X |
| Single-turn encoder | 25-bit right-justified | 64 ... $2^{25}$ all values | X |
| Multiturn encoder | 25-bit fir tree | 64 ... 8192 in powers of 2 | |
| Multiturn encoder | 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:<br>Multiturn encoder in single-turn mode | 25-bit half fir tree | 64 ... 8192 in powers of 2 | |

**Note**

The number of encoder pulses is calculated by multiplying the "increments per encoder revolution" by the "number of revolutions" (see chapter "Resolution (Page 91)").

## Number of encoder revolutions

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 36.0 | NO_REV | DINT | L#1024 | **Number of encoder revolutions**<br>Range of values:<br>1 (single-turn encoder)<br>2 to $2^{19}$ (multiturn encoder) |

The machine data "number of encoder revolutions" is only required for absolute encoders. You use it to define the maximum number of revolutions of this encoder. To obtain more information about absolute encoders, start by reading the "Absolute encoder (Page 141)" section in this manual.

**Single-turn encoder**

Only the value "1" is possible.

**Multiturn encoder**

Multiturn encoder / listen in (fir tree): 2 ... 4096 in powers of 2

Multiturn encoder / listen in (right-justified): 2 ... $2^{19}$ all values, but with the following restriction: Increments/encoder revolution * number of encoder revolutions ≤ $2^{25}$.

**Linear scale**

You can also interconnect a linear scale. To do so, enter the value "1".

**Total number of encoder steps**

The total number of steps is not a machine data element.

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

## Baud rate

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment</th></tr>
<tr><td>40.0</td><td>BAUD RATE</td><td>DINT</td><td>L#0</td><td>Baud rate<br>Range of values:<br>0 = 125 kHz<br>1 = 250 kHz<br>2 = 500 kHz<br>3 = 1000 kHz</td></tr>
<tr><td colspan="5">With the "BAUDRATE" machine data, you define the data transfer speed between the SSI encoder and FM 352.<br>This entry has no significance for incremental encoders.<br>The maximum cable length depends on the transmission rate:<br>• 125 kHz → 320 m<br>• 250 kHz → 160 m<br>• 500 kHz → 63 m<br>• 1000 kHz → 20 m</td></tr>
</table>

## Count direction

<table>
<tr><th>Address</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment</th></tr>
<tr><td>59.0</td><td>CNT_DIR</td><td>BOOL</td><td>FALSE</td><td>Count direction<br>0 = normal<br>1 = inverted</td></tr>
<tr><td colspan="5">With the "count direction" machine data, you adapt the position feedback direction to the direction of the axis movement. Also, take the rotation directions of all transmission elements into account (for example, couplings and gears).<br>• Normal = ascending count pulses (incremental encoder) or encoder values (absolute encoder) correspond to ascending actual position values<br>• Inverted = ascending count pulses (incremental encoder) or encoder values (absolute encoder) corresponding to descending actual position values<br>**It is not allowed to implement a lead time in combination with an absolute encoder (SSI) and inverted count direction.**</td></tr>
</table>

## Monitoring

| 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 its monitoring function is enabled, the FM 352 monitors the A, /A, B, /B, N, and /N signals of an incremental encoder. The monitoring function detects:

- Wire break
- Short circuit on individual cables

  For incremental encoders without a zero mark, you must alternatively:

  - Disable the wire-break monitoring function
  - Interconnect the N and /N signals externally (see chapter "Incremental encoders (Page 137)")
- Edge spacing of count pulses
- Encoder supply failure

**Frame error**

Frame error monitoring for absolute encoders (SSI) cannot be disabled. It monitors the frame:

- Start and stop bit errors
- Monitoring of the monoflop time of the connected encoder

**Missing pulses (incremental encoder)**

An incremental encoder must always return the same number of increments between two successive zero marks. FM 352 checks whether the zero mark of an incremental encoder coincides with the correct encoder value. Disable missing pulse monitoring at encoders without zero mark. Also disable wire-break monitoring, or interconnect the zero mark inputs N and /N externally.

## 9.11 Resolution

### Definition

The resolution reflects the accuracy of cam processing. It also determines the maximum possible traversing range.

The resolution (RES) is calculated as follows:

| | Incremental encoder | Absolute encoder / initiator |
|---|---|---|
| Input values | • Distance per encoder revolution<br>• Increments per encoder revolution<br>• Pulse evaluation: quadruple<br>• 1 increment = 4 pulses | • Distance per encoder revolution<br>• Increments per encoder revolution<br>• 1 increment = 1 pulse |
| Calculation | RES = (distance/encoder revolution) / (pulse/encoder revolution) | |

**Note**

The resolution of the physical unit pulses is always 1.

All position values are rounded to the integer multiple of the resolution. This allows you to distinguish between the set and used values.

### Range of values of the resolution

Convert the range of values for the resolution according to the defined physical units. The resolution must be kept within this range when setting the "distance per encoder revolution" and "increments per encoder revolution" values.

Range of values for the resolution derived from the physical units:

| Physical units system | Representation in... | Range of values of the resolution |
|---|---|---|
| mm | $10^{-3}$ mm | 0.1 * $10^{-3}$ mm to 1000 x $10^{-3}$ mm/pulse |
| inch | $10^{-4}$ inch | 0.1 * $10^{-4}$ inch to 1000 x $10^{-4}$ inch/pulse |
| degrees | $10^{-4}$ degrees<br>$10^{-3}$ degrees<br>$10^{-2}$ degrees | 0.1 * $10^{-4}$ degrees to 1000 x $10^{-4}$ degrees/pulse<br>0.1 * $10^{-3}$ degrees to 1000 x $10^{-3}$ degrees/pulse<br>0.1 * $10^{-2}$ degrees to 1000 x $10^{-2}$ 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

  Resultant resolution (quadruple evaluation):

  Resolution

  = 1000 mm / 5000 increments

  = 0.2000 $^{\text{mm}}/_{\text{increment}}$

  = 0.2000 $^{\text{mm}}/_{\text{4 pulses}}$

  = 0.0500 $^{\text{mm}}/_{\text{pulse}}$
- An SSI encoder has the following data:
  - Increments per encoder revolution: 4096
  - Distance per encoder revolution: 1000 mm
  - 1 increment = 1 pulse

  Resultant resolution:

  Resolution

  = 1000 mm / 4096 increments

  = 0.2441 $^{\text{mm}}/_{\text{increment}}$

  = 0.2441 $^{\text{mm}}/_{\text{pulse}}$

## Dependency between the traversing range and the resolution

The traversing range is limited by the numeric representation in FM 352. The number representation varies, depending on the resolution. You should thus make sure that your specifications are always within the permitted limits.

The table below shows the maximum traversing range:

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

### Dependency between the velocity and resolution

The velocity indicated may vary within the following limits, depending on the resolution (data relate to mm units):

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

The velocity value is calculated and filtered by the module at intervals of 4 ms.

Its minimum inaccuracy of one pulse/4 ms rules it out for closed-loop control.

## 9.12 Quantity framework and track data

### Number of cams

The number of cams available determines the cam cycle time and the maximum number of assignable cams.

| 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 | Start value | Comment |
|---|---|---|---|---|
| 76.0 | C_QTY | DINT | UDT3: L#0<br>UDT4: L#1<br>UDT5: L#2<br>UDT6: L#3 | Number of cams:<br>0 = max. 16 cams<br>1 = max. 32 cams<br>2 = max. 64 cams<br>3 = max. 128 cams |

### Track data in the parameter DB

#### Activation of track outputs

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 90.0 | TRACK_OUT | WORD | W#16#0 | **Activation of track outputs**<br>Range:<br>0 = cam controller<br>1 = CPU<br>Bit number = track number<br>Bits 13 to 15 must be 0. |
| The machine data "activation of track outputs" defines how the track signals of tracks 0 to 12 are activated. Tracks can be activated by:<br>• **The cam controller:** Track signals are activated and deactivated by the FM 352 cam processing functions.<br>• **CPU:** The track signals represent the corresponding values of the track enables in the channel DB.<br>This allows the explicit activation of track outputs in the user program. | | | | |

### Enable input

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 95.0 | EN_IN_I3 | BOOL | FALSE | **Enable input**<br>1 = track signal track 3 AND enable input I3<br>Bits 95.1 to 95.7 must be 0. |
| The track signal Q3 is activated when all the following conditions have been met:<br>• The track is enabled with TRACK_EN.<br>• The relevant external enable input I3 is set.<br>• The track result of the track = 1. | | | | |

### Special tracks

| Address | Name | Type | Start 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 assign tracks 0, 1 and 2 as special tracks. | | | | |

### High count value of counter cam track

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 100.0 | CNT_LIM0 | DINT | L#2 | **High count value of counter cam track** (track 0) |
| 104.0 | CNT_LIM1 | DINT | L#2 | **High count value of counter cam track** (track 1)<br>Range: 2 ... 65535 |

With this machine data, you define the high count value of the assigned counter cam track.

# 9.13 Interrupt enable

## Definition

In the cam data, you can specify whether hardware interrupts are to be generated when cams 0 to 7 are activated and/or deactivated (see chapter "Cam data (Page 97)").

## Machine data for interrupt enable in the parameter DB

| Address<br>Absolute | Name | Type | Start 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<br>relative | Name | Type | Start 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 |

## 9.14 Cam data

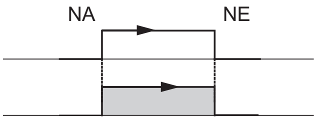
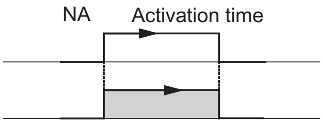
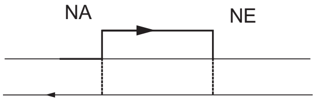
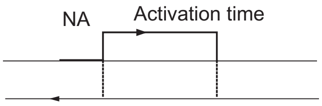
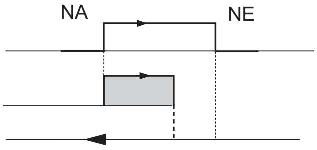
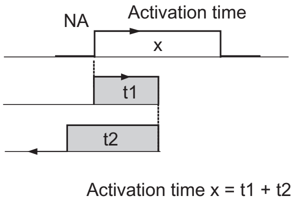
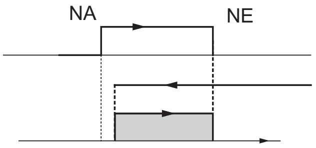
### Definition

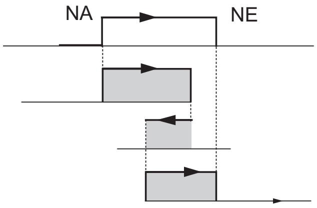
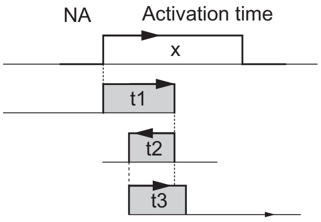
Cam data describe the properties of a cam, the assignment of each cam to a track, and the switching characteristic of the cam. The cam data listed below are set separately at each cam.

- The module interprets and processes only the cams with "valid" settings.
- Cams 0 to 7 support hardware interrupts.
- The number of assignable cams depends on the number of cams available.

### Switching characteristics of cams based on their effective direction

A positive effective direction is always assumed, with the exception of example 5.

| No. | Description | Position-based cam | Time-based cam |
|---|---|---|---|
| 1 | A cam is traversed in the effective direction |  |  |
| 2 | A cam is traversed in reversed effective direction |  |  |
| 3 | A cam is approached in effective direction; the motion direction of the axis is reversed while the cam is active |  |   NA<br>Activation time<br>x<br>t1<br>t2<br>Activation time x = t1 + t2 |
| 4 | A cam is approached in reversed effective direction; the axis reverses its direction of movement on the cam in effective direction |  | Cam not switched |

| No. | Description | Position-based cam | Time-based cam |
|---|---|---|---|
| 5 | A cam is approached from any direction, and exited into any direction; **both directions** are set as effective direction |  |  <br>Activation time x = t1 + t2 + t3 |
| □ Assigned cam<br>▨ 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 = positive effective direction (plus) |
| +0.2 | EFFDIR_M | BOOL | TRUE | 1 = negative effective direction (minus) |
| +0.3 | CAM_TYPE | BOOL | FALSE | 0 = position-based cam<br>1 = time-based 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**<br>Range: 0 to 31 |

**Effective direction**

Two effective directions are supported:

positive: The cam is activated at the cam start, if the axis is moving in the direction of increasing actual values.

negative: The cam is activated at the cam end, if the axis is moving in the direction of decreasing actual values.

You may set both effective directions in parallel.

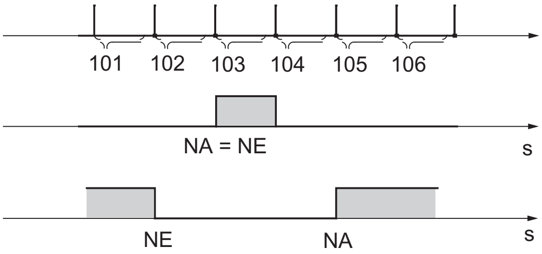
**Track number**

You define the track controlled by the cam by setting the track number.

### Note

Unused cams should always be set "invalid" (CAMVALID = FALSE).

## Cam start (NA)/Cam end (NE) of positioning cams

<table>
<tr><th>Address<br>relative</th><th>Name</th><th>Type</th><th>Initial value</th><th>Comment<br>Of position-based cams</th></tr>
<tr><td>+2.0<br>+6.0</td><td>CBEGIN<br>CEND</td><td>DINT<br>DINT</td><td>L#-100000000<br>L#100000000</td><td>Cam start (NA)<br>Cam end (NE)<br>Range:<br>- 1 000 000 000 µm to 1 000 000 000 µm</td></tr>
<tr><td colspan="5">Minimum length of a position-based cam<br>

101<br>102<br>103<br>104<br>105<br>106<br>NA = NE<br>s<br>NE<br>NA<br>s

<br>Pulses; derived from the encoder signals<br>Shortest cam CBEGIN = 103 and CEND = 103<br>Shortest inactive cam, when CBEGIN is greater than CEND: CBEGIN = 105 and CEND = 101<br>Shortest cam with axis motion in positive direction<br>The inactive section of a cam must always have an interval of at least 4 pulses between the cam end (NE) and cam start (NA).<br>If NE = NA, the cam is activated for the duration of one pulse.</td></tr>
</table>

## Cam start (NA)/Cam end (NE) for time-based cam

| Address<br>relative | Name | Type | Initial value | Comment<br>of time cams |
|---|---|---|---|---|
| +2.0 | CBEGIN | DINT | L#-100000000 | Cam start (NA) |
| +6.0 | CEND | DINT | L#100000000 | Cam end (NE)<br>Activation time<br>Range:<br>(0 to 13421) x 100 µs with up to 16 cams<br>(0 to 26843) x 100 µs with up to 32 cams<br>(0 to 53686) x 100 µs with up to 64 cams<br>(0 to 65535) x 100 µs with up to 128 cams |

With a time-based cam, you must specify a cam start and an activation time in place of the cam end. You can set a resolution of 100 µs for the activation time. The time runs starting with the activation of the cam.

Conditions of setting default times:

- 0 µs: A cam with 0 µs activation time is never activated
- 0 µs < t ≤ 400 µs: The FM 352 sets a minimum cam activation time of approx. 330 µs.
- t > 400 µs: FM 352 calculates the actual activation time $t_{act}$ based on the default activation time $t_{def}$ according to this formula:

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

The maximum error is always less than the cam cycle time.

## Lead time

| Address relative | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| + 10.0 | LTIME | INT | 0 | **Lead time**<br>Range:<br>(0 to 53686) x 100 µs with max. 16 cams<br>(0 to 65535) x 100 µs with max. 32, 64 or 128 cams |

You can compensate any delays caused by the connected switchgear by setting a lead time. Define the lead time with a resolution of 100 µs. You can assign one lead time to each cam. The lead time applies to the cam start and cam end.

**Anticipation distance**

The anticipation distance of a cam is calculated continuously based on the current velocity and lead time. The entire cam is shifted in direction of the actual value by this distance. The assigned range is the "static range", and the range calculated based on the lead time is the "dynamic range".

Anticipation distance = [lead time] x [current velocity]

FM 352 calculates the anticipation distances of all cams within $^1/_4$ of the longest assigned lead time. A very high lead time setting for a cam reduces the frequency of the dynamic adjustment calculation.

**Actual lead time**

To calculate the actual lead time:

Determine the cam cycle time: This is the time that the FM 352 requires to complete processing of all cams. It depends on the number of cams available.

Calculate the actual lead time based on the following formula:

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

The identifiers have the following meanings:

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

Lead time $_{\text{d}}$ is your default setting.

Integer ( ) means that the values after the decimal point are ignored in the calculation of the parenthesis.

The maximum error of the lead time$_{\text{act}}$ is always < [cam cycle time] x 4.

**Example:**

The following values are defined:

Number of cams: maximum of 32 cams

Cam cycle time: 40.96 µs

Lead time$_{\text{V}}$ = 1000 µs

Result: The result is an actual lead time of 983 µs

**It is not allowed to implement a lead time in combination with an absolute encoder (SSI) and inverted count direction.**

**Note**

The actual lead time is always less than the assigned lead time. It may be 0, even though the assigned lead time ≥100 µs.

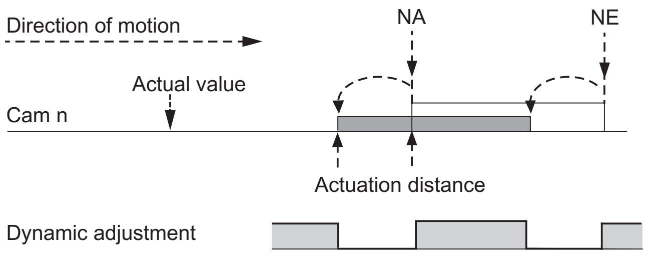
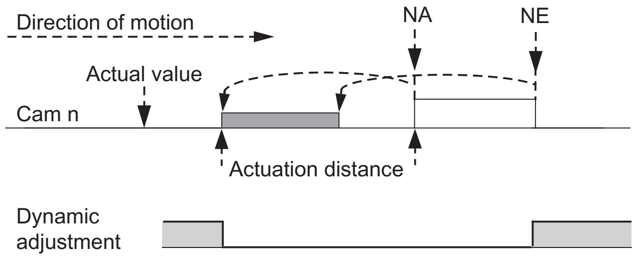
The anticipation distance of a rotary axis must be less than the rotary axis range and the inactive part of the cam. This must be ensured for all velocities.

## Dynamic cam adjustment

There are two distinct situations relating to the cam range:

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

Table 9- 1 Dynamic cam adjustment (different use cases)

| Dynamic adjustment | Description |
|---|---|
|   Direction of motion<br>NA<br>NE<br>Actual value<br>Cam n<br>Actuation distance<br>Dynamic adjustment | If the dynamic range of the cam overlaps its static range:<br>• The cam is activated when its dynamic range is reached. At the same time, calculation of a new dynamic adjustment is disabled.<br>• When the actual value reaches the static range of the cam, the calculation of a new dynamic adjustment is enabled again. A change in velocity affects the cam end.<br>• When the cam is deactivated at the end of the dynamic range, dynamic adjustment will be disabled again until the end of the static range of the cam. |
|   Direction of motion<br>NA<br>NE<br>Actual value<br>Cam n<br>Actuation distance<br>Dynamic adjustment | If the cam's dynamic and static ranges do not overlap:<br>• The cam is activated when its dynamic range is reached. At the same time, calculation of a new dynamic adjustment is disabled.<br>• At the end of the static range of the cam, dynamic adjustment is enabled again. |
| ■ Dynamic range<br>□ Static range<br>▨ A new dynamic adjustment is possible | |

**Note**

When the direction of rotation changes, calculation of the dynamic adjustment is enabled again.

# Settings 10

## 10.1 Influence of settings on the switching characteristics of time-based 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

### Activating a time-based cam

If you skip the start of a time-based cam due to one of the settings listed above, this cam is activated provided the actual direction of the axis motion is the same as the effective direction assigned for the cam. The assigned activation time starts.

---

Note

If the axis is at a standstill, the direction of movement is influenced by fluctuations of the actual value.

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

This retains the last determined direction of movement while the axis is at a standstill.

---

⚠ WARNING

Risk of injury and material damage.

Any modification of the actual value at rotary axes may cause the unwanted activation of time-based cams.

You should always set the "invalid" option at the time-based cams of a rotary axis if you want to influence the actual value using the settings mentioned earlier.

## 10.2 Set Actual Value/Set Actual Value on-the-fly/Cancel Set Actual Value

### Definition

You program the "Set actual value/Set actual value on-the-fly" settings in order to assign a new coordinate to the actual encoder value. This shifts the coordinate system by the value: $ACT_{new}$ - $ACT_{current}$

Whereby:

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

### Determining new coordinates

Calculate all your default positions in the shifted coordinate system based on the following formula:

**$Coordinate_{new}$ = $Coordinate_{old}$ + ($ACT_{new}$ - $ACT_{current}$)**

### Requirements

- The axis must be synchronized.
- With "set actual value on-the-fly": Digital input I1 must be interconnected.

### Programming steps

1. Enter the coordinate for the actual value, or for the actual value to set on-the-fly in the channel DB.
   – Linear axis:

     Select an actual value so that the software limit switches are still within the permissible traversing range after the setting is called.

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

   – Rotary axis:

     Rule for the defined actual value:

     $0 \leq$ actual value < end of rotary axis
2. Set the appropriate trigger bits at the channel DB.
3. Call the FB CAM_CTRL.

   "Set actual values" is executed immediately.

   "Set actual value on-the-fly" is executed at the next positive 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 | Actual value coordinate |
| 94.0 | FVAL | DINT | L#0 | Coordinate for on-the-fly actual value |
| 25.5 | FVAL_DONE | BOOL | FALSE | 1 = set actual value on-the-fly executed |

## Effects of the setting

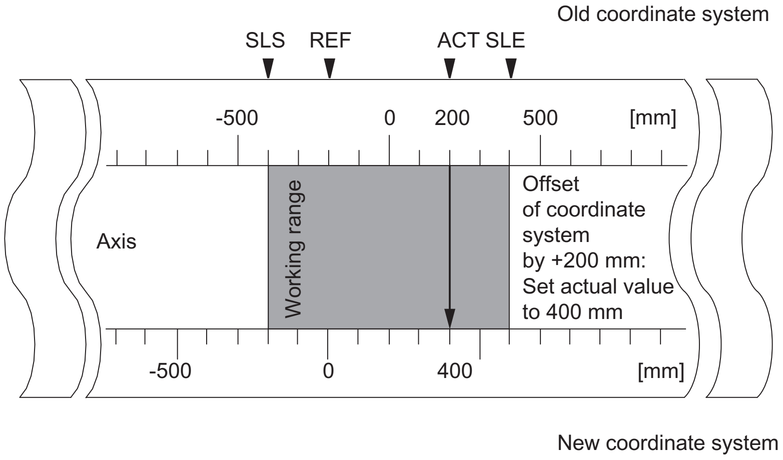
Based on the example "set actual value" to 400 mm (at position 200 mm), you can see how this setting shifts the coordinate system. Resultant effects:

- The position of the working range is **not** physically shifted.
- The various 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 may skip cam edges or complete cams as a result of this setting.
- Status changes of the cam which would normally trigger an interrupt may be lost.

**Note**

For information on switching characteristics of time-based cams, refer to chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)".

Table 10- 1 Shift 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<br>SLS<br>REF<br>ACT<br>SLE<br>-500<br>0<br>200<br>500<br>[mm]<br>Axis<br>Working range<br>Offset of coordinate system by +200 mm: Set actual value to 400 mm<br>-500<br>0<br>400<br>[mm]<br>New coordinate system | -400 | -200 | 200 | 400 |
| | -200 | 0 | 400 | 600 |

## Canceling the setting

The "Cancel set actual value" can be used to reset the coordinate shift caused by "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 positive edge at input I1. However, it can be overwritten by a new "Set actual value on-the-fly".

These settings will be reset at the next start of the module.

## Parameter used in the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 35.2 | AVALREM_EN | BOOL | FALSE | 1: Cancel actual value setting |

## Possible causes of error

"Set actual value on-the-fly" and "Retrigger reference point" may not be executed in parallel.

The "set actual value on-the-fly" can be monitored in order to signal an operating error if this setting causes a software limit switch to exceed the permissible traversing range at a positive edge at input I1. This operating error is signaled by a diagnostic interrupt, and written to the diagnostic buffer.

## 10.3 Set zero offset

### Definition

The "zero offset" setting lets you shift the zero position in the coordinate system by a defined value. The sign determines the offset direction.

### Determining a new coordinate

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

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

$\text{ZPO}_{\text{old}}$ identifies any existing zero offset. If no zero offset was active prior to the call, set a 0 value at $\text{ZPO}_{\text{old}}$.

Based on this formula, you can calculate the coordinates for the software limit switches, for example.

### Programming steps

1. Write the zero offset value to the channel DB.
   - Linear axis:

     The zero offset must be selected so that the software limit switches remain within the permissible traversing range after the setting is called.
   - Rotary axis:

     Rule for the zero offset:

     value of zero offset ≤ end of the rotary axis.
2. Set the relevant trigger bit.

## Data used in the channel DB

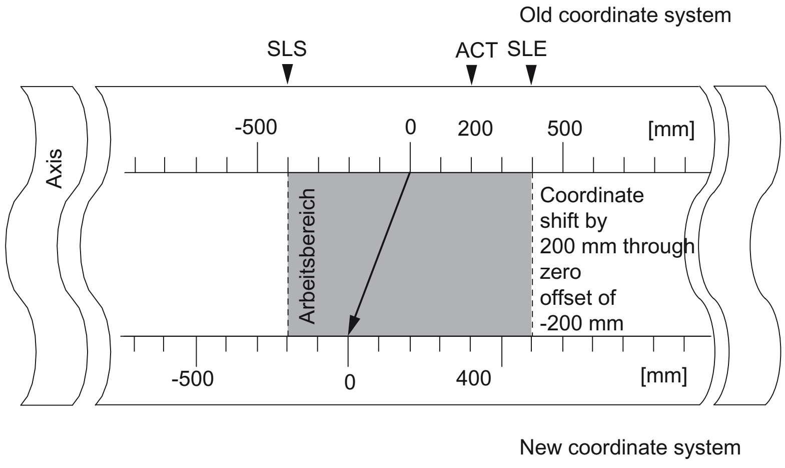
| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 36.6 | ZOFF_EN | BOOL | FALSE | 1 = set zero offset |
| 86.0 | ZOFF | DINT | L#0 | Zero offset |

## 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 positive direction. Resultant effects:

- The working range is **not** physically shifted.
- The various 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 may skip cam edges or complete cams as a result of this setting.
- Status changes of the cam which would normally trigger an interrupt may be lost.

Table 10- 2 Coordinate system shift as a result of zero offset

| Zero offset | SLS<br>[mm] | REF<br>[mm] | ACT<br>[mm] | SLE<br>[mm] |
|---|---|---|---|---|
|  | -400 | -200 | 200 | 400 |
|  | -200 | 0 | 400 | 600 |

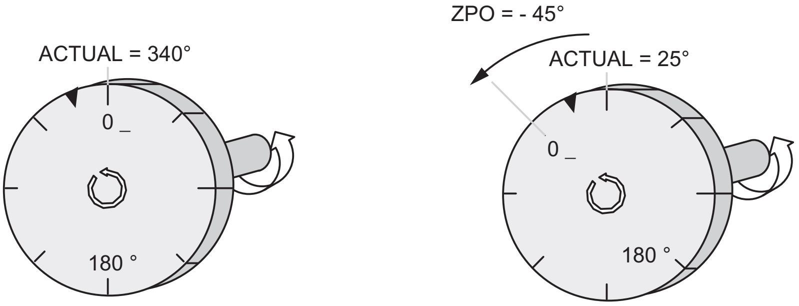
### Note

For information on switching characteristics of time-based cams, refer to chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)".

## Effects on a rotary axis

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

Table 10- 3 Rotation of the coordinate system as a result of zero offset

| Tool at ACT = 340° | Tool when ACT = 25° |
|---|---|
|  ACTUAL = 340°<br>0 _<br>180 °<br>ZPO = - 45°<br>ACTUAL = 25°<br>0 _<br>180 ° | |
| The zero position rotates by - 45 degrees. All axis points are assigned new coordinate values. | |

Including a **$\text{ZPO}_{\text{old}}$ = 0**, the result is a new value of 385°

As actual value resumes at 0 at the end of the rotary axis operating in positive directional rotation, the calculation returns an actual value of 25°:

**$\text{Coordinate}_{\text{new}}$ = $\text{Coordinate}_{\text{old}}$ - ($\text{ZPO}_{\text{new}}$ - $\text{ZPO}_{\text{old}}$) - end of rotary axis**

The **end of rotary axis** value only needs to be subtracted when

**$\text{Coordinate}_{\text{old}}$** - (**$\text{ZPO}_{\text{new}}$ - $\text{NPV}_{\text{old}}$**) is greater than the end of rotary axis.

## Loss of synchronization

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

## Canceling a setting

A zero offset of 0 resets any existing offset.

# 10.4 Set reference point

## Definition

The "set reference point" setting is used to synchronize the axis. This setting shifts the working area. All shifts generated by a zero offset or "set actual value" function are retained.

The setting maps the working range onto the axis. Different value settings will thus move the working range to different positions within the physical range of the axis.

## Requirement

Cam processing must be disabled.

## Programming steps

1. Write the value for the reference point coordinate to the channel DB.
   - Linear axis:

     The reference-point coordinate may not exceed the range of the software limit switches. This also applies to the reference point coordinate in a shifted coordinate system.
   - Rotary axis:

     Rule for the reference point coordinate:

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

## Data 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 |

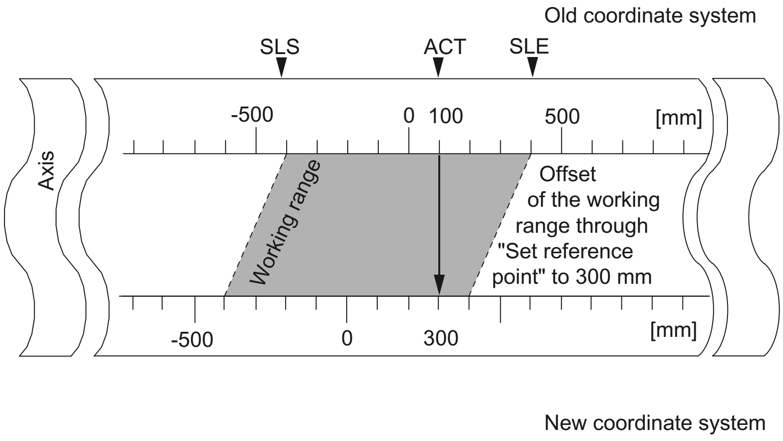
## Effects of the setting

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 various points retain their original coordinates, but are now at new physical positions.
- The SYNC bit is set in the checkback signals.

Table 10- 4 Shifting the working range on the axis using "Set Reference Point"

| Set reference point | SLS<br>[mm] | REF<br>[mm] | ACT<br>[mm] | SLE<br>[mm] |
|---|---|---|---|---|
|   Old coordinate system<br>SLS<br>ACT<br>SLE<br>-500<br>0<br>100<br>500<br>[mm]<br>Axis<br>Working range<br>Offset of the working range through "Set reference point" to 300 mm<br>-500<br>0<br>300<br>[mm]<br>New coordinate system | -400 | -200 | 100 | 400 |
| | -400 | -200 | 300 | 400 |

## Special features of absolute encoders

This setting is required for an absolute encoder adjustment (see chapter "Determining the correct absolute encoder adjustment (Page 82)").

# 10.5 Change cam edges

## Definition

The "change cam edges" setting can be used to change the cam start during operation. With a position-based cam, the cam end of an individual position-based cam can also be changed during operation.

## Requirement

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 position-based cam:

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

   For a time-based cam:

   Enter the cam start value in the channel DB.
3. Set the relevant 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 (1 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-triggering edge, and then the off-triggering edge of the cam. This sequence does not depend on the direction in which the cam is shifted.

Exception:

The sequence described above may briefly generate an inverse cam if the new cam start is greater than the old cam end.

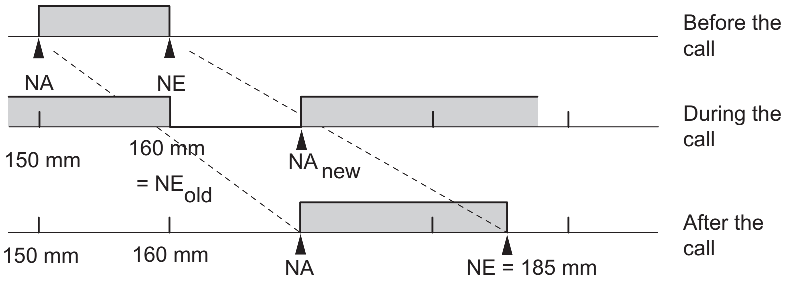


Figure 10-1 Step-by-step change of the cam edges

### Note

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

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

For information on switching characteristics of time-based cams, refer to chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)".

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

## Reading modified values

You can read modified values by calling one of the jobs CAM1RD_EN to CAM8RD_EN.

## Canceling the setting

The modified values are lost when you restart the module.

## 10.6 Perform "Fast Cam Parameter Change"

### Definition

The "Fast cam parameter change" setting can be used to modify a group of up to 16 cams while the system is in RUN.

### Requirement

The cams you want to modify must be valid.

### Programming steps

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. Declare the new values at the channel DB.
5. Repeat steps 2 to 4 for each cam to be modified.
6. Set the relevant trigger bit in the channel DB.

### Data used in the channel DB

| Address Absolute | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 37.0 | CH16CAM_EN | BOOL | FALSE | 1 = write fast cam parameter change settings (16 cams) |
| 176.0 | C_QTY | BYTE | B#16#0 | Number of cams to modify |
| 177.0 | DIS_CHECK | BOOL | FALSE | 1 = disable data check |

| Address relative | Name | Type | Start value | Comment |
|---|---|---|---|---|
| +0.0 | CAM_NO | BYTE | B#16#0 | Number of the cam to modify |
| +1.0 | C_EFFDIR | BOOL | FALSE | 1 = change the effective direction of the cam |
| +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 / activation time to the value CEND |
| +1.3 | C_LTIME | BOOL | FALSE | 1 = change the lead time to the value in LTIME |
| +1.4 | CAM_OFF | BOOL | FALSE | 1 = deactivate the cam during the cam modification |
| +1.5 | EFFDIR_P | BOOL | FALSE | 1 = positive effective direction (plus) |

| Address relative | Name | Type | Start value | Comment |
|---|---|---|---|---|
| +1.6 | EFFDIR_M | BOOL | FALSE | 1 = negative effective direction (minus) |
| +2.0 | CBEGIN | DINT | L#0 | New cam start |
| +6.0 | CEND | DINT | L#0 | New cam end / new activation time |
| +10.0 | LTIME | INT | L#0 | New lead time |

## Deactivating a cam when making modifications

To maintain consistency, always deactivate the cam (CAM_OFF) when you modify the cam start and cam end settings.

## Data check by the module

With the DIS_CHECK (channel DB) parameter, you specify whether the check of transferred data by the FM 352 is to be disabled. If you disable the data check, you must take steps to verify that only permitted values are transferred. If you transfer illegal values without a check, the module can behave unexpectedly.

- FALSE: The module checks all data to be transferred
- TRUE: The check of cam parameter data is disabled. This allows the faster integration of the data to be changed on the FM 352.

  Regardless of this setting, the module always checks whether

  - the axis is assigned
  - the number of cams to be changed (C_QTY) is permitted
  - the cam (cam number) to change is valid.

The data are only enabled on the module after having been checked and found faultless.

Any faulty data are rejected.

## Effects of the setting

**Note**

For information on switching characteristics of time-based cams, refer to chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)".

## Reading modified values

You can read the modified values by calling one of the jobs CAM1RD_EN to CAM8RD_EN .

## Canceling the setting

The modified values are lost when you restart the module.

# 10.7 Executing "Length measurement and edge detection"

## Definition

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

Length measurement and edge detection are active and remain active until you disable these functions or select a different measuring method. If you select both measuring methods in parallel, FB CAM_CTRL enables length measurement.

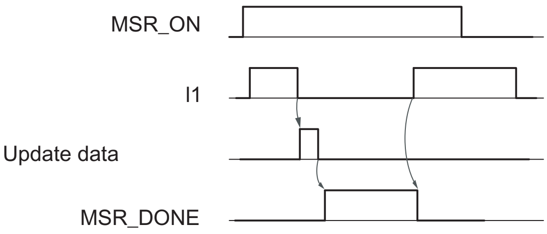
## Requirement

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

## Sequence of the Settings

Depending on the type of measurement, the FM 352 updates the data on the module at different times. FM 352 reports each update in a parameter on the checkback interface.

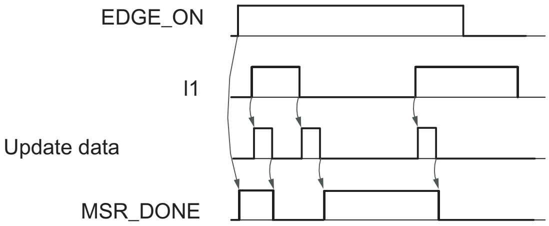
### Length measurement



1. Set the function switch for "length measurement".
2. A positive edge at input I1 starts the length measurement.
3. The negative edge at input I1 stops the current measurement. FM 352 updates the start value, end value, and length data.
4. When parameter MSR_DONE is set, FM 352 reports the data update. The parameter indicates completion of the measurement. The results of the measurement can be read out.
5. The next start of a measurement at the positive edge at I1 resets the MSR_DONE parameter.

If the setting is disabled during a length measurement, the FM 352 does not update the data. The MSR_DONE parameter remains reset.

### Edge detection



1. Enter a value for the minimum edge distance in the parameter DB. Write and enable machine data.
2. Set the "edge detection" function switch. This sets the MSR_DONE parameter.
3. The positive edge at input I1 starts edge detection. The results of the measurement are updated and can be read out, and the start value of the measurement is entered; the end value and length assume the value -1.
4. After the update, FM 352 reports the change by resetting the MSR_DONE parameter.
5. The negative edge at input I1 stops the current measurement. The FM 352 updates the data for the end value of the measurement and length.
6. After the update, FM 352 reports the change by setting the MSR_DONE parameter. The results of the measurement can be read out.
7. The next start of a measurement at the positive edge at I1 resets the MSR_DONE parameter.

If the setting is disabled during edge detection, the FM 352 does not update the data. The MSR_DONE parameter remains reset.

## Data used in the channel DB

| Address | Name | Type | Start 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 | Start value | Comment |
|---|---|---|---|---|
| 4.0 | EDGEDIST | DINT | L#0 | Minimum edge distance for edge detection<br>Range: 0 ... 1 000 000 000 µm |
| The minimum edge distance is used to define a range after the start of a measurement is detected with an edge detection. The measurement will be discarded if the measuring operation ends within this range.<br>The start of the measurement is not signaled unless the minimum edge distance has been traveled. | | | | |

## Conditions of length measurement

- The CPU program requires an interval of sufficient length between the off and on edges at input I1 in order to be able to evaluate the result of the measurement before a new measurement is triggered.
- The minimum interval between the positive and negative edges at input I1 and between the negative edge and the next positive edge at input I1 must be greater than 2 ms.

## Faulty measurement

FM 352 returns the length value -1 for the length when it detects a faulty measurement / edge detection.

A "length measurement" or "edge detection" may only perform up to 126 zero transitions in one direction. The FM 352 reports a faulty "length measurement" or "edge detection" if it detects more than 126 zero transitions in one direction, regardless of whether or not it then detects any zero transitions in the opposite direction. The zero transition represents the rotary axis transition from the end of rotary axis value to 0, and vice versa.

A length measurement is also considered faulty if:

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

This event can be signaled as a hardware interrupt.

### Shift of the coordinate system during a length measurement

Conditions under which a shift of the coordinate system will influence the measured length:

- You are using an incremental encoder or an initiator or are operating the FM 352 in simulation mode.
- You are executing a "set reference point" or "retrigger reference point" function while a length measurement is active.

### Example

To utilize the above mentioned influences on the measured length:

Your system always develops slip when you perform a length measurement.

The retrigger reference point function can be used to correct this slip in order to output correct length measurement values.

## 10.8 Retrigger reference point

### Definition

The "Retrigger reference point" setting can be used to synchronize the axis as a reaction to a recurring external event.

The setting remains active until you deactivate it.

### Requirements

- You are using an incremental encoder or an initiator.
- The external event may represent the zero mark signal of an incremental encoder or reference point switch at input I2.

### Programming steps

1. Set the value for the reference point coordinate at the parameter DB.
2. Set the type of "retrigger reference point" at the parameter DB.

   Options:

   - Only the zero mark of the encoder is evaluated (RETR_TYPE = 7).
   - Only the reference point switch is evaluated (RETR_TYPE = 6).
   - Evaluation of the zero mark signal

     in positive direction: evaluation of the first positive edge of the zero mark after passing the reference point switch in positive direction (RETR_TYPE = 0).

     in negative direction: evaluation of the first negative edge of the zero mark signal after passing the reference point switch in negative direction (RETR_TYPE = 1).
3. Write and enable machine data.
4. Set the function switch in the channel DB.

## Data used in the channel DB

| Address | Name | Type | Start 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 | Start value | Comment |
|---|---|---|---|---|
| 44.0 | REFPT | DINT | L#0 | Reference point coordinate |
| 52.0 | RETR_TYPE | DINT | L#0 | Type of reference point retriggering |

## Effects of the setting

- FM 352 evaluates the zero mark signal and reference point switch based on the direction of movement of the axis.
  - It evaluates the positive edges when the axis moves in positive direction.
  - It evaluates the negative edges when the axis moves in negative direction.
- It sets the actual position to the value of the reference point coordinate.
- The working range is physically shifted on the axis.
- The various points retain their original values, but are now at new physical positions.
- Cam status changes that would normally trigger a hardware interrupt can be lost.
- The SYNC bit is set in the checkback signals.

### Note

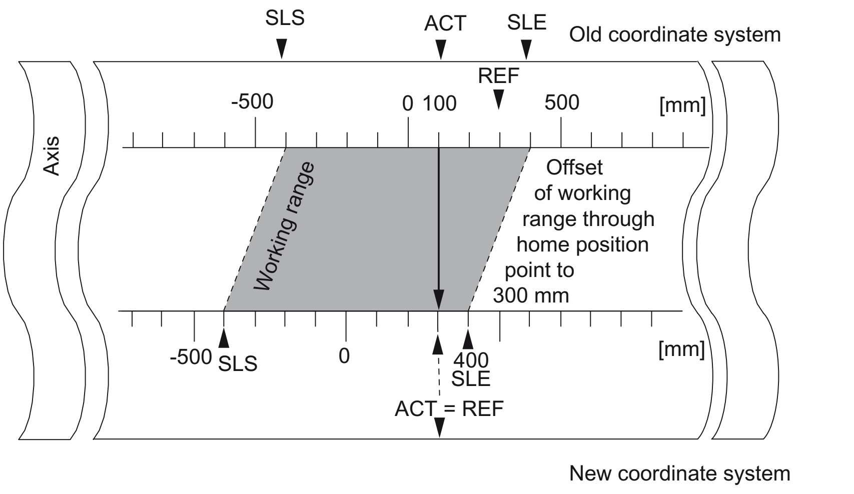
For information on switching characteristics of time-based cams, refer to chapter "Influence of settings on the switching characteristics of time-based cams (Page 103)".

## Example

Rules for the example:

- The module evaluates the positive edges of the reference point switch and zero mark signals (axis moving in positive direction).
- Value of the reference point coordinate = 300 mm.
- No zero offset is active at the time of execution.

Table 10- 5 Shift of the axis working range by "retrigger reference point"

| Retrigger reference point | SLS<br>[mm] | REF<br>[mm] | ACT<br>[mm] | SLE<br>[mm] |
|---|---|---|---|---|
|   SLS<br>ACT<br>SLE<br>Old coordinate system<br>REF<br>-500<br>0 100<br>500<br>[mm]<br>Axis<br>Working range<br>Offset of working range through home position point to 300 mm<br>-500<br>SLS<br>0<br>400<br>SLE<br>[mm]<br>ACT = REF<br>New coordinate system | -400 | 300 | 100 | 400 |
| | -400 | 300 | 300 | 400 |

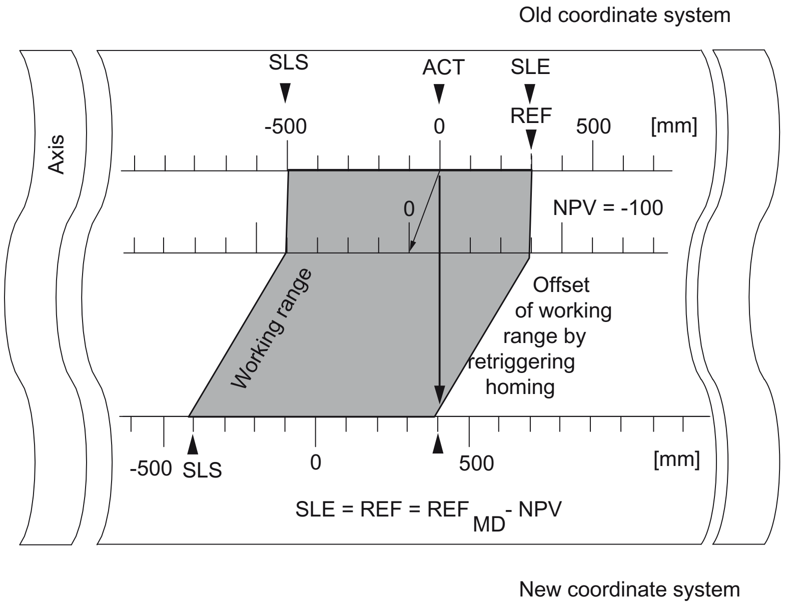
## Inclusion of a zero offset

Any active zero offset is included in the retrigger reference point setting. The reference point coordinate setting is thus calculated according to the formula:

**$\text{Ref} = \text{Ref}_{MD}$ - Zero offset**

$\text{Ref}_{MD}$ is the value of the reference point coordinate store in machine data.

Table 10- 6 Shift of the axis working range by "Retrigger reference point" when zero offset is active

| Retrigger reference point | SLS<br>[mm] | REF<br>[mm] | ACT<br>[mm] | SLE<br>[mm] |
|---|---|---|---|---|
|   Old coordinate system<br>Axis<br>SLS<br>ACT<br>SLE<br>-500<br>0<br>REF<br>500<br>[mm]<br>0<br>NPV = -100<br>Working range<br>Offset of working range by retriggering homing<br>-500<br>SLS<br>0<br>500<br>[mm]<br>SLE = REF = REF MD - NPV<br>New coordinate system | -500 | 300 | 0 | 300 |
| | -400 | 400 | 100 | 400 |
| | -400 | 400 | 400 | 400 |

## 10.9 Disabling software limit switches

### Definition

Use the "Disable software limit switches" function to disable monitoring of the software limit switches at a linear axis.

The setting remains active until you deactivate it. This re-enables the originally assigned software limit switches.

### Programming steps

Set the function switch in the channel DB.

### Data used in the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 34.4 | SSW_OFF | BOOL | FALSE | 1 = software limit switch disabled |

### Data used in the parameter DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 64.0 | SSW_STRT | DINT | L#-1000000000 | Software limit switch start |
| 68.0 | SSW_END | DINT | L#1000000000 | Software limit switch end |

### Effects of the setting

- simulation
  - Simulation mode stops when the axis passes a software limit switch.
  - You can resume simulation mode by enabling software limit switch monitoring. The axis moves in the defined direction.
- Zero offset when monitoring is disabled

  With a zero offset setting, and software limit switches operating within traversing range limits, the actual value may still be out of the permissible number range.
- Cams located outside the assigned software limit switches can be switched.

> ⚠ CAUTION
>
> Risk of material damage!
>
> When taking safety measures such as reducing the traversing range by setting software limit switches, you risk damage to your equipment when these switches are disabled.
>
> In the planning and engineering phases for your plant, you should be certain that the drive can travel in the entire physical traversing range.

## 10.10 Simulating

### Definition

The "Simulation" setting allows you to activate the cam controller with open encoder connections.

### Programming steps

1. Set the simulation velocity at the parameter DB.
2. Write and enable machine data.
3. Set either a positive or negative simulation direction at the channel DB.
4. Set the function switch in the channel DB.

### Data used in the channel DB

| Address | Name | Type | Start 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 | Start value | Comment |
|---|---|---|---|---|
| 84.0 | SIM_SPD | DINT | L#0 | Simulation velocity |

### Effects when simulation mode is activated

- Encoder signals will be ignored.
- The encoder input monitoring functions are disabled.
- All encoder errors reported will be reset.
- FM 352 simulates axis motion at a constant simulation velocity.
- Cam processing is disabled while simulation mode is active. However, you can then enable these operations again. Synchronism will be retained in this case.
- Starting at the current actual value, the actual position value changes dynamically based on the simulation velocity and direction.

### Effects when simulation mode is deactivated

- Cam processing will be disabled.
- The synchronization of an incremental encoder or initiator will be cleared. The actual value will be reset to the value of the reference point coordinate.
- The module reports the actual position value which corresponds with the absolute encoder value. The module then evaluates the encoder signals as defined at the machine parameters.

### Limit values

The min./max. simulation velocity depends on the resolution (see chapter "Machine data of the axis (Page 75)").

### Velocity

The module may operate with differences between the online velocity and offline settings (see chapter "Machine data of the axis (Page 75)").

## 10.11 Read "count values of counter cam tracks"

### Definition

The "count values of counter cam tracks" is used to read the actual count values.

### Programming steps

1. Specify the counter cam tracks and the high count values in the machine data.
2. Write and enable machine data.
3. Enable the count function.
4. The module sets the count value to its high limit.
5. The count value decrements by the count of 1 at each positive edge of the track result signal.
6. Set the trigger bit at the channel DB to read the count values.
7. The module writes both count values to the channel DB. The module outputs a 0 value for tracks not assigned as a counter cam track.
8. The module sets track identifier bit = 1 at the counter cam track when the count value = 0.
9. It resets the track identifier bit = 0 at the next negative edge of the track result signal, and resets the counter to its high limit.

### Data used in the channel DB

| Address | Name | Type | Start 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 count value of counter cam track 0 |
| 126.0 | CNT_TRC1 | INT | 0 | Current count value of counter cam track 1 |

### Data used in the parameter DB

| Address | Name | Type | Start 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 | High count value of counter cam track 0 |
| 104.0 | CNT_LIM1 | DINT | L#2 | High count value of counter cam track 1 |

# 10.12 Read "position and track data"

## Definition

The "position and track data" function can be used to read the actual position value, the velocity, and the track identifier bits. The track identifier bits are recorded before being logically linked to machine and channel data.

The algorithm implemented in the FM 352 calculates velocity changes greater than 1 pulse/4 ms. The indicated velocity includes this inaccuracy, and is thus unsuitable in particular for closed-loop control. The internal velocity value used for dynamic cam control offers a higher precision.

## Programming steps

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

## Data used in the channel DB

| Address | Name | Type | Start 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 velocity |
| 136.0 | TRACK_ID | DWORD | DW#16#0 | Track identifier bits of tracks 0 to 31 |

# 10.13 Read encoder data

## Definition

The "encoder data" setting an be used to read actual encoder data, and the value for absolute encoder adjustment.

## Requirements

The value for absolute encoder adjustment can be read after "set reference point" is configured (see chapter "Determining the correct absolute encoder adjustment  (Page 82)").

## Programming steps

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

## Data used in the channel DB

| Address | Name | Type | Start 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 mark (internal representation) |
| 148.0 | ENC_ADJ | DINT | L#0 | Absolute encoder adjustment |

# 10.14 Read cam and track data

## Definition

The "cam and track data" setting can be used to read the actual cam / track identifier bits and the position. The track identifier bits are recorded before being logically linked to machine and channel data.

## Programming steps

1. Enter type ID = 1 at the FM_TYPE parameter of the channel DB. This allows you to read 24 bytes of cam and track data.

   If you enter type ID = 0, only the cam identifier bits (16 bytes) will be read.
2. The data are stored in the channel DB.

## Data used in the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 12.0 | FM_TYPE | BOOL | FALSE | 0 = FM 352 up to V4.0<br>1 = FM 352 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 identifier bits for cams 0 to 31 |
| 156.0 | CAM_32_63 | DWORD | DW#16#0 | Cam identifier bits for cams 32 to 63 |
| 160.0 | CAM_64_95 | DWORD | DW#16#0 | Cam identifier bits for cams 64 to 95 |
| 164.0 | CAM_96_127 | DWORD | DW#16#0 | Cam identifier bits for cams 96 to 127 |
| 168.0 | TRACK_ID1 | DWORD | DW#16#0 | Track identifier bits of tracks 0 to 31 |
| 172.0 | ACTPOS1 | DINT | L#0 | Current position |

## 10.15 Setting control signals for the cam controller

### Definition

The "control signals for the cam controller" setting can be used to enable cam processing and the tracks.

### Programming steps

1. Set the required bits at the channel DB.
2. The data are transferred to the module at each call of FB CAM_CTRL.

### Data used in the channel DB

| Address | Name | Type | Start 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<br>Bit 0 = track 0 |

### Effects

Cam processing will be started or stopped based on the enable status.

The track identifier bits of enabled tracks are transferred to the track signals and digital outputs.

# 10.16 Querying checkback signals for the cam controller

## Definition

The "checkback signals for the cam controller" setting informs you about the current state of the cam control and track signals. Consistency between the reported position and track signals is not guaranteed.

## Programming steps

The data are stored in the channel DB at each call of FB CAM_CTRL.

## Data used in the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 23.4 | CAM_ACT | BOOL | FALSE | 1 = cam processing busy |
| 26.0 | ACT_POS | DINT | L#0 | Current axis position |
| 30.0 | TRACK_OUT | DWORD | DW#16#0 | Current track signals of tracks 0 to 31<br>Bit 0 = track 0 |

## 10.17 Setting the return signals for diagnostics

### Programming steps

The module sets the DIAG bit in the checkback interface each time it writes a new entry to the diagnostics buffer. Error events belonging to any of the error classes listed in Appendix "Data blocks / error lists (Page 177)" are logged in the diagnostics buffer.

1. The module sets the DATA_ERR bit in the check-back interface when it detects faulty data in a write job. The cause of the error is logged to the diagnostic buffer.
2. The FB CAM_CTRL stores the checkback interface in the channel DB.
3. The FM 352 resets the DIAG bit to 0 after the diagnostic buffer is read by FB DIAG.

### Data used in the channel DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 22.2 | DIAG | BOOL | FALSE | 1 = diagnostic buffer modified |
| 22.4 | DATA_ERR | BOOL | FALSE | 1 = data error |

# Encoders 11

## 11.1 Incremental encoders

### Connectable incremental encoders

The module supports incremental encoders outputting two pulses with 90° phase shift, and with or without zero mark signal:

- Encoders with asymmetrical 24 V output signals
  - Limit frequency = 50 kHz
  - Cable length max. 100 m
- Encoders with symmetrical output signals and 5 V differential interface conforming to RS422
  - Limit frequency = 1 MHz
  - with 5 V supply voltage: Cable length max. 32 m
  - with 24 V supply voltage: Cable length max. 100 m

**Note**

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

## Signal shapes

The diagram below shows the signal shapes of encoders with asymmetrical and symmetrical output signals.

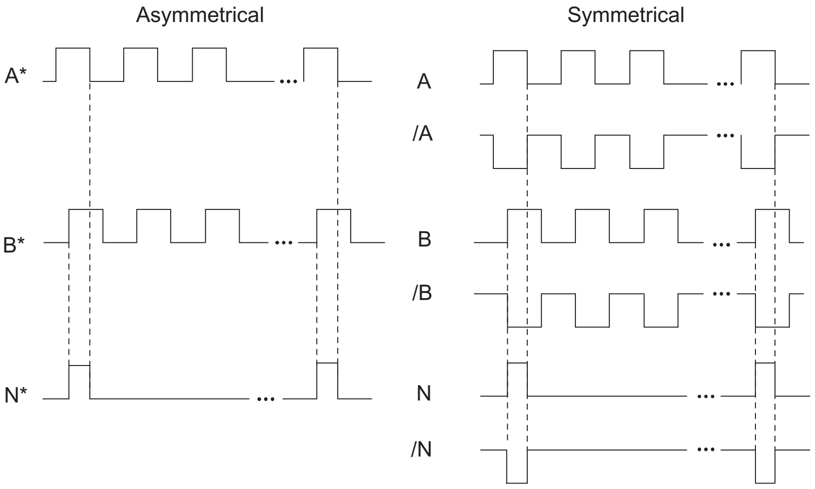


Figure 11-1 Signal shapes of incremental encoders

## Signal evaluation

### Increments

An increment identifies a signal period of the encoders signals A and B. This value is specified in the technical data and/or on the rating plate of the encoder.

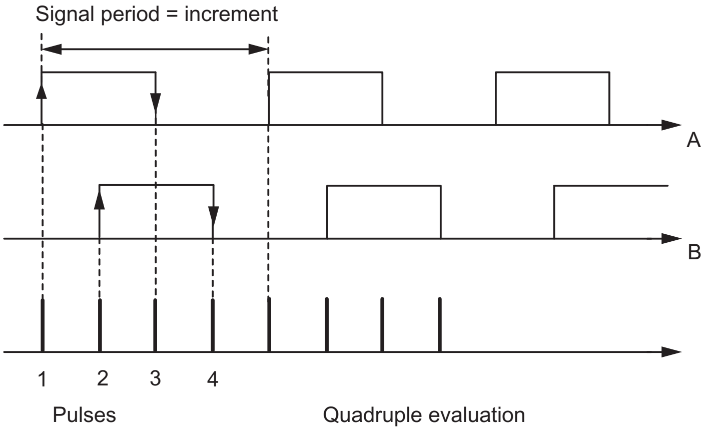


Figure 11-2 Increments and pulses

### Pulses

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

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

### Reaction times

The FM 352 has the following reaction times for connected incremental encoders:

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

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

### Example

Example of the min./max. reaction time with 16 cams available:

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

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

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

---

Note

You can compensate the reaction time by assigning the cam parameters accordingly or using dynamic adjustment.

---

### Flat gain

The flat gain is equivalent to the difference between the min./max. reaction time. For incremental encoders this is:

Flat gain = cam cycle time

---

Note

If the switching time of the FM 352 hardware and of the connected switching elements can be disregarded, reliable cam activation is always ensured if the cam is longer than the distance covered within the cam cycle time.

---

## 11.2 Proximity switches

### Definition

Initiators are simple switches which output pulse-shaped signals, and do not return a directional signal. You define the direction based on the machine data for selecting the initiator.

⚠ CAUTION

Risk of material damage!

Incorrect direction settings can cause serious errors in the system (for example, faulty control of a unit of equipment).

Check the direction settings in the commissioning phase, and whenever you replace an initiator.

### Supported initiators

The FM 352 supports the following initiators:

- Initiators with 24 V signal level (proximity switches)
  Limit frequency = 50 kHz
- Cable length max. 100 m

### Signal evaluation

With an initiator, the positive edges of signal A* are counted.

# 11.3 Absolute encoder

## Single-turn and multiturn encoders

Absolute encoders are divided into the categories:

- Single-turn encoder

  The total range of single-turn encoders is scale to one revolution.
- Multiturn encoder

  The total range of multiturn encoders is scaled to several revolutions.

## Supported absolute encoders

Absolute encoders with serial interface. Position data are transferred synchronously using the SSI protocol (**S**ynchronous**S**erial**I**nterface). FM 352 only supports 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 encoder | 13-bit half fir tree |
| Single-turn encoder | 13-bit right-justified |
| Single-turn encoder | 25-bit right-justified |
| Multiturn encoder | 25-bit fir tree |
| Multiturn encoder | 25-bit right-justified |
| Listen in | Fir tree |
| Listen in | Right-justified |
| Special setting:<br>Multiturn encoder in single-turn mode | 25-bit half fir tree |

## Data transfer

The data rate for data transmission depends on the cable length (see chapter "Technical data (Page 166)").

## Pulse evaluation with absolute encoders

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

## Listen in

"Listen in" means: 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 **baud rate** is irrelevant. Depending on the encoder type select "Listen in" or "Listen in Right-Justified" for "Frame Length".

## Wiring Listen in

The diagram below is based on the example of an FM 351 and FM 352, and shows how to wire the absolute encoder so that the FM 352 listens.

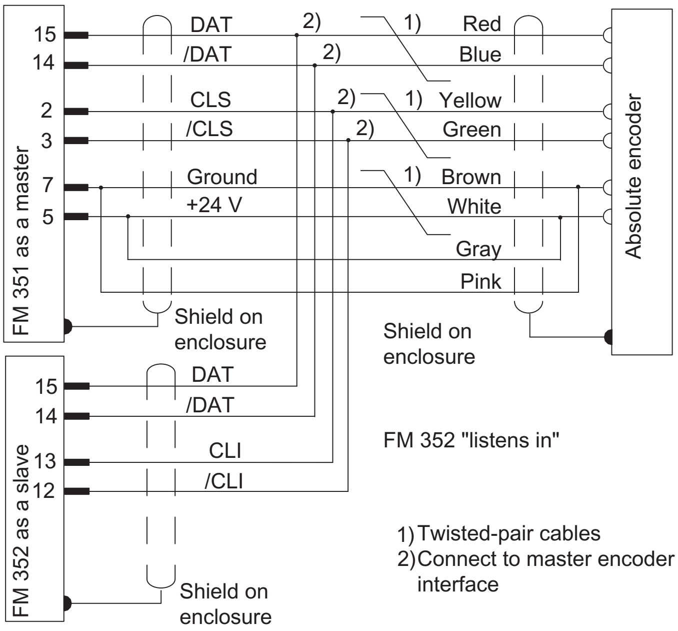


Figure 11-3 Connection of absolute encoders (SSI)

### Note

If you want the FM 352 to listen in, you must connect the ground (M) of the encoder supply of the master (for example, FM 351: front connector, pin 2) and of the slave module (FM 352: front connector, pin 2) to the ground of the CPU with low resistance.

## Reaction times

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

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

Maximum reaction time = 2 x frame run time + monoflop time + 2 x cam cycle time + switching time of the connected switching elements

With programmable absolute encoders:

Maximum reaction time = frame run time + monoflop time + 2 x cam cycle time + switching time of the connected switching elements +1/max. step sequence rate

## Monoflop time

The following limit values apply to the monoflop time:

- Minimum monoflop time: > 15 µs
- Maximum monoflop time: < 64 µs

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

## Frame run time

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 |
| 1000 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 time: approx. 20 μs for max. 16 cams
- Switching time of the hardware: approx. 150 μs
- Frame run time: 26 μs at a baud rate of 1 MHz (25-bit frame)
- Monoflop time: 20 μs (depends on the encoder: typical 20 μs to 40 μs

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

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

### Note

You can compensate the reaction time by assigning the cam parameters accordingly or using dynamic adjustment.

## Flat gain

The flat gain is equivalent to the difference between the min./max. reaction time.

With an absolute encoder it is as follows:

Flat gain = cam cycle time + frame run time + monoflop time

With a programmable absolute encoder, it is as follows:

Flat gain = cam cycle time + frame run time + monoflop time
+ 1/max. step sequence frequency

### Note

If the switching time of the FM 352 hardware and of the connected switching elements can be disregarded, reliable cam activation is always ensured if the cam is longer than the distance covered within the cam cycle time.

# Diagnostics 12

## 12.1 Possibilities for error evaluation

### Overview

- 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. The following options are available:
  – The RETVAL return values in the instance DBs of the integrated FBs as a group display for errors that occurred during execution of the FBs.
  – 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 identifier in JOB_ERR, for the cause of an error during communication between the FB and FM 352.
  – FB 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.

## 12.2 Meaning of the error LEDs

### Display

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

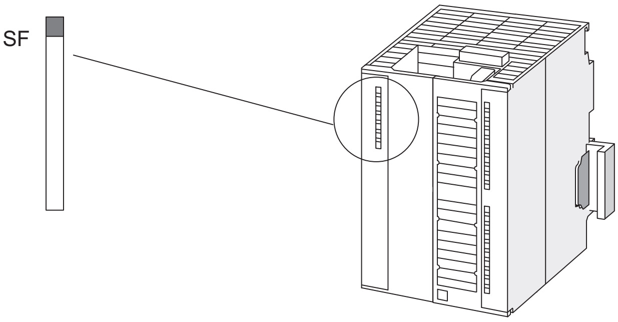


Figure 12-1 Status and error displays of FM 352

| Display | Meaning | Notes |
|---|---|---|
| SF (red)<br>LED - ON | Group error for internal and external errors | This LED indicates the following error states on the FM 352:<br>• Hardware interrupt lost<br>• Watchdog expired<br>• FM 352 is not configured<br>• Incorrect FM 352 parameter assignment (only when parameters assigned with SDB)<br>• No external 24 V auxiliary supply<br>• Front connector missing<br>• Encoder wire break<br>• Operating error<br>• Absolute encoder frame error<br>• Incremental encoder pulse missing or zero mark signal missing |

# 12.3 Diagnostic interrupts

## 12.3.1 Enable diagnostic interrupts

### Interrupt processing

The FM 352 can trigger hardware and diagnostic interrupts. Process those interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU goes to STOP mode (refer to the *Programming with STEP 7* Manual).

You enable the servicing of diagnostic interrupts as follows:

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

### Overview of the Diagnostic Interrupts

Events and errors triggering a diagnostic interrupt:

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

These errors are explained in detail in the appendix "Error classes (Page 190)".

## 12.3.2 Reaction of FM 352 to errors with diagnostics interrupt

### Reactions

- Cam processing will be disabled.
- The synchronization will be cleared by the following diagnostic interrupts:
  - Front connector missing, external power supply missing
  - zero mark error detected, cable fault (5-V encoder signals)
  - traversing range exceeded (indicated by a process/hardware error)
  - Set actual value cannot be executed (indicated by a process error).
- With one exception, control signals are no longer processed.

  Exception:

  When the software limit switch is crossed, a direction reversal is still possible in simulation mode.
- Function switch and job processing continues.

### FM 352 detects an error ("incoming")

A diagnostic interrupt is an "incoming" event if at least one error is pending. If any errors are pending clearance, the queued errors are reported again as "incoming" events.

Sequence:

1. FM 352 detects one or several errors, and generates a diagnostic interrupt. The "SF" LED is lit. The error event is logged to the diagnostic buffer.
2. The CPU operating system calls OB82.
3. You can now evaluate the start information of OB82.
4. The OB82_MOD_ADDR parameter indicates which module triggered the interrupt.
5. Further information is available when the FB CAM_DIAG is called.

### FM 352 detects the transition to the error-free state ("outgoing")

A diagnostic interrupt is only registered "outgoing" if all errors on the module are cleared.

Sequence:

1. FM 352 detects that all errors have been cleared and triggers a diagnostic interrupt. The "SF" LED is no longer lit. The diagnostic buffer remains unchanged.
2. The CPU operating system calls OB82.
3. The OB82_MOD_ADDR parameter indicates which module triggered the interrupt.
4. Evaluate the OB82_MDL_DEFECT bit.

   When this bit is "0", no errors are present on the module. You can close the evaluation session at this point.

### Diagnostic interrupt control by CPU states

- Diagnostic interrupts are blocked by the FM 352 when the CPU is in STOP mode.
- If none of the queued errors were cleared while the CPU was in STOP, the FM 352 reports all these errors as "incoming" event at the next CPU transition to RUN.
- If all existing errors were cleared while the CPU was in STOP, FM 352 does **not** report its error-free state with a diagnostic interrupt at the next CPU transition to RUN.

# Examples 13

## 13.1 Introduction

### Example project folder

The FM 352/FM 452 software package you installed contains example projects showing you several typical applications based on a number of selected functions.

The English example project for the FM 352 is in the following folder:

...\STEP7\EXAMPLES\zEn19_02

This folder contains several S7 programs of varying complexity and objectives.

## 13.2 Requirements

### Overview

The following requirements must be met:

- You have installed and wired an S7 station, consisting of a power supply module, a CPU and an FM 352 module (version ≥V5). The characteristics of earlier module versions may deviate from the description.
- STEP 7 and the FM 352 configuration package are properly installed on your PG/PC. The handling instructions are based on STEP 7 V5.0. The procedure may differ for other versions.
- The PG is connected to the CPU.

You can operate an FM 352 using these example projects. All examples can also be executed on an FM 352 in a distributed configuration. To use the "MultiModules" example, you require 2 modules.

## 13.3 Preparing the examples

### Procedure

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

1. Open the \STEP7\EXAMPLES\zEn19_02_FMx52___Prog example project in SIMATIC Manager, then copy it under a suitable name to your project folder.
2. Insert a station in this project according to your hardware configuration.
3. Complete the hardware configuration with HW Config and save the configuration.
4. Select an example program and copy its block container to your station.
5. Assign parameters for the FM 352 in HW Config using the instructions provided in the SIMATIC Function Modules FM 352 - First Steps in Commissioning, section FM 352 parameter assignment (http://support.automation.siemens.com/WW/view/en/1407842).
6. Enter the module address in the associated channel DB and, if necessary, also in the corresponding diagnostic DB in the "MOD_ADDR" parameter (refer to the section entitled Basics of Programming an FM 352 (Page 40)).
7. Download the hardware configuration to your CPU.
8. Download the blocks to your CPU.
9. To try out the next example, go to step 4.

## 13.4 Displaying the code of the examples

### Display

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 "Comment." If your screen provides sufficient space, you can also open the "Symbol information" view.

## 13.5 Testing the example

### Procedure

After you have successfully completed all necessary entries, download the entire block folder to the CPU.

The example programs include variable tables (VATs) you can use to view and change data blocks online (i.e., in CPU RUN mode).

1. From the variable table, select the "Symbol" and "Symbol Comment" views.
2. Open a variable table.
3. Open the variable table with the configured CPU, and monitor the variables cyclically.

This updates the variables dynamically when the CPU is in RUN mode.

All the examples require that the machine data and cam data were entered and saved using the parameter assignment interface. This allows you to work through the examples sequentially.

## 13.6 Reusing an example project

### Restrictions

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

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

## 13.7 Sample program 1 "Getting Started"

### Objective

In this example, you commission your cam controller after you have assigned its parameters in the parameter assignment interface according to the "Getting Started" manual.

The example extends the program shown in the "Integration in the User Program" chapter of the getting started by adding error evaluation.

### Requirements

- You have assigned the cam controller parameters as described in the "Getting Started" Manual.

### Startup

Enter the address of your module in channel DB at the MOD_ADDR address.

In the startup OB (OB 100), call FC CAM_INIT to reset all control and checkback signals as well as job management in the channel DB.

### Cyclic operation

1. Open the variable table.
2. Go online to the configured CPU to monitor the variables.
3. Transfer the prepared control values.

   The module changes to simulation mode. You can see how the actual value CAM.ACT_POS and track signals CAM.TRACK_OUT change dynamically.
4. Now change the simulation direction, specify different reference point coordinates, then disable simulation etc. by modifying and transferring the control values.

### Error evaluation

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

Open the hardware configuration and double-click the FM 352. This opens the parameter assignment interface. Select **Test > Error evaluation** to view the cause of the error.

To clear the error:

1. Enter a valid control value.
2. Switch the CPU to STOP.
3. Switch the CPU to RUN mode.
4. Enable the control values. If you enable the control values before restarting the CPU, they are canceled by the initialization routine in OB100, and thus have no effect.

## 13.8 Sample Program 2 "Commissioning"

### Objective

In this sample, you commission a cam controller without using the programming interface. You control and monitor the system using the variable tables (VATs).

### Requirements

You have assigned the cam controller parameters as described in the "Getting Started" Manual.

The module address is entered in the MOD_ADDR block parameter in the channel and diagnostic DBs.

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

PARADB included in this example contains default machine and cam data.

### Startup

In the startup OB (OB100), call FC CAM_INIT to initialize the channel DB. Next, set the trigger bits for all jobs and control signals you require when the module has completed its startup.

### Cyclic operation

Open the variable tables VAT1 and VAT2, then go online to the configured CPU to monitor the variables.

At VAT1, you can view 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. For information on error classes and numbers, refer to the appendix "Error classes (Page 190)".

Edit the machine and cam data at DB PARADB, download the DB to the CPU, and then enable the control values in VAT1. This writes the new data to the module, and enables these. Faulty data are indicated in VAT2. For information on machine and cam data, refer to the chapter "Machine and cam data (Page 67)".

### Error evaluation

Try to generate further errors:

- Define a reference point coordinate which is greater than the end of the rotary axis.
- Switch off the external power supply.
- Delete PARADB from the CPU (online), and then attempt to write machine data. The error evaluation is intentionally programmed here so that the CPU goes to STOP mode. If you update VAT1 once again, the error code for this error is indicated in CAM.JOB_ERR.

## 13.9 Sample program 3 "One Module"

### Objective

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

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

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

- Issuing several jobs simultaneously
- Mixing write and read jobs
- Reading with a continuous job, without waiting for the end of the job
- Evaluation of the checkback signals of the block
- Evaluation of the checkback signals for an individual job
- Resetting of done bits and error bits for individual jobs or all jobs
- Central 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 the cam controller parameters as described in the "Getting Started" Manual.
- The module address is entered in the MOD_ADDR block parameter in the channel and diagnostic DBs.
- The included channel DB already contains the DB number (3) of the parameter DB in the PARADBNO parameter.
- PARADB included in this example contains default machine and cam data.

### Startup

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

## Operation

The CPU is in STOP.

1. Open variable table VAT1, then transfer the control values.
2. Restart the CPU (STOP > RUN). 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 0 and 1 are reassigned to the values you specified in VAT 1. You can view the change in the VAT.

   Next, the program waits for an external event.
3. Once again, transfer the prepared control values from the VAT (this time, PROGDB.SWITCH is evaluated). The previous values will be restored in the cam data.

The step sequence is completed after this cycle, the step number = -2, and simulation is stopped.

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

If you have not activated the PROGDB.SWITCH switch before a CPU STOP, the cam parameters in the parameter DB will not be reset to their original values. In this case, once again download the parameter DB to the CPU.

## Error evaluation

Any processing error will stop the step sequence and disable simulation mode. Step number -1 will be entered.

Try to generate cam errors the central error evaluation will save to the PROGDB.CAM_ERR bit as group error.

- Set cam positions in VAT1 which are greater than the end of rotary axis.
- Define negative cam positions in VAT1.

## User program (FB PROG)

The user program accesses data in the module-specific data blocks using the <blockname>.<symbolic name> syntax. The user program can thus operate exactly one module.

With this type of programming, you can access DB data using symbolic names. Indirect addressing of several modules is part of sample program 5 "MultiModules".

The user program executes a step sequence as follows:

**Step 0**: Initialization of the cam controller. Sets the jobs and corresponding data to be executed at a restart of the module. The restart of the module may be triggered by a CPU restart, or by the return of a rack, for example.

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

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

Step 3: Cams 0 and 1 receive new parameters. To let you view the change, the cam data are read before and after the change and indicated at VAT1.

Step 4: The program waits for the set jobs to be executed.

Step 5: The program waits for the "external" event "switch on" (CAM.SWITCH = 1), which you can set via the VAT.

Step 6: The incoming event resets cams 0 and 1 to the value read in the initialization step.

Step 7: The program waits for the set jobs to be executed.

FB CAM_CTRL and FB CAM_DIAG are called at the end of the step sequence. The CAM_ERR output will be set if the diagnostics function has detected a message about incorrect cam data.

## 13.10 Sample program 4 "Interrupts"

### Objective

This sample contains a user program with the same task as in sample program 3 "One Module". In this sample, you are shown how to evaluate a diagnostic interrupt for specific modules, and how to process this in the user program to produce a general module error.

### Requirements

- You have assigned the cam controller parameters as described in the "Getting Started."
- The module address is entered in the MOD_ADDR block parameter in the channel and diagnostic DBs.
- In HW Config, enable the diagnostic interrupt for this module with **Edit > Object Properties > Basic Parameters > Select Interrupt > Diagnostics**. Compile the hardware configuration, and then download it to the CPU.
- The included channel DB already contains the DB number (3) of the parameter DB in the PARADBNO parameter.
- PARADB included in this example contains default machine and cam data.

### Startup

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

### Operation

As in sample program 3 "One Module".

### Error evaluation

As in sample program 3 "One Module".

Generate diagnostic interrupts by disconnecting the auxiliary power supply to the module, or by removing the front connector. The module error MOD_ERR and diagnostic error OB82_ERR will be set to 1, and the step number assumes a -1. The error identifiers will be canceled once you have cleared the error. Cam processing and simulation, however, remain disabled.

## User program (FB PROG)

The task is the same as in sample program 3 "One Module". However, the block was expanded by adding evaluation of the diagnostics 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 identifier in the corresponding instance DB of the user program is entered in the diagnostic interrupt.

## 13.11 Sample program 5 "MultiModules"

### Objective

This sample contains the same user program as sample program 3 "One Module", but this time it is used to operate two modules with different cam parameters. The user program uses an own instance of CAM_CTRL and CAM_DIAG for each module, a multiple instance is not possible. The user program expects a module address as input parameter. The DB numbers for channel and diagnostic DBs associated with this address are stored as constants in the program and can be modified by you.

### Requirements

You have inserted two FM 352 modules and configured these in HW Config.

You have assigned parameters for both cam controllers as described in the "Getting Started" Manual.

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

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

The PARADB and PARADB2 parameter DBs of the sample project contain default machine and cam data for both modules.

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

### Startup

In the startup OB (OB 100), set the startup identifier (step 0) for the user program at both instance DBs.

### Operation

The CPU is in STOP.

- Open VAT1 and VAT11, and transfer their control values.
- Start the CPU (STOP > RUN).

You can see how monitor the change of the actual positions, of cam data, and of the track signals of both modules.

### Error evaluation

As in sample program 4 "Interrupts", but separately for each of the two modules.

## User program (FB PROG)

The objective and sequence of the user program are as in sample program 4 "Interrupts" and sample program 3 "One Module".

The user program is designed for the operation of more than one module, since it accesses the module-specific data blocks: channel DB, diagnostic DB, and parameter DB. The DB number specified during call up is used in the user program to select the instance DB. With this type of programming, you cannot use symbolic names for the data in the data blocks because of the "Open global data block" instruction used in the user program.

## Diagnostic interrupt (OB 82)

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

# Technical data A

## A.1 General technical data

The following technical data are available in the Operating Instructions SIMATIC S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499).

- Standards and licenses
- Electromagnetic compatibility
- Transport and storage conditions
- Mechanical and climatic environmental conditions
- Specifications for insulation tests, protection class, degree of protection, and rated voltage
- Rated voltages

### Observe installation guidelines

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

# A.2 Technical data

## Technical specifications

| Dimensions and weights | |
|---|---|
| Dimensions W x H x D (mm) | 80 x 125 x 120 |
| Weight | Approx. 530 g |
| **Current, voltage and power** | |
| Current consumption (from the backplane bus) | max. 100 mA |
| Power loss | Typically 8.1 W |
| Current consumption of encoders, digital inputs, and digital outputs from L+ (no-load) | max. 200 mA (X1, terminal 1) |
| Supply of digital inputs and digital outputs | • Supply voltage: 24 V DC (permissible range: 20.4 to 28.8 V)<br>• Permissible potential difference between input of ground connection M (X1, terminal 2) and the central grounding point (shield): 60 V AC; 75 V DC<br>• Insulation test voltage: 500 V DC |
| Encoder supply | • Horizontal installation of S7-300, 20 °C:<br>– 5.2 V/300 mA<br>– 24 V/300 mA<br>• Horizontal installation of S7-300, 60 °C:<br>– 5.2 V/300 mA<br>– 24 V/300 mA<br>• Vertical installation of S7-300, 40 °C:<br>– 5.2 V/300 mA<br>– 24 V/300 mA<br>• Encoder power supply 24 V, non-regulated (X2, terminal 5)<br>• L+ -0.8 V<br>• Short-circuit protection: yes, thermal<br>• Encoder supply 5.2 V (X2, terminal 6) short-circuit protection: Yes, electronic<br>• Permissible potential difference between input (ground) and central ground connection of the CPU: 1 V DC |
| Load voltage polarity reversal protection | No |

| Encoder inputs | |
|---|---|
| Position detection | • Incremental<br>• Absolute |
| Signal voltages | • Symmetrical inputs: 5 V in accordance with RS 422<br>Asymmetrical inputs: 24 V/ typically 9 mA |
| Input frequency and cable length for symmetrical incremental encoders with 5 V supply | max. 1 MHz with 32 m shielded cable length |
| Input frequency and cable length for symmetrical incremental encoders with 24 V supply | max. 1 MHz, with 100 m shielded cable length |
| Input frequency and cable length for symmetrical incremental encoders with 24 V supply | • max. 50 kHz, with 25 m shielded cable length<br>• max. 25 kHz, with 100 m shielded cable length |
| Data transfer rate and cable length for absolute encoders | • max. 125 kHz with 320 m shielded cable length<br>• max. 250 kHz, with 160 m shielded cable length<br>• max. 500 kHz, with 60 m shielded cable length<br>• max. 1 MHz, with 20 m shielded cable length |
| Listen mode with absolute encoders | Yes |
| Input signals | • Incremental: 2 pulse trains, 90° phase shift, 1 zero pulse<br>• Absolute: Absolute value |
| **Digital inputs** | |
| Number of digital inputs | 4 |
| Number of simultaneously controllable digital inputs | 4 |
| Electrical isolation | No |
| Status display | Yes, one green LED per input |
| Input voltage | • 0-signal: -30 ... 5 V<br>• 1-signal: 11 ... 30 V |
| Input current | • 0-signal: ≤ 2 mA (quiescent current)<br>• 1-signal: 9 mA |
| Input delay | • 0- → 1-signal: max. 200 µs<br>• 1- → 0-signal: max . 200 µs |
| Connection of a 2-wire BERO | supported |
| Unshielded cable length | 32 m |
| Shielded cable length | 600 m |
| Switching rate | max. 500 Hz |
| Insulation test | VDE 0160 |

| Digital outputs | |
|---|---|
| Number of outputs | 13 |
| Electrical isolation | No |
| Status display | Yes, one green LED per output |
| Output current | • 0-signal: 0.5 mA<br>• 1-signal: 0.5 A at 100% concurrence (permitted range: 5 ... 600 mA)<br>• Lamp load: 5 W |
| Output delay when output current = 0.5 A | • 0- → 1-signal: max. 300 µs<br>• 1- → 0-signal: max. 300 µs |
| Signal level for 1-signal | L+: -0.8 V |
| Control of a digital input | Yes |
| Control of a count input | no, due to 50 µs pulse error |
| Short-circuit protection | Yes, thermal, clocked<br>Switching threshold 1.8 A |
| Limiting of inductive switch-off voltage | typically L+ -48 V |
| Switching rate | • resistive load: max. 500 Hz<br>• inductive load: max. 0.5 Hz |
| Cumulative current of digital outputs with horizontal installation of S7-300 | Demand factor 100%:<br>• at 20 °C: 6 A<br>• at 60 °C: 3 A |
| Cumulative current of digital outputs with vertical installation of S7-300 | Demand factor 100%:<br>at 40 °C: 3 A |
| Unshielded cable length | max. 100 m |
| Shielded cable length | 600 m |
| Insulation test | VDE 0160 |

**Note**

If the 24 V power supply is connected using a mechanical contact, the FM 352 transfers a pulse to the outputs. The pulse may assume a length of 50 µs within the permissible output current range. You must take this into account when using the FM 352 in combination with high-speed counters.

# Connection Diagrams B

## B.1 Encoder types

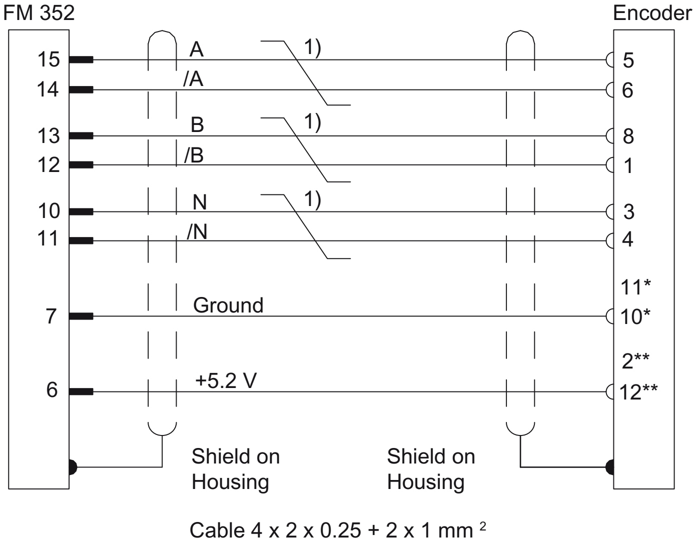
### Overview

The table below describes the encoders supported by FM 352. The connection diagrams for these encoders are described in this chapter:

| Encoder type | Connecting cable | Comment |
|---|---|---|
| Incremental encoder<br>Siemens<br>6FX 2001-2□□□□ | 4 x 2 x 0.25 + 2 x 1 mm$^2$ | Incremental encoder:<br>$V_p$=5 V, RS422 |
| Incremental encoder<br>Siemens<br>6FX 2001-2□□□□ | 4 x 2 x 0.5 mm$^2$ | Incremental encoder:<br>$V_p$=24 V, RS422 |
| Incremental encoder<br>Siemens<br>6FX 2001-4□□□□ | 4 x 2 x 0.5 mm$^2$ | Incremental encoder:<br>$V_p$=24 V, HTL |
| Absolute encoder<br>Siemens<br>6FX 2001-5□□□□ | 4 x 2 x 0.5 mm$^2$ | Absolute encoder:<br>$V_p$=24 V, SSI |

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

## Connection diagram



1) Twisted-pair cables

* Pins 10 and 11 are jumpered internally
** Pins 2 and 12 are jumpered internally

Figure B-1 Connection diagram for incremental encoder Siemens 6FX 2001-2□□□□ (Up=5 V: RS422)

### Circular connector

12-pin socket, Siemens 6FX2003-0SU12

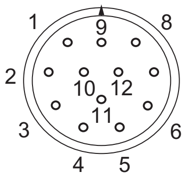


Figure B-2 Circular connector, terminal end (solder side)

### Sub D connector

15-pin sub D connector, metallized housing with screw interlock 6FC9 341-1HC

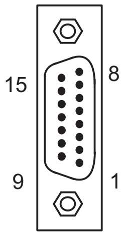


Figure B-3 Sub D connector, terminal end (solder side)

# B.3 Connection Diagram for Incremental Encoder Siemens 6FX 2001-2 (Up=24V; RS 422)

## Connection diagram

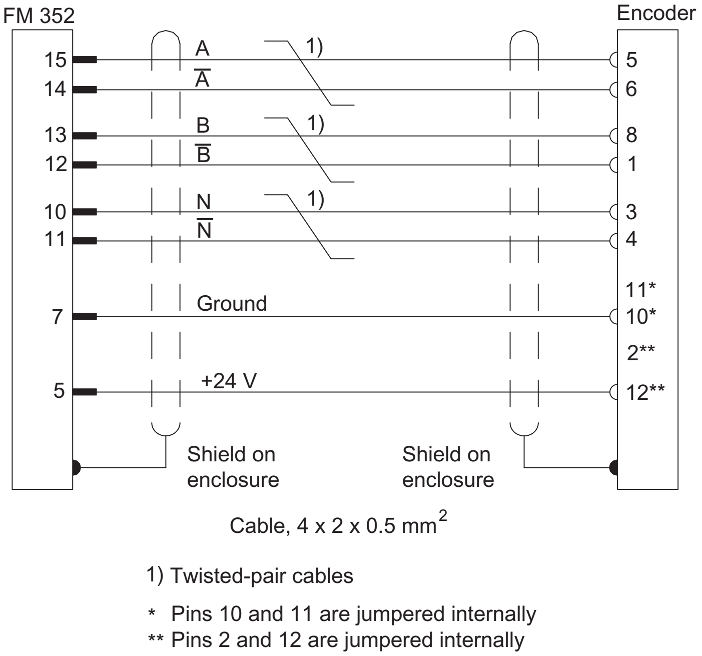


Figure B-4 Connection diagram for incremental encoder Siemens 6FX 2001-2□□□□ (Up=24V; RS422)

### Circular connector

12-pin socket, Siemens 6FX2003-0SU12

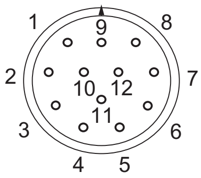


Figure B-5 Circular connector, terminal end (solder side)

### Sub D connector

15-pin sub D connector, metallized housing with screw interlock 6FC9 341-1HC

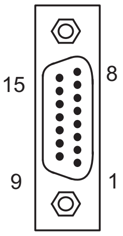


Figure B-6 Sub D connector, terminal end (solder side)

# B.4 Wiring Diagram of the Incremental Encoder Siemens 6FX 2001-4 (Up = 24 V; HTL)

## Connection diagram

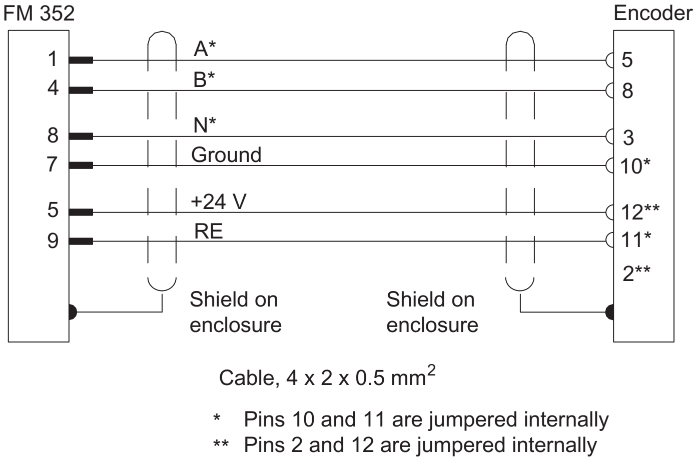


Figure B-7 Connection diagram for incremental encoder Siemens 6FX 2001-4□□□□ (Up=24V; HTL)

### Circular connector

12-pin Siemens socket 6FX2003-0SU12

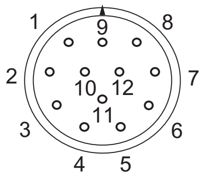


Figure B-8 Circular connector, terminal end (solder side)

### Sub D connector

15-pin sub D connector, metallized housing with screw interlock 6FC9 341-1HC

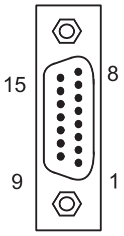


Figure B-9 Sub D connector, terminal end (solder side)

### Note

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

current sourcing: Connect RE (9) to ground (7).

current sinking: Connect RE (9) to +24 V (5).

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

## Connection diagram

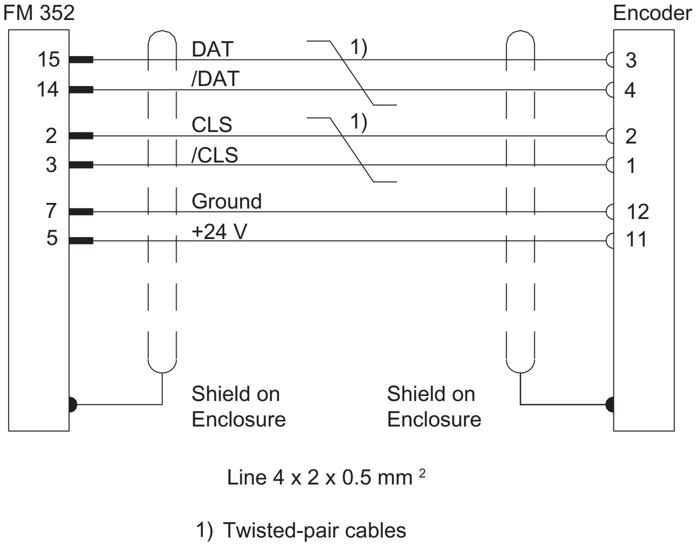


Figure B-10 Connection diagram for absolute encoder Siemens 6FX 2001-5□□□□ (Up=24V; SSI)

### Circular connector

12-pin Siemens socket 6FX2003-0SU12

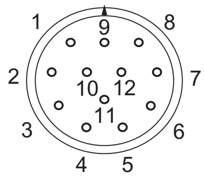


Figure B-11 Circular connector, terminal end (solder side)

### Sub D connector

15-pin sub D connector, metallized housing with screw interlock 6FC9 341-1HC

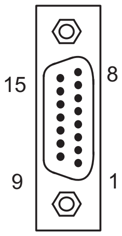


Figure B-12 Sub D connector, terminal end (solder side)

# Data blocks / error lists C

## C.1 Content of the channel DB

**Note**

Do not modify any data not listed in this table.

### 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<br>-1 = DB not available |
| 12.0 | FM_TYPE | BOOL | FALSE | 0 = FM 352 up to V4.0<br>1 = FM 352 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<br>Bit 0 = track 0 |
| Checkback signals | | | | |
| 22.2 | DIAG | BOOL | FALSE | 1 = diagnostic buffer changed |
| 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 busy |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 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 axis |
| 30.0 | TRACK_OUT | DWORD | DW#16#0 | Current signals of tracks 0 to 31<br>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 deactivated |
| Trigger bits for write jobs | | | | |
| 35.0 | MDWR_EN | BOOL | FALSE | 1 = write machine data |
| 35.1 | MD_EN | BOOL | FALSE | 1 = enable machine data |
| 35.2 | AVALREM_EN | BOOL | FALSE | 1 = set actual value, cancel set actual value on-the-fly |
| 35.3 | CAM1WR_EN | BOOL | FALSE | 1 = write cam data 1<br>(cams 0 to 15) |
| 35.4 | CAM2WR_EN | BOOL | FALSE | 1 = write cam data 2<br>(cams 16 to 31) |
| 35.5 | CAM3WR_EN | BOOL | FALSE | 1 = write cam data 3<br>(cams 32 to 47) |
| 35.6 | CAM4WR_EN | BOOL | FALSE | 1 = write cam data 4<br>(cams 48 to 63) |
| 35.7 | CAM5WR_EN | BOOL | FALSE | 1 = write cam data 5<br>(cams 64 to 79) |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 36.0 | CAM6WR_EN | BOOL | FALSE | 1 = write cam data 6<br>(cams 80 to 95) |
| 36.1 | CAM7WR_EN | BOOL | FALSE | 1 = write cam data 7<br>(cams 96 to 111) |
| 36.2 | CAM8WR_EN | BOOL | FALSE | 1 = write cam data 8<br>(cams 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 fast cam parameter change settings (16 cams) |
| **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<br>(cams 0 to 15) |
| 37.3 | CAM2RD_EN | BOOL | FALSE | 1 = read cam data 2<br>(cams 16 to 31) |
| 37.4 | CAM3RD_EN | BOOL | FALSE | 1 = read cam data 3<br>(cams 32 to 47) |
| 37.5 | CAM4RD_EN | BOOL | FALSE | 1 = read cam data 4<br>(cams 48 to 63) |
| 37.6 | CAM5RD_EN | BOOL | FALSE | 1 = read cam data 5<br>(cams 64 to 79) |
| 37.7 | CAM6RD_EN | BOOL | FALSE | 1 = read cam data 6<br>(cams 80 to 95) |
| 38.0 | CAM7RD_EN | BOOL | FALSE | 1 = read cam data 7<br>(cams 96 to 111) |
| 38.1 | CAM8RD_EN | BOOL | FALSE | 1 = read cam data 8<br>(cams 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 |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 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 |
| Done bits for write jobs | | | | |
| 41.0 | MDWR_D | BOOL | FALSE | 1 = "write machine data" job completed |
| 41.1 | MD_D | BOOL | FALSE | 1 = "Activate 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 = "set actual value" job completed |
| 42.5 | FVAL_D | BOOL | FALSE | 1 = "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 1 cam" job completed |
| 43.0 | CH16CAM_D | BOOL | FALSE | 1 = "change 16 cams" completed (fast cam parameter change) |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 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 |
| 44.5 | ENCVAL_D | BOOL | FALSE | 1 = "read actual encoder value" job completed |
| 44.6 | CAMOUT_D | BOOL | FALSE | 1 = "read position 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 |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 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 1 cam" job |
| 49.0 | CH16CAM_ERR | BOOL | FALSE | 1 = error in "Change 16 cams" (fast cam parameter change) |
| 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 |
| 49.7 | 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 FB CAM_CTRL | | | | |
| 52.0 | JOB_ERR | INT | 0 | Communication errors |
| 54.0 | JOBBUSY | BOOL | FALSE | 1 = at least one job is running |
| 54.1 | JOBRESET | BOOL | FALSE | 1 = reset all error and done bits |
| Data element for "Zero offset" job | | | | |
| 86.0 | ZOFF | DINT | L#0 | Zero offset |
| Data element for "Set actual value" job | | | | |
| 90.0 | AVAL | DINT | L#0 | Coordinate for "Set actual value" |
| Data element for "Set actual value on-the-fly" job | | | | |
| 94.0 | FVAL | DINT | L#0 | Coordinate for "Set actual value on-the-fly" |
| Data element for "Set reference point" job | | | | |
| 98.0 | REFPT | DINT | L#0 | Coordinate for "Set reference point" |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| 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 "Length measurement/edge detection" job | | | | |
| 112.0 | BEG_VAL | DINT | L#0 | Initial value |
| 116.0 | END_VAL | DINT | L#0 | End value |
| 120.0 | LEN_VAL | DINT | L#0 | Length |
| Data for "Read count values" job | | | | |
| 124.0 | CNT_TRC0 | INT | 0 | Current count value of counter cam track 0 |
| 126.0 | CNT_TRC1 | INT | 0 | Current count value of counter cam track 1 |
| Data for "Read position and track data" job | | | | |
| 128.0 | ACTPOS | DINT | L#0 | Current position |
| 132.0 | ACTSPD | DINT | L#0 | Current velocity |
| 136.0 | TRACK_ID | DWORD | DW#16#0 | Track identifier bits of tracks 0 to 31 |
| Data for "Read encoder data" job | | | | |
| 140.0 | ENCVAL | DINT | L#0 | Encoder value |
| 144.0 | ZEROVAL | DINT | L#0 | Count value at the last zero mark |
| 148.0 | ENC_ADJ | DINT | L#0 | Absolute encoder adjustment |
| Data for "Read cam and track data" job | | | | |
| 152.0 | CAM_00_31 | DWORD | DW#16#0 | Cam identifier bits for cams 0 to 31 |
| 156.0 | CAM_32_63 | DWORD | DW#16#0 | Cam identifier bits for cams 32 to 63 |
| 160.0 | CAM_64_95 | DWORD | DW#16#0 | Cam identifier bits for cams 64 to 95 |
| 164.0 | CAM_96_127 | DWORD | DW#16#0 | Cam identifier bits for cams 96 to 127 |
| 168.0 | TRACK_ID1 | DWORD | DW#16#0 | Track identifier bits of tracks 0 to 31 |
| 172.0 | ACTPOS1 | DINT | L#0 | Current position |
| Data for "Fast cam parameter change" job | | | | |
| 176.0 | C_QTY | BYTE | B#16#0 | Number of cams to modify |
| 177.0 | DIS_CHECK | BOOL | FALSE | 1 = disable data check |
| 180.0 | CAM | ARRAY [0...15]<br>STRUCT | | Note:<br>The following structure must be completed for each cam to be modified |

| Address | Name | Type | Initial value | Comment |
|---|---|---|---|---|
| Relative address | | | | |
| +0.0 | CAM_NO | BYTE | B#16#0 | Number of the cam to modify |
| +1.0 | C_EFFDIR | BOOL | FALSE | 1 = change the effective 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 / activation time to the value CEND (new cam end) |
| +1.3 | C_LTIME | BOOL | FALSE | 1 = change the lead time to the LTIME value (new lead time) |
| +1.4 | CAM_OFF | BOOL | FALSE | 1 = deactivate the cam during the cam change |
| +1.5 | EFFDIR_P | BOOL | FALSE | 1 = new effective direction positive (plus) |
| +1.6 | EFFDIR_M | BOOL | FALSE | 1 = new effective direction negative (minus) |
| +2.0 | CBEGIN | DINT | L#0 | New cam start |
| +6.0 | CEND | DINT | L#0 | New cam end / new activation time |
| +10.0 | LTIME | INT | 0 | New lead time |

# C.2 Content of the parameter DB

**Note**

Do not modify any data not listed in this table.

## Content of the Parameter DB

| Address | Name | Type | Start 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 distance for edge detection |
| 8.0 | UNITS | DINT | L#1 | Physical units system |
| 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:<br>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 | Software limit switch start |
| 68.0 | SSW_END | DINT | L#100000000 | Software limit switch end |
| 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 velocity |
| 90.0 | TRACK_OUT | WORD | W#16#0 | Control of track outputs:<br>0 = cam controller, 1 = CPU;<br>Bit number = track number |

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 95.0 | EN_IN_I3 | BOOL | FALSE | Enable input I3 |
| 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 | High count value for counter cam track 0 |
| 104.0 | CNT_LIM1 | DINT | L#2 | High count value for counter cam track 1 |
| 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: Positive effective direction (plus) |
| +0.2 | EFFDIR_M | BOOL | TRUE | 1: Negative effective direction (minus) |
| +0.3 | CAM_TYPE | BOOL | FALSE | 0: Distance cam, 1: Time-based 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#-100 000 000 | Cam start |
| +6.0 | CEND | DINT | L#100 000 000 | Cam end/activation time |
| +10.0 | LTIME | INT | 0 | Lead time |

# C.3 Data and Structure of the Diagnostic DB

**Note**

Do not modify any data not listed in this table.

## Content of the diagnostic DB

Table C- 1 Structure of the diagnostic DB

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| 0.0 | MOD_ADDR (enter!) | INT | 0 | Module address |
| 256.0 | JOB_ERR | INT | 0 | Communication errors |
| 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 |

## Structure of the Diagnostic Entry

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

Table C- 2 Structure of the diagnostic entry DIAG[n]

| Address | Name | Type | Start value | Comment |
|---|---|---|---|---|
| +0.0 | STATE | BOOL | FALSE | 0 = outgoing event<br>1 = incoming event |
| +0.1 | INTF | BOOL | FALSE | 1 = Internal error |
| +0.2 | EXTF | BOOL | FALSE | 1 = external error |
| +2.0 | FCL | INT | 0 | Error class:<br>1: Operating error<br>4: Data error<br>5: Machine data error<br>7: Cam data error<br>15: Messages<br>128: Diagnostic errors |
| +4.0 | FNO | INT | 0 | Error numbers 0 to 255 |
| +6.0 | CH_NO | INT | 0 | Channel number (always 1) |
| +8.0 | CAMNO | INT | 0 | Cam numbers 0 to 127 with error class = cam data error |

## 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 | Protocol error on Layer 2 (data transfer interrupted within PROFINET / PROFIBUS DP, for example, due to wire break, missing connector, parameter assignment error, etc.) |
| 80A3 | 32931 | -32605 | Protocol error at user interface/user (data transfer interrupted within PROFINET / PROFIBUS DP, for example, due to wire break, missing connector, parameter assignment error, etc.) |
| 80A4 | 32932 | -32604 | Communication problem on K bus |
| 80B1 | 32945 | -32591 | Specified length wrong. Faulty FM_TYPE parameter setting at 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 has not yet prepared 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. |

| JOB_ERR (hex) | JOB_ERR (dec) | JOB_ERR (int) | Meaning |
|---|---|---|---|
| 80C4 | 32964 | -32572 | Communication errors |
| 80C5 | 32965 | -32571 | Distributed I/Os not available. |
| 80C6 | 32966 | -32570 | Priority class abort (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, i.e. these can be cleared after a waiting time without user intervention. Messages in the form 7xxx indicate temporary states in communication. | | | |

# C.4 Error classes

## Class 1: Operating error

Operating errors are detected asynchronously to an operator input/control.

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

## Class 4: Data error

Data errors are detected synchronously to an operator input/control.

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 10 | **Zero offset error** | | No |
| | Cause | The zero offset is greater than ±100 m or ±1000 m.<br>The software limit switches are outside the traversing range (-100 m to +100 m or -1000 m to +1000 m)<br>after setting the zero offset.<br>Rotary axis: The absolute value of the zero offset is greater than the end of rotary axis. | |
| 11 | **Faulty actual value setting** | | No |
| | Cause | Linear axis: The coordinate lies outside the current (possibly shifted) software limit switches.<br>Rotary axis: The coordinate is < 0 or greater than the end of rotary axis. | |
| 12 | **Reference point error** | | No |
| | Cause | Linear axis: The coordinate lies outside the current (possibly offset) software limit switches.<br>Rotary axis: The coordinate is < 0 or greater than the end of rotary axis. | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 20 | **Enable 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.<br>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.<br>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 | **Incorrect lead time** | | No |
| 31 | **Incorrect cam number** | | No |
| | Cause | Cam is invalid.<br>The cam number is not in the range 0 to 127. | |
| 32 | **Incorrect cam start** | | No |
| | Cause | The cam start is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m).<br>Rotary axis: The cam start is < 0 or greater than the end of rotary axis. | |
| 33 | **Incorrect cam end / incorrect activation time** | | No |
| | Cause | The cam end is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m).<br>Rotary axis: The cam end is < 0 or greater than the end of rotary axis.<br>The cam is not active at least for the duration of one pulse.<br>With an inverse cam, there are not at least 4 pulses between the cam start and cam end. | |
| 34 | **Cancel set actual value not possible** | | No |
| | Cause | The actual position value would be outside the operating range with an SSI encoder and linear axis after making the setting. | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 35 | **Incorrect actual value specified by "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.<br>When this setting is applied, the software limit switches would be outside the traversing range (-100 m to +100 m or -1000 m to +1000 m).<br>The offset derived from set actual value / set actual value on-the-fly would be more than ±100 m or ±1000 m. | |
| 107 | **Axis parameters not assigned** | | No |
| | Cause | There are no machine data on the axis.<br>There are no machine data activated on the axis. | |
| 108 | **Axis not synchronized** | | No |
| | Cause | One of the settings "set actual value" or "set actual value on-the-fly" was initiated although the axis is not synchronized. | |
| 109 | **Cam processing running.** | | No |
| 110 | **Incorrect number of cams to be modified** | | No |

## Class 5: Machine data error

The diagnostic interrupt is only triggered if an error is detected 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 | **Incorrect minimum edge distance** | | Yes |
| | Cause | You have entered a value <0 or >$10^9$ μm as the minimum edge distance | |
| 8 | **Incorrect axis type** | | Yes |
| | Cause | You have specified neither 0 nor 1 as the axis type | |
| 9 | **Incorrect end of rotary axis** | | Yes |
| | Cause | The value for the end of rotary axis is outside the permitted range of 1 to $10^9$ μm or 1 to $10^8$ μm (depending on the resolution). | |
| 10 | **Incorrect encoder type** | | Yes |
| | Cause | The value for the encoder type is outside the permitted range of 1 to 10 | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 11 | **Incorrect 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 | **Incorrect number of increments/encoder revolution** (see chapter "Machine data of the encoder (Page 86)") | | Yes |
| 14 | **Incorrect number of increments/encoder revolution** (see chapter "Machine data of the encoder (Page 86)") | | Yes |
| 15 | **Incorrect baud rate** | | Yes |
| | Cause | You have specified a baud rate outside the permitted range of 0 to 3. | |
| 16 | **Incorrect reference point coordinate** | | Yes |
| | Cause | The coordinate is outside the range of -100 m to +100 m or -1000 m to +1000 m, depending on the resolution.<br>Linear axis: The coordinate is outside the operating range.<br>Rotary axis: The coordinate is < 0 or greater than the end of rotary axis. | |
| 17 | **Incorrect absolute encoder adjustment** | | Yes |
| | Cause | SSI encoder: The value of the absolute encoder adjustment is not in the encoder range: [increments per encoder revolution] x [number of revolutions - 1]. | |
| 18 | **Incorrect type of reference point retrigger** | | Yes |
| | Cause | You have specified a value other than 0, 1, 6 and 7. | |
| 19 | **Incorrect direction adaptation** | | Yes |
| | Cause | You have specified a value other than 0 and 1. | |
| 20 | **Hardware monitoring not possible** | | Yes |
| | Cause | You set frame error monitoring = FALSE at the parameter DB.<br>The monitoring of missing pulses is not possible with the encoder used. Disable the MON_PULSE parameter. | |
| 21 | **Incorrect software limit switch start** | | Yes |
| | Cause | Linear axis: The software limit switch start is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m, depending on the resolution).<br>Linear axis: The software limit switch start (including any existing zero offset) is less than -100 m or -1000 m (depending on the resolution). | |
| 22 | **Incorrect software limit switch end** | | Yes |
| | Cause | Linear axis: The software limit switch end is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m, depending on the resolution) or is less than the software limit switch start.<br>The software limit switch end (including any existing zero offset) is greater than +100 m or +1000 m (depending on the resolution). | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 144 | **Incorrect number of cams** | | Yes |
| | Cause | You have specified a value other than 0 to 3 for the number of cams. | |
| 145 | **Incorrect hysteresis** | | Yes |
| | Cause | The hysteresis is outside the range 0 to 65535 * resolution.<br>The hysteresis is greater than [¼ x operating range] or {¼ x rotary axis range]. | |
| 146 | **Incorrect simulation velocity** | | Yes |
| | Cause | The simulation velocity is outside the range 1000*RES to 3*$10^{7}$*RES, or is greater than 5* $10^{8}$ µm/min.<br>The simulation velocity cannot be set internally. | |
| 147 | **Incorrect track** | | Yes |
| | Cause | Activation of a track outside 0 to 15 (bits 0 to 15) was selected. | |
| 148 | **Incorrect selection of enable inputs** | | Yes |
| | Cause | You wanted to enable a track outside 3 to 10 (bits 0 to 7) using an external signal. | |
| 149 | **Incorrect selection of special tracks** | | Yes |
| | Cause | You wanted to define a track outside 0, 1 and 2 (bits 0, 1 and 2) as a special track | |
| 150 | **Incorrect high count value track 0** | | Yes |
| | Cause | You have specified a count value < 2 or > 65535 as the high count value. | |
| 151 | **Incorrect high count value track 1** | | Yes |
| | Cause | You have specified a count value < 2 or > 65535 as the high count value. | |
| 200 | **Incorrect resolution** | | Yes |
| | Cause | You have specified a resolution < 0.1 µm/pulse or >1000 µm/pulse.<br>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 | **Position encoder does not match the operating range/rotary axis range** | | Yes |
| | Cause | SSI position encoder and rotary axis: The encoder does not exactly cover the rotary axis range.<br>Linear axis: The encoder does not cover at least the operating range (including software limit switches). | |

## Class 7: Cam data error

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

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 1 | Illegal hardware interrupt | | Yes |
| | Cause | You attempted to define a hardware interrupt for a cam with a cam number > 7. | |
| 2 | Incorrect track number | | Yes |
| | Cause | The track number is outside the range 0 to 31 | |
| 3 | Incorrect cam start | | Yes |
| | Cause | The cam start is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m).<br>Rotary axis: The cam start is < 0 and/or greater than the end of rotary axis. | |
| 4 | Incorrect cam end | | Yes |
| | Cause | The cam end is outside the traversing range (-100 m to +100 m or -1000 m to +1000 m).<br>The cam length is not at least one pulse.<br>Rotary axis: The cam end is < 0 and/or greater than the end of rotary axis.<br>With an inverse cam, there are not at least 4 pulses between the cam start and cam end. | |
| 5 | Incorrect activation time | | Yes |
| | Cause | The activation time is < 0 μs. The maximum value depends on the number of cams available (see chapter "Cam data (Page 97)"). | |
| 6 | Incorrect lead time[1] | | Yes |
| | Cause | The lead time is < 0 μs. The maximum value depends on the number of cams available (see chapter "Cam data (Page 97)"). | |
| 50 | Too many cam sets | | 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 | Axis parameters not assigned | | Yes |
| | Cause | You want to enter cam data although not machine data are active yet. | |

[1] The error message may also be issued if you have assigned the parameter "inverted" as the count direction in connection with an absolute encoder (SSI).

### Class 15: Messages

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 1 | Start of parameter assignment | | No |
| | Cause | The module has detected a parameter assignment via a system data block. | |
| 2 | End of parameter assignment | | No |
| | Cause | The module has processed the parameter assignment via a system data block error-free. | |

### 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, short circuit (e.g., at connected encoder) | |
| | Effect | See chapter "Reaction of FM 352 to errors with diagnostics interrupt (Page 148)".<br>• Cam processing will be deactivated<br>• Track outputs will be disabled<br>• With incremental encoders, synchronization is canceled<br>• The FM 352 has not had parameters assigned (checkback signal PARA = 0). | |
| | Remedy | Make sure that the 24 V connection is correct (If the 24 V connection is correct, then the module is defective.) | |
| 51 | Watchdog expired | | Yes |
| | Cause | • Strong interference on the FM 352<br>• Error in the FM 352 | |
| | Effect | • Module is reset<br>• Provided that after resetting the module, no module defect is detected, the module is ready for operation again.<br>• The module signals the expired WATCHDOG with "incoming" and "outgoing" | |
| | Remedy | • Eliminate the interference<br>• Contact the relevant sales department who will require details of the circumstances leading to the error.<br>• Replace the FM 352 | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 52 | **Internal module power supply failed** | | Yes |
| | Cause | Error in the FM 352 | |
| | Effect | • Module is reset<br>• Provided that after resetting the module, no module defect is detected, the module is ready for operation again. | |
| | Remedy | Replace the FM 352 | |
| 70 | **Hardware interrupt lost** | | Yes |
| | Cause | A hardware interrupt event detected by FM 352 cannot be reported, because the same event has not yet been processed by the user program/CPU. | |
| | Effect | • Cam processing will be deactivated<br>• Track outputs will be disabled<br>• With incremental encoders, synchronization is canceled | |
| | Remedy | • Link OB40 into the user program<br>• Check the bus connection of the module<br>• Deactivate hardware interrupt<br>• Adapt your 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<br>• Encoder has no transverse signals<br>• Incorrect pin assignment<br>• Cable length too long<br>• Encoder signals short-circuited | |
| | Effect | • Cam processing will be deactivated<br>• Track outputs will be disabled<br>• With incremental encoders, synchronization is canceled | |
| | Remedy | • Check the encoder cable<br>• Keep within encoder specifications<br>• Monitoring can be temporarily disabled using the parameter assignment interface, but at the responsibility of the operator.<br>• Keep to the module's technical data | |

| No. | Meaning | | Diagnostic interrupt |
|---|---|---|---|
| 145 | **Absolute encoder frame error** | | Yes |
| | Cause | The frame traffic between FM 352 and the absolute encoder (SSI) is incorrect or interrupted:<br>• Encoder cable cut or not plugged in<br>• Incorrect encoder type<br>• Encoder incorrectly set (programmable encoders)<br>• Frame length incorrectly specified<br>• Encoder returns incorrect values (encoder defective)<br>• Interference on measuring system cable<br>• Selected baud rate is too high | |
| | Effect | • Cam processing will be deactivated<br>• Track outputs will be disabled<br>• The last correct actual value remains unchanged until the end of the next correct SSI transfer | |
| | Remedy | • Check the encoder cable<br>• Check the encoder<br>• Check the frame traffic between the encoder and FM 352 | |
| 146 | **Missing pulses of incremental encoder** | | Yes |
| | Cause | • Encoder monitoring has detected missing pulses<br>• Number of increments per encoder revolution is incorrectly entered<br>• Encoder defective: does not return the defined number of pulses<br>• Bad or missing zero marker<br>• Interference on the encoder cable | |
| | Effect | • Cam processing will be deactivated<br>• Track outputs will be disabled<br>• Synchronization is canceled | |
| | Remedy | • Enter the correct number of increments/encoder revolution<br>• Check the encoder and its cable<br>• Comply with shielding and grounding regulations<br>• Monitoring can be temporarily disabled using the parameter assignment interface, but at the responsibility of the operator. | |

# Programming without SFB 52 and SFB 53 D

## D.1 Overview of the Programming without SFB 52 and SFB 53 section

### If your CPU does not support the system blocks SFB 52 and SFB 53 with DPV1 functionality

Then use the blocks from the program folder "FM 352,452 CAM V1" to program the FM 352.

You will find a description in this section.

## D.2 Basics of Programming an FM 352

### Task

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

### Preparatory steps

- Open the FMx52LIB block library in SIMATIC Manager, then 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): This can only be used with FM 452
  - CAM_CHANTYPE (UDT1): This is required to generate a channel DB; used by the FCs CAM_INIT, CAM_CTRL and CAM_MSRM.
  - CAM_DIAGTYPE (UDT2): This is required to generate a diagnostic DB; used by FC CAM_DIAG.
  - CAM_P016TYPE (UDT3): This is required to generate a parameter DB with machine data and data for 16 cams; 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 are using multiple modules, you require a separate set of data blocks for each module used.
- Enter the module address in the channel DB and, if applicable, in the diagnostic DB in MOD_ADDR.
- If your PG/PC is connected to a CPU, you can now download the FCs and DBs to the CPU.

# D.3 FC CAM_INIT (FC 0)

## Tasks

FC CAM_INIT initializes the following data in the channel DB:

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

## Call

The function must be executed after a startup (power on) of the module or CPU. You should therefore insert it, for example, in the restart OB (OB100) and the removal/insertion OB (OB83) or call it in the initialization phase of your user program. This ensures that your user program does not access obsolete data after a CPU or module restart.

## Call parameters

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

## Return values

This function does not return a return value.

## D.4 FC CAM_CTRL (FC 1)

### Tasks

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

On each call, the function performs the following actions:

- Read checkback signals:

  FC CAM_CTRL reads all checkback signals from the module and enters them in the channel DB. The control signals and jobs are not executed until this task is completed, and thus the checkback signals reflect the module status prior to the block call.

- Write control signals:

  The control signals written to the channel DB are transferred to the module. Enabling of cam processing, however, is delayed as long as the trigger for a "Set reference point" job or "Write cam data" job is set. The activation (or reactivation) of cam processing is delayed by 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 required 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 checkback signals is handled by using jobs.

To start a job, set the corresponding trigger bit in the channel DB and provide the relevant data for write jobs. You then call FC 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 in a distributed system, a read job may take several cycles.

Due to the required confirmations from the module, a write job requires at least 3 calls (or OB cycles). If you use the FM 352 in a distributed system, a write job may take more than 3 calls.

You can send several jobs at the same time, if necessary, along with control signals. With the exception of the job for writing the function switches, the jobs are executed in the order of the trigger bits specified in the channel DB. Once a job has been completed, the trigger bit is canceled. The next time the block is called, the subsequent job is identified 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"), these jobs 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 reset to 0.

## Function switches

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

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. The length measurement function is activated if you enable both function switches at the same time (0 → 1).

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

Call FC CAM_INIT at the startup of the module or CPU (see chapter "FC CAM_INIT (FC 0) (Page 201)"). Among other things, this also resets resets the function switches.

FC CAM_CTRL acknowledges the module startup. During this time, RET_VAL and JOBBUSY = 1.

## Call parameters

| Name | Data type | P-type | 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 1 job active |
| 0 | 1 | No job active, no error |
| -1 | 0 | Error:<br>Data error (DAT_ERR) or<br>Communication error (JOB_ERR) occurred |

## Job status

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

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

## Reaction to errors

If faulty data were written by a write job, the module returns the message DATA_ERR = 1. If an error occurs during communication with the module for 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 canceled and the error bit (_ERR) and the done bit (_D) are set. The trigger bit is also canceled and the error bit (_ERR) is set for all write jobs still pending.

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

- Error in a read job:

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

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

  For further error information, refer to the JOB_ERR and DATA_ERR parameters (see chapter "Possibilities for error evaluation (Page 145)").

## D.5 FC CAM_DIAG (FC 2)

### Tasks

Use FC CAM_DIAG to read the data of the diagnostic buffer of the module and make these available for visualization on an operator control and monitoring system or for a programmed evaluation.

### Call

This function must be called cyclically. A further job in an interrupt OB is not permitted. At least 2 calls (cycles) are required to complete execution of this function..

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

### Data used

- Diagnostic DB:

  The module address must be entered in the diagnostic DB. The last entry in the diagnostic buffer is entered in the DIAG[1] structure and the first 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 | P-type | Meaning |
|---|---|---|---|
| DB_NO | INT | I | Number of the diagnostic DB |
| RET_VAL | INT | O | Return value |

## Return values

The function returns the following return values:

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

## Reaction to errors

The cause of a job error can be read in the JOB_ERR parameter of the diagnostic DB (see chapter "Possibilities for error evaluation (Page 145)").

# D.6 Data blocks

## D.6.1 Templates for data blocks

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

### Optimizing the UDT

To save memory, you can delete unused data areas at the end of the UDT CAM_CHANTYPE. 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 included UDTs for the machine and cam data are already tuned to the possible numbers of cams. They can be optimized in increments of 16 cams.

## D.6.2 Channel DB

### Task

The channel DB forms the data interface between the user program and the FM 352 electronic cam controller. It contains and accepts all data required for controlling and operating the module.

### Configuration

The channel DB is divided into various areas:

| Channel DB |
|---|
| Address* /version switch |
| Control signals |
| Checkback signals |
| Function switches |
| Trigger bits for write jobs |
| Trigger bits for read jobs |
| Done bits |
| Error bits |
| Job management for functions |
| Data for jobs |
| * You can enter the address in the parameter assignment interface. |

### D.6.3 Diagnostics DB

#### Task

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

#### Configuration

| Diagnostic DB |
|---|
| Module address |
| Internal data |
| Job status |
| Trigger bit |
| Prepared diagnostic buffer |

## D.6.4 Parameter DB

### Task

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

A module may contain several parameter data sets (for example, for various recipes) that can be selected from the program.

### Configuration

| Parameter DB |
|---|
| CAM_P016TYPE (UDT3)<br>Machine data<br>Cam data of cams 0 to 15 |
| CAM_P032TYPE (UDT4)<br>Machine data<br>Cam data of cams 0 to 31 |
| CAM_P064TYPE (UDT5)<br>Machine data<br>Cam data of cams 0 to 63 |
| CAM_P0128TYPE (UDT6)<br>Machine data<br>Cam data of cams 0 to 127 |

## D.7 Interrupts

### Interrupt processing

The FM 352 can trigger hardware and diagnostic interrupts. You process those interrupts in an interrupt OB. If an interrupt is triggered and the corresponding OB is not loaded, the CPU goes to STOP mode (refer to the *Programming with STEP 7* Manual).

You can enable interrupt processing in the following stages:

1. Global interrupt enable for the entire module
   - Select the module in HW Config

     Select **Edit > Object Properties > Basic Parameters**, then enable the diagnostic and/or hardware interrupt.
   - 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. Enable the hardware interrupt events in the machine data.
3. Assign the hardware interrupts in the cam data for cams 0 to 7.

## D.8 Evaluation of a hardware interrupt

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

Table D- 1 Content of 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 bytes 2 and 3 according to the table.

### Lost hardware interrupts

If the hardware interrupt OB is still busy processing a hardware interrupt, the module registers all subsequent hardware interrupt events. If an event occurs again before the hardware interrupt could be triggered, the module triggers a "hardware interrupt lost" diagnostic interrupt.

## D.9 Evaluating a diagnostics interrupt

Following a diagnostic interrupt, the diagnostic information is available in the variables of OB82 and can be used for a fast analysis. Call FC CAM_DIAG to find out the exact cause of the error by reading 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 fault |
| OB82_EXT_FAULT | BOOL | External fault |
| OB82_PNT_INFO | BOOL | Channel fault |
| OB82_EXT_VOLTAGE | BOOL | External auxiliary voltage missing |
| OB82_FLD_CONNCTR | BOOL | Front connector missing |
| OB82_WTCH_DOG_FLT | BOOL | Watchdog timeout |
| OB82_INT_PS_FLT | BOOL | Internal power supply of the module failed |
| OB82_HW_INTR_FLT | BOOL | Hardware interrupt lost |

# D.10 Technical specifications

## Overview

The table below provides an overview of the technical data of the FM 352 functions.

Table D- 2 Technical data of FM 352 functions

| No. | Block name | Version | Allocation in load memory (bytes) | Allocation in work memory (bytes) | Allocation in local data area (bytes) | MC7 code / data (bytes) | System functions called |
|---|---|---|---|---|---|---|---|
| FC 0 | FC CAM_INIT | 1.0 | 192 | 138 | 2 | 102 | |
| FC 1 | FC CAM_CTRL | 1.0 | 5232 | 4754 | 32 | 4718 | SFC 58: WR_REC,<br>SFC 59: RD_REC |
| FC 2 | FC CAM_DIAG | 1.0 | 1758 | 1614 | 42 | 1578 | SFC 59: RD_REC |
| | Channel DB | - | 986 | 804 | - | 372 | |
| | Parameter DB 16<br>Parameter DB 32<br>Parameter DB 64<br>Parameter DB 128 | -<br>-<br>-<br>- | 616<br>808<br>1192<br>1960 | 336<br>528<br>912<br>1680 | -<br>-<br>-<br>- | 300<br>492<br>876<br>1644 | |
| | Diagnostic DB | - | 460 | 338 | - | 302 | |

## Module cycle

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

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

## D.11 Fast access to module data

### Application

Very fast access to checkback and control signals is required in special applications or in an alarm level. You can access these data directly via the input and output areas of the module.

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

#### Note

For direct access to FM 352 data, always use the non-internal data and method described in this section. Otherwise, your user program will encounter difficulties accessing the module.

### Reading checkback signals via direct access

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

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

| Address | Bit number | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Byte 0 | PARA | Interna<br>l | 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_DONE | SYNC |
| Byte 4 | ACT_POS | | | | | | | |
| Byte 5 | | | | | | | | |
| Byte 6 | | | | | | | | |
| Byte 7 | | | | | | | | |
| Byte 8 | TRACK_OUT | | | | | | | |
| Byte 9 | | | | | | | | |
| Byte 10 | | | | | | | | |
| Byte 11 | | | | | | | | |

## Writing control signals via direct access

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

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

| 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)

The start address of the module is 512

| STL | |
|---|---|
| `L PID 516` | Read the current actual position value (ACT_POS) with direct access:<br>Module start address + 4 |

# D.12 Parameter transfer routes

## Transmission paths

The term parameter refers to the following machine and cam data.

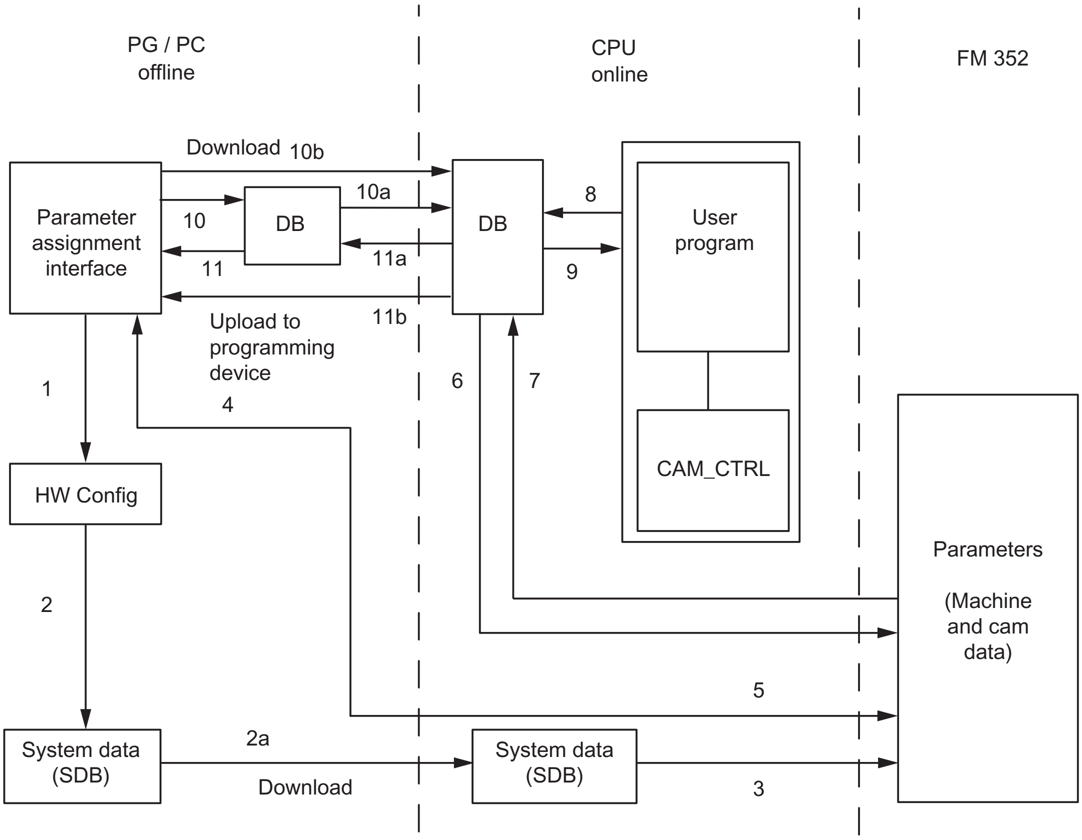


Figure D-1 Parameter transmission paths

| | |
|---|---|
| 1 | Save the parameters in the parameter assignment interface. |
| 2 | Save and compile the HW configuration and download it to the CPU. |
| 3 | The CPU writes the parameters to the module during system parameter assignment. |
| 4 | Upload the module parameters to the PG by selecting the "PLC > Upload to PG" command. |
| 5 | Download the parameters from the parameter assignment interface to the module with the "PLC > 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 | Save parameters from the user program to the online DB. |
| 9 | Read in parameters from the online DB to the user program. |
| 10 | Export parameters from the parameter assignment interface to the DB (offline or online DB); an online DB must then be downloaded to the CPU. |
| 11 | Import parameters from an online or offline DB into the parameter assignment interface. |

## Some use cases for the transfer of parameters

| Use case | Steps |
|---|---|
| You edit the parameters on the parameter assignment interface. The parameters should then be assigned automatically to the module during startup. | Perform steps 1, 2, and 3. |
| You modify parameters for commissioning in test mode in the parameter assignment interface: | Perform steps 4 and 5 |
| The parameters modified during commissioning should be downloaded automatically during startup. | Perform steps 1, 2, and 3. |
| You create the parameters using the parameter assignment interface. When it starts up, the module should be assigned parameters only by the user program via data blocks. | Perform steps 10 and 6. |
| You want to create convenient data sets for recipes. | Perform step 10. |
| You create the parameters using the parameter assignment interface. These should be available to the user program for temporary modifications. | Perform steps 1, 2, and 3 for automatic parameter assignment. Perform steps 10, 7 to enable access by the user program. |
| You modify existing parameters (exclusively) using the user program. | Perform steps 7, 9, 8, and 6. |
| You want to view the data modified by the user program on the parameter assignment interface. | Perform step 11. |
| Parameters modified by the user program should also be loaded automatically during startup. | Perform steps 6, 11, 1, 2, and 3. |

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