SIEMENS

SIMATIC

S7-300
FM 350-1 Counter module

Manual

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Preface

Purpose of this Manual

This manual gives you a complete overview of FM 350-1 function module. It helps you during installation and commissioning. The procedures for installing and removing, wiring, assigning parameters, and programming are explained.

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

Basic Knowledge

To understand the manual, you require general experience 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 this Manual

The present manual contains the description of function module FM 350-1 applicable at the time the manual was published. We reserve the right to describe changes of FM 350-1 functionality in a Product Information Leaflet.

The contents of the Manual....	... Apply to the FM 350-1	
	Order no. [MLFB]	Version
Without latch Without measuring operating modes Without isochronous mode	6ES7 350-1AH00-0AE0 6ES7 350-1AH01-0AE0	1 1
Without measuring operating modes Without isochronous mode	6ES7 350-1AH02-0AE0	1
	6ES7 350-1AH03-0AE0	1

Standards

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

Recycling and Disposal

FM 350-1 is recyclable due to its non-toxic materials. For environmentally compliant recycling and disposal of your discarded device, please contact a company certified for the disposal of electronic waste.

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)

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

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- 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".

Table of contents

Product Overview

1

Chapter overview

This chapter provides an overview of the FM 350-1 function module.

- You get to know the properties of FM 350-1.
- Examples demonstrate various applications of FM 350-1.
- You will learn how the FM 350-1 is integrated into the S7-300 automation system, and familiarize yourself with the vital components of FM 350-1.

1.1 Properties

Properties

The FM 350-1 function module is a high-speed counter module for use in the S7-300 programmable controller. There is one counter on the module that can operate alternatively in the following ranges:

- 0 to +32 bit:
  0 to 4 294 967 295 (0 to $2^{32} – 1$)
- -31 to +31 Bit:
  $–2\ 147\ 483\ 648$ to $+ 2\ 147\ 483\ 647$ ($–2^{31}$ to $2^{31} – 1$)

The maximum input frequency of the counter signals is up to 500 kHz depending on the encoder signal.

The FM 350-1 can be used for the following tasks:

- Continuous counting
- Single counting
- Periodic counting
- Frequency measurement
- Speed measurement
- Period measurement

You can start and stop each mode either via the user program (software gate) or via external signals (hardware gate).

Comparison Values

You can store two comparison values on the module assigned to the two relevant outputs on the module. If the counter status reaches one of the two comparison values, the relevant output can be set to initiate control actions direct in the process.

Load value

You can specify a value on the FM 350-1 from which it should begin counting. This value is the load value. Any value within the count limits can be set for the load value.

Hardware Interrupts

The FM 350-1 can trigger a hardware interrupt in the CPU if the comparison values are reached, or in the case of overflow, underflow and/or a zero crossing of the counter.

Diagnostic Interrupt

The FM 350-1 can trigger a diagnostics interrupt if any of the following occur:

- External auxiliary voltage faulty
- Fault in 5.2 VDC encoder supply
- Module not assigned parameters or errors in parameter assignment
- Watchdog timeout
- RAM defective
- Hardware interrupt lost
- Fault in signal A, B or N of the 5 V encoder

Pulse Duration

You can specify a pulse duration for the digital outputs of the FM 350-1. The pulse duration is used to specify how long the corresponding digital output is to be set. A value between 0 and 500 ms may be set for the pulse duration. This value applies to both outputs. You can adapt the FM 350-1 to existing actuators by specifying a pulse duration.

Which Signals Can the FM 350-1 Register?

The FM 350-1 can register the signals from the following sources:

- Incremental 5-V encoders
- Incremental 24-V encoders
- 24-V pulse encoders with direction level
- 24-V initiators without direction level for example, light barrier or BERO
- Internal 1 MHz time base

Input Filters

For the purpose of suppressing interference, you can assign input filters (RC elements) with a uniform filter time for the 24 V inputs A*, B*, and N* and for the digital inputs. The following two input filters are available:

Table 1- 1 Input filter

Characteristics	Input Filter 1 (default)	Input Filter 2
Typical input delay	1 µs	15 µs
Maximum count frequency	200 kHz	20 kHz
Minimum pulse width of the count signals	2.5 µs	25 µs

Centralized Application

You can use the FM 350-1 in S7-300 systems centrally.

Distributed application

You can use the FM 350-1 via IM 153-1, IM 153-2 and IM 153-4 PN distributed in ET 200M. Examples of application are:

- ET 200M with single backplane bus
- ET 200M with active backplane bus
- ET 200M as modular isochronous slave
- ET 200M in one-sided mode in an H system
- ET 200M in interconnected mode in an H system

Firmware Update

For upgrades and bugfixes it is possible with the help of STEP 7 HW Config (as of V 5.2) to download firmware updates to the operating system memory of FM 350-1.

Note

Starting the firmware updates deletes the old FM 350-1 firmware.

If the firmware update is interrupted or terminated, the FM 350-1 will no longer be capable of functioning.

In this case start the firmware update again and wait until it has been completed successfully.

CiR

The FM 350-1 is CiR-compatible, i. e. via configuration modification at RUN of the CPU you can change the FM 350-1 parameters. Parameter changes resets the FM 350-1 and is essentially a reparameterization. /3/

The FM 350-1 allows parameter changes from the user program during operation.

Isochronous mode

The module supports isochronous mode.

1.2 Areas of application of the FM 350-1

Usages of the FM 350-1

The main application area of the FM 350-1 is where signals with high frequencies are counted and/or high-speed responses have to be triggered to predefined counter statuses.

Examples include:

- Packaging plants
- Sorting plants
- Dosing or proportioning plants.

Example Application for the FM 350-1

In this example, a carton is to be filled with a specific number of parts. One counter of the FM 350-1 counts the parts and controls the motor for transporting the parts and the motor for transporting the carton.

If the carton is in the correct position, Conveyor belt A is stopped via Light barrier A, the count is started and Motor B for Conveyor belt B is switched on. When the carton contains the programmed number of parts, the FM 350-1 stops Motor B for Conveyor belt B and switches on Motor A for Conveyor belt A so that the carton is removed. The count can start again when the next carton reaches Light barrier A.

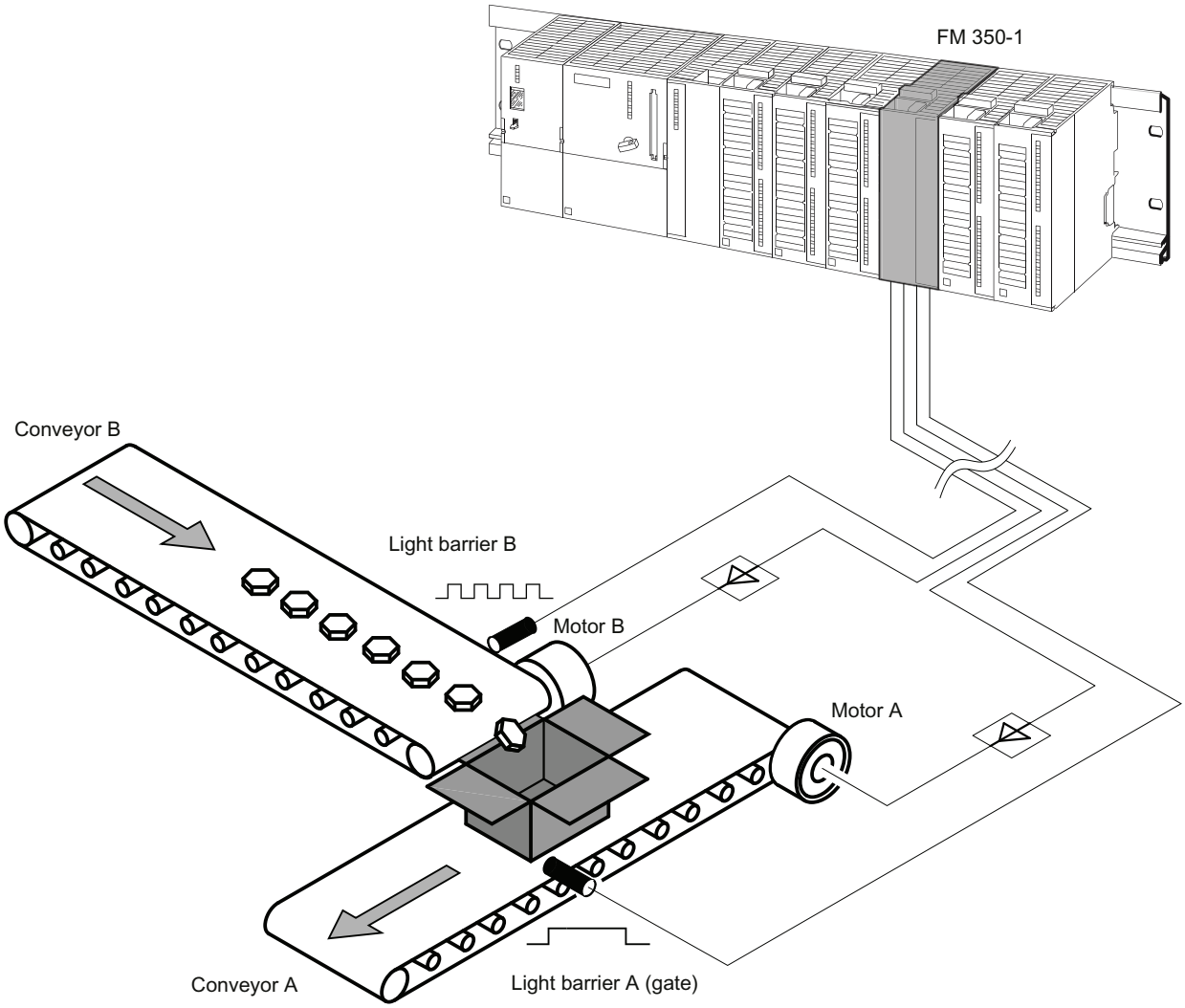


Figure 1-1 Example for Using an FM 350-1 in the S7-300

1.3 The FM 350-1 hardware

Module view

The figure shows the FM 350-1 module with a front connector and the expansion bus with the front panel closed.

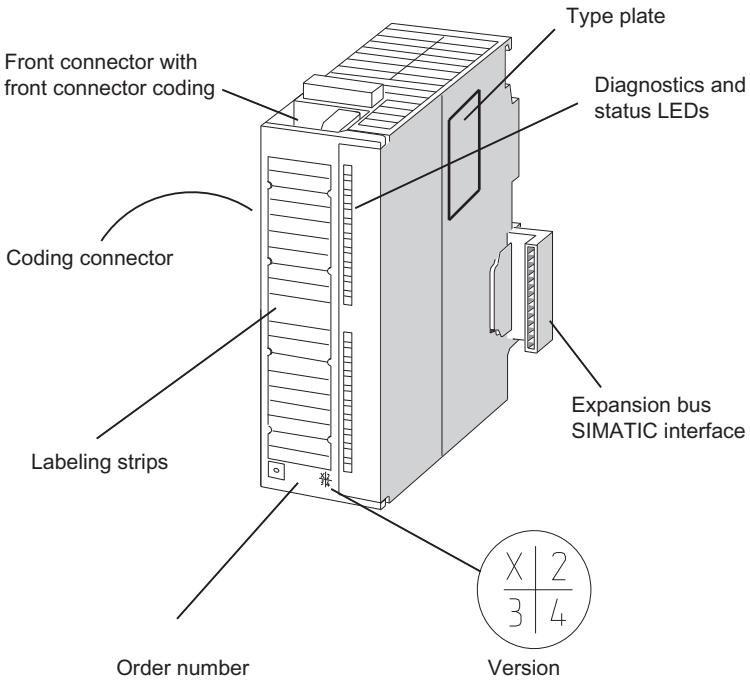


Figure 1-2 FM 350-1 module view

Front Connector

The FM 350-1 offers the following connection possibilities at the front connector:

- 5 V or 24 V encoder signals
- Encoder supply
- Digital input signals for starting, stopping and setting the counter
- Digital output signals Q0 and Q1
- Auxiliary voltage 1L+ for generating the encoder supply voltages
- Load voltage 2L+ for supplying the digital outputs

The front connector can be ordered separately (refer to the chapter Spare Parts (Page 187)).

Front Connector Coding

When you press the front connector from the wiring position to the operating position, the front connector coding engages. Thereafter, this front connector can only be attached to an FM 350-1 module.

Coding Plug

The coding plug is used to set the FM 350-1 to the encoder signals used.

Table 1- 2 Settings for the coding plug

Coding plug at setting...	...Corresponds to the following encoder signals
A	5 V differential signals (state as supplied)
D	24-V signals

The coding plug is located on the left side of the FM 350-1.

Labeling Strips

Enclosed with the module is a labeling strip on which you can write your relevant signal names.

The pin assignments are printed on the inside of the front panel.

Order Number and Version

The order number and the version of the FM 350-1 are specified at the bottom end of the front panel.

Firmware Version

The firmware version indicates the version at the time of delivery. It can be updated with a firmware update.

Bus Connector

The communication within a row of the S7 300 takes place via the bus connector. The bus connector is enclosed with the FM 350-1.

Diagnostics and Status LEDs

The FM 350-1 has eight LEDs that can be used both for diagnostics and for indicating the status of the FM 350-1 and its digital inputs and outputs.

Table 1- 3 LEDs with their labeling, color and function

Label	Color	Function
SF	Red	Group errors
CR	Green	Counter running; status of the least significant bit of the counter
DIR	Green	Direction of count LED lights up, if the counter is counting down.
I0	Green	Status of DI Start
I1	Green	Status of DI Stop
I2	Green	Status of DI Set
Q0	Green	Status of output DO0
Q1	Green	Status of output DO1

1.4 The software of the FM 350-1

Configuration Package

To integrate the FM 350-1 into the S7-300, use the configuration package on the supplied CD . It includes:

- Parameterization software with parameterization interfaces
- Software for the CPU (blocks)
- Documentation

The figure shows an S7-300 configuration with an FM 350-1 and several signal modules.

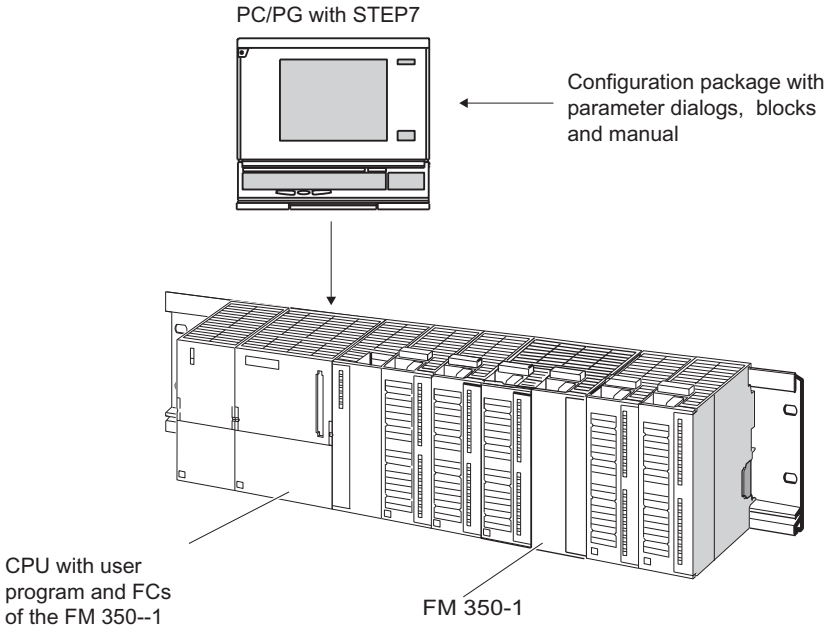


Figure 1-3 SIMATIC S7-300 configuration with an FM 350-1

Parameterization Interfaces

The FM 350-1 is adapted to the task in hand via parameters. These parameter are stored in an SDB and transferred to the module from the CPU.

You can specify the parameters via the parameterization interfaces. These parameterization interfaces are installed on your programming device and are called up within STEP 7.

Software for the S7-300 CPU

The software for the CPU consists of the FC CNT_CTL1 and FC CNT_CTL2 functions called in the user program of the CPU. These FCs enable communication between the CPU and the FM 350-1. There is also the FC DIAG_INF function for the FM 350-1, with which you can transfer diagnostics information into the DB of the FC CNT_CTL1 and FC CNT_CTL2. The FC CNT_CTL2 function is only used at isochronous mode.

Installing and removing FM 350-1

2

Chapter Overview

This chapter contains information on installing and removing the FM 350-1.

- You will learn what you must look out for when installing.
- You will get notes and hints on configuring, arranging and installing an FM 350-1.
- You will learn, step-by-step, how to install and remove an FM 350-1.

2.1 Preparing for installation

Important Safety Information

There are important rules you must observe for integrating an S7-300 with an FM 350-1 into a plant or a system. These rules and directives are explained further in the /1/ manual.

Vertical or Horizontal Arrangement

Give preference to horizontal installation of the rack. In case of vertical installation of the rack limited ambient temperatures (max. 40 °C) apply for the modules.

Specifying the Slot

The 350-1 function module can be installed like a signal module in any of Slots 4 to 11.

Rules for Configuring the Mechanical Installation

Refer to manual /1/ for possibilities for the mechanical structure and how to proceed when configuring. The following offers brief extra information.

- A maximum of eight SMs or FMs are permissible per rack.
- The maximum number is restricted by the width of the modules or the length of the mounting rail. The FM 350-1 requires an installation width of 40 mm.
- The maximum number is restricted by the total current consumptions of all modules to the right of the CPU and that are supplied from the 5 V backplane bus supply. The current consumption of the FM 350-1 amounts to 160 mA.
- The maximum number is restricted by the memory required by the CPU software for communications with the FM 350-1.

2.2 Installation of the FM 350-1

Rules

No special protection measures (ESD guidelines) are required for installing an FM 350-1.

Required Tools

You require a flat-bladed screwdriver 4.5 mm to install the FM 350-1.

Setting the Signal Type (Coding Plug)

Before mounting an FM 350-1 on the mounting rail, you must place the coding key in the correct position.

Table 2- 1 Correlation between the position of the coding plug and the signal mode

Position of the coding plug	Signal mode
A	5 V differential signals
D	24-V signals

The letter of the coding plug must point to the arrow.

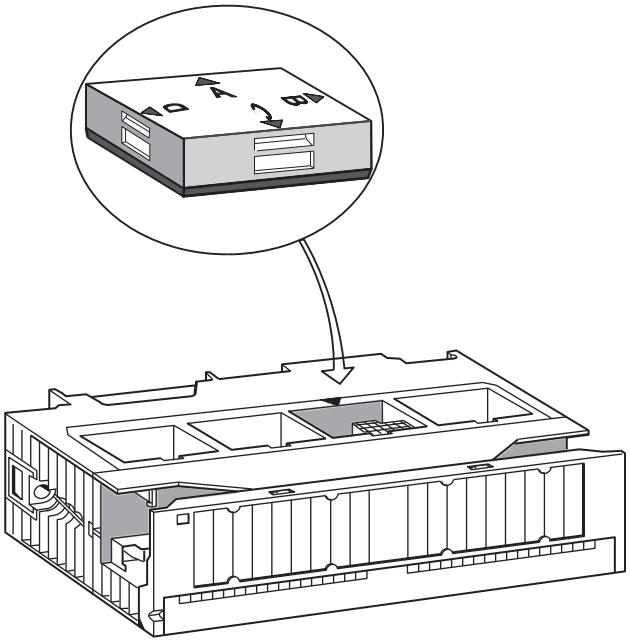


Figure 2-1 Installing the coding plug

Procedure for the Installation

How to mount the FM 350-1 on the mounting rail:

1. Switch the CPU to STOP. Switch off the power supply.
2. An bus connector is enclosed with the FM 350-1. Plug this into the bus connector of the module to the left of the FM 350-1. (The bus connector is located on the back and you may have to loosen the neighboring module.)
3. Hang the FM 350-1 onto the rail and swing it down.
4. Tighten the screw on the FM 350-1 (tightening torque approximately 0.8 to 1.1 Nm).

   If you want to install further modules to the right of the FM 350-1, first connect the expansion bus of the next module to the right-hand backplane bus connector of the FM 350-1.

   If the FM 350-1 is the last module in the rack, **do not** connect an expansion bus!
5. Label the FM 350-1 with its slot number. Use the number wheel supplied with the CPU for this purpose.

   Manual /1/ describes the numbering scheme you must use and how to connect the slot numbers.
6. Install the shield connecting element

Further Notes

Manual /1/ contains further notes on installing and removing modules.

2.3 Removing FM 350-1

Rules

No special protection measures (ESD guidelines) are required for removing the FM 350-1.

Required Tools

You require a flat-bladed screwdriver 4.5 mm to remove the FM 350-1.

Procedure for Removal/Replacement of Modules

How to remove the FM 350-1:

1. Switch off the auxiliary voltage and the load voltage at the front connector.
2. Switch the CPU to STOP. Switch off the power supply.
3. Open the front door. If necessary, remove the labeling strips.
4. Release the front connector and pull it out.
5. Loosen the fixing screw on the module.
6. Swing the module out of the mounting rail and unhook it.
7. Install the new module if applicable.

Further Notes

Manual /1/ contains further notes on installing and removing modules.

Wiring the FM 350-1

3

Chapter overview

This chapter contains the following information on wiring the FM 350-1:

- Terminal assignment of the front connector.
- The functions of the connections.
- Notes on selecting cables.
- The steps to take when wiring the front connector.
- The status of the wired module after switching on the power supply.

3.1 Pin assignments of the front connector

Front connector

You connect the count signals, the digital inputs and digital outputs, the encoder supply and the auxiliary voltage and load voltage via the 20-pin front connector.

The figure shows the front of the module, the front connector and the inside of the front panel with the pin assignments.

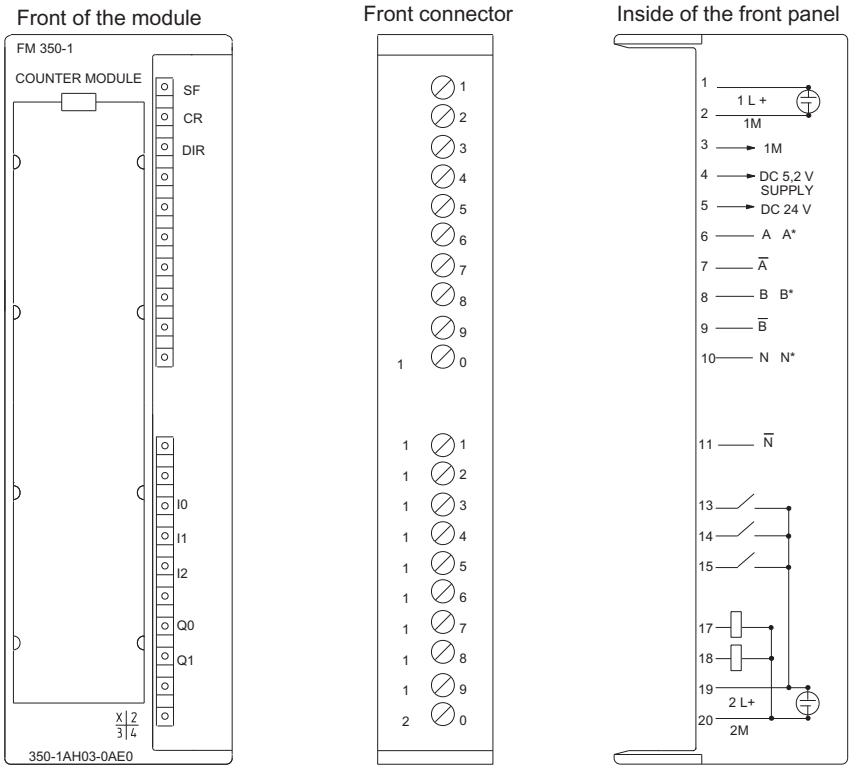


Figure 3-1 Front connector of the FM 350-1

Pin Assignments of the Front Connector

Table 3- 1 Pin assignments of the front connector

Connection	Name	Input / Output	Function			
Auxiliary voltage						
1	1L+	ON	24 V auxiliary voltage			
2	1M	ON	Auxiliary voltage ground			
			5 V encoder RS 422, symmetric	24 V encoder, asymmetric	24 V pulse encoders with direction level	24 V initiator
3	1M	OFF	Encoder supply ground			
4	5.2 VDC	OFF	Encoder power supply 5.2 V			
5	24 VDC	OFF	Encoder power supply 24 V			
6	A A*	ON	Encoder signal A	Encoder signal A *		
7	/A	ON	Encoder signal /A	—		
8	B B*	ON	Encoder signal B	Encoder signal B *	Directional signal	—
9	/B	ON	Encoder signal /B	—		
10	N N*	ON	Encoder signal N	Encoder signal N *	—	
11	/N	ON	Encoder signal /N	—		
12	—	—	—			
Digital Inputs and Digital Outputs						
13	I0	ON	Digital input DI Start			
14	I1	ON	Digital input DI Stop			
15	I2	ON	Digital input DI Set			
16	—	—	—			
17	Q0	OFF	Digital output DO0			
18	Q1	OFF	Digital output DO1			
Load voltage						
19	2L+	ON	24 V load voltage			
20	2M	ON	Load voltage ground for the digital inputs and outputs			

Note

The circuits for the counter inputs (encoder supply, encoder signals) are non-isolated to the ground of the CPU, that is, terminal 2 (1M) must have a low-resistance connection to CPU ground. If this connection does not exist, a malfunction or a defect of the FM 350-1 can result.

If you supply the encoders externally, you must also connect the ground of this external voltage with the ground of the CPU.

Auxiliary Voltage 1L+/1M

Connect a direct voltage of 24 V to the 1L+ and 1M terminals for the voltage supply of the 5 V and 24 V encoders.

An integral diode protects the module from reverse polarity of the auxiliary voltage.

The module monitors the connection of the auxiliary voltage.

5.2 V DC encoder supply

The module generates a voltage of 5.2 V from the auxiliary voltage 1L+/1M at a maximum current of 300 mA that is available at the `5.2 VDC' connection for the short-circuit-proof supply of a 5 V encoder. The encoder supply is monitored for short-circuit.

24 V DC encoder supply

For the 24 V voltage supply of an encoder, the voltage 1L+/1M is made available and short-circuit proof at the `24 VDC' output. The encoder supply is monitored for short-circuit.

5 V Sensor Signals A and /A, B and /B, N and /N

You can connect incremental encoders with 5 V differential signals to the front connector in accordance with RS 422, that is, incremental encoders with the differential signals, A and /A, B and /B, N and /N.

The signals A and /A, B and /B, N and /N are connected via the correspondingly labeled terminals.

The signals N and /N are only connected if you want to set the counter to the zero mark of the encoder.

The inputs are not isolated from the bus of the S7-300.

24 V Encoder Signals A*, B* and N*

24 V signals are represented by the letters A*, B* and N*.

You can connect three different encoder types to each counter:

- Incremental encoders with 24 V signals:

  The signals A*, B* and N* are connected via the correspondingly labeled terminals.

- Pulse encoders without direction level:

  The signal is connected to terminal A*.

- Pulse encoders with direction level:

  The count signal is connected to terminal A*. The direction level is connected to terminal B*.

The inputs are not isolated from the bus of the S7-300.

Input Filters for 24 V Encoder Signals

For the purpose of suppressing interference, you can parameterize input filters (RC elements) with a uniform filter time for the 24 V inputs A*, B* and N*. The following two input filters are available.

Table 3- 2 Input Filters for 24 V Encoder Signals

Characteristics	Input Filter 1 (default)	Input Filter 2
Typical input delay	1 µs	15 µs
Maximum frequency of count	200 kHz	20 kHz
Minimum pulse width of the count signals	2.5 µs	25 µs

Digital Inputs DI Start, DI Stop and DI Set

You can use digital inputs DI Start and DI Stop for the gate control of the counter. Gate control can be both level-controlled and edge-controlled (refer to the chapter Operating Modes, Parameters and Commands (Page 83)).

Digital input DI Set is used to set the counter to the load value.

The digital inputs are operated with a nominal voltage of 24 V.

The digital inputs are optically isolated from the bus of the S7-300 and the counter inputs.

Input Filters for Digital Inputs

For the purpose of suppressing interference, you can parameterize input filters DI-Start, DI-Stop and DI-Set (RC elements) with a uniform filter time for digital inputs. The following two input filters are available.

Table 3- 3 Input Filters for Digital Inputs

Characteristics	Input Filter 1 (default)	Input Filter 2
Typical input delay	1 µs	15 µs
Maximum frequency of the input signals	200 kHz	20 kHz
Minimum pulse width of the input signals	2.5 µs	25 µs

Digital Outputs DO0 and DO1

The FM 350-1 features two digital outputs, DO0 and DO1, for directly triggering control processes.

The digital outputs are supplied via the load voltage 2L+.

The digital outputs are optically isolated from the bus of the S7-300 and the counter inputs.

The digital outputs are source outputs and can be loaded with a load current of 0.5 A. They are protected from overload and short-circuit.

Note

Relays and contactors can be connected direct without external circuitry.

The time characteristics of the digital outputs depend on the parameterization and are explained in more detail in the chapter Operating Modes, Parameters and Commands (Page 83).

Load Voltage 2L+/ 2M

For supplying digital outputs DO0 and DO1, a load voltage of 24 V must be supplied to the module via terminals 2L+ and 2M.

An integrated diode protects the module from polarity reversal of the load voltage.

The load voltage 2L+/2M is not monitored by the FM 350-1.

3.2 Wiring front connectors

Cables

Here are some rules for you to observe when selecting cables:

- The cables for digital inputs DI Start, DI Stop and DI Set must be shielded.
- The cable for the counter signals must be shielded.
- You must apply the shields of the counter signal cables both at the pulse encoder and in the immediate vicinity of the module via the shield attachment, for example.
- The following cables of the incremental 5 V encoder have to be twisted in pairs.
  - A and /A
  - B and /B
  - N and /N

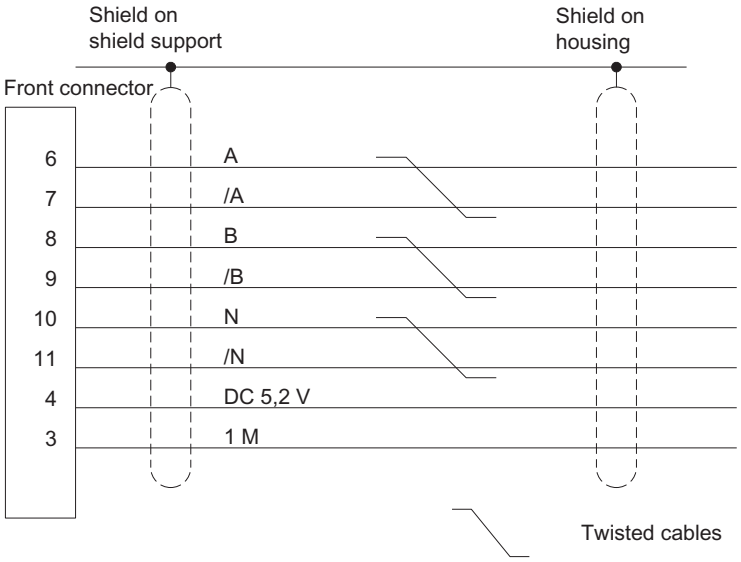


Figure 3-2 Details Regarding the Connection of an Incremental 5V Encoder

Terminal 2 (1M) of the front connector must have a low-resistance connection to the ground of the CPU. If you supply the encoder with an external voltage, you must also connect the ground of this external voltage with the CPU ground.

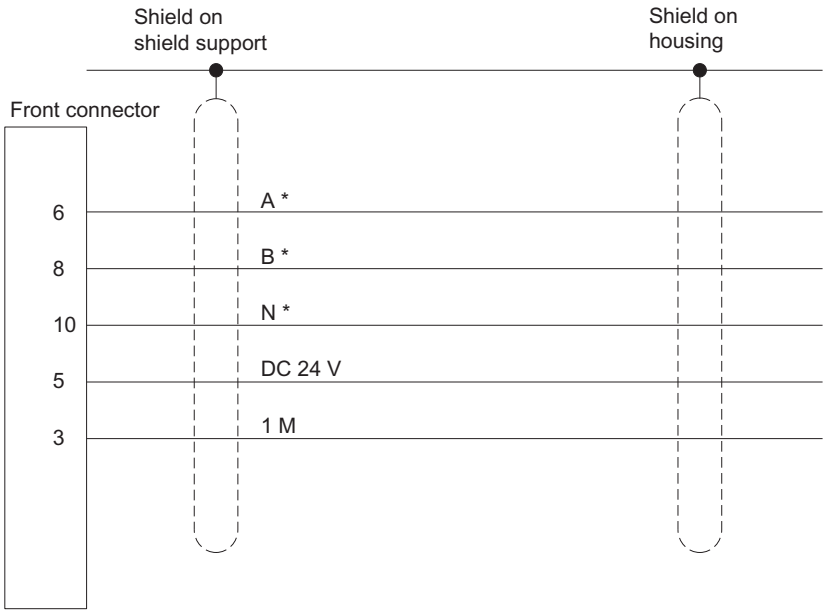


Figure 3-3 Details Regarding the Connection of an Incremental 24V Encoder

- Use flexible cables with cross-sections of 0.25 to 1.5 mm^2.

Note

If the encoders are supplied via the module, the cable cross-section must be large enough to carry the required voltage to the encoder despite voltage drops over the cable. This applies especially in the case of incremental 5 V encoders.

- You do not need wire end ferrules. If you use wire end ferrules then use only those without insulation collar in accordance with DIN 46228 Form A, short version!

Wiring

Proceed as follows when wiring the front connector:

⚠ WARNING

Injury to persons may result.

If you wire the front connector of the FM 350-1 when the power is switched on, you are in danger of injury from electric shock.

Wire the FM 350-1 only when the power is switched off!

1. Open the front panel and place the front connector in the wiring position.
2. Strip the conductors (length 6 mm).
3. Do you want to use end ferrules?

   If yes: Press the end ferrules and the cables together.
4. Feed the enclosed strain relief clamp into the front connector.
5. If the wires leave the module at the bottom, begin wiring at the bottom, otherwise begin at the top. Also screw tight unassigned terminals (tightening torque 0.6 to 0.8 Nm).
6. Tighten the strain relief clamp for the cable chain.
7. Push the front connector into the operating position.
8. Apply the cable shields to the shield connecting element or to the shield bar.
9. Label the terminals on the labeling strip.

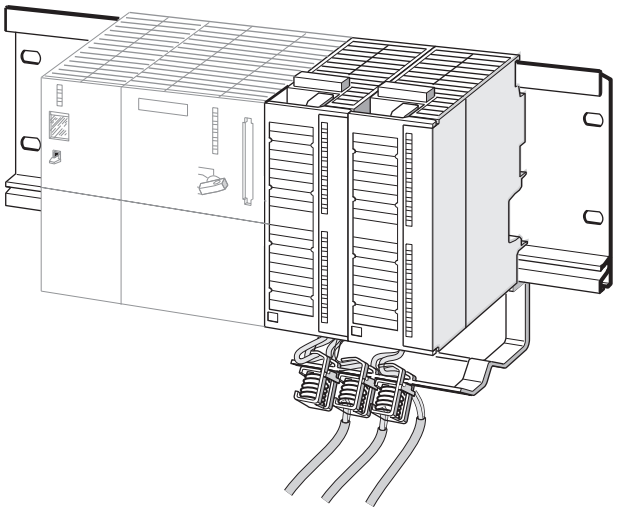


Figure 3-4 FM 350-1 with Shielded Cables and the Shield Connecting Element

3.3 Module status after power on

Default setting

Module status after power on and before any parameters were transferred:

- No gate - i.e., the gate is open
- Counter inputs with default setting for 5 V differential signals, track B not inverted; single evaluation (refer to the section Signal Evaluation (Page 166))
- 0 to +32 bit counting range
- Counter status zero
- Set counter with signal at input DI Set (and zero mark) locked
- Input delay for digital inputs DI Start, DI Stop and DI Set typically 1 µs
  (max. frequency: 200 kHz, minimum pulse width: 2.5 µs)
- Input delay at 24 V counter inputs: typically 1 µs
  (max. frequency: 200 kHz, minimum pulse width: 2.5 µs)
- Outputs DO0 and DO1 disabled
- Pulse duration = 0
- No hardware interrupts set
- "Continuous count" mode is set
- Status messages are updated

Programming FM 350-1

4

Chapter Overview

In this chapter, you will learn how to install and start parameterization interfaces.

The parameterization interfaces have an integrated help function that supports you in parameterizing and starting up the FM 350-1.

4.1 Installing Parameterization Interfaces

Supplementary conditions

The following conditions apply for transferring parameterization data to the CPU:

- STEP 7 is installed correctly on your programming device.
- The programming device is connected correctly to the CPU
- The CPU is in STOP

Note

You must not plug in or remove any S7-300 modules during data exchange over the MPI!

Installing the Parameterization Interfaces

To install the configuration package:

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

Important information about the installation can be found in the readme file.

Result

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

- **SIEMENS\STEP7\S7LIBS\FMx501LIB:** FCs, UDTs
- **SIEMENS\STEP7\S7FCOUNT:** Configuring software, Readme, Online help
- **SIEMENS\STEP7\EXAMPLES:**Examples
- **SIEMENS\STEP7\S7MANUAL\S7FCOUNT:** Getting Started, manuals

Note

If you selected a directory other than SIEMENS\STEP7 when you installed STEP 7, that directory will be entered.

4.2 Starting Parameterization Interfaces

Starting the Parameterization Interfaces

1. In HW Config: Select the FM 350-1 in your hardware catalog. Place the module on a vacant slot.
2. Double-click the FM 350-1.
3. Adapt the configuration of the FM 350-1 to your requirements.
4. You are prompted to save the entries when you exit the parameterization interface. Confirm with "OK."

Programming the FM 350-1

5

Chapter Overview

This chapter contains all the information necessary for programming the FM 350-1 in the S7-300. For linking the FM 350-1 into a user program, you are provided with STEP 7 blocks that make handling the desired functions easy for you.

Table 5- 1 Blocks that are described in this chapter

Block number	Block name	Meaning
FC 2	CNT_CTL1	Controlling of the FM 350-1
FC 3	CNT_CTL2	Controlling of the FM 350-1 (only in isochronous mode)
FC 1	DIAG_INF	Read Diagnostics data record 1 from the FM 350-1

Use of the blocks is illustrated in an example program. The example program shows block calls and contains the necessary data block.

You can also operate the FM 350-1 without FCs, in which case you control and monitor the FM 350-1 via the control and feedback interface.

5.1 Data exchange between the user program and FM 350-1

Data Exchange

You can access the FM 350-1 control and feedback interface from the user program either using standard FCs or with load and transfer commands. Mixed operation is not permitted.

Table 5- 2 Possibilities of accessing the control and feedback interface

	Standard FC	Load and transfer commands
Control interface	Write with • FC CNT_CTL1 • FC CNT_CTL2	Transfer command, e.g. T PAD
Feedback interface	Read with • FC CNT_CTL1 • FC CNT_CTL2	Load command, e.g. L PED

The figure illustrates the data exchange on the basis of standard FCs:

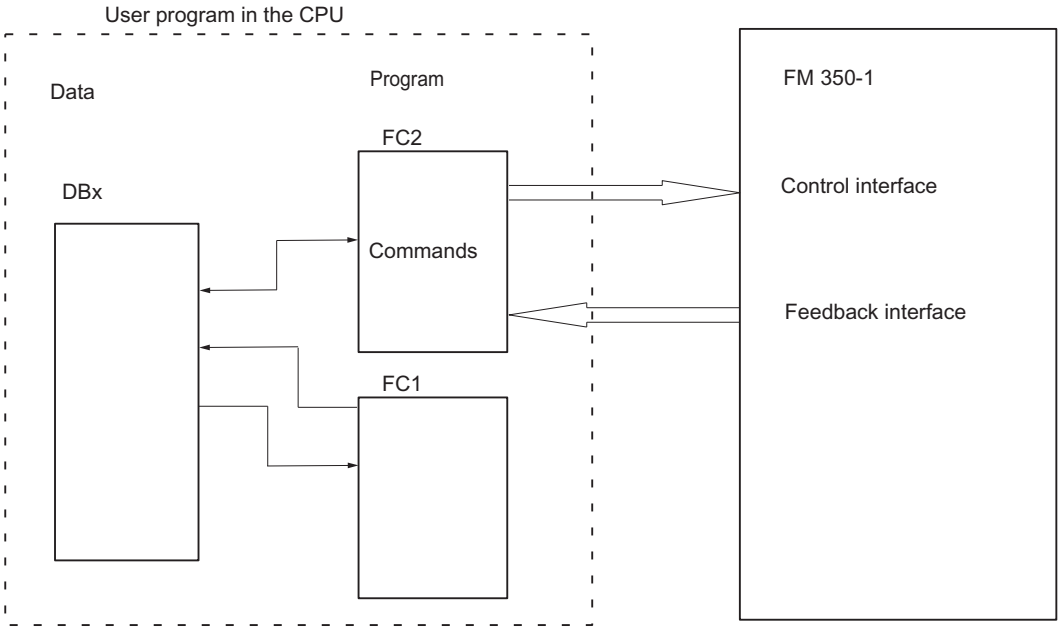


Figure 5-1 Exchange of Data between the User Program and FM 350-1 with FC`s (Example)

5.2 The function FC CNT_CTL1 (FC 2)

Functionality

The data required for the CNT_CTL1 function is stored in a DB on the CPU. The CNT_CTL1 function transfers data cyclically between this DB and the FM.

Requirements

- You have created a DB under STEP 7 as a data block with assigned user-specific data type.

  To do so, select UDT 2 as the source file. UDT 2 was copied to the function block library called FMx50LIB when the FCs were installed. Do not modify the UDT 2. Copy the UDT 2 together with the functions into your project.

- The DB required for the CNT_CTL1 function must have the following valid data assigned:
  - Module address
    You set the module address (start address of the FM 350-1) during the configuration of your hardware.
    You can enter the address automatically in the DB by selecting the module in HW Config, and then selecting a data block from the "Properties" dialog box by clicking on the "Mod Addr" button.
  - Channel address

    The channel address is the same as the module address in pointer format.
  - User data length

    The user data length amounts to 16.

  You can save these data by means of a parameter assignment screen (refer to "Getting Started with Commissioning") or by means of the user program in the DB.

CAUTION
Actual values in the DB are overwritten You can check the block consistency in the SIMATIC Manager. After selecting the block folder of your project, start the consistency check using the menu command "Edit > Check block consistency". The "Check block consistency" dialog box is opened. If you select the menu command "Program > Compile all" in this dialog box, the current values in the DB are overwritten. Therefore, explicitly initialize the module start address of the FM 350-1 in OB 100. This address must be the same as the address configured in HW Config.

Example

The following contains an example of how you can implement the transfer of the module address, the channel address, and the length of the user data to the DB in OB 100.

The symbol table contains the following assignments for this example:

CNT_CHAN1	DB 1	DB with the counter data

You program the transfer in STL as follows:

```
STL
L       512;                        // Module address = 512
T       CNT_CHAN1.MOD_ADR;          // Transfer of module address
L       P# 512.0;                   // Module address in pointer format
T       CNT_CHAN1.CH_ADR;           // Transfer of the channel address
L       16;                         // User data length = 16
T       CNT_CHAN1.U_D_LGTH;         // Transfer of the user data length
```

Call

The CNT_CTL1 function can be called in the cycle or alternatively in a time-controlled or isochronous interrupt OB. Calling in an event-driven interrupt program is not permitted.

The CNT_CTL1 function call in the STL and LAD notations is given below.

STL representation

```
CALL    "CNT_CTL1"   (
        DB_NO        :=
        SW_GATE      :=
        GATE_STP     :=
        OT_ERR_A     :=
        SET_DO0      :=
        SET_DO1      :=
        OT_ERR       :=
        L_DIRECT     :=
        L_PREPAR     :=
        T_CMP_V1     :=
        T_CMP_V2     :=
        C_DOPARA     :=
        RES_SYNC     :=
        RES_ZERO     :=)
```

LAD representation

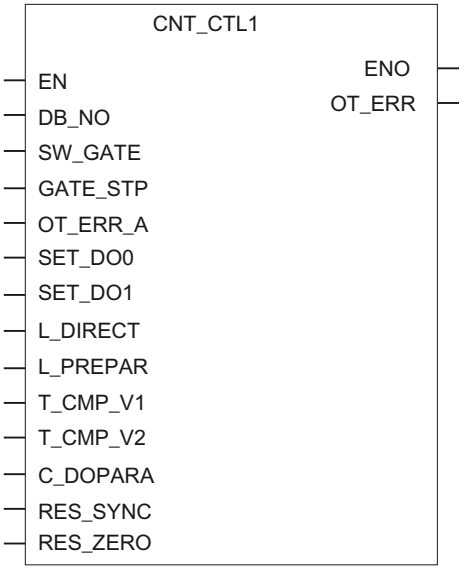


Figure 5-2 Calling the CNT_CTL1 function

CNT_CTL1 Function Parameters

Table 5- 3 The Parameters of the CNT_CTL1 Function

Name	Declaration type	Data type	Meaning	The user...	The block...
DB_NO	INPUT	INT	DB number with the counter data	enters	polls
SW_GATE	INPUT	BOOL	Counter control bit "SW gate (start/stop)"	sets and resets	polls
GATE_STP	INPUT	BOOL	Counter control bit "Gate stop"	sets and resets	polls
OT_ERR_A	INPUT	BOOL	Acknowledge operator error	sets and resets	polls
SET_DO0	INPUT	BOOL	Set/Reset DO0	sets and resets	polls
SET_DO1	INPUT	BOOL	Set/Reset DO1	sets and resets	polls
OT_ERR	OUTPUT	BOOL	Operator error occurred	polls	sets and resets
L_DIRECT [2)]	IN-OUT	BOOL	**Counting**: Trigger bit for "direct and preparatory loading" of a counter	sets	polls and resets
			Measuring: Must NOT be set	-	
L_PREPAR [2)]	IN-OUT	BOOL	**Counting**: Trigger bit for "preparatory loading" of a counter	sets	polls and resets
			Measuring: Transfer of the low limit		
T_CMP_V1 [2)]	IN-OUT	BOOL	**Counting**: Transfer "Comparison value 1" trigger bit	sets	polls and resets
			Measuring: Transfer of the high limit		
T_CMP_V2 [2)]	IN-OUT	BOOL	**Counting**: Transfer "Comparison value 2" trigger bit	sets	polls and resets
			Measuring: Update time		
C_DOPARA [1)]	IN-OUT	BOOL	Trigger bit for parameter change	sets	polls and resets
RES_SYNC	IN-OUT	BOOL	Reset "Synchronization" status bit	sets	polls and resets
RES_ZERO	IN-OUT	BOOL	Reset zero crossing, overflow, underflow and comparator or end of measurement status bit	sets	polls and resets

[1)] This parameter must not be set at the same time as one of the parameters L_DIRECT, L_PREPAR, T_CMP_V1 or T_CMP_V2.

[2)] This parameter must not be set at the same time as the C_DOPARA parameter.

Processing Jobs

You make a job request for the FM 350-1 via the relevant FC parameters L_DIRECT, L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA, RES_SYNC, RES_ZERO, and OT_ERR_A.

You must enter the appropriate values for the job (load value, comparison values, low limit, high limit, update time) before you call the FC in the DB.

A set in/out parameter (L_DIRECT, L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA, RES_SYNC and RES_ZERO) is deleted again by the CNT_CTL1 function after completion of the job. This enables you to recognize that the job has been executed by the FM 350-1. If necessary, you can incorporate this information in your user program.

Transferring Values

Depending on the operating mode, you can transfer values by setting the function parameter.

Table 5- 4 Function Parameters for Transferring Values

Operating mode	Function parameter
Counting	L_DIRECT, L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA
Measuring	L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA

You can transfer several values at the same time.

Table 5- 5 Simultaneous transfer of several values

In the operating mode ...	... You can transfer at the same time	
Counting	• Load value • Comparison value 1 • Comparison value 2	(DB parameter LOAD_VAL) (DB parameter CMP_V1) (DB parameter CMP_V2)
Measuring	• Low limit • High limit • Update time	(DB parameter LOAD_VAL) (DB parameter CMP_V1) (DB parameter CMP_V2)

If a value is incorrect, you must first acknowledge this operator error with OT_ERR_A before the FM 350-1 can accept any further values. You should then correct the value rejected with the operator error and transfer it again.

Note

If you use the function parameter L_DIRECT, L_PREPAR, T_CMP_V1 or T_CMP_V2 to load the value LOAD_VAL, CMP_V1 or CMP_V2, you cannot change the parameter assignments at the same time using function parameter C_DOPARA.

This would lead to an OT_ERR operator error that you would have to acknowledge with OT_ERR_A.

Time Required to Transfer Values

Table 5- 6 Time Required to Transfer Values

Use of the FM 350-1	Time requirement	
Centralized	At least 4 OB 1 cycles	
Distributed (Non-isochronous mode)	At least 5 PROFIBUS DP cycles	
Distributed (Isochronous mode)	At transmission of only one value	5 PROFIBUS DP cycles
	At simultaneous initiation of the transmission of several values	• for the 1st value: 5 PROFIBUS DP cycles after initiation • for the 2nd value: 6 PROFIBUS DP cycles after initiation • for the 3rd value: 7 PROFIBUS DP cycles after initiation

Parameters for Transferring Values in the DB (Count Modes)

The following table shows the range of the DB in which you transfer the LOAD_VAL, CMP_V1 and CMP_V2 parameters.

The LOAD_VAL parameter (bytes 14 to 17) has two meanings:

- If you set function parameter L_DIRECT or L_PREPAR, LOAD_VAL is interpreted as a load value.
- If you set function parameter C_DOPARA, you can use Byte 14 to define the behavior of outputs DO0 and DO1. Bytes 15 and 16 are interpreted as hysteresis and pulse duration.

Table 5- 7 Parameters for Transferring Values in the DB (Count Modes)

DB address	Parameters	Meaning				
14.0	LOAD_VAL	Load value; direct and preparatory loading with function parameter L_DIRECT Load value; preparatory loading with function parameter L_PREPAR				
14.0	LOAD_VAL	The behavior of outputs DO0 and DO1, hysteresis and pulse duration, are defined using function parameter: C_DOPARA				
		Bit 3	Bit 2	Bit 1	Bit 0	Reaction of output DO0
		x	0	0	0	Inactive
		x	0	0	1	Active from comparison value to overflow
		x	0	1	0	Active from comparison value to underflow
		x	0	1	1	Active on reaching the comparison value for pulse duration (up/down)
		x	1	0	0	Active on reaching the comparison value for pulse duration (up)
		x	1	0	1	Active on reaching the comparison value for pulse duration (down)

DB address	Parameters	Meaning				
		x = irrelevant				
		Bit 7	Bit 6	Bit 5	Bit 4	Reaction of output DO1
		x	0	0	0	Inactive
		x	0	0	1	Active from comparison value to overflow
		x	0	1	0	Active from comparison value to underflow
		x	0	1	1	Active on reaching the comparison value for pulse duration (up/down)
		x	1	0	0	Active on reaching the comparison value for pulse duration (up)
		x	1	0	1	Active on reaching the comparison value for pulse duration (down)
		x	1	1	0	Switch to comparison values
		x = irrelevant				
15.0		Hysteresis (range of values 0 to 255)				
16.0		Pulse duration (value range 0 to 250)				
17.0		Reserve = 0				
18.0	CMP_V1	Comparison value 1; load with function parameter: T_CMP_V1				
22.0	CMP_V2	Comparison value 2; load with function parameter: T_CMP_V2				

Parameters for Transferring Values in the DB (Measuring Modes)

The following table shows the range of the DB in which you transfer the LOAD_VAL, CMP_V1 and CMP_V2 parameters.

The LOAD_VAL parameter (bytes 14 to 17) has two meanings:

- If you set function parameter L_PREPAR, LOAD_VAL is interpreted as a low limit
- If you set function parameter C_DOPARA, Byte 14 is used to define the behavior of Output DO0.

You must not set the L_DIRECT parameter for a measuring mode.

Table 5- 8 Parameters for Transferring Values in the DB (measuring modes)

DB address	Parameter	Meaning			
14.0	LOAD_VAL	Low limit; load with function parameter L_PREPAR			
14.0	LOAD_VAL	Behavior of DO0; define with function parameter: C_DOPARA			
		Bits 2 to 7	Bit 1	Bit 0	Reaction of output DO0
		Irrelevant	0	0	No comparison
		Irrelevant	0	1	Out of limits
		Irrelevant	1	0	Below the low limit
		Irrelevant	1	1	Above the high limit
15.0		Reserve = 0			
16.0		Reserve = 0			
17.0		Reserve = 0			
18.0	CMP_V1	High limit; Load with function parameter T_CMP_V1			
22.0	CMP_V2	Update time; Load with function parameter T_CMP_V2			

Startup characteristics

As soon as the CNT_CTL1 function detects a startup (CPU start or FM start), any pending job is deferred and the startup is acknowledged first. Any job you have already initiated is carried out once the startup is finished and is therefore not lost.

Error Messages

If an operator error occurred when the FC is called, it is reported in the OT_ERR parameter. The error information can then be read out in DB (OT_ERR_B variable). With the help of the OT_ERR_A parameter, you can then acknowledge operator errors. No new operator error will be reported until you have acknowledged the previous one.

5.3 The FC CNT_CTL2 function (FC 3)

Functionality

The functionality of FC CNT_CTL2 and FC CNT_CTL1 is basically the same. The differences between both are explained in the next sections.

Use cases

FC CNT_CTL2 can only be operated in an isochronous OB.

Any call of FC CNT_CTL2 in a non-isochronous OB will generate an operator error 91, and thus prevent data exchange with FM 350-1.

Principle of operation

FC CNT_CTL2 is in particular suitable for applications for high-speed repetition of a job request ("Load comparison value", for example) to FM 350-1. Under favorable conditions, FC CNT_CTL1 lets you initiate a new job at every fifth PROFIBUS DP cycle, whereas FC CNT_CTL2 supports initiation at every second PROFIBUS DP cycle.

The block is ready to execute a job when the corresponding init bit=0. Completion of a job is not indicated separately.

Any communication problems, or data errors, or operator errors, can thus not be allocated to a particular job. In such situations, the block will interrupt job processing, and generate an operator error 90 which can be acknowledged. You may be able to resume execution of any queued or interrupted jobs by acknowledging the error by executing parameter OT_ERR_A.

The acknowledgement of an operator error will be accepted if parameter OT_ERR is reset. Parameter OT_ERR_A should remain set while this action is performed in order to guarantee acknowledgement. There is no point in initiating further jobs until successful completion of the acknowledgement.

Note

When operating in isochronous mode, do not use FC CNT_CTL2 to start several simultaneous value transfers.

5.4 The FC DIAG_INF function (FC 1)

Functionality

FC DIAG_INF reads data record DS1 from FM 350-1 and makes it available at the DB of FC CNT_CTL1. The transfer sequence in particular:

- DS1 will be read from FM 350-1 by setting the init parameter IN_DIAG = TRUE.
- DS1 will be written to the DB of FC CNT_CTL1, starting at DW 54. DS1 is transferred by calling SFC RDSYSST.
- The function copies the return code (RET_VAL) of the SFC to the RET_VAL parameter of FC DIAG_INF.
- When the function has been executed, the function resets init parameter IN_DIAG and reports completion of the transfer.

Manual /2/ contains a detailed description of SFC RDSYSST.

Call

FC DIAG_INF can be called within the cycle, and in the interrupt program. There is no point in calling it in the time-controlled program.

The call of FC DIAG_INF is demonstrated below in STL and LAD format.

STL representation

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

LAD representation

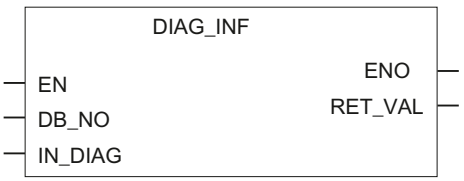


Figure 5-3 Call of FC DIAG_INF

Parameters of FC DIAG_INF

Table 5- 9 Parameters of FC DIAG_INF

Name	Declaration type	Data type	Meaning	User action	Block action
DB_NO	INPUT	INT	Number of the DB of FC CNT_CTL1	entry	query
RET_VAL	OUTPUT	INT	Return code of SFC 51	query	entry
IN_DIAG	IN-OUT	BOOL	Read init bit of diagnostics data record DS1	set and query	reset

5.5 Application example

Introduction

The example below shows how the CNT_CTL1 function can be used for the functions `Transfer load value to FM 350-1' and `Start counter'. These functions are representative of all functions here.

Prerequisites

The load value to be transferred must have been entered in DB 1.

Example for Transferring the Load Value to the FM 350-1 and Starting the Counter

```
STL                                                    Explanation
      L     #1000;                                     // Enter load value in
      T     T CNT_CHAN1.LOAD_VAL;                      // DB1 (double integer).
      U     TRIGGER;
      S     L_DIRECT;                                  // DIRECT input parameter
      R     TRIGGER;
      CALL  CNT_CTL1              (                    // FC call with the DB 1
            DB_NO                 :=1,                 //Channel 1
            SW_GATE               :=SW_GATE            // Control software gate
            GATE_STP              :=GATE_STP,          // Stop gate
            OT_ERR_A              :=CON_OT_ERR,        // Acknowledge operator error
            SET_DO0               :=SET_DO0,           // Set Output DO0
            SET_DO1               :=SET_DO1,           // Set Output DO1
            OT_ERR                :=OT_ERR,            // Operator error occurred
            L_DIRECT              :=L_DIRECT,          // Load new counter value
            L_PREPAR              :=L_PREPAR,          // Prepare new counter value
            T_CMP_V1              :=T_CMP_V1,          // Load new Comparison value 1
            T_CMP_V2              :=T_CMP_V2,          // Load new Comparison value 2
            C_DOPARA              :=C_DOPARA,          // Initiate parameter change
            RES_SYNC              :=RES_SYNC,          // Delete synchronization status bit
            RES_ZERO              :=RES_ZERO);         // Delete zero pass status bit
      AN    OT_ERR;                                    // If no error has occurred,
      JC    CONT;                                      // CONTinue
                                                       // *** Error evaluation START ***
      L     CNT_CHAN1.OT_ERR_B;                        // Read and display additional
      T     DISPLAY;                                   // information.
      SET                                              // Generate RLO 1
      S     CON_OT_ERR                                 // Acknowledge error
      ...                                              // Further error response
      JL    END;                                       // ***Error evaluation END ***
```

```
STL                                                    Explanation
CONT    ...                                            // Continue with normal execution
        AN      L_DIRECT;                              // Load direct function is ready
        S       SW_GATE;                               // Open software gate;
END:
```

Description of the Symbols

The table lists the symbols used in the example. You define your own symbol assignments in the S7 Symbol Table.

Table 5- 10 Symbols in Example

Symbols	Absolute (Example)	Comments
CNT_CHAN1	DB 1	Data block for CNT_CTL1 function
CNT_CHAN1.LOAD_VAL	DB1.DBD14	Counter value specification in DB 1 (double word)
TRIGGER	M 10.0	Trigger memory marker formed as a result of the technological requirement
SW_GATE	M 20.0	Start counter
GATE_STP	M 20.1	Close counter gate
OT_ERR_A	M 20.2	Acknowledge operator error
SET_DO0	M 20.3	Set output DO1
SET_DO1	M 20.4	Set output DO2
OT_ERR	M 20.5	Operator error occurred
L_DIRECT	M 20.6	Direct and preparatory loading of counter value
L_PREPAR	M 20.7	Load value of counter in preparation
T_CMP_V1	M 21.0	Load comparison value 1
T_CMP_V2	M 21.1	Load comparison value 2
C_DOPARA	M 21.2	Initiate parameter change
RES_SYNC	M 21.3	Reset synchronization status bit
RES_ZERO	M 21.4	Reset zero pass, overflow, underflow and comparator or end of measurement status bit
CNT_CHAN1.OT_ERR_B	DB1.DBB40.0	Operator error information in DB 1

Description of the Procedure

The load value of the channel is transferred to the FM 350-1 by means of the function call. When calling the CNT_CTL1 function, select either the L_DIRECT parameter or the L_PREPAR parameter.

Parameter L_DIRECT defines that the load value is transferred directly and in preparation to the counter (you set the trigger bit L_DIRECT=1 in your user program).

Parameter L_PREPAR defines that the load value is only loaded in preparation (you have to set the trigger bit L_PREPAR=1 in your user program).

The load value loaded in preparation is then applied at the next cause that sets the counter.

The FC must therefore be called until the FC has reset the selected trigger bit (L_DIRECT or L_PREPAR). The in/out parameter remains set during the transfer. The CNT_CTL1 function does not issue an error message with regard to the exchange of data with the FM.

If the trigger bit you set has been reset by the CNT_CTL1 function, the FM 350-1 has applied the load value. The read load value stored in DB 1 is updated by the CNT_CTL1 function (applicable only if you are working without the latch setting).

It takes at least four FC calls to transfer the load value.

5.6 Technical specifications of the blocks

Table 5- 11 Technical Specifications for the Blocks

Technical data	FC CNT_CTRL	FC CNT_CTL1	FC CNT_CTL2	FC DIAG_INF
Block number	FC 0	FC 2	FC 3	FC 1
Version	3.0	3.0	3.0	3.0
Assignment in work memory	540 bytes	894 bytes	1422 bytes	246 bytes
Assignment in load memory	634 bytes	1062 bytes	1572 bytes	326 bytes
Assignment in data area	70 bytes long data block that is specified when the FC is called			
Assignment in local data area	4 bytes	46 bytes	46 bytes	38 bytes
System function called	–	SFC 6 (RD_INFO)	SFC 6 (RD_INFO)	SFC 51 RDSYSST
Isochronous mode	No	Yes	Yes	Yes
Non-isochronous mode	Yes	Yes	No	Yes

5.7 Programming FM 350-1 without FCs

To operate FM 350-1 without FCs, you can operate and monitor the module directly using the control and check-back interface (user data interface.)

User data have a length of 16 bytes, starting at the module's start address.

Load commands allow you to read the check-back interface.

Transfer commands are used to write to the control interface.

Mixed use of load / transfer commands and programming with FCs is not permitted.

5.7.1 Control interface for the count modes

Control interface for the count modes

Parameter LOAD_VAL (bytes 0 to 3) has two different meanings:

- You set the L_DIRECT or L_PREPAR bit to define the LOAD_VAL parameter as load value.
- You set the C_DOPARA bit in byte 0 to define the reaction of outputs DO0 and DO1. Bytes 1 and 2 define the hysteresis and pulse duration.

Table 5- 12 Control interface for count modes (outputs)

Offset to the start address	Parameters	Meaning				
Bytes 0 to 3	LOAD_VAL	Load value; direct and preparatory loading with bit L_DIRECT Load value; preparatory loading with bit L_PREPAR				
Byte 0	LOAD_VAL	You set the bit C_DOPARA to define the reaction of outputs DO0 and DO1, and the hysteresis and pulse duration				
		Bit 3	Bit 2	Bit 1	Bit 0	Reaction of output DO0
		x	0	0	0	Inactive
		x	0	0	1	Active within the range from comparison value to overflow
		x	0	1	0	Active within the range from comparison value to underflow
		x	0	1	1	Active on reaching the comparison value for pulse duration (up/down)
		x	1	0	0	Active on reaching the comparison value of the up count pulse width
		x	1	0	1	Active on reaching the comparison value of the down count pulse width

Offset to the start address	Parameters	Meaning				
		x = irrelevant				
		Bit 7	Bit 6	Bit 5	Bit 4	Reaction of output DO1
		x	0	0	0	Inactive
		x	0	0	1	Active within the range from comparison value to overflow
		x	0	1	0	Active within the range from comparison value to underflow
		x	0	1	1	Active on reaching the comparison value for pulse duration (up/down)
		x	1	0	0	Active on reaching the comparison value of the up count pulse width
		x	1	0	1	Active on reaching the comparison value of the down count pulse width
		x	1	1	0	Switch to Comparison Value
		x = irrelevant				
Byte 1		Hysteresis (range of values 0 to 255)				
Byte 2		Pulse duration (range of values 0 to 250)				
Byte 3		Reserve = 0				
Bytes 4 to 7	CMP_V1	Comparison value 1; load with bit:T_CMP_V1				
Bytes 8 to 11	CMP_V2	Comparison value 2; load with bit T_CMP_V2				
Byte 12	–	Bit 7: Reserve = 0				
	NEUSTQ	Bit 6: Restart acknowledgement				
	–	Bit 5: Reserve = 0				
	–	Bit 4: Reserve = 0				
	OT_ERR_A	Bit 3: Operator error acknowledgement				
	–	Bit 2: Reserve = 0				
	–	Bit 1: Reserve = 0				
	–	Bit 0: Reserve = 0				
Byte 13	–	Bit 7: Reserve = 0				
	–	Bit 6: Reserve = 0				
	–	Bit 5: Reserve = 0				
	–	Bit 4: Reserve = 0				
	SW_GATE	Bit 3: SW gate control bit				
	GATE_STP	Bit 2: General gate stop				
	ENSET_DN	Bit 1: Enable synchronization down				
	ENSET_UP	Bit 0: Enable synchronization up				

Offset to the start address	Parameters	Meaning
Byte 14	–	Bit 7: Reserve = 0
	–	Bit 6: Reserve = 0
	–	Bit 5: Reserve = 0
	–	Bit 4: Reserve = 0
	SET_DO1	Bit 3: Control bit DO1
	SET_DO0	Bit 2: Control bit DO0
	CTRL_DO1	Bit 1: Enable DO1
	CTRL_DO0	Bit 0: Enable DO0
Byte 15	–	Bit 7: Reserve = 0
	C_DOPARA [1)]	Bit 6: Change function of DO0/DO1, hysteresis or pulse duration
	RES_ZERO	Bit 5: Status bits of zero transition, overflow, underflow and comparator Resetting
	RES_SYNC	Bit 4: Reset synchronization status bit
	T_CMP_V2 [2)]	Bit 3: Load comparison value 2
	T_CMP_V1 [2)]	Bit 2: Load comparison value 1
	L_PREPAR [2)]	Bit 1: Load counter in preparation
	L_DIRECT [2)]	Bit 0: Direct and preparatory loading of counter
[1)] Do not set this bit at the same time as bits 0, 1, 2 or 3 of byte 15.		
[2)] Do not set this bit at the same time as bit 6 of byte 15.		

Explanation of the control bits for the count modes

Table 5- 13 Explanation of the control bits for the count modes

Control bits	Explanation
C_DOPARA	Set this bit to change the function and reaction of DO0 and DO1, and the hysteresis and pulse duration. The values of bytes 0 to 2 are accepted as a new function, hysteresis and pulse duration at DO0 and DO1. Transfer the old values if you want to prevent changes.
CTRL_DO0	Enable DO0 Set this bit to enable output DO0.
CTRL_DO1	Enable DO1 Set this bit to enable output DO1.
ENSET_DN	Set this bit to enable loading of the counter for up counts
ENSET_UP	Set this bit to enable loading of the counter for down counts
GATE_STP	Set this bit to close the internal gate.
L_DIRECT	Set this bit to enable direct and preparatory loading of the counter.
L_PREPAR	Set this bit to enable preparatory loading of the counter.
NEUSTQ	Set this bit to acknowledge a startup of FM 350-1. After its restart, FM 350-1 will not recognize any control or data input unless this bit has been set. FC CNT_CNTL1 sets the NEUSTQ bit when the return signal FM_NEUST is set, and the return signal FM_NEUSTQ = 0. FC CNT_CNTL1 resets the bit when FM 350-1 has reset the FM_NEUST bit and set the FM_NEUSTQ bit. If you are not using FC CNT_CNTL1, the restart must be coordinated in the user program.
OT_ERR_A	Set this bit to acknowledge an operator error. For detailed information on operator errors, read the checkback interface before you acknowledge the error. The error message is no longer valid after its acknowledgement.
RES_SYNC	Use this bit to reset and acknowledge the check-back bit STS_SYNC and thus enable loading of the counter at synchronization input DI-Set.
RES_ZERO	Use this bit to reset the check-back bits STS_ZERO, STS_OFLW, STS_UFLW, STS_COMP1 and STS_COMP2.
SET_DO0	Provided you have set the output reaction "inactive", and the enable bit CRTL_DO0 is set, you can use this bit to toggle the digital output DO0 on and off.
SET_DO1	Provided you have set the output reaction "inactive", and the enable bit CRTL_DO1 is set, you can use this bit to toggle the digital output DO1 on and off.
SW_GATE	Set/reset this bit to open/close the SW gate.
T_CMP_V1	Set this bit to load the value of bytes 4 to 7 to comparison value 1.
T_CMP_V2	Set this bit to load the value of bytes 8 to 11 to comparison value 2.

5.7.2 Checkback interface for count modes

Checkback interface for count modes

Table 5- 14 Checkback interface for count modes (inputs)

Offset to the start address	Parameters	Meaning
Bytes 0 to 3	LATCH_LOAD	Load value which can be returned, or stored counter value for the latch function at the digital input
Bytes 4 to 7	ACT_CNTV	Counter value
Bytes 8 to 9	DA_ERR_W	Data error
Byte 10	OT_ERR_B	Operator error
Byte 11	PARA	Bit 7: Parameter assignment done
	FM_NEUST	Bit 6: Restart request
	FM_NEUSTQ	Bit 5: Restart acknowledgement done
	DATA_ERR	Bit 4: Data error
	OT_ERR	Bit 3: Operator error
	DIAG	Bit 2: Diagnostics event
	–	Bit 1: –
	–	Bit 0: –
Byte 12		Bit 7: Reserve = 0
		Bit 6: Reserve = 0
		Bit 5: Reserve = 0
		Bit 4: Reserve = 0
		Bit 3: Reserve = 0
		Bit 2: Reserve = 0
		Bit 1: Reserve = 0
		Bit 0: Reserve = 0
Byte 13	STS_SW_GATE	Bit 7: SW gate status
	STS_GATE	Bit 6: Gate status
	STS_SYNC	Bit 5: Synchronization
	STS_UFLW	Bit 4: Underflow
	STS_OFLW	Bit 3: Overflow
	STS_ZERO	Bit 2: Zero transition
	STS_DIR	Bit 1: Direction bit
	STS_RUN	Bit 0: Counter active

Offset to the start address	Parameters	Meaning
Byte 14	STS_COMP2	Bit 7: Latched state of comparator 2
	STS_COMP1	Bit 6: Latched state of comparator 1
	STS_CMP2	Bit 5: Status at output DO1
	STS_CMP1	Bit 4: Status at output DO0
	STS_STP	Bit 3: Status at digital input DI-Stop
	STS_STA	Bit 2: Status at digital input DI-Start
	STS_LATCH	Bit 1: New latch value for isochronous mode
	STS_SET	Bit 0: Status at digital input DI-Set
Byte 15	–	Bit 7: Reserve = 0
	STS_C_DOPARA	Bit 6: Change function of DO0/DO1, hysteresis or pulse duration
	STS_RES_ZERO	Bit 5: Status bit of zero transition, overflow, underflow or comparator Resetting
	STS_RES_SYNC	Bit 4: Reset synchronization status bit
	STS_T_CMP_V2	Bit 3: Load comparison value 2
	STS_T_CMP_V1	Bit 2: Load comparison value 1
	STS_L_PREPAR	Bit 1: Load counter in preparation
	STS_L_DIRECT	Bit 0: Direct and preparatory loading of counter

Description of the check-back bits for the count modes

Table 5- 15 Description of the check-back bits for the count modes

Acknowledgement bits	Explanation
DATA_ERR	This bit indicates a faulty data (parameter assignment error) entry in the checkback interface.
DIAG	The bit will be set if diagnostics data record DS1 was updated to signal a diagnostics event. The bit will be reset when data record DS1 has been read. If no diagnostics interrupt is enabled, this bit may be used as init bit for the FC DIAG_INF you embedded in OB1.
FM_NEUST	FM 350-1 sets this bit when it performs a restart, or detects a system startup, regardless of whether the system starts up automatically or manually. The FM_NEUST bit will be reset at the next positive edge at bit NEUSTQ. FM 350-1 will then accept control commands, and allow the input and output of values.
FM_NEUSTQ	FM 350-1 resets this bit when it performs a restart, or detects a system startup, regardless of whether the system starts up automatically or manually. It will be set after you reset the FM_NEUST bit.
OT_ERR	This bit will be set after an operator error was logged at the checkback interface. It will be reset after bit OT_ERR_A is reset. As long as bit OT_ERR is set, the function does not report any further operator errors.
PARA	This bit will be set when the module parameters are free of errors. The parameter data record on the module does not contain any errors. This bit will not be set, however, unless bit FM_NEUSTQ was reset. From that moment on, the values in the checkback interface are valid and up to date.
STS_C_DOPARA	Bit used to acknowledge simultaneous changes of the reaction of DO0 and DO1, and of the hysteresis and pulse duration. Transfer the old values if you want to discard all changes.
STS_CMP1	Status at output DO0
STS_CMP2	Status at output DO1
STS_T_CMP_V1	Bit used to acknowledge loading of comparison value 1
STS_T_CMP_V2	Bit used to acknowledge loading of comparison value 2
STS_COMP1	This bit indicates the stored status that output DO0 was set. That also applies if output DO0 was not enabled by setting CTRL_DO0. The stored status is reset with RES_ZERO by acknowledging.
STS_COMP2	This bit indicates the stored status that output DO1 was set. That also applies if output DO1 was not enabled by setting CTRL_DO1. The stored status is reset with RES_ZERO by acknowledging.
STS_DIR	This bit indicates the count direction of the counter: 0 = up (LED DIR is off) 1 = down (LED DIR is lit)
STS_GATE	This bit indicates the gate status. 0 = gate closed 1 = gate open
STS_LATCH	In isochronous mode, this bit indicates whether at least one new latch value was saved between the one to last Ti and the last Ti. If the bit is set, LATCH_LOAD contains the last latch value. The bit will not be set if no new latch value was saved. The bit is not set in non-isochronous mode.
STS_L_DIRECT	Acknowledgement bit for direct and preparatory loading of the counter and load value.
STS_L_PREPAR	Acknowledgement bit for preparatory loading of the load value.
STS_OFLW	This bit indicates overflow. The stored status is reset with RES_ZERO by acknowledging.
STS_RES_SYNC	Resets the acknowledgement bit STS_SYNC.

Acknowledgement bits	Explanation
STS_RES_ZERO	Acknowledgement bit for resetting saved states in the acknowledgement bits STS_ZERO, STS_OFLW, STS_UFLW, STS_COMP1 and STS_COMP2
STS_RUN	This bit corresponds to counter bit 2^0. 0 = LED CR is off 1 = LED CR is lit
STS_SET	Status at digital input DI-Set
STS_STA	Status at digital input DI-Start
STS_STP	Status at digital input DI-Stop
STS_UFLW	This bit indicates underflow. The stored status is reset with RES_ZERO by acknowledging.
STS_SYNC	This bit indicates the saved state, which shows that the counter was loaded by an event at DI-Set (synchronization.) The saved status is reset with RES_SYNC by acknowledging.
STS_ZERO	This bit indicates the saved state, which shows that the counter value has passed a zero transition. The saved status is reset with RES_ZERO by acknowledging.

5.7.3 Control interface for measuring modes

Control interface for measuring modes

Parameter LOAD_VAL (bytes 0 to 3) has two different meanings:

- You set bit L_PREPAR to define the LOAD_VAL parameter as a low limit.
- You set bit C_DOPARA bit in byte 0 to define the reaction at output DO0.

Table 5- 16 Control interface for measuring modes (outputs)

Offset to the start address	Parameter	Assignment			
Bytes 0 to 3	LOAD_VAL	Load low limit with bit L_PREPAR			
Byte 0	LOAD_VAL	Define reaction of DO0 at bit C_DOPARA			
		Bits 2 to 7	Bit 1	Bit 0	Reaction of output DO0
		Irrelevant	0	0	No comparison
		Irrelevant	0	1	Out of limits
		Irrelevant	1	0	Below the low limit
		Irrelevant	1	1	Above the high limit
Byte 1		Reserve = 0			
Byte 2		Reserve = 0			
Byte 3		Reserve = 0			
Bytes 4 to 7	CMP_V1	High limit; load with bit T_CMP_V1			
Bytes 8 to 9	CMP_V2	Update time; load with bit: T_CMP_V2			
Bytes 10 to 11	–	–			
Byte 12	–	Bit 7: Reserve = 0			
	NEUSTQ	Bit 6: Restart acknowledgement			
	–	Bit 5: Reserve = 0			
	–	Bit 4: Reserve = 0			
	OT_ERR_A	Bit 3: Operator error acknowledgement			
	–	Bit 2: Reserve = 0			
	–	Bit 1: Reserve = 0			
	–	Bit 0: Reserve = 0			
Byte 13	–	Bit 7: Reserve = 0			
	–	Bit 6: Reserve = 0			
	–	Bit 5: Reserve = 0			
	–	Bit 4: Reserve = 0			
	SW_GATE	Bit 3: SW gate control bit			
	GATE_STP	Bit 2: General gate stop			
	–	Bit 1: –			
	–	Bit 0: –			

Offset to the start address	Parameter	Assignment
Byte 14	–	Bit 7: Reserve = 0
	–	Bit 6: Reserve = 0
	–	Bit 5: Reserve = 0
	–	Bit 4: Reserve = 0
	SET_DO1	Bit 3: Control bit DO1
	SET_DO0	Bit 2: Control bit DO0
	CTRL_DO1	Bit 1: Enable DO1
	CTRL_DO0	Bit 0: Enable DO0
Byte 15	–	Bit 7: Reserve = 0
	C_DOPARA [1)]	Bit 6: Change function DO0
	RES_ZERO	Bit 5: Reset status bits of overflow, underflow and end of measurement
	–	Bit 4: Reserve = 0
	T_CMP_V2 [2)]	Bit 3: Change update time
	T_CMP_V1 [2)]	Bit 2: Load high limit
	L_PREPAR [2)]	Bit 1: Load low limit
	–	Bit 0: –
[1)] Do not set this bit at the same time as bit 1, 2 or 3 of byte 15.		
[2)] Do not set this bit at the same time as bit 6 of byte 15.		

Description of the control bits for measuring modes

Table 5- 17 Description of the control bits for measuring modes

Control bits	Explanation
C_DOPARA	Set this bit to change the reaction and function of DO0. The values at byte 0 are accepted as new function of DO0. Transfer the old values if you want to discard all changes.
CTRL_DO0	Enable DO0 Set this bit to enable output DO0.
CTRL_DO1	Enable DO1 Set this bit to enable output DO1.
GATE_STP	Set this bit to close the internal gate.
L_PREPAR	Set this bit to load the low limit.
NEUSTQ	Set this bit to acknowledge a startup of FM 350-1. After its restart, FM 350-1 will not recognize any control or data input unless this bit has been set. FC CNT_CNTL1 sets the NEUSTQ bit when the return signal FM_NEUST is set, and the return signal FM_NEUSTQ = 0. FC CNT_CNTL1 resets the bit when FM 350-1 has reset the FM_NEUST bit and set the FM_NEUSTQ bit. If you are not using FC CNT_CNTL1, the restart must be coordinated in the user program.
OT_ERR_A	Set this bit to acknowledge an operator error. For detailed information on operator errors, read the checkback interface before you acknowledge the error. The error message is no longer valid after its acknowledgement.
RES_ZERO	Set this bit to reset the acknowledgement bits STS_OFLW, STS_UFLW and STS_COMP1.
SET_DO0	Provided you have set the output reaction "inactive", and the enable bit CRTL_DO0 is set, you can use this bit to toggle the digital output DO0 on and off.
SET_DO1	Provided you have set the output reaction "inactive", and the enable bit CRTL_DO1 is set, you can use this bit to toggle the digital output DO1 on and off.
SW_GATE	Set/reset this bit to open/close the SW gate.
T_CMP_V1	Set this bit to load the high limit.
T_CMP_V2	Set this bit to load the refresh interval time.

5.7.4 Checkback interface for the measuring modes

Checkback interface for the measuring modes

Table 5- 18 Checkback interface for the measuring modes (inputs)

Offset to the start address	Parameter	Assignment
Bytes 0 to 3	LATCH_LOAD	Measured value
Bytes 4 to 7	ACT_CNTV	Counter value
Bytes 8 to 9	DA_ERR_W	Data error
Byte 10	OT_ERR_B	Operator error
Byte 11	PARA FM_NEUST FM_NEUSTQ DATA_ERR OT_ERR DIAG – –	Bit 7: Parameter assignment done Bit 6: Restart request Bit 5: Restart acknowledgement done Bit 4: Data error Bit 3: Operator error Bit 2: Diagnostics event Bit 1: – Bit 0: –
Byte 12		Bit 7: Reserve = 0 Bit 6: Reserve = 0 Bit 5: Reserve = 0 Bit 4: Reserve = 0 Bit 3: Reserve = 0 Bit 2: Reserve = 0 Bit 1: Reserve = 0 Bit 0: Reserve = 0
Byte 13	– STS_GATE – STS_UFLW STS_OFLW STS_COMP1 STS_DIR STS_RUN	Bit 7: – Bit 6: Gate status Bit 5: – Bit 4: Underflow Bit 3: Overflow Bit 2: End of measurement Bit 1: Direction bit Bit 0: Counter active

Offset to the start address	Parameter	Assignment
Byte 14	–	Bit 7: –
	–	Bit 6: –
	STS_CMP2	Bit 5: Status at output DO1
	STS_CMP1	Bit 4: Status at output DO0
	STS_STP	Bit 3: Status at digital input DI-Stop
	STS_STA	Bit 2: Status at digital input DI-Start
	–	Bit 1: –
	STS_SET	Bit 0: Status at digital input DI-Set
Byte 15	–	Bit 7: Reserve = 0
	STS_C_DOPARA	Bit 6: Change function DO0
	STS_RES_ZERO	Bit 5: Reset end of measurement status bit
	–	Bit 4: –
	STS_T_CMP_V2	Bit 3: Change refresh time
	STS_T_CMP_V1	Bit 2: Load high limit
	STS_L_PREPAR	Bit 1: Load low limit
	–	Bit 0: –

Description of the acknowledgement bits for the measuring modes

Table 5- 19 Description of the acknowledgement bits for the measuring modes

Acknowledgement bits	Explanation
DATA_ERR	This bit indicates that a data error was entered in the checkback interface.
DIAG	The bit will be set if diagnostics data record DS1 was updated to signal a diagnostics event. The bit will be reset when data record DS1 has been read. If no diagnostics interrupt is enabled, this bit may be used as init bit for the FC DIAG_INF you embedded in OB1.
FM_NEUST	FM 350-1 sets this bit when it performs a restart, or detects a system startup, regardless of whether the system starts up automatically or manually. The FM_NEUST bit will be reset at the next positive edge at bit NEUSTQ. FM 350-1 will then accept control commands, and allow the input and output of values.
FM_NEUSTQ	FM 350-1 deletes this bit when it performs a restart, or detects a system startup, regardless of whether the system starts up automatically or manually. It will be set after you reset the FM_NEUST bit.
OT_ERR	This bit will be set after an operator error was logged at the checkback interface. It will be reset after bit OT_ERR_A is reset. As long as bit OT_ERR is set, the function does not report any further operator errors.
PARA	This bit will be set when the module parameters are free of errors. The parameter data record on the module does not contain any errors. This bit will not be set, however, unless bit FM_NEUSTQ was reset. From this moment on, the values in the checkback interface are valid and up to date.
STS_C_DOPARA	Bit used to acknowledge simultaneous changes of the reaction of DO0 and DO1, and of the hysteresis and pulse duration. Transfer the old values if you want to discard all changes.
STS_CMP1	Status at output DO0
STS_CMP2	Status at output DO1
STS_CMP_T_VAL1	Acknowledgement bit for loading the high limit
STS_CMP_T_VAL2	Acknowledgement bit for loading of the refresh time
STS_DIR	This bit indicates the count direction of the counter: 0 = Up (LED DIR is off) 1 = Down (LED DIR is lit)
STS_GATE	This bit indicates the gate status. 0 = Gate closed 1 = Gate open
STS_L_PREPAR	Acknowledgement bit for loading the low limit
STS_OFLW	This bit indicates the saved status, which shows the overflow of a measured value. The saved status is reset with RES_ZERO by acknowledging.
STS_RES_ZERO	Acknowledgement bit for resetting the stored states in the acknowledgement bits STS_OFLW, STS_UFLW and STS_COMP1
STS_RUN	This bit corresponds to counter bit 2^0. 0 = LED CR is off 1 = LED CR is lit
STS_SET	Status at digital input DI-Set
STS_STA	Status at digital input DI-Start
STS_STP	Status at digital input DI-Stop
STS_UFLW	This bit indicates the saved state, which shows underflow of a measured value. The saved status is reset with RES_ZERO by acknowledging.

5.7.5 Operating the interface with full acknowledgement principle

Complete Acknowledgement Principle

The complete acknowledgement principle is always used to control the FM 350-1 from the user program:

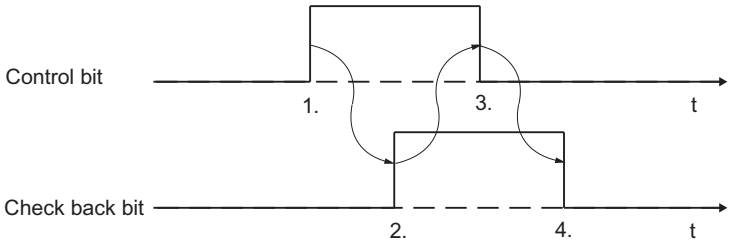


Figure 5-4 Complete Acknowledgement Principle

The sequence is as follows:

1. If the feedback bit = 0, you can request processing via the user program by setting the control bit.
2. The FM 350-1 detects the request, acknowledges it by setting the feedback bit and starts the processing.
3. Once the FM 350-1 has set the feedback bit, you can reset the control bit.
4. At the end of processing, the FM 350-1 responds to the resetting of the control bit by resetting the feedback bit.

Transferring values

Values are also transferred using the complete acknowledgement principle with the FM 350-1. If incorrect values are transferred, the FM 350-1 signals an operator error with the feedback bit OT_ERR. You must then first acknowledge the operator error bit OT_ERR with the operator error acknowledgement OT_ERR_A before you can transfer a new, correct value.

Table 5- 20 Transferring the values depending on the operating mode

Operating mode	Control bits
Counting	L_DIRECT, L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA
Measure	L_PREPAR, T_CMP_V1, T_CMP_V2, C_DOPARA

The figure shows an example of the chronological sequence for the value transfer during initializing loading of the counter.

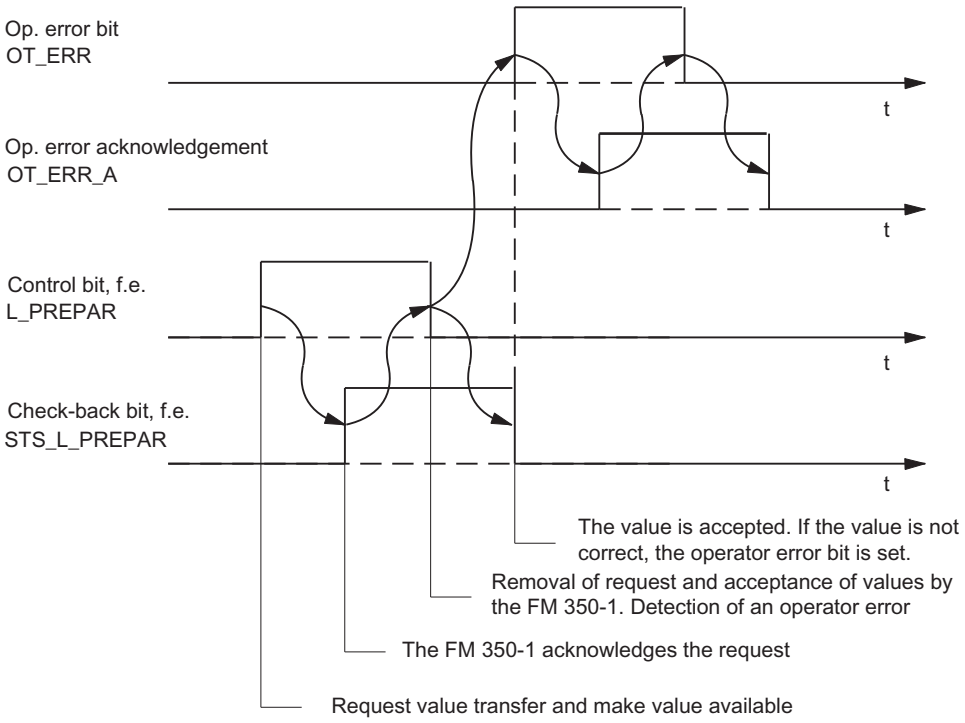


Figure 5-5 Transferring values

Table 5- 21 Simultaneous transfer of several values

In the operating mode ...	... You can transfer at the same time	
Counting	• Load value • Comparison value 1 • Comparison value 2	(Parameter LOAD_VAL) (Parameter CMP_V1) (Parameter CMP_V2)
Measure	• Low limit • High limit • Update time	(Parameter LOAD_VAL) (Parameter CMP_V1) (Parameter CMP_V2)

If a value is incorrect, you must first acknowledge this operator error with OT_ERR_A before the FM 350-1 can accept any further values. You should then correct the value rejected with the operator error and transfer it again.

Note

If you use the control bits L_DIRECT, L_PREPAR, T_CMP_V1 or T_CMP_V2 to load the value LOAD_VAL, CMP_V1 or CMP_V2, you cannot change the parameter assignments at the same time using the C_DOPARA control bit.

This would lead to an OT_ERR operator error that you would have to acknowledge with OT_ERR_A.

Time Required to Transfer Values

Table 5- 22 Time Required to Transfer Values

Use of the FM 350-1	Time requirement	
Centralized	At least 3 OB 1 cycles	
Distributed (non-isochronous mode)	At least 4 PROFIBUS DP cycles	
Decentralized (isochronous mode)	At transmission of only one value	4 PROFIBUS DP cycles
	At simultaneous initiation of the transmission of several values	• For the 1st value: 4 PROFIBUS DP cycles after initiation • For the 2nd value: 5 PROFIBUS DP cycles after initiation • For the 3rd value: 6 PROFIBUS DP cycles after initiation

Reading Back Values

Values are read from the record DS 2 of the FM 350-1. You can also read this record with SFC 59 RD_REC. The DS 2 has the following structure:

Table 5- 23 Data record DS 2

Address	Value	
	Counting	Measure
Bytes 0 to 3	Load value	Low limit
Bytes 4 to 7	Comparison value 1	High limit
Bytes 8 to 11	Comparison value 2	Update time

Resetting the status bits

With the FM 350-1, the status bits are also reset using the complete acknowledgement principle.

Table 5- 24 Resetting the status bits depending on the operating mode

Operating mode	Status bits
Counting	STS_ZERO, STS_OFLW, STS_UFLW, STS_COMP1, STS_COMP2
Measure	STS_OFLW, STS_UFLW, STS_COMP1

The chronological sequence when resetting the status bits is shown in the figure:

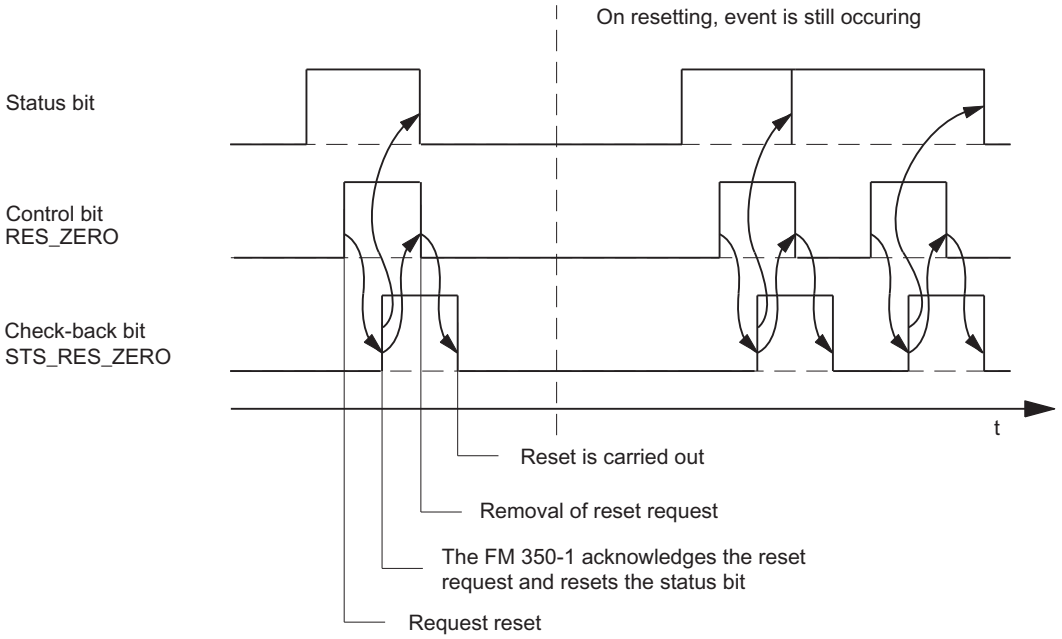


Figure 5-6 Resetting the status bits

5.7.6 Restart coordination

Restart coordination

FM 350-1 always sets the acknowledgement bit FM_NEUST when it performs a restart or detects a system startup

If you do not use any FCs, coordinate the restart in the user program:

Acknowledge the FM_NEUST bit by setting the NEUSTQ control bit.

FM 350-1 then resets acknowledgement bit FM_NEUST, and sets acknowledgement bit FM_NEUSTQ.

You can reset control bit NEUSTQ after FM 350-1 has reset acknowledgement bit FM_NEUST.

The diagram shows the restart coordination sequence.

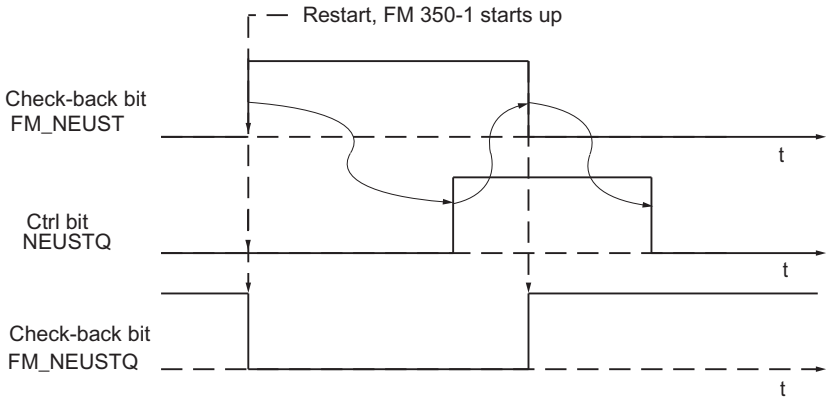


Figure 5-7 Restart sequence

An FC when used will automatically coordinate the restart.

5.8 Reaction to CPU STOP and CPU STOP to RUN

Behavior at CPU-STOP

The behavior of the FM 350-1 when the higher-level controller fails is set using the Basic Parameters dialog box (shortcut menu **Object Properties > Basic Parameters**).

Table 5- 25 FM 350-1 reaction to CPU STOP depending on the basic parameters

Basic parameters	FM 350-1 reaction to CPU STOP
STOP	The FM cancels the counting operation and switches off the outputs.
Continue operating	The FM continues working and does not switch off the outputs.
Terminate active job	For single counting, the counting operation is continued until it is ended by reaching the counting limit. For periodic counting, the current counting operation is continued until it is ended by reaching the counting limit. Measurements are cancelled immediately. The FM then switches off the outputs.
Substitute value	The current Count mode is cancelled. The module outputs the set substitute values to the digital outputs. The substitute values are retained after the CPU STOP-RUN transition until the next time the digital outputs are used. The outputs are reset when you change the "Reaction to CPU STOP" with new parameters. The current measuring mode is cancelled, and the outputs are reset.
Keep last value	The current counting or measuring mode is cancelled. The module outputs at the digital outputs the values that were valid at the time of canceling until the next time the digital outputs are used after the CPU STOP-RUN transition.

Behavior during CPU STOP-RUN transition

The FM 350-1 behavior at the CPU transition from STOP to RUN if the job is continued or in response to plant changes during operation using CiR is set using the Basic Parameters dialog box.

Table 5- 26 FM 350-1 reaction to new parameters at the CPU STOP-RUN transition depending on the basic parameters

Basic parameters	FM 350-1 Reaction to New Parameters at the CPU STOP-RUN Transition
Always reset	The FM cancels the counting and measuring operations, resets itself and accepts the new parameters.
Only reset when parameters have been changed	The FM only cancels the counting and measuring operations if the parameters have changed.

Commissioning FM 350-1

6

Chapter overview

This chapter contains the checklists for commissioning FM 350-1. Those checklists help you to

- check all working steps before you put the module into operation
- prevent faulty reactions of the module in runtime.

6.1 Working steps for mechanical installation

Checklist

Use the checklist below to check and document the working steps for mechanical installation of the FM 350-1.

Table 6- 1 Checklist of the steps during mechanical installation

Working step	Options/Procedure				✓
Specifying the slot	Slot 4 to 11 in Rack 0 Slot 4 to 11 in Rack 1 Slot 4 to 11 in Rack 2 Slot 4 to 11 in Rack 3				
Determine counter signals (coding plug)	5 V differential signals Position A 24-V signals Position D				
Install FM 350-1	1. Loosen neighboring module and connect bus connector 2. Hang module into position and tighten screw 3. Attach slot number 4. Install shield connecting element				
Select cables	Observe the rules and specifications in the chapter Wiring front connectors (Page 31).				
Connecting the 5 V encoder	Incremental 5 V encoder with the differential signals • A and /A • B and /B • N and /N	**Connection** 3 4 6 7 8 9 10 11	**Name** 1M 5.2 VDC AA* /A BB* /B NN* /N	**Function** Encoder supply ground Encoder power supply 5.2 V Encoder signal A Encoder signal /A Encoder signal B Encoder signal /B Encoder signal N Encoder signal /N	
Connecting the 24 V encoder	incremental 24 V encoder	**Connection** 3 5 6 8 10	**Name** 1M 24 VDC AA* BB* NN*	**Function** Encoder supply ground Encoder power supply 24 V Encoder signal A * Encoder signal B * Encoder signal N *	
	24 V pulse encoder without direction level (initiator/BERO)	**Connection** 3 5 6	**Name** 1M 24 VDC AA*	**Function** Encoder supply ground Encoder power supply 24 V Encoder signal A *	

Working step	Options/Procedure				✓
	24 V pulse encoders with direction level	**Connection**	**Name**	**Function**	
		3	1M	Encoder supply ground	
		5	24 VDC	Encoder power supply 24 V	
		6	AA*	Encoder signal A *	
		8	BB*	Direction level B*	
Wire digital inputs and digital outputs	Digital inputs and digital outputs	**Connection**	**Name**	**Function**	
		13	I0	Digital input DI Start	
		14	I1	Digital input DI Stop	
		15	I2	Digital input DI Set	
		17	Q0	Digital output DO0	
		18	Q1	Digital output DO1	
Connecting the auxiliary voltage and the load voltage	Auxiliary voltage and load voltage	**Connection**	**Name**	**Function**	
		1	1L+	24 V auxiliary voltage	
		2	1M	Auxiliary voltage ground	
		19	2L+	24 V load voltage	
		20	2M	Load voltage ground	

6.2 Procedure for assigning parameters

Check lists

Use the check lists below to check and document the working steps for parameterizing the FM 350-1.

Table 6- 2 Check list for Count Modes

Working step	Options/Procedure			✓
Configuring FM 350-1 in HW Config	**Select encoder**			
	5-V encoder with symmetrical signals	Monitoring	A + B + N	
			A + B	
			A	
			None	
	24-V encoder with asymmetrical signals	Max. count frequency	≤200 kHz/≥2.5 µs	
			≤20 kHz/≥25 µs	
		Encoder inputs	Sinking output	
			Sourcing output/push-pull	
	24 V encoders with pulse train and direction signal	Max. count frequency	≤200 kHz/≥2.5 µs	
			≤20 kHz/≥25 µs	
		Encoder inputs	Sinking output	
			Sourcing output/push-pull	
	24 V initiator	Max. count frequency	≤200 kHz/≥2.5 µs	
			≤20 kHz/≥25 µs	
		Encoder inputs	Sinking output	
			Sourcing output/push-pull	
	Internal 1 MHz time base			
	Signal evaluation	Single		
		Double		
		Quadruple		
	Count direction	Normal		
		Inverted		
	Set operating mode			
	Continuous counting			
	Single counting			
	Periodic counting			
	Set count range	0 to +32 bit		
		-31 to +31 bit		
	Main count direction (only with single counting or periodic counting)	None		
		Up		
		Down		

Working step	Options/Procedure			✓
Configuring FM 350-1 in HW Config	Gate control	Gateless (continuous counting only)		
		SW gate		
		HW gate		
		Latch		
		Latch/retrigger		
	Gate function	Cancel		
		Interrupt		
	Latch	Positive edge		
		Negative edge		
		Both edges.		
	Determine the behavior of the digital inputs			
	HW gate	Level-controlled hardware gate		
		Edge-controlled hardware gate		
	Minimum pulse width	≥2.5 µs		
		≥25 µs		
	Setting the counter	Single		
		Multiple		
	Evaluate zero mark for setting			
	Determine the behavior of the digital outputs			
	Pulse duration	0 to 500 ms		
	Hysteresis	0 to 255		
	Output DO0	Inactive		
		Active from Comparison value 1 to overflow		
		Active from Comparison value 1 to underflow		
		Active on reaching Comparison value 1 for pulse duration (up/down)		
		Active on reaching Comparison value 1 for pulse duration (up)		
		Active on reaching Comparison value 1 for pulse duration (down)		
		Substitute value for CPU stop	0	
			1	

Working step	Options/Procedure			✓
Configuring FM 350-1 in HW Config In the S7 user program	Output DO1	Inactive		
		Active from Comparison value 2 to overflow		
		Active from Comparison value 2 to underflow		
		Active on reaching comparison value for pulse duration (up/down)		
		Active on reaching Comparison value 2 for pulse duration (up)		
		Active on reaching Comparison value 2 for pulse duration (down)		
		Switch to comparison values		
		Substitute value for CPU stop	0	
			1	
	Select hardware interrupts			
	Interrupt on opening the gate (hardware or software gate)			
	Interrupt on closing the gate (hardware or software gate)			
	Interrupt in case of overflow			
	Interrupt in event of underflow			
	Interrupt in case of zero crossing			
	Interrupt on reaching Comparison value 1 in up direction			
	Interrupt on reaching Comparison value 1 in down direction			
	Interrupt on reaching Comparison value 2 in up direction			
	Interrupt on reaching Comparison value 2 in down direction			
	Interrupt on setting counter			
	Interrupt on latch			
	Enable digital outputs			
	CTRL_DO0 in DB CTRL_DO1 in DB			
	Enable synchronization			
	ENSETUP in DB ENSETDN in DB			
	Determine load value and comparison values and enter in DB			
	Load value			
	Comparison value 1			
	Comparison value 2			
	Integrate FCs in user program			
	Integrate FC CNT_CTL1 or FC CNT_CTL2			
	Integrate FC DIAG_INF			

Table 6- 3 Check list for Measuring Modes

Working step	Options/Procedure			✓
Configuring FM 350-1 in HW Config	**Select encoder**			
	5-V encoder with symmetrical signals	Monitoring	A + B + N	
			A + B	
			A	
			None	
	24-V encoder with asymmetrical signals	Max. count frequency	≤200 kHz/≥2.5 µs	
			≤20 kHz/≥25 µs	
		Encoder inputs	Sinking output	
			Sourcing output/push-pull	
	24-V encoder with pulse train and direction signal	Max. count frequency	≤200 kHz/≥2.5 µs	
			≤20 kHz/≥25 µs	
		Encoder inputs	Sinking output	
			Sourcing output/push-pull	
	Count direction	Normal		
		Inverted		
	Set operating mode			
	Frequency measurement			
	Speed measurement			
	Period measurement			
	Update time			
	Pulses per encoder revolution			
	Resolution of period duration	1 µs		
		1/16 µs		
	Gate control			
	Gate control	SW gate		
		HW gate		

Working step	Options/Procedure			✓
Configuring FM 350-1 in HW Config	**Determine the behavior of the digital inputs**			
	HW gate	Level-controlled hardware gate		
		Edge-controlled hardware gate		
	Minimum pulse width	≥2.5 µs		
		≥25 µs		
	Determine the behavior of the digital outputs			
	Output DO0	Low limit		
		High limit		
		No comparison		
		Out of limits		
		Below the low limit		
		Above the high limit		
	Select interrupts			
	Interrupt on opening the gate (hardware or software gate)			
	Interrupt on closing the gate (hardware or software gate)			
	Interrupt on violation low limit			
	Interrupt on violation high limit			
	Interrupt at end of measurement			
In the S7 user program	**Enable digital outputs**			
	CTRL_DO0 in DB CTRL_DO1 in DB			
	Determine load value and comparison values and enter in DB			
	Low limit			
	High limit			
	Update time			
	Integrate FCs in user program			
	Integrate FC CNT_CTL1 or FC CNT_CTL2			
	Integrate FC DIAG_INF			

Operating Modes, parameters and commands

7

Chapter overview

Contents of this chapter:

- A description of the operating modes
- A description of the commands
- Conditions and information to observe.

7.1 Basics on calling operating modes, settings and commands

Calling operating modes, settings and commands

- You select the operating modes in the programming interfaces of FM 350-1.

  The parameter data are saved on the PG and transferred to the rack SDB.

  For information about the installation of programming interfaces and programming FM 350-1, refer to the chapter Programming FM 350-1 (Page 35) and to the Online Help system of the installed software.
- You change the operating mode or edit settings in programming interfaces. The new mode or settings are applied after the next restart of FM 350-1.
- Count commands are generated using either the hardware signals wired to the front connector, or by setting the relevant input parameter at FC CNT_CTL1 or with isochronous mode FC CNT_CLT2 in the user program. The input parameters are stored as control bits in the DB of FC CNT_CTL1.

Control and status bits in the DB

In addition to the control bits, the DB contains status bits which report the status of count and measuring operations. The control and status bits are each allocated two bytes in the DB (see the chapter DB Assignments (Page 169).)

Transferring the control and status bits

Status and control bits are transferred between the CPU and the module by calling FC CNT_CTRL or FC CNT_CTL2, which must be embedded in the user program:

The control and status bits should be addressed symbolically in the user program. The symbolic names are used in the description of FCs in this chapter.

For details on FC CNT_CTL1 or FC CNT_CTL2, refer to the chapter Programming FM 350-1 (Page 39). The DB assignments are listed in chapter DB assignments (Page 169).

7.2 Isynchronous mode

Note

Basic information on isochronous mode is available in the SIMATIC Isochronous Mode (http://support.automation.siemens.com/WW/view/en/15218045) function manual.

Hardware requirements

Requirements of operating FM 350-1 in isochronous mode:

- The CPU supports isochronous mode
- The DP master supports constant bus cycle times

Principle of isochronous operation of FM 350-1

FM 350-1 supports non-isochronous and isochronous mode, depending on the configuration. The default is non-isochronous mode. FM 350-1 automatically changes to isochronous mode if configured accordingly, without signaling the change.

In isochronous mode, data are exchanged between the DP master and FM 350-1 in synchronism with the PROFIBUS DP cycle, i.e.:

- All control signals transferred to FM 350-1 are activated at the time T_o within the same PROFIBUS DP cycle.
- All values and FM 350-1 status bits recorded at the time T_i are made available at the checkback interface within the same PROFIBUS DP cycle.

  All 16 bytes of the checkback interface are consistent when operating in isochronous mode, i.e., the values and status bits always match.
- The counter value which is influenced by signals at the digital outputs can only take effect within the same PROFIBUS DP cycle if the event occurred prior to time T_i of this PROFIBUS DP cycle. This applies to the following actions:
  - Load counter by opening the hardware gate
  - Load counter by synchronization
  - Latch and latch / retrigger a counter value

Parameter errors will prevent FM 350-1 from changing over to isochronous mode.

If isochronous mode is blocked as a result of errors or failure / delay of Global Control (GC), FM 350-1 will ignore the error and returns to isochronous mode at the next cycle.

The checkback interface will not be updated if isochronous mode is deactivated.

7.3 Count modes

7.3.1 Overview of the count modes

Overview

You define FM 350-1 functionality by setting a default mode of operation. The table shows an overview of the count modes.

Table 7- 1 Count modes of FM 350-1

Designation	Description
Continuous count with or without SW or HW gate	FM 350-1 performs a continuous count, starting at the current counter value.
Single count with SW or HW gate	When the gate opens, FM 350-1 starts the count at the load value, and stops at the count limit.
Cyclic count with SW or HW gate	FM 350-1 starts counting in the range between the load value and the count limit when the gate opens.

Those operating modes are enabled by programming FM 350-1.

7.3.2 Basic principles

Load value

The load value is the counter level from which the FM 350-1 starts the counting process.

You can assign a load value LOAD_VAL to the FM 350-1 during operation. This will overwrite the starting count.

You can assign this load value directly (control signal L_DIRECT). It is then accepted directly by the FM 350-1 as a new counter value and loaded in preparation.

You can load the load value in preparation only (control signal L_PREPAR). A load value that is loaded in preparation is accepted by the FM 350-1 as a new counter value in response to the following events:

- In the single counting and periodic counting modes
  - When the high or low count limit is reached if no main count direction is set.
  - When the set high count limit is reached with main count direction up.
  - When 0 is reached with main count direction down.
- In all counting modes
  - The counting process is started by the canceling SW or HW gate (the load value is not accepted when the counting continues).
  - Synchronization
  - Latch/retrigger

Gate control

You can use the hardware gate (HW gate) and software gate (SW gate) to control the FM 350-1 counting processes, meaning to start and stop them.

Maximum Count Range without Main Count Direction

The 32-bit binary counter of the FM 350-1 can work in two different modes, depending on the parameterization.

Table 7- 2 Modes for the 32-bit binary counter of the FM 350-1, depending on the parameterization

	Count range "0 to +32-bit" (32-bit unsigned)	**Count range "–31 to +31-bit" (31-bit signed)**
Decimal count range	0 to +4 294 967 295	-2 147 483 648 to +2 147 483 647
Hexadecimal count range	0000 0000 to FFFF FFFF	8000 0000 to 7FFF FFFF
	An overflow is detected when the counter value (hexadecimal) changes from FFFF FFFF to 0, and an underflow is detected when it changes from 0 to FFFF FFFF.	An overflow is detected when the counter value (hexadecimal) changes from 7FFF FFFF to 8000 0000, and an underflow is detected when it changes from 8000 0000 to 7FFF FFFF.

Main Count Direction

When you set a main count direction (up or down), you can limit the maximum count range to a smaller range by setting the high count limit. The set count range is then between 0 and the set high counter limit. This can be used to create incrementing or decrementing counting applications, for example. The set main count direction has no effect on the direction evaluation when the count pulses are detected.

Starting Counts According to Parameterization

Table 7- 3 Start values

Value	Main count direction	Start value
Load value	None	0
	Up	0
	Down	Parameterized high count limit
Count value	None	0
	Up	0
	Down	Parameterized high count limit
Comparison value 1 and 2	None	0
	Up	0
	Down	Parameterized high count limit
Latch value	None	0
	Up	0
	Down	Parameterized high count limit

Isochronous Mode

In isochronous mode, the FM 350-1 accepts control bits and control values from the control interface in each PROFIBUS DP cycle and returns its response to them within the same cycle.

In each cycle, the FM 350-1 sends the counter state or latch value that was valid at the time T_i and the status bits that were valid at the time T_i.

Thus, a counter level that is affected by hardware input signals can only be transferred in the same cycle if the input signal occurs before the time T_i.

Commands for the Counting Modes

You can apply five commands to the FM 350-1 counting process during operation:

Table 7- 4 The FM 350-1 commands

Name	Description
Open and close gate	The counting process starts when a gate opens and ends when it closes.
Setting the counter	The counter can be set to the load value using various signals.
Latch/retrigger	Saves the counter level and loads the counter with the load value in response to a positive edge at DI Start.
Latch	Saves the counter level in response to a positive edge at DI.Start.
Measure times between two edges	Measures the times between two immediately successive edges at the DI Start digital input.

7.3.3 Endless counting

Overview

In this operating mode, the FM 350-1 counts continuously from the count value:

- If the counter reaches the high limit when counting up and a further count pulse is received, it jumps to the low count limit and continues to count from there without any pulse losses.
- If the counter reaches the low limit when counting down and a further count pulse is received, it jumps to the high limit and continues to count from there without any pulse losses.

The following applies to the 31-bit count range:

- The high count limit is set to +2 147 483 647 (2^{31} - 1).
- The low count limit is set to -2 147 483 648 (-2^{31}).

The following applies to the 32-bit count range:

- The high count limit is set to +4 294 967 295 (2^{32} - 1).
- The low count limit is set to 0 (zero).

Behavior at the Count Limits

If the counter reaches the high or low count limit and a further count pulse is received, then the counter is set to the other count limit. An appropriate status bit is set in the DB.

Table 7- 5 Behavior at the Count Limits (Continuous Counting)

Count limit reached	Status bit in DB
High count limit	STS_OFLW is set
Low count limit	STS_UFLW is set

Selecting the Gate Function

You can select the gate control in this mode. The following possibilities are available to you:

- Without gate (default)
- SW gate
- Hardware gate, level-controlled or edge-controlled

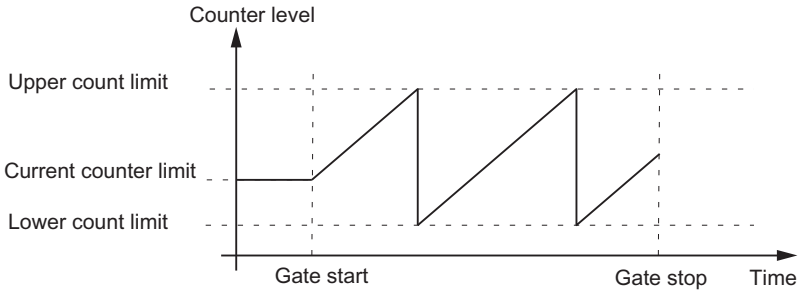


Figure 7-1 Continuous counting with gate control

Opening and Closing the Software Gate

You open and close the software gate of the counter in each case with the input parameter SW_GATE of the FC CNT_CTL1.

Table 7- 6 Triggering the Opening/Closing of a SW Gate (Continuous Counting)

Action	...Is initiated by
Open software gate	Setting SW_GATE
Close software gate	Resetting SW_GATE

When the software gate opens, the counting operation resumes with the current counter level.

Opening and Closing the Hardware Gate

You open and close the hardware gate by applying the relevant signals to or removing the signals from the digital inputs DI Start and DI Stop.

Table 7- 7 Triggering the Opening/Closing of a HW Gate (Continuous Counting)

Action	...Is initiated by
Open hardware gate (level-controlled)	Apply signal to digital input DI Start
Close hardware gate (level-controlled)	Remove signal from digital input DI Start
Open hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Start
Close hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Stop

When the hardware gate opens, the counting operation resumes with the current counter level.

Terminating the Count with the Gate Stop Function

You can also terminate the count when counting with the software gate or hardware gate by using the gate stop function. Set the GATE_STP input parameter of FC_CNT_CTL1 for this.

Effects of the Latch Setting on the Counter at the Beginning of a Count Operation

You can find information on this in the section command: Latch/retrigger (Page 127) and command: Latch (Page 130) in this section.

7.3.4 Single counting

Overview

In this operating mode the FM 350-1 counts once in the assigned main count direction and then stops the counting process automatically. You can assign the following behavior:

- Single counting – No main count direction
- Single counting - Main count direction up
- Single counting - Main count direction down

Single counting – No main count direction

In single counting mode with no main count direction, when the gate is opened, the FM 350-1 counts up or down from the load value until one of the count limits is exceeded.

When one of the count limits is exceeded, the following occurs:

- The gate is closed
- The STS_OFLW or STS_UFLW bit in the feedback interface is set
- The counter is loaded to the other count limit

The count limits are fixed at the maximum count range.

The STS_ZERO bit is set if the counter level is zero.

You must open the gate again to restart the counting.

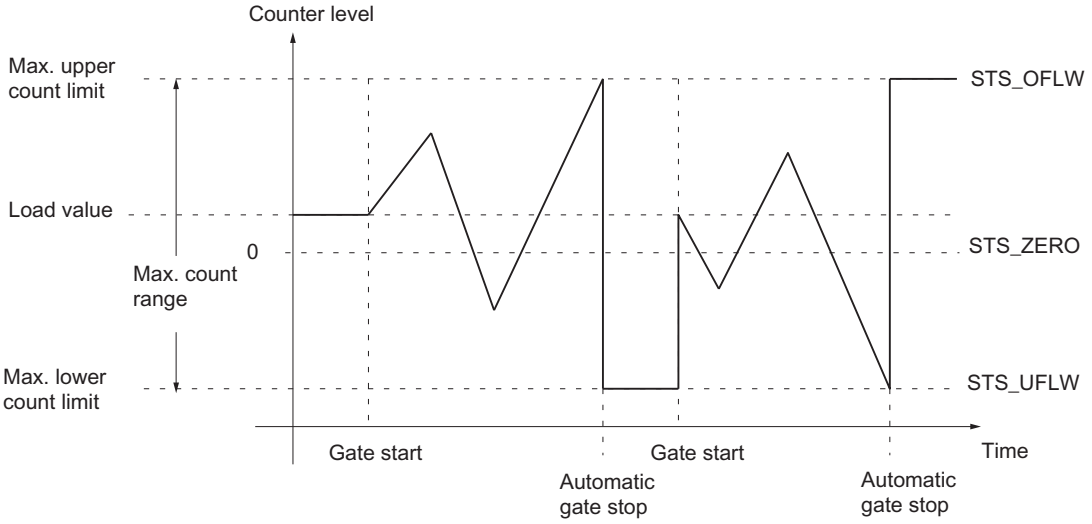


Figure 7-2 Single counting without main count direction; canceling gate function

Single Counting - Main Count Direction Up

In single counting mode with main count direction up, when the gate is opened, the FM 350-1 counts up or down from the load value until the high count limit is exceeded.

If the high count limit is exceeded, the following occurs:

- The gate is closed
- The STS_OFLW bit in the feedback interface is set
- The counter is loaded with the load value

The high count limit can be set. The load value has a starting count and can be changed.

You must open the gate again to restart the counting.

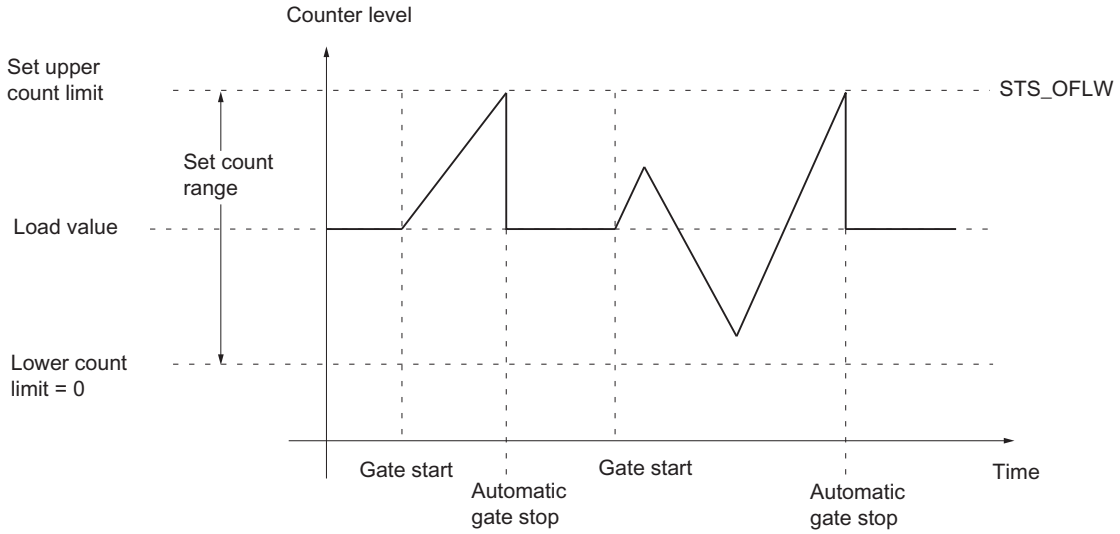


Figure 7-3 Single counting without main count direction; canceling gate function

Single Counting - Main Count Direction Down

In single counting mode with main count direction down, when the gate is opened, the FM 350-1 counts up or down from the load value until the low count limit is exceeded.

If the low count limit is under-run, the following occurs:

- The gate is closed
- The STS_UFLW bit in the feedback interface is set
- The counter is loaded with the load value

The low count limit is 0. The load value has a starting count and can be changed.

You must open the gate again to restart the counting.

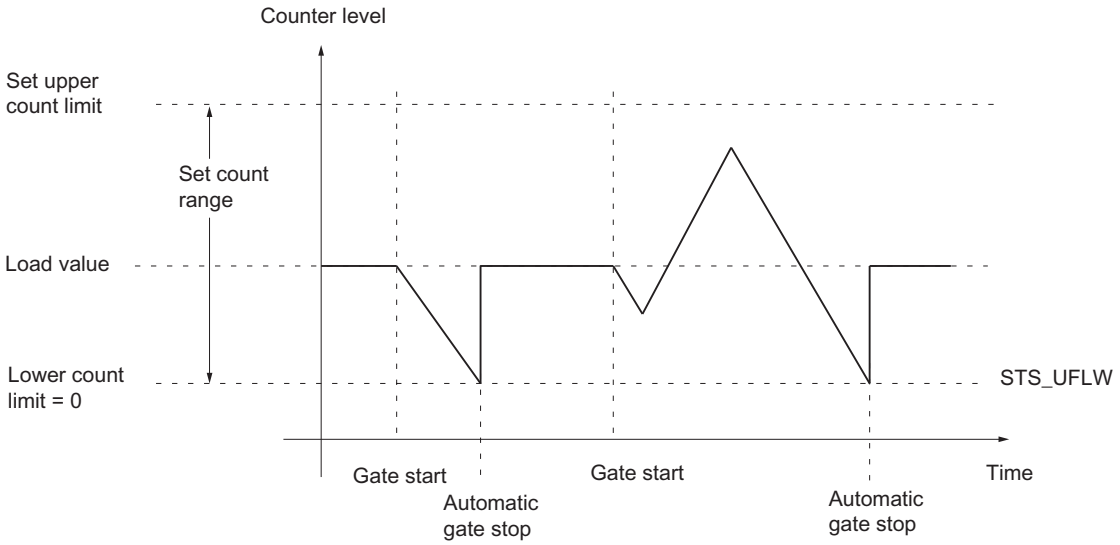


Figure 7-4 Single counting with main count direction down; canceling gate function

Selecting the Gate Function

You can select the gate control in this mode. The following options are available to you:

- SW gate
- Hardware gate, level-controlled or edge-controlled

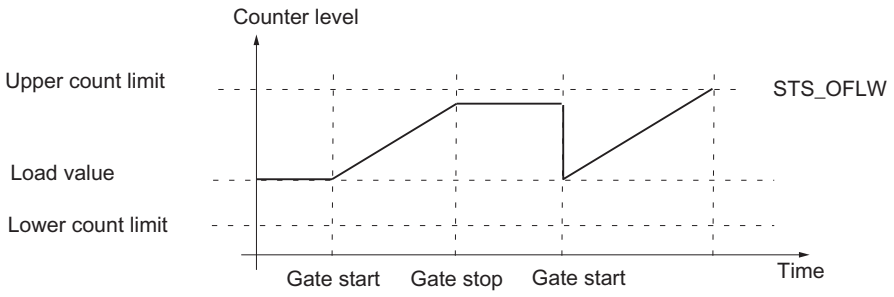


Figure 7-5 Single Counting with Load Value and gate control

Opening and Closing the Software Gate

You open and close the software gate and set the counter to the load value with the SW_GATE input parameter of FC CNT_CTL1.

Table 7- 8 Triggering the Opening/Closing of a SW Gate (Single Counting)

Action	...Is initiated by
Open software gate	Setting SW_GATE
Close software gate	Resetting SW_GATE

Opening and Closing the Hardware Gate

You open and close the hardware gate and set the counter to the load value by applying and removing the corresponding signals to and from digital inputs DI Start and DI Stop.

Table 7- 9 Triggering the Opening/Closing of a HW Gate (Single Counting)

Action	...Is initiated by
Open hardware gate (level-controlled)	Apply signal to digital input DI Start
Open hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Start
Close hardware gate (level-controlled)	Remove signal from digital input DI Start
Close hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Stop

With a level-controlled hardware gate, the renewed opening of the gate and setting of the counter to the load value is performed by a signal across DI Start.

If a positive pulse edge is reapplied across DI Start in the case of an edge-controlled hardware gate, the counter will again start counting from the load value, irrespective of whether the gate is closed or still open (retrigger); that is, provided that the DI Stop is not set.

Behavior at the Count Limits

If the counter has reached the high or low count limit and a further count pulse is received, the counter is set as follows:

- To the other count limit when counting without a main count direction
- To the load value when counting with a main count direction

The gate is then closed and the count is terminated even if the SW_GATE parameter is still set or the hardware gate is still open. An appropriate status bit is set in the DB.

Table 7- 10 Behavior at the Count Limits (Single Counting)

Count limit reached	Status bit in DB
High count limit	STS_OFLW is set
Low count limit	STS_UFLW is set

If you wish to restart the counter, you must reset the SW_GATE parameter or reopen the HW gate. The counting process is then continued from the load value.

Terminating the Count with the Gate Stop Function

You can also terminate the count at any time with the gate stop function. Set the GATE_STP input parameter of the FC_CNT_CTL1 for this.

7.3.5 Cyclic count

Overview

In this operating mode, the FM 350-1 counts periodically when the gate is open. You can assign the following behavior:

- Periodic counting – No main count direction
- Periodic counting - Main count direction up
- Periodic counting - Main count direction down

Periodic counting – No main count direction

In periodic counting mode without a main count direction, when the gate is opened, the FM 350-1 counts up or down from the load value until one of the count limits is exceeded.

If one of the count limits is exceeded, the following occurs:

- The STS_OFLW or STS_UFLW bit in the feedback interface is set
- The counter is set to the load value, from which it resumes counting

The count limits are fixed at the maximum count range

The STS_ZERO bit is set if the counter level is zero.

The counting is continued until the gate is closed.

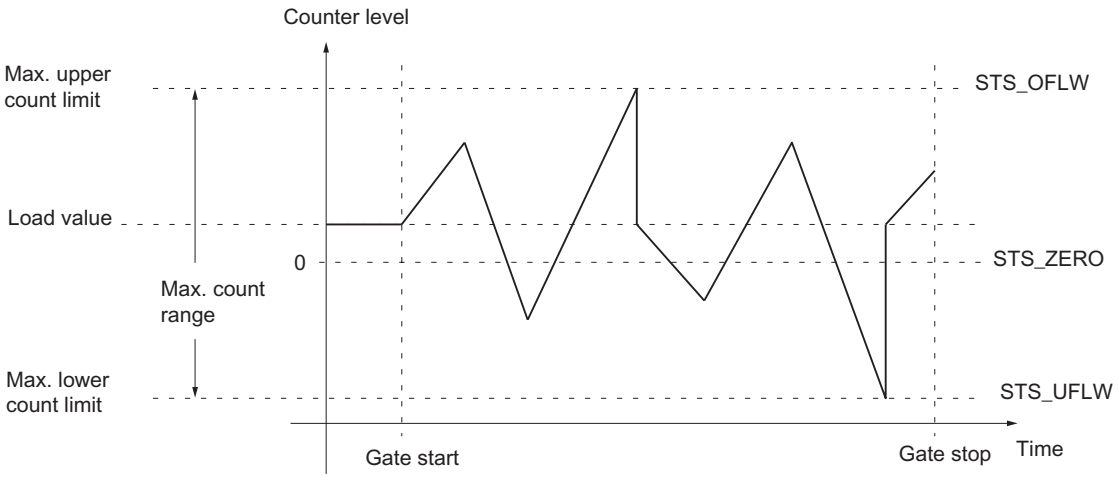


Figure 7-6 Periodic Counting Without Main Count Direction

Periodic Counting - Main Count Direction Up

In periodic counting mode with main count direction up, when the gate is opened, the FM 350-1 counts up or down from the load value until the high count limit is exceeded.

If the high count limit is exceeded, the following occurs:

- The STS_OFLW bit in the feedback interface is set
- The counter is set to the load value, from which it resumes counting

The high count limit can be set. The load value has a starting count and can be changed.

The counting is continued until the gate is closed.

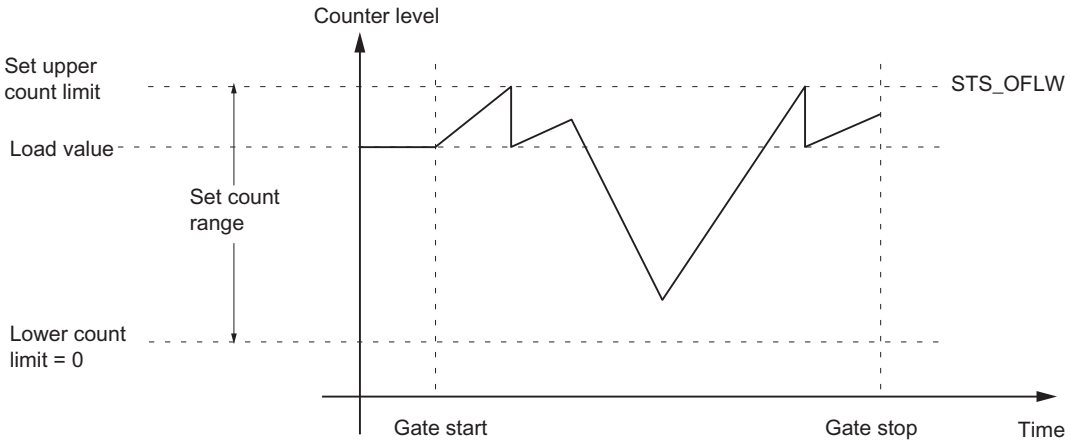


Figure 7-7 Periodic Counting With Main Count Direction Up

Periodic Counting - Main Count Direction Down

In periodic counting mode with main count direction down, when the gate is opened, the FM 350-1 counts up or down from the load value until the low count limit is fallen below.

If the low count limit is fallen below, the following occurs:

- The STS_UFLW bit in the feedback interface is set
- The counter is set to the load value from which it resumes counting

The low count limit is 0. The load value has a starting count and can be changed.

The counting is continued until the gate is closed.

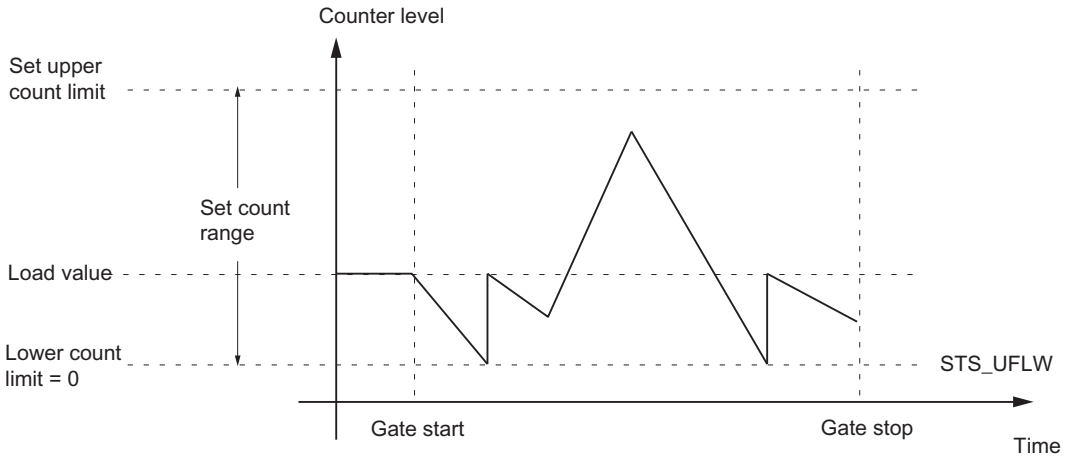


Figure 7-8 Periodic Counting With Main Count Direction Down

Selecting the Gate Function

You can select the gate control in this mode. The following options are available to you:

- SW gate
- Hardware gate, level-controlled or edge-controlled

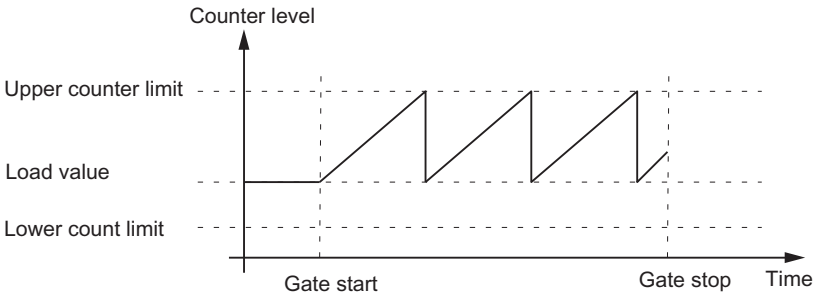


Figure 7-9 Periodic Counting with Load Value and Gate Control

Opening and Closing the Software Gate

You open and close the software gate and set the counter to the load value with the SW_GATE input parameter of FC CNT_CTL1.

Table 7- 11 Opening/Closing the Software Gate

Action	...Is initiated by
Open software gate	Setting SW_GATE
Close software gate	Resetting SW_GATE

Opening and Closing the Hardware Gate

You open and close the hardware gate and set the counter to the load value by applying and removing the corresponding signals to and from digital inputs DI Start and DI Stop.

Table 7- 12 Triggering the Opening/Closing of a HW Gate (Periodic Counting)

Action	...Is initiated by
Open hardware gate (level-controlled)	Apply signal to digital input DI Start
Open hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Start
Close hardware gate (level-controlled)	Remove signal from digital input DI Start
Close hardware gate (edge-controlled)	Apply positive pulse edge across digital input DI Stop

If a positive pulse edge is reapplied across the digital input DI Start in the case of an edge-controlled hardware gate, the counter will again start counting from the load value, irrespective of whether the gate is closed or still open (retrigger); that is, provided that the digital input DI Stop is not set.

Behavior at the Count Limits

If the counter

- has reached one of the count limits when counting without a main count direction,
- has reached the high count limit when counting with main count direction up, or
- has reached the low count limit when counting with main count direction down

and another pulse then comes, the counter is set to the load value, from which it resumes counting. An appropriate status bit is set in the DB.

Table 7- 13 Behavior at the Count Limits (Periodic Counting)

Count limit reached	Status bit in DB
High count limit	STS_OFLW is set
Low count limit	STS_UFLW is set

Terminating the Count with the Gate Stop Function

You can also terminate the count at any time with the gate stop function. Set the GATE_STP input parameter of FC CNT_CTL1 for this.

7.3.6 Counting range

Introduction

There is a 32-bit wide count register on the module. With the Count range, you select whether the module is to count only in the positive range or whether the 32nd bit is interpreted as a sign bit thus allowing negative numbers to be represented. You can only select a count range if no main counting direction is set.

Counting range

The FM 350-1 counts in different count ranges at the two count range limits 0 to +32 bits and -31 to +31 bits. An overflow or an underflow is detected at the respective count limits.

In the -31 to +31 bits count mode, the counter status is represented in 2's complement.

Table 7- 14 Counting Ranges and Overflow/Underflow

Counting range		Overflow	Underflow
0 to +32 bits*	0 to 4 294 967 295 0 to FFFF FFFFH	When the counter status changes from 4 294 967 295 to 0	When the counter status changes from 0 to 4 294 967 295
-31 to +31 bit	–2 147 483 648 to 2 147 483 647 8000 0000H to 7FFF FFFFH	When the counter status changes from +2 147 483 647 to –2 147 483 648	When the counter status changes from –2 147 483 648 to 2 147 483 647

*In this count range, you can only specify and evaluate hexadecimal values.

Overflow, Underflow and Zero Pass

At both count limits, a bit is set in the DB of the FC CNT_CTRL1 in the event of overflow and underflow (see chapter DB Assignment (Page 169)).

At the "-31 to +31-bit" count range, a bit is similarly set in the DB with a zero pass.

At the "0 to +32-bit" count range, an overflow or underflow, depending on the direction of counting, is additionally indicated upon zero pass.

Table 7- 15 Status Bit in DB at Overflow/Underflow and Zero Pass

Event	Status bit in DB
Overflow	STS_OFLW is set
Underflow	STS_UFLW is set
Zero pass	STS_ZERO is set

Initiating Hardware Interrupts

You can also signal the overflow, underflow and zero pass events via hardware interrupts.

7.3.7 Command: Open and close gate

Overview

Gates of FM 350-1:

- A HW gate, level- or edge-triggered.
- A SW gate which you can open and close by setting control bits in the user program.

Selecting a gate

You define which gate you are going to use for the count in the mode interface.

The diagrams below illustrate the various options of opening and closing the gates of FM 350-1.

Level-triggered opening and closing of the HW gate

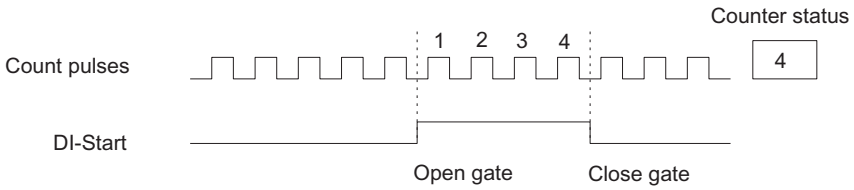


Figure 7-10 Level-triggered opening and closing of the HW gate

The transfer of count pulses to the counter is always enabled as long as digital input DI-Start is set. A reset at digital input DI-Start closes the gate. The counter stops and ignores any further count pulses.

If the gate was closed as a result of overflow or underflow, you open it again by a reset > set cycle at digital input DI-Start.

The level-triggered HW gate is activated by the first positive edge at input DI-Start after you set the parameters.

Whole you programming those parameters, the module does not evaluate input DI-Stop, but indicates its status at bit STS_STP.

Edge-triggered opening and closing of the HW gate

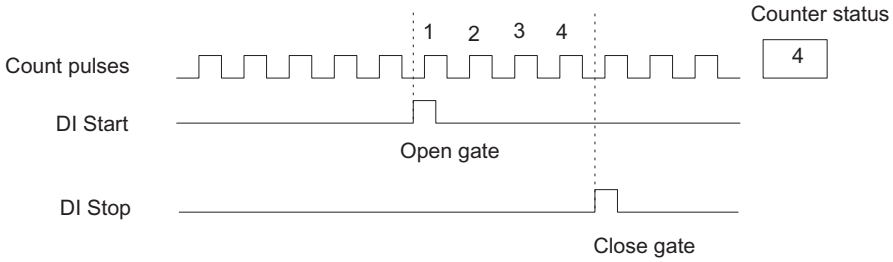


Figure 7-11 Edge-triggered opening and closing of the HW gate

The edge-triggered HW gate is opened by setting a positive edge at digital input DI-Start. It is closed again by setting a positive edge at digital input DI-Stop.

If a positive edges is set in parallel at both inputs, an open gate will be closed, whereas a closed gate remains closed. When digital input DI-Stop is set, a positive edge at digital input DI-Start can not open the gate.

Status at the inputs DI-Start and DI-Stop

The status at inputs DI-Start and DI-Stop is returned at the green LEDs I0 and I1, and in the user program at the STS_STA and STS_STP bits in the DB of FC CNT_CTL1.

Gate status

The gate status is indicated by the STS_GATE bit in the user program.

Opening and closing the SW gate

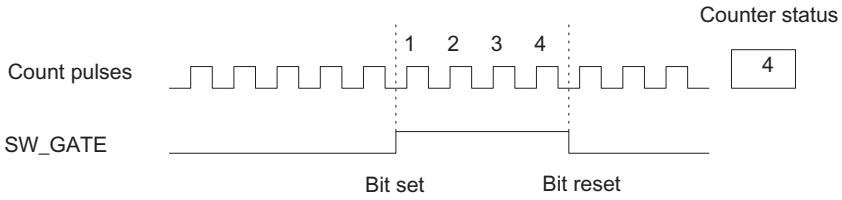


Figure 7-12 Opening and closing the software gate

You open /close the SW gate by setting / resetting input parameter SW_GATE at FC CNT_CTL1.

You can retrigger the closed gate by setting input parameter SW_GATE once again. Edge-triggered opening and closing of the SW gate is not supported.

SW gate status

The status of the SW gate is indicated at the STS_SW_G bit in the DB of FC CNT_CTL1.

Cancel and interrupt function of the gate

In your gate function parameters, you can define whether the gate should cancel or interrupt the count.

When the canceling gate function is active, the count stop when the gate closes, and is restarted at the load value when the gate is retriggered (time ① in the figure below):

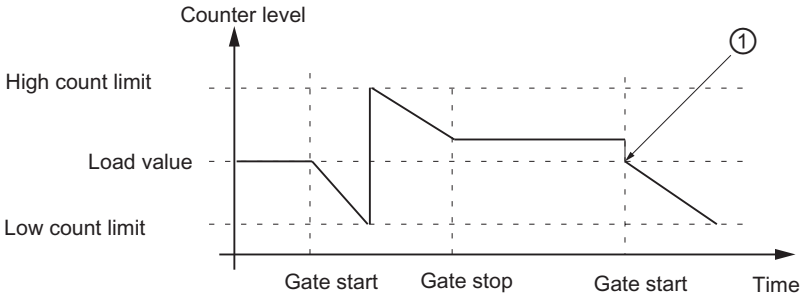


Figure 7-13 Continuous down count, canceling gate function

When the interrupting gate function is active, the count stops when the gate closes, and resumes at the last actual count value when the gate is retriggered (time ① in the figure below):

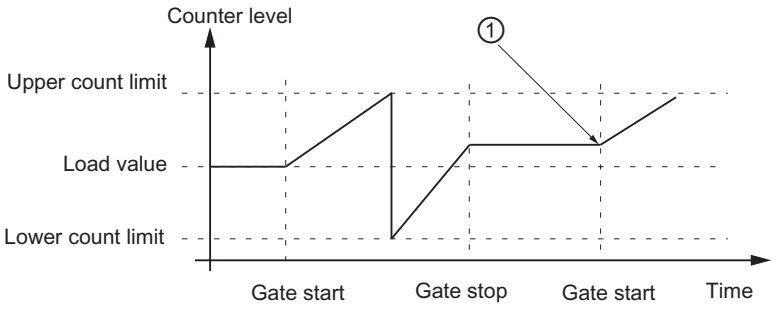


Figure 7-14 Continuous up count, interrupting gate function

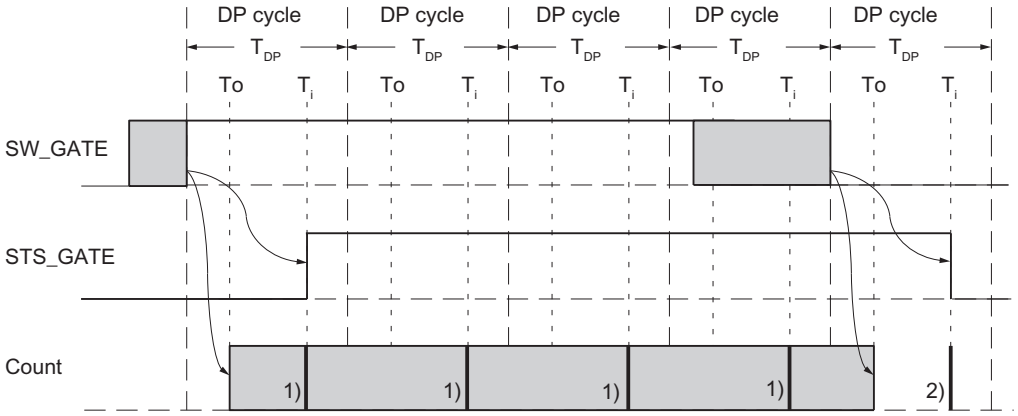
Stopping the count using the gate stop function

You can also stop the count by setting the gate stop function, regardless of the status or signals set at the SW gate. This is done by setting input parameter GATE_STP at FC_CNT_CTL1.

When you reset this parameter, you can only retrigger the gate by setting a positive edge at digital input DI-Start (HW gate), or you once again set input parameter SW_GATE.

Gate control in isochronous mode

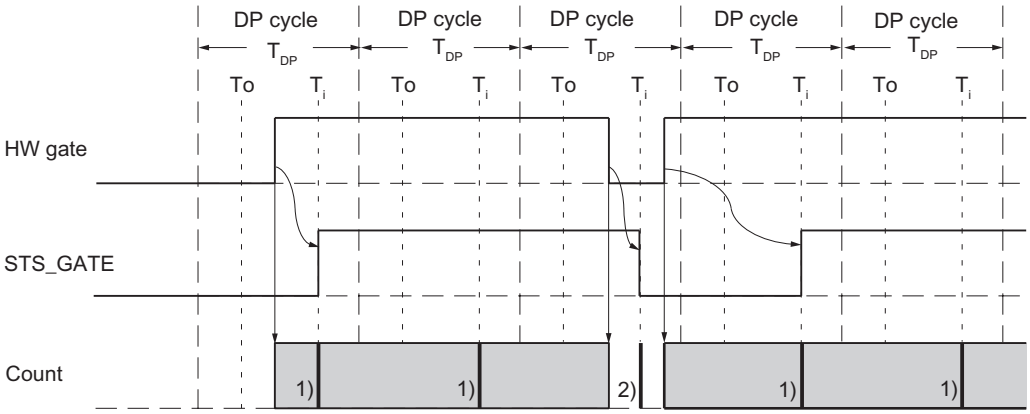
SW gate control: To control the SW gate, you set and reset the SW_GATE control bit in the user program. After the control bit has changed, the count starts and ends at time T_o in the next PROFIBUS DP cycle:



1) Provision of actual count value
2) Provision of the count value that was valid at the end of the count

Figure 7-15 Starting and stopping the count using the SW gate (SW_GATE)

HW gate control: In HW gate control mode, the count starts or stops instantaneously when the gate opens or closes:



1) Provision of actual count value
2) Provision of the count value that was valid at the end of the count

Figure 7-16 Starting and stopping the count using the HW gate (HW_GATE)

Hardware interrupt

Opening and closing of a HW or SW gate can be used to trigger a hardware interrupt (see the chapter Triggering hardware interrupts (Page 156).)

Defaults

All gates are open, and the count pulses are counted.

7.3.8 Behavior of the Digital Outputs

Introduction

You can store two comparison values (Comparison value 1 and 2) on the FM 350-1 for each counter. These comparison values are assigned to the two digital outputs (Comparison value 1: DO0, Comparison value 2: DO1). The relevant output can be set depending on the counter level and the comparison value. This section describes the behavior of the outputs.

Comparison Values 1 and 2

You enter the two comparison values in the DB of the FC CNT_CTL1 (CMP_V1, CMP_V2) and transfer them to the FM 350-1 by setting the bits T_CMP_V1 or T_CMP_V2 (see the section DB Assignments (Page 169)). The count is not affected by this.

The comparison values must be within the limits of the selected count range. The comparison value is interpreted according to the selected count range. If you give FFFF FFFF H, for example, as the comparison value, the value is interpreted as 4 294 967 295 within the 0 to +32 bit count range, and as -1 within the -31 to +31 bit count range.

Table 7- 16 Permissible Range of Values for Comparison Values

Range of values for comparison values	Main count direction		
	None	Up	Down
Low limit	Maximum low count limit	-2^{31}	1
High limit	Maximum high count limit	Parameterized high count limit -1	$2^{31} - 1$

Enabling the Outputs

Before you can activate the outputs, you must first enable them by setting the appropriate bits in the DB (see the section DB Assignments (Page 169)). If you reset one of these bits, the associated output is disabled immediately even if you have assigned a pulse duration for them.

Table 7- 17 Enabling the Outputs

Output	... Is enabled by enable bit
DO0	CTRL_DO0
DO1	CTRL_DO1

Setting and Resetting the Outputs

If you set the behavior of an output to "Inactive", you can set and reset enabled outputs using the appropriate bits in the DB.

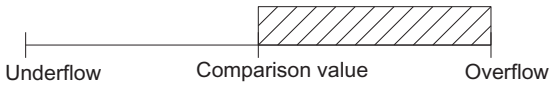
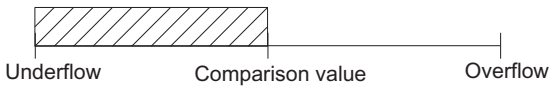
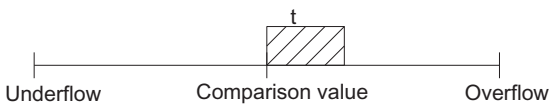
Table 7- 18 Setting and Resetting the Outputs

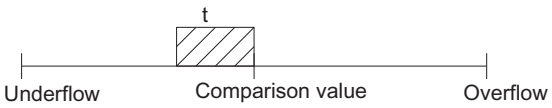
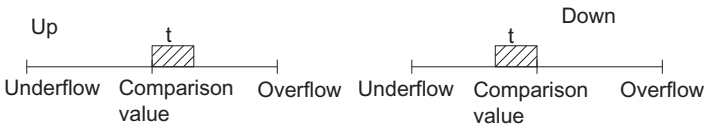
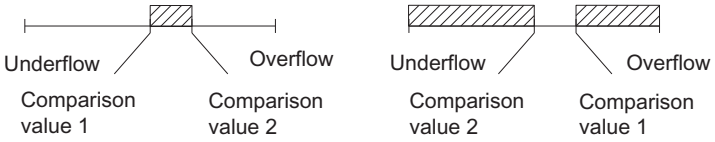
Output	... Is set by	... Is reset by
DO0	SET_DO0 = 1	SET_DO0 = 0
DO1	SET_DO1 = 1	SET_DO1 = 0

Behavior of the Digital Outputs

For both digital outputs you can program one of 7 possible responses to reaching the comparison value. The various options are shown in the table below.

Table 7- 19 Behavior of the Digital Outputs Depending on the Parameterization

Digital Output Parameter Assignment	Behavior of the Digital Outputs
Inactive	
	The output remains deactivated and is not affected by the comparison value, zero crossing, overflow, or underflow events. The output DOx may be used purely as a digital output. When enabled, it can be set and reset with the SET_DOx bit.
Active from comparison value to overflow *	
	The output is set to 1 if the counter is in the range between the comparison value and overflow. Setting the counter to a value between the comparison value and overflow sets the output to 1.
Active from comparison value to underflow *	
	The output is set to 1 if the counter is in the range between the comparison value and underflow. Setting the counter to a value between the comparison value and underflow sets the output to 1.
Active on reaching the comparison value for pulse duration (up)*	

Digital Output Parameter Assignment	Behavior of the Digital Outputs
	The output is set to 1 for the period of the pulse duration when the counter reaches the comparison value while counting up. This requires either: • No main count direction • Main count direction up
Active on reaching the comparison value for pulse duration (down)*	
	The output is set to 1 for the period of the pulse duration when the counter reaches the comparison value while counting down. This requires either: • No main count direction • Main count direction down
Active on reaching the comparison value for pulse duration (up/down)	
	The output is set to 1 for the period of the pulse duration, regardless of the counting direction, when the counter reaches the comparison value while counting down. Requirements: • No main count direction
DO1: Switch to comparison value This deactivates DO0	
	Output DO1 switches if the counter level lies in the range between two comparison values.

* Note the boundary conditions

A shaded area in the table signifies: The output is active.

t = Pulse duration

Status of the Outputs and Status Bits

The status of the two outputs is indicated by the green LEDs and the corresponding status bits in the DB.

Table 7- 20 Output DO0

Comparison condition	Enable bit CTRL_DO0	Status bit STS_COMP1	Status bit STS_CMP1/ Output DO0	LED DO0
Not fulfilled	0	0	0	Out
	1	0	0	Out
Fulfilled	0	1	0	Out
	1	1	1	Is lit

Table 7- 21 Output DO1

Comparison condition	Enable bit CTRL_DO1	Status bit STS_COMP2	Status bit STS_CMP2/ Output DO1	LED DO1
Not fulfilled	0	0	0	Out
	1	0	0	Out
Fulfilled	0	1	0	Out
	1	1	1	Is lit

Status bits STS_CMP1 and STS_CMP2 indicate the current status of outputs DO0 and DO1. If enabled, they are set by CTRL_DO0 and CTRL_DO1 if a comparison condition is fulfilled and are reset if the condition is not fulfilled.

Status bits STS_COMP1 and STS_COMP2 are set by CTRL_DO0 and CTRL_DO1 if a comparison condition is fulfilled, regardless of whether they are enabled, and remain set until you acknowledge the status bits with RES_ZERO.

Switching to Comparison Values

Output DO1 switches at two comparison values if the following conditions are fulfilled:

- You have set the behavior of DO0 to "Inactive".
- You have set the behavior of DO1 to "Active for switching to comparison values".
- You loaded both comparison values CMP_V1 and CMP_V2.
- You have enabled output DO1 with CRTL_DO1.

The following table shows when DO1 is activated and deactivated:

Table 7- 22 Output DO1 Switch to comparison values

Comparison values CMP_V1 and CMP_V2	DO1 is activated if	DO1 is deactivated if
CMP_V1 < CMP_V2	CMP_V1 ≤ Counter level ≤ CMP_V2	Counter level < CMP_V1 or Counter level > CMP_V2
CMP_V1 = CMP_V2	CMP_V1 = Counter level = CMP_V2	CMP_V1 ≠ Counter level ≠ CMP_V2
CMP_V1 > CMP_V2	Counter level < CMP_V2 or Counter level > CMP_V1	CMP_V2 ≤ Counter level ≤ CMP_V1

The result of the comparison is indicated by the status bit STS_COMP2.

You cannot acknowledge and thus reset the status bit STS_COMP2 until the comparison condition is no longer fulfilled.

The status of the DO1 output is indicated by the status bit STS_CMP2.

There is no hysteresis with this output behavior.

With this output behavior, it is not possible to control output DO1 with the SET_DO1 control bit.

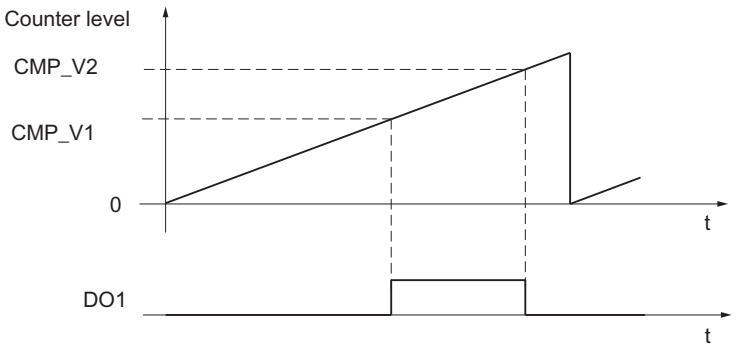


Figure 7-17 At the start of the counting process, V2 > V1

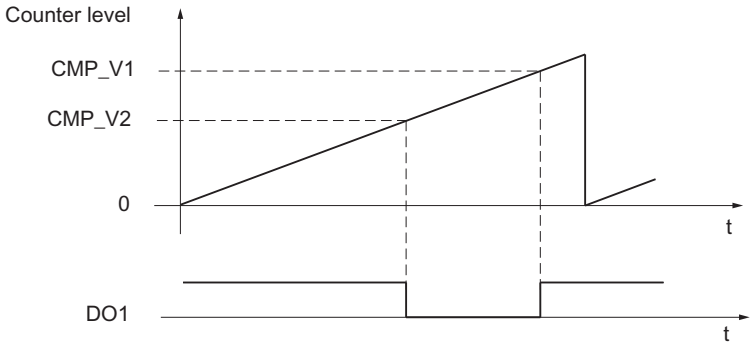


Figure 7-18 At the start of the counting process, V2 < V1

Pulse Duration

You can set a pulse duration in order to adapt to the actuators (contactors, actuators, etc) used in your process. The pulse duration indicates how long outputs DO0 and DO1 are active when a comparison value is reached.

If main count direction up or main count direction down is set, then the pulse duration is only active in the main count direction.

If no main count direction is set, then the pulse duration can be active in both counting directions.

The pulse duration starts when the output is set. The pulse duration inaccuracy is less than 1 ms.

You can specify a value between 0 and 500 ms for the pulse duration. This value applies to both outputs together.

If the pulse duration = 0 ms, the output is set when the comparison value is reached and is reset at the next count pulse.

The default value for the pulse duration is 0.

Note

If you set the pulse duration = 0 ms, the output remains active until the counter level is equal to the comparison value.

Control pulses may be lost at the outputs if the time interval between the count pulses is less than the switching times of the digital outputs (up to 300 µs).

You should therefore make sure that the interval between the count pulses is greater than the switching times of the digital outputs.

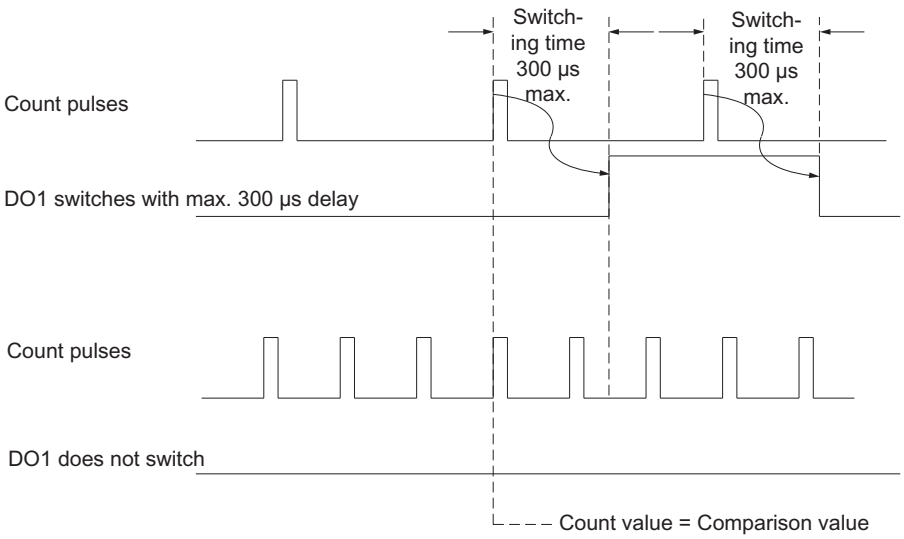


Figure 7-19 Reactions of an output for a pulse duration = 0 ms

Boundary conditions for the behavior of the digital outputs

If you assign the behavior of the digital outputs, you must observe the following boundary conditions.

Table 7- 23 Boundary Conditions for the Behavior of the Digital Outputs

If...	Then...
... ...You want to parameterize an output "Active from comparison value to overflow or underflow"	... ...You must ensure that the time between these events is greater than the minimum switching time of the outputs (switching time: 300 µs); otherwise, the control pulses at the outputs are lost. If the counter status reaches the relevant comparison value again while the output is still active, no new pulse is initiated. A further pulse can only be initiated when the output is no longer active.
... ...You want to parameterize an output "Active from comparison value to overflow"	... ...you must not enable a hardware interrupt on "Reaching the relevant comparison value (up/down)".
... ...You want to parameterize an output "Active from comparison value to underflow"	... ...you must not enable a hardware interrupt on "Reaching the relevant comparison value (up/down)".
... ...You want to parameterize an output "Active on reaching the comparison value for pulse duration (up)"	... ...You must not enable a hardware interrupt on "Reaching the relevant comparison value (down)".
... ...You want to parameterize an output "Active on reaching the comparison value for pulse duration (down)"	... ...You must not enable a hardware interrupt on "Reaching the relevant comparison value (up)".

Default Setting of the Outputs

The outputs are disabled in the default setting.

Behavior of the Digital Outputs in Isochronous Mode

In isochronous mode, the outputs DO0 and DO1 switch immediately after the comparison conditions are fulfilled, and are thus independent of the PROFIBUS DP cycle.

Exception:

If you have set the behavior of the digital outputs to "inactive" and, after enabling with CTRL_DO0 or CTRL_DO1, you activate the outputs with the control signal SET_DO0 or SET_DO1, the outputs are set and reset at the time T_o.

7.3.9 Hysteresis

Function principle of the hysteresis

An encoder can come to rest at a particular position and then "oscillate" about this position. This causes the count value to fluctuate around a certain value. If there is a comparison value within this fluctuation range, for example, the associated output would be switched on and off in time with these fluctuations. FM 350-1 features a programmable hysteresis in order to prevent this switching in response to small fluctuations.

A value between 0 and 255 may be set for the hysteresis.

Table 7- 24 Effect of the hysteresis

Hysteresis	Effect
Hysteresis value n = 0, 1	The hysteresis has no effect (switched off) The output reacts to the slightest change in the counter value.
2 ≤ Hysteresis value n ≤ 255	The hysteresis takes effect. The output does not react until the counter value is offset by n units to the comparison value.

The hysteresis applies to both overflow and underflow.

Function principle of the hysteresis when "Active within the range between the comparison value and overflow/underflow" is set

The following figure shows an example of the effect of hysteresis. The diagram shows the differences in the output behavior when hysteresis values of 0 (= switched off) and 3 are assigned. In the example, the comparison value = 5

Parameter settings in this example:

- Main count direction up
- Active within the range from comparison value to overflow

The hysteresis is set when the comparison condition (counter value = 5) is fulfilled. When the hysteresis is active, the comparison result remains unchanged.

If the count value overshoots/undershoots the range of the hysteresis (at counter value 2 or 8 in the example) the hysteresis ceases to be active. The comparator switches again according to its comparison conditions, i.e., in the example at counter value 5.

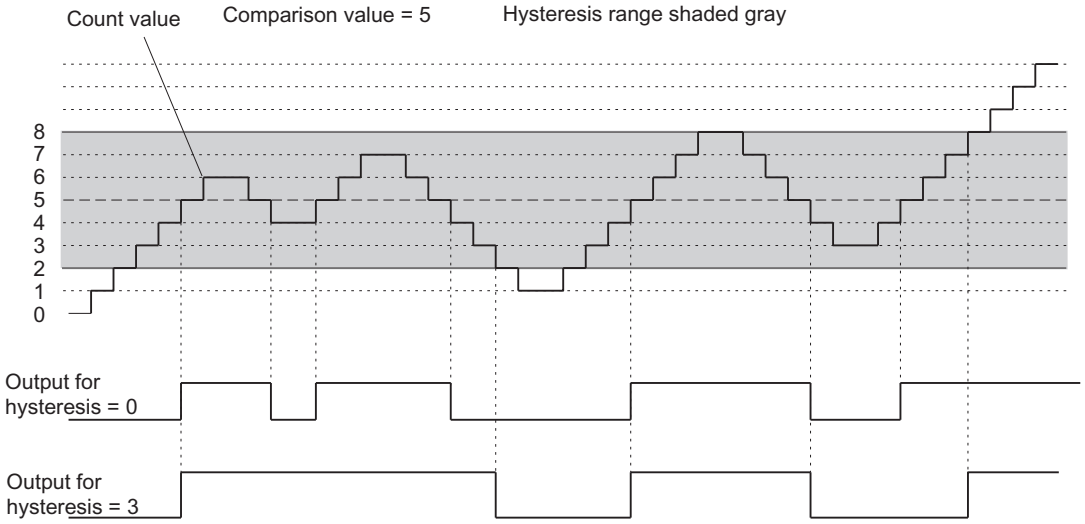


Figure 7-20 Example showing the effect of the hysteresis

Note

If the counter value is equal to the comparison value, and the hysteresis is active, FM 350-1 resets the output when the count direction changes at the comparison value (see the diagram below.)

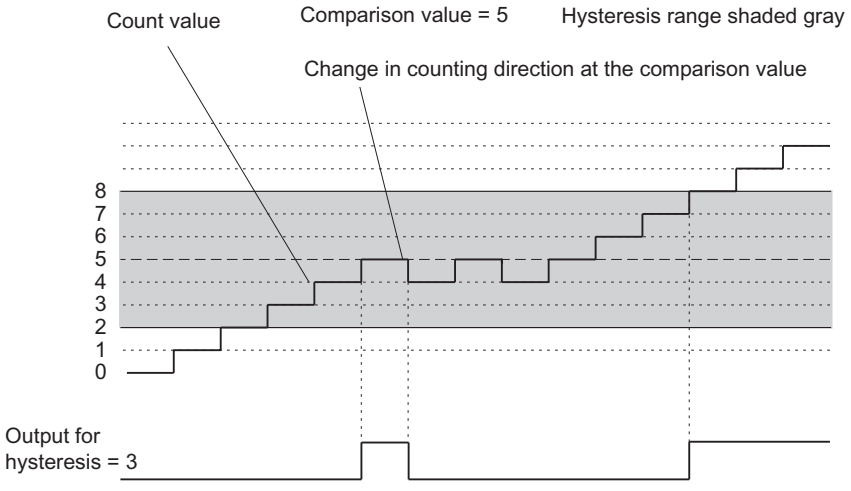


Figure 7-21 Example of a hysteresis for a change of direction at the comparison value

Function principle of the hysteresis with "Active on reaching the comparison value for pulse duration (up/down)" setting

The following figure shows an example of the effect of hysteresis. The diagram shows the differences in the output behavior when hysteresis values of 0 (= switched off) and 3 are assigned. In the example, the comparison value = 5

Parameter settings in this example:

- No main count direction
- Active on reaching the comparison value for pulse duration (up)
- Pulse duration > 0

The hysteresis is set when the comparison condition (counter value = 5) is fulfilled, and a pulse of the assigned duration is output.

If the counter value leaves the hysteresis range, the hysteresis ceases to be active.

FM 350-1 saves the count direction when hysteresis is activated. A pulse is output if the signal overshoots hysteresis range in opposite direction of the direction saved previously.

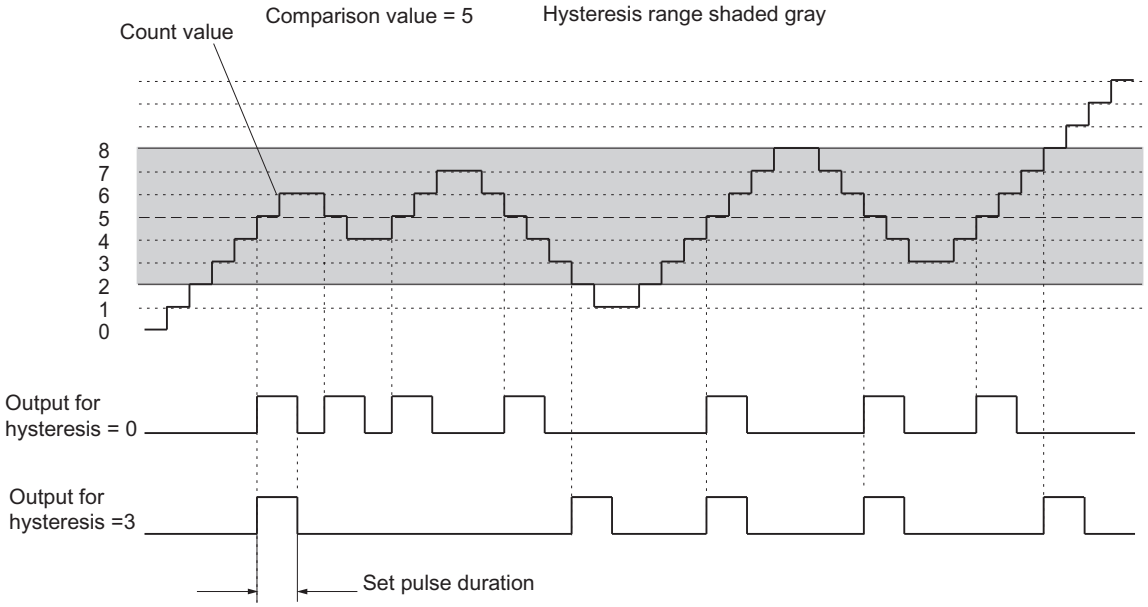


Figure 7-22 Example showing the effect of the hysteresis

7.3.10 Command: Setting the counter

Overview

If you want to start the count from a specific value (the load value), you must parameterize the signal that is to be used to set this counter to the load value. You can set the counter as follows:

- With the L_DIRECT or L_PREPAR input parameter of the FC_CNT_CTL1
- With an external signal, either by means of the DI Set input or by means of DI Set in connection with the zero crossing of the encoder

This section describes the different methods and the time sequence when setting a counter.

Load value

Any number within the limits of the count range can be set for the count range.

The load value is interpreted according to the selected count range. If, for example, you specify FFFF FFFF H as the load value, this is interpreted as 4 294 967 295 within the count range from 0 to +32 bit and as -1 within the count range from -31 to +31 bit.

Enter the load value in the DB of the CNT_CTL1 function and transfer it with the CNT_CTL1 function to the module. The counter is then set to the load value:

- Directly and in preparation if input parameter L_DIRECT is set,
- In preparation only if input parameter L_PREPAR is set,

The following ranges of values are permitted for the load value:

Table 7- 25 Permissible Range of Values for Load Values

Range of values for load values	Main count direction		
	None	Up	Down
Low limit	Maximum low count limit	$-2^{31} + 1$	2
High limit	Maximum high count limit	Parameterized high count limit - 2	$2^{31} - 1$

Setting the Counter via the User Program

You can set a counter with the FC CNT_CTL1 using the L_DIRECT input parameter regardless of external events. This can also be done while a count is in progress.

The input parameter L_DIRECT is reset by FC CNT_CTRL once the job is successfully completed.

If you set the counter via the FC_CNT_CTL1 call, this can initiate a hardware interrupt.

Setting the Counter with an External Signal

The L_PREPAR input parameter prepares a new load value. You can select two different external signals with which you can set a counter to the load value:

- Only DI Set
- DI Set and zero mark of the encoder

You use the zero mark of the encoder if you want to synchronize the counter to a specific counter status at a specific point in your process. Hence you achieve greater precision in the count process.

The counter is set independently of the Count mode.

After the counter has been set with an external signal, bit STS_SYNC in the DB is set. The STS_SYNC bit is cleared by the RES_SYNC bit.

Note

The synchronization of a counter with the zero mark only makes sense if the gate is open.

If you have only enabled one count direction when setting a counter with an external signal, you must note that when the gate is closed the current count direction is saved (frozen). Hence it is possible for the counter to be synchronized in the opposite direction to the enabled count direction.

Setting the Counter with DI Set

The counter can be loaded with the load value by means of a rising pulse edge across DI Set.

You can set the response of the FM 350-1 to a positive pulse edge across DI Set by means of the tags ENSET_UP and ENSET_DN in the DB of the FC CNT_CTL1 and by parameterization.

Table 7- 26 Setting the Counter with DI Set

Parameters	Behavior of the FM 350-1
ENSET_UP set	The counter is only set in the case of up counting
ENSET_DN set	The counter is only set in the case of down counting
ENSET_UP and ENSET_DN set	The counter is set in the case of up and down counting
Parameter assignment "single setting of counter"	The counter is set only at the first rising edge at DI Set. If the counter is to be set again, you must first set ENSET_UP or ENSET_DN again. The counter is then set again with the next positive edge at DI Set.
Parameter assignment "Multiple setting of counter"	As long as ENSET_UP and/or ENSET_DN are set, the counter will be set with each rising edge at DI-Set.

Note

It is imperative that you set one of the two tags ENSET_UP or/and ENSET_DN so that the counter can be set via digital input DI Set.

Single Setting with DI Set

The following figure shows single setting of the counter with digital input DI Set. In the case represented here, only ENSET_UP is set, i.e., the counter is set during up counting.

With the first rising pulse edge at digital input DI Set, the counter is set provided that ENSET_UP is similarly set. If you want to set the counter again, you must first reset ENSET_UP and then set it again. The next positive pulse edge at digital input DI Set will then result in the counter being set.

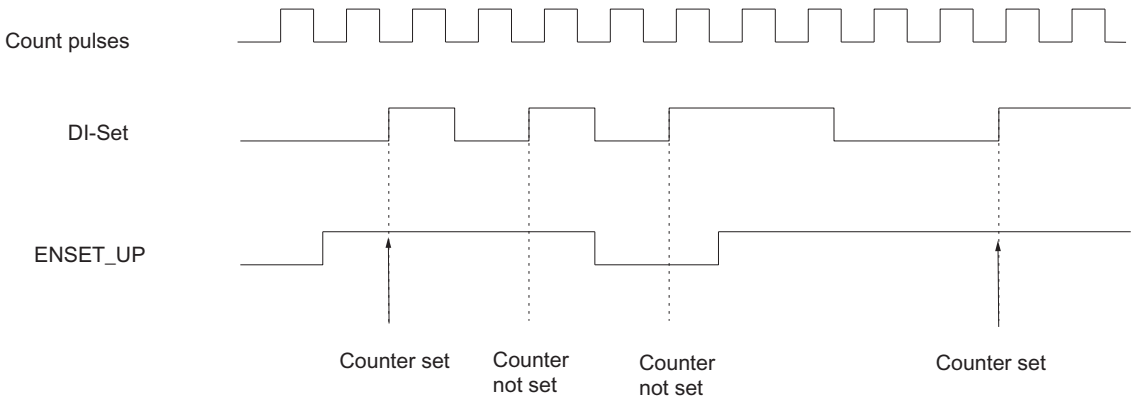


Figure 7-23 Single Setting with DI Set

Multiple Setting with DI Set

The following figure shows multiple setting of the counter with DI Set. In the case represented here, only ENSET_UP is set, i.e., the counter is set during up counting.

With every rising pulse edge at digital input DI Set, the counter is set provided that ENSET_UP is similarly set. If you reset ENSET_UP, the counter will not be set by DI Set. Only when you have set ENSET_UP again, will the next positive edge at DI Set result in the setting of the counter.

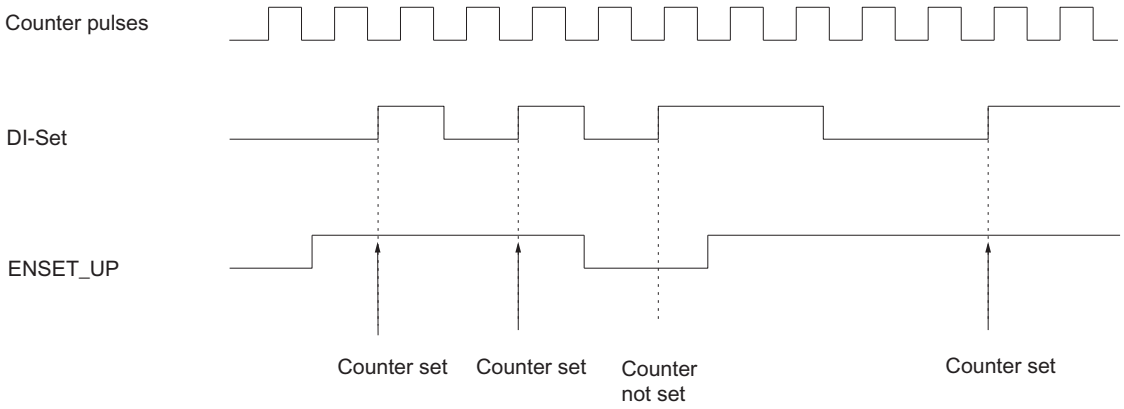


Figure 7-24 Multiple Setting with DI Set

Setting the Counter with DI Set and Zero Mark

If you parameterize setting of a counter with the zero mark of the encoder, the counter will be set with the rising edge of the zero mark.

Setting is performed only if DI Set is additionally set at the time of the rising pulse edge of the zero mark.

You can determine the behavior of the FM 350-1 in the case of a rising edge of the zero mark via the ENSET_UP and ENSET_DN variables in the DB of the FC CNT_CTL1 and via parameterization.

Table 7- 27 Setting the Counter with DI Set and Zero Mark

Input parameters	Behavior of the FM 350-1
ENSET_UP set	The counter is only set in the case of up counting
ENSET_DN set	The counter is only set in the case of down counting
ENSET_UP and ENSET_DN set	The counter is set in the case of up and down counting
Parameter assignment "single setting of counter"	The counter is set only at the first rising edge of the zero mark. If the counter is to be set again, you must first set ENSET_UP or ENSET_DN again (edge evaluation). The counter is then set again with the next rising edge of the zero mark.
Parameter assignment "multiple setting of counter"	As long as ENSET_UP and/or ENSET_DN are set, the counter will be set with each rising edge of the zero mark.

Note

You must always set one of the two variables ENSET_UP and/or ENSET_DN so that the counter can be set with the zero mark.

Single Setting of the Counter with DI Set and Zero Mark

The following figure shows single setting of the counter with the zero mark. In the case represented here, only ENSET_UP is set, i.e., the counter is set during up counting.

With the first rising pulse edge of the zero mark, the counter is set provided that ENSET_UP and DI Set are similarly set.

If you want to set the counter again, you must first reset ENSET_UP and then set it again. If DI Set is not set, setting is performed with the first zero mark after DI Set has been set. If DI Set is set, setting is performed with the next zero mark.

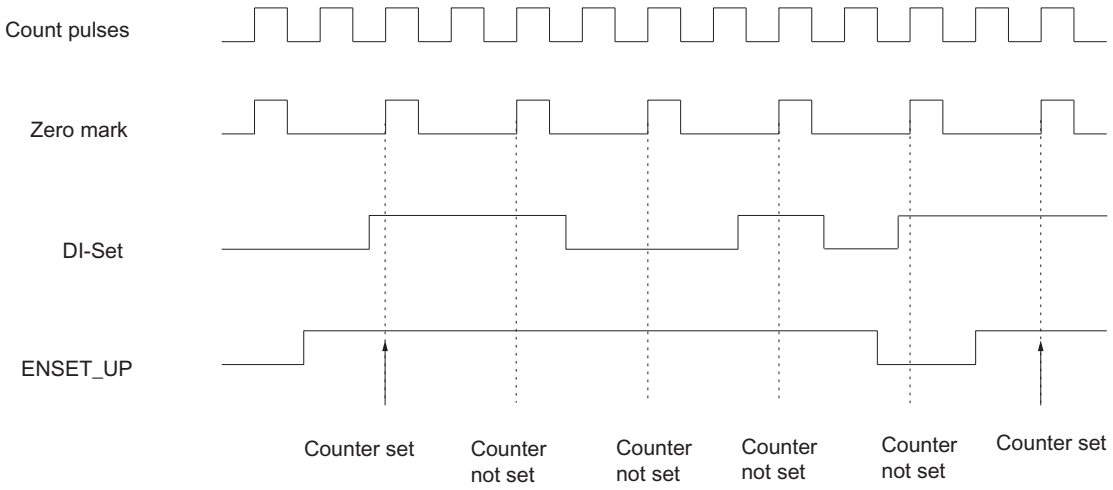


Figure 7-25 Single Setting of the Counter with the Zero Mark

Multiple Setting of the Counter with DI Set and Zero Mark

The following figure shows multiple setting of the counter with the zero mark. In the case represented here, only ENSET_UP is set, i.e., the counter is set during up counting.

With every rising pulse edge of the zero mark, the counter is set provided that ENSET_UP and DI Set are set.

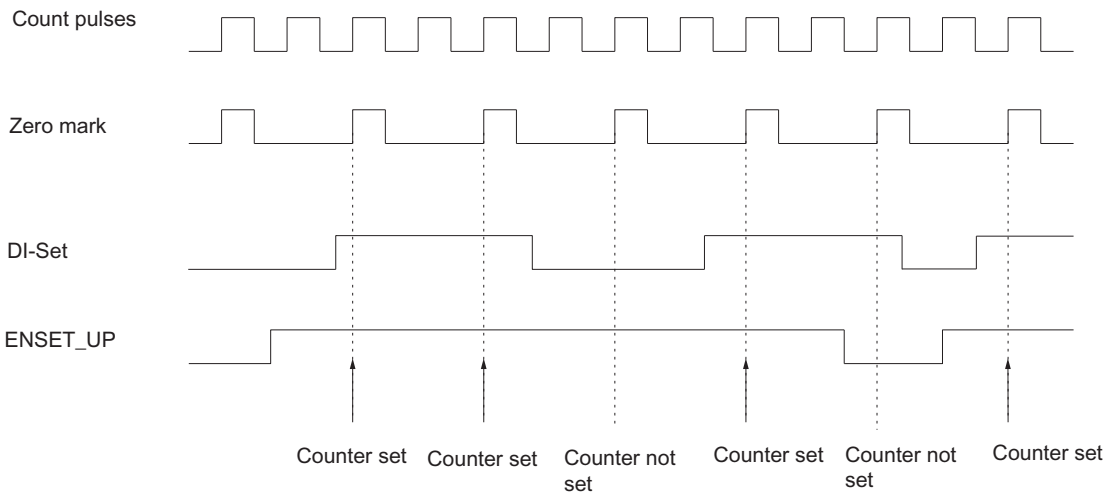


Figure 7-26 Multiple Setting of the Counter with the Zero Mark

Hardware interrupt

Setting the counter with an external signal can be used to initiate a hardware interrupt (see section Triggering of a Hardware Interrupt (Page 156)).

7.3.11 Command: Latch / retrigger

Introduction

The latch/retrigger command can be used to save (latch) counter values using the edges of signals at digital input DI-Start. After each latching operation, the counter will be initialized with the load value, and resumes the count starting at the load value (retrigger.)

Requirement

Set the SW gate to enable this command.

The minimum interval between latch edges is 1 ms. Values may be lost if this edge interval is less than this time.

Selecting edge signals

You can assign the following behavior:

- Latch/retrigger at the positive edge at DI-Start.
- Latch/retrigger at the negative edge at DI-Start
- Latch/retrigger at both edges at DI-Start

Function principle

The counter function is enabled by opening the SW gate.

The counter and latch values are assigned a start value. These values do not change by opening the SW gate.

The first edge at input DI-Start starts the count at the load value.

The counter will be initialized with the load value at each further edge at input DI-Start.

The latch value is always equivalent to the counter value at the time the edge trigger is generated.

The status at input DI-Start is indicated at the STS_STA status bit in the DB.

The latch value is indicated at LATCH_LOAD in the DB.

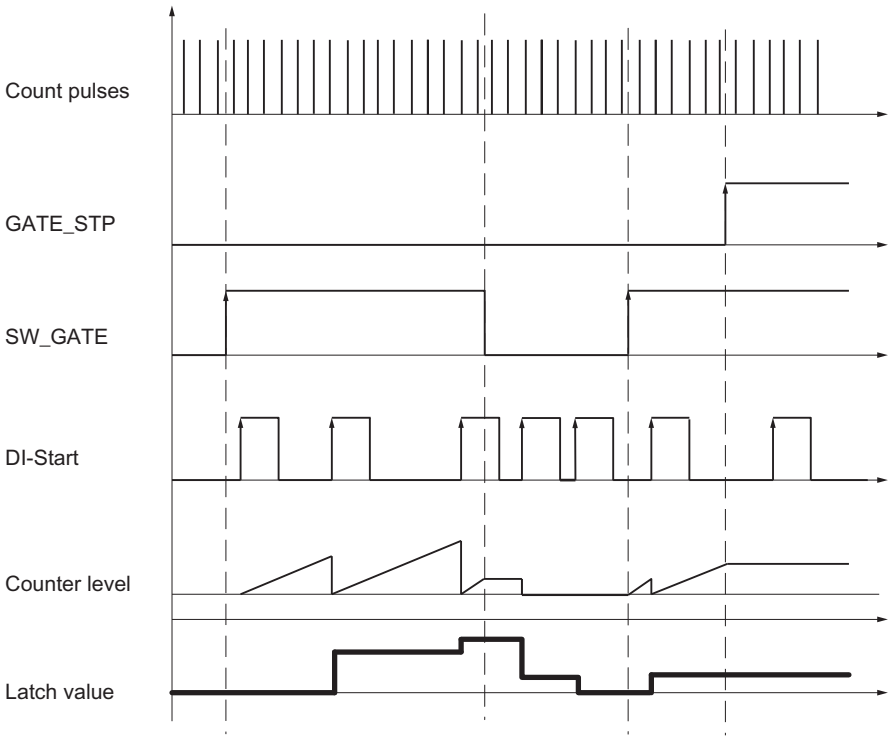


Figure 7-27 Latch/Retrigger when load value = 0 and positive edge at DI-Start

Interrupting and canceling the command

When you close the software gate, counting is interrupted (interrupting gate function); this means counting resumes at the most recent count value the next time the software gate opens.

The current count is also stored at an edge at digital input DI-Start with a closed software gate and the count begins again with the load value.

However, counting is terminated if you close the SW gate by executing GATE_STP of FC CNT_CTL1. The signal at input DI-Start can thus no longer be used to save any counter values.

Hardware interrupt on latch/retrigger commands

A hardware interrupt may be triggered each time a counter values is saved by executing the latch/retrigger command. As a consequence, you may need to increase the interval between the edges. The hardware interrupts will be lost if the interrupt rate is higher than the acknowledgement rate of the system. This situation is reported by a diagnostic interrupt.

7.3.12 Command: Latch

Introduction

The latch command is used to save (latch) counter values using the edges at digital input DI-Start. This operation does not change the counter value.

Requirement

Set the SW gate to enable this command.

The minimum interval between latch edges is 1 ms. Values may be lost if this edge interval is less than this time.

Selecting edge signals

You can assign the following behavior:

- Latching at a positive edge at DI-Start.
- Latching at a negative edge at DI-Start
- Latching at both edges at DI-Start

Function principle

The counter and latch values are assigned a start value.

The count function starts when the SW gate has opened. The counter starts at the load value.

The latch value is always equivalent to the counter value at the time the edge trigger is generated.

The status at input DI-Start is indicated at the STS_STA status bit in the DB.

The latch value is indicated at LATCH_LOAD in the DB.

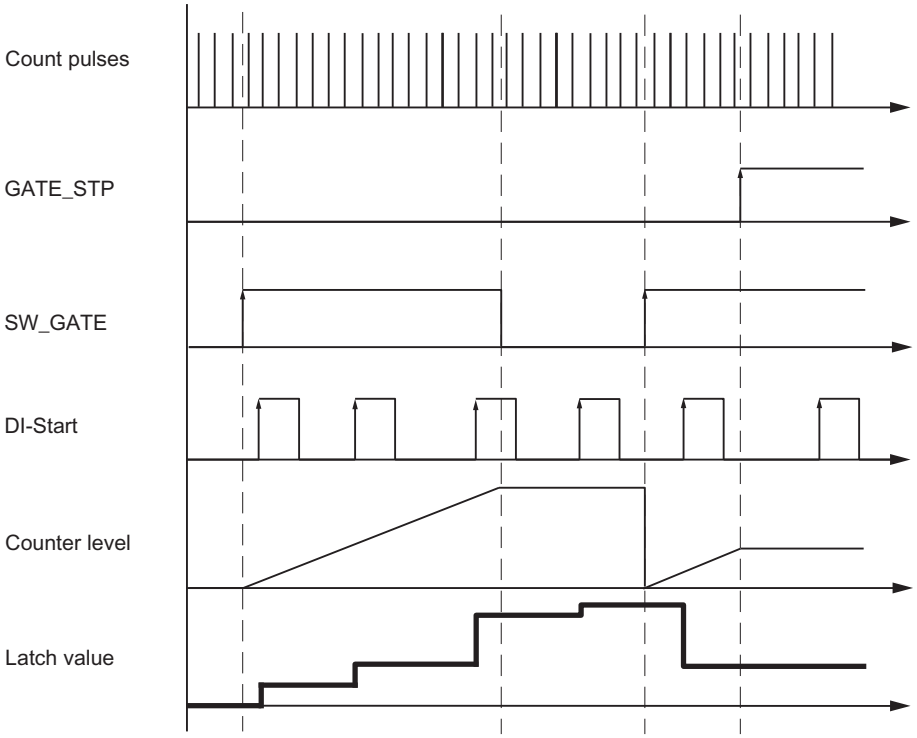


Figure 7-28 Latch when load value = 0 and positive edge at input DI-Start

Canceling and terminating the command

When you close the software gate, counting is cancelled (canceling gate function); this means counting begins again at the load value the next time the software gate opens.

The current count is also stored at an edge at digital input DI-Start with a closed software gate and the count does not change.

However, counting is terminated if you close the SW gate by executing GATE_STP of FC CNT_CTL1. DI-Start can then no longer be used to save any counter values.

Hardware interrupt on latching

A hardware interrupt may be triggered each time a counter value is saved by latching. As a consequence, you may need to increase the interval between the edges. The hardware interrupts will be lost if the interrupt rate is higher than the acknowledgement rate of the system. This situation is reported by a diagnostic interrupt.

7.3.13 Command: Measure edge intervals

Introduction

You can use this command to measure the time between two immediately successive edges at the Start DI digital input.

Prerequisites

The following prerequisites must be fulfilled in order to use this command:

- There must be no encoders connected to the FM 350-1.
- Set the operating mode to any count mode.
- For Gate Control, set: Latch/Retrigger.
- For Encoder, set: Internal time Base 1 MHz

Selecting the Edges

Table 7- 28 Selecting the Edges for the Time Measuring

To measure the time between two immediately successive ...	... Parameterize
Rising edges at DI Start	Latch with positive edge
Falling edges at DI Start	Latch with negative edge
Any edges at DI Start	Latch with both edges

Mode of operation

The FM 350-1 uses an internal time base of 1 MHz in order to measure times. The time measurement starts with the first edge at DI Start. With every further edge at DI Start, the time in µs that has elapsed since the last edge is always saved as the latch value LATCH_LOAD in the feedback interface.

7.4 Measuring modes

7.4.1 Overview of measuring modes

Overview

You define FM 350-1 functionality by setting a default mode of operation. The table shows an overview of measuring modes.

Table 7- 29 Measuring modes supported by FM 350-1

Name	Description
Frequency measurement	FM 350-1 counts the pulses received within a dynamic measuring time.
Speed measurement	FM 350-1 counts pulses received from a tacho generator within a dynamic measuring time, and calculates the velocity based on this value and the number of pulses per encoder revolution.
Period measurement	FM 350-1 indicates the dynamic measuring time as a period. If the period is less than the update time, then an average is calculated for the period.

These operating modes are enabled by programming FM 350-1.

7.4.2 Basics

Measuring principle

FM 350-1 counts each positive edge of a pulse and assigns it a time value in µs.

The dynamic measuring time is defined as the difference between two time values.

At a pulse sequence with one or several pulses per update interval:

Dynamic measuring time = time value of the last pulse in the current update interval
minus
time value of the last pulse in the previous update interval

If no pulses are received within the next update intervals after the dynamic measuring time is calculated, the measuring time is extended by these update intervals. Any "1 pulse per dynamic measuring time" value less than the last measured is output as the new value.

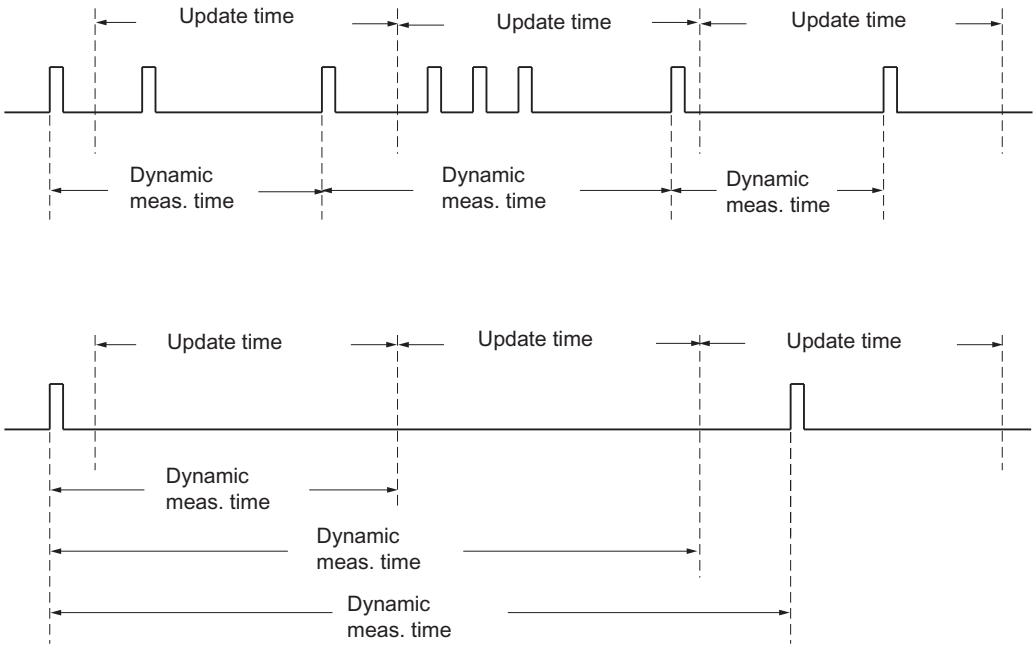


Figure 7-29 Measuring principle

Measurement sequence

FM 350-1 measures continuously. You define a specific update time in the parameter settings.

The module returns the value "-1" until the first update time has expired. The first update time starts when the gate has opened.

When the gate has opened, continuous measurement starts at the first pulse of the pulse sequence to measure. The first measured value can not be calculated until the second pulse was received.

On each expiration of the update time, a measured value is output at the checkback interface (frequency, period or rpm.) The end of a measurement is reported at the STS_COMP1 status bit. This bit is reset by the RES_ZERO and STS_RES_ZERO bits according to the acknowledgement principle.

If the rotary direction is reversed within an update time, the measured value remains indefinite for this measuring period. You can respond to any disturbance in the process by evaluating the STS_DIR checkback bits (evaluation of the direction.)

The diagram below shows the principle of continuous measurement, based on the example of a frequency measurement.

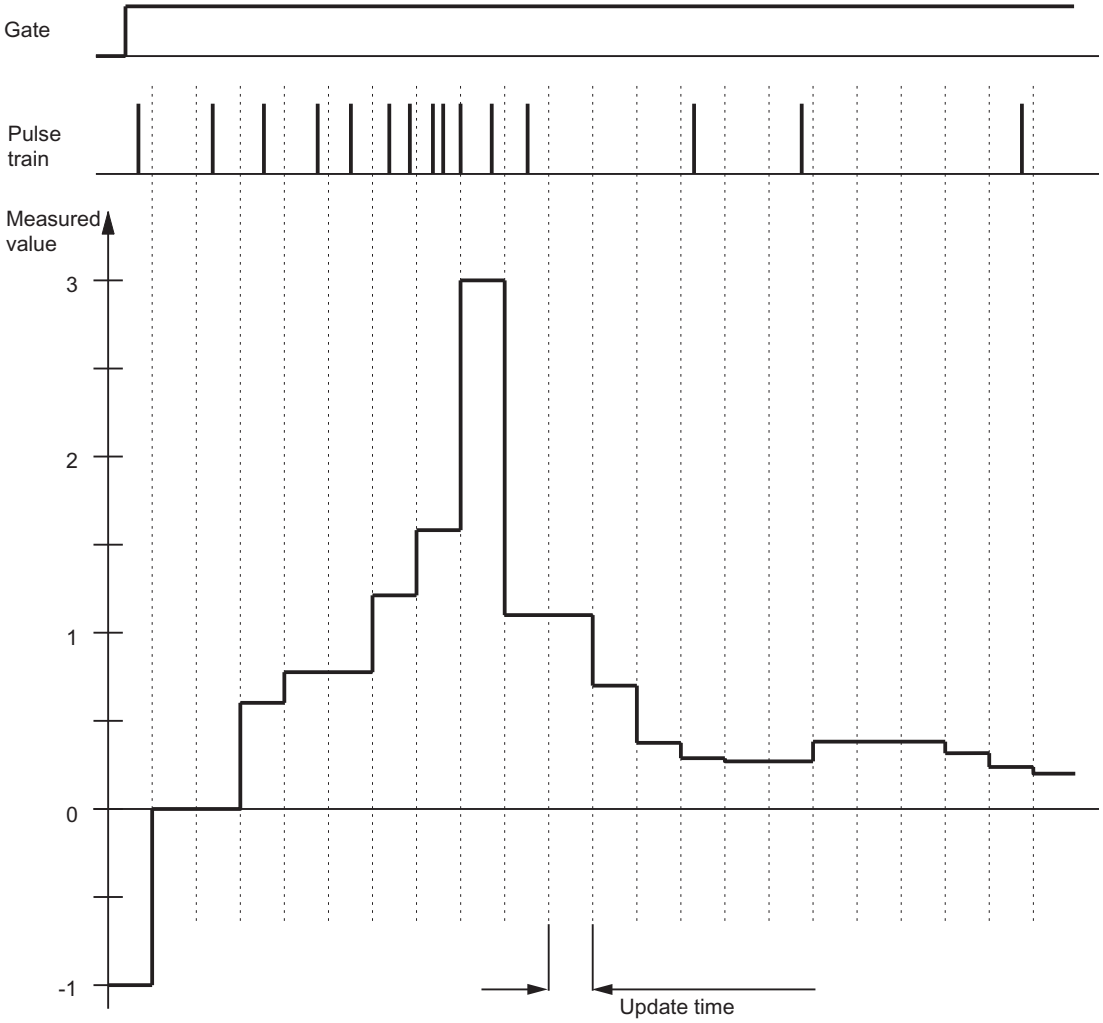


Figure 7-30 Principle of continuous measurement (example frequency measurement)

Limit monitoring

On expiration of the update time, the module compares the measured value (frequency, speed or period) with the set low and high limits.

If the module detects an underflow of the actual measured value (measured value < low limit), it sets the status bit STS_UFLW = 1. A hardware interrupt may also be generated.

If the module detects an overflow of the actual measured value (measured value > high limit), it sets the status bit STS_OFLW = 1. A hardware interrupt may also be generated.

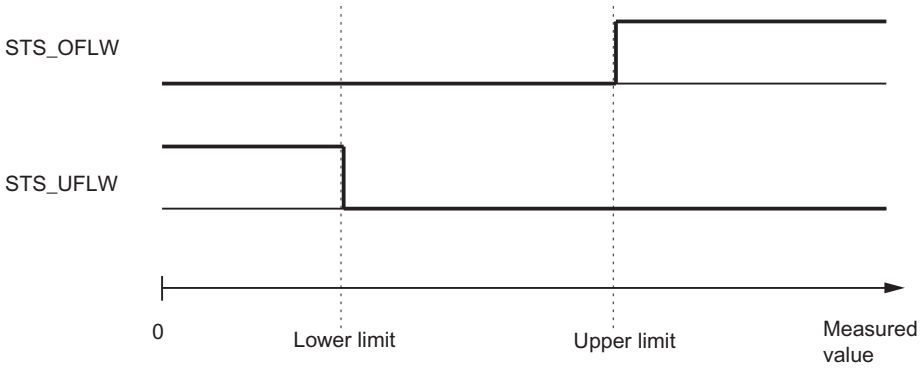


Figure 7-31 Limit monitoring in measuring mode

Reset the STS_OFLW and STS_UFLW bits by setting the RES_ZERO and STS_RES_ZERO bits according to the acknowledgement principle. The module sets the status bits again if it detects overflow of the measured value after the acknowledgement bits were set.

If programmed accordingly, you also can use the limit monitoring function to set output DO0.

Gate control

You can control, i.e. start and stop, measurements at FM 350-1 using the HW and SW gates.

Start values after programming

Table 7- 30 Start value

Value	Start value
Low limit	programmed value
High limit	programmed value
Refresh time	programmed value

Isochronous mode

When operating in isochronous mode, FM 350-1 accepts the control signals output by the control interface at time T_o in each PROFIBUS DP cycle. As a result, all control operations are executed in isochronous mode and take effect at the time T_o. The reaction to the control signals is reported within the same PROFIBUS DP cycle.

FM 350-1 returns a measured value and the status bits at time T_i in each PROFIBUS DP cycle.

Each measurement starts and ends at the time T_i.

Note

As you need to define the update time as an integer multiple of 10 ms for operation in non-isochronous mode, and in integer multiples of the PROFIBUS DP cycle time for operation in isochronous mode, you should also adapt the update time parameter when you toggle these modes in order to retain the actual update time.

Commands in the measuring modes

You can control measurements at FM 350-1 by executing the following commands.

Table 7- 31 Commands of FM 350-1

Designation	Description
Open and close gate	You start the measurement by opening a gate, and stop it by closing this gate.

7.4.3 Frequency measuring

Frequency Measurement

In the frequency measurement operating mode, the FM 350-1 counts the pulses that occur within a dynamic measuring time.

The value of the calculated frequency is made available in the unit 10^{-3} Hz. You can read the measured frequency value at the feedback interface (Bytes 0 to 3).

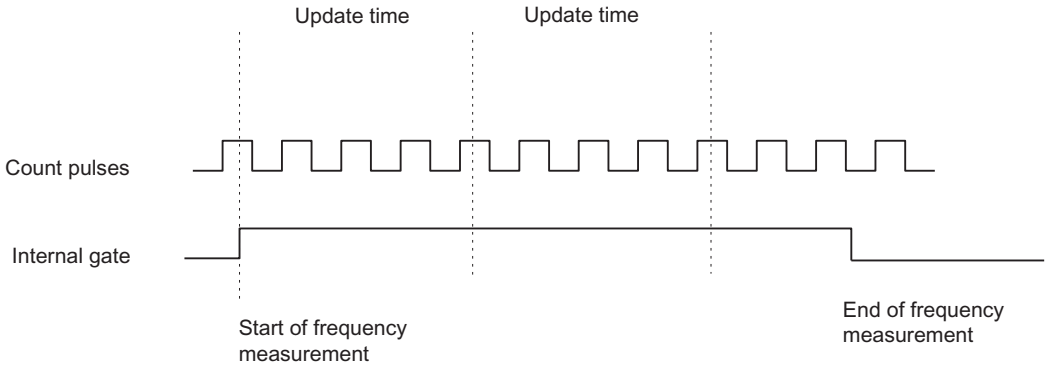


Figure 7-32 Frequency Measurement With Gate Function

Update Time

The FM 350-1 updates the measured values cyclically. You specify the update time with the "Update time" parameter. You can change the update time during operation.

Table 7- 32 Calculating the Update Time

Boundary conditions		Update time	Value range of n	
			n_{min}	n_{max}
Non-isochronous mode	Any T_{DP}	n × 10 ms	1	1000
Isochronous mode	T_{DP} < 10 ms	n × T_{DP}	(10 ms/T_{DP} [ms]) +1 [1)]	1000
	T_{DP} ≥ 10 ms	n × T_{DP}	1	10000 ms/T_{DP} [ms] [1)]

[1] The decimal places obtained after division by T_{DP} are omitted.

It is prohibited to exceed these limits. If these limits are exceeded, the FM 350-1 generates a parameterization error and does not switch to isochronous mode.

Limit Monitoring

The following value ranges are permitted for limit value monitoring:

Table 7- 33 Frequency Measurement: Value Ranges for Limit Monitoring

Encoder type	Low limit f_u	High limit f_o
5-V encoders	0 to 499 999 999 × 10^{-3} Hz	f_u+1 to 500 000 000 × 10^{-3} Hz
24-V encoders	0 to 199 999 999 × 10^{-3} Hz	f_u+1 to 200 000 000 × 10^{-3} Hz

Possible Measuring Ranges with Error Indication

Table 7- 34 Frequency Measurement: Measuring Ranges and Errors

Frequency f_{min}	Absolute error	Frequency f_{min}	Absolute error
0.1 Hz	±0.001 Hz	1 000 Hz	±0.18 Hz
1 Hz	±0.001 Hz	10 000 Hz	±1.8 Hz
10 Hz	±0.003 Hz	100 000 Hz	±18 Hz
100 Hz	±0.02 Hz	500 000 Hz	±90 Hz

Function of the DI Start and DI Stop Digital Inputs

You can choose between the following functions for the digital inputs:

- Level-controlled hardware gate
- Edge-controlled hardware gate

See section Command: Open and close gate (Page 149))

Function of Digital Output DO0

You can choose between the following functions for digital output DO0:

- No comparison (no switching by limit value monitoring)
- Measured value outside limits
- Measured value under low limit
- Measured value above high limit

(See the section Behavior of the Digital Outputs (Page 153))

Variable Values during Operation:

- Low limit (L_PREPAR)
- High limit (T_CMP_V1)
- Update time (T_CMP_V2)
- Function of digital output DO0 (C_DOPARA)

(See the sections Behavior of the Digital Outputs (Page 153) , Control interface for the measuring modes (Page 62) and Checkback interface for the measuring modes (Page 65))

7.4.4 Speed capture

Speed measurement

In the RPM measurement operating mode, the FM 350-1 counts the pulses that are received from a tacho-generator within a dynamic measuring time, and calculates the speed from this value with the number of pulses per encoder revolution.

For the RPM measurement mode, you must also set the pulses per encoder revolution.

This returns the speed expressed in units of $1x10^{-3}$ /min.

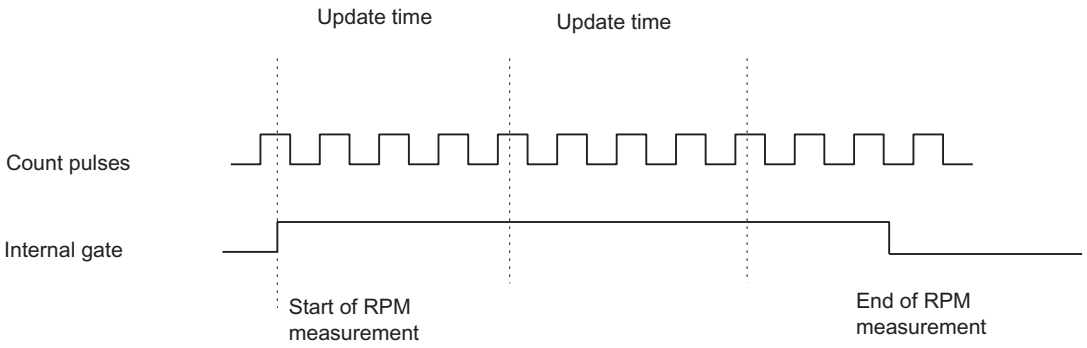


Figure 7-33 RPM Measurement with Gate Function

Update Time

The FM 350-1 updates the measured values cyclically. You enable the update time by means of the "Update time" parameter. You can change the update time during operation.

Table 7- 35 Calculating the Update Time

Boundary conditions		Update time	Value range of n	
			n_{min}	n_{max}
Non-isochronous mode	Any T_{DP}	n × 10 ms	1	1000
Isochronous mode	T_{DP} < 10 ms	n × T_{DP}	(10 ms/T_{DP} [ms]) +1 [1)]	1000
	T_{DP} ≥ 10 ms	n × T_{DP}	1	10000 ms/T_{DP} [ms] [1)]

[1] The decimal places obtained after division by T_{DP} are omitted.

It is prohibited to exceed these limits. If these limits are exceeded, the FM 350-1 generates a parameterization error and does not switch to isochronous mode.

Limit Monitoring

The following value ranges are permitted for limit value monitoring:

Table 7- 36 Speed capture: Value Ranges for Limit Monitoring

Lower limit n_u	Upper limit n_o
0 to 24 999 999 *10^{-3} /min	n_u+1 to 25 000 000 *10^{-3} /min

Possible Measuring Ranges with Error Information (for Number of Pulses per Encoder Revolution = 60)

Table 7- 37 Speed Capture: Measuring Ranges and Errors

Speed n_{min}	Absolute error	Speed n_{min}	Absolute error
1 /min	±0.04 /min	1 000 /min	±0.21 /min
10 /min	±0.04 /min	10 000 /min	±1.82 /min
100 /min	±0.05 /min	25 000 /min	±4.5 /min

Function of the DI Start and DI Stop Digital Inputs

You can choose between the following functions for the digital inputs:

- Level-controlled hardware gate
- Edge-controlled hardware gate

See Chapter Command: Open and close gate (Page 149))

Function of Digital Output DO0

You can choose between the following functions for digital output DO0:

- No comparison (no switching by limit value monitoring)
- Measured value outside limits
- Measured value under lower limit
- Measured value above upper limit

(See the section Behavior of the Digital Outputs (Page 153))

Variable Values during Operation:

- Lower limit (L_PREPAR)
- Upper limit (T_CMP_V1)
- Update time (T_CMP_V2)
- Function of digital output DO0 (C_DOPARA)

(See the sections Behavior of the Digital Outputs (Page 153) , Control interface for the measuring modes (Page 62) and Checkback interface for the measuring modes (Page 65))

7.4.5 Period measurement

Period measurement

In period measurement mode, the FM 350-1 indicates the dynamic measuring time as a period. If the period is less than the update time, then an average is calculated for the period.

The value of the calculated period is displayed in units 1 µs or 1/16 µs. You can read the measured period at the feedback interface (Bytes 0 to 3).

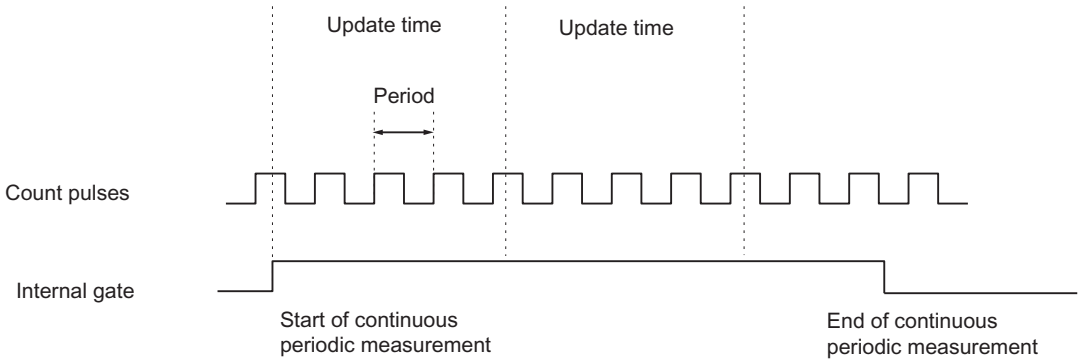


Figure 7-34 Period Measurement with Gate Function

Update Time

The FM 350-1 updates the measured values cyclically. You specify the update time with the "Update time" parameter. You can change the update time during operation.

Table 7- 38 Calculating the Update Time

Boundary conditions		Update time	Value range of n	
			n_{min}	n_{max}
Non-isochronous mode	Any T_{DP}	n × 10 ms	1	12000
Isochronous mode	T_{DP} < 10 ms	n × T_{DP}	(10 ms/T_{DP} [ms]) +1 1)	12000
	T_{DP} ≥ 10 ms	n × T_{DP}	1	120000 ms/T_{DP} [ms] 1)

1 The decimal places obtained after division by T_{DP} are omitted.

It is prohibited to exceed these limits. If these limits are exceeded, the FM 350-1 generates a parameterization error and does not switch to isochronous mode.

Limit Monitoring

The following value ranges are permitted for limit value monitoring:

Table 7- 39 Value Range for Limit Monitoring at a Resolution of 1 µs

Low limit T_u	High limit T_o
0 to 119 999 999 µs	T_u+1 to 120 000 000 µs

Table 7- 40 Value Range for Limit Monitoring at a Resolution of 1/16 µs

Low limit T_u	High limit T_o
0 to 1 919 999 999 µs	T_u+1 to 1 920 000 000 µs

Possible Measuring Ranges with Error Indication

Table 7- 41 Period Measurement: Measuring Ranges and Errors at a Resolution of 1 µs

Resolution 1 µs	
Period T_{min} ± Absolute error	Period T_{min} ± Absolute error
1 µs* (10 ± 0)	1 µs* (100 000 ± 10)
1 µs* (100 ± 0)	1 µs* (1 000 000 ± 100)
1 µs* (1 000 ± 0)	1 µs* (10 000 000 ± 1 002)
1 µs* (10 000 ± 1)	1 µs* (100 000 000 ± 10 020)

Table 7- 42 Period Measurement: Measuring Ranges and Errors at a Resolution of 1/16 µs

Resolution 1/16 µs	
Period T_{min} ± Absolute error	Period T_{min} ± Absolute error
1/16 µs* (160 ± 1)	1/16 µs* (1 600 000 ± 160)
1/16 µs* (1 600 ± 1)	1/16 µs* (16 000 000 ± 1 600)
1/16 µs* (16 000 ± 3)	1/16 µs* (160 000 000 ± 16 000)
1/16 µs* (160 000 ± 20)	1/16 µs* (1 600 000 000 ± 160 000)

Function of the DI Start and DI Stop Digital Inputs

You can choose between the following functions for the digital inputs:

- Level-controlled hardware gate
- Edge-controlled hardware gate

See section Command: Open and close gate (Page 149)

Function of Digital Output DO0

You can choose between the following functions for digital output DO0:

- No comparison (no switching by limit value monitoring)
- Measured value outside limits
- Measured value under low limit
- Measured value above high limit

See the section Behavior of the Digital Outputs (Page 153)

Variable Values during Operation:

- Low limit (L_PREPAR)
- High limit (T_CMP_V1)
- Update time (T_CMP_V2)
- Function of digital output DO0 (C_DOPARA)

See the sections Behavior of the Digital Outputs (Page 153), Control interface for the measuring modes (Page 62) and Checkback interface for the measuring modes (Page 65)

7.4.6 Command: Open and close gate

Overview

Gates of FM 350-1:

- A HW gate, level- or edge-triggered.
- A SW gate which you can open and close by setting control bits in the user program.

Selecting a gate

You define which gate you are going to use for the measurement in the mode interface.

The diagrams below illustrate the various options of opening and closing the gates of FM 350-1.

Level-triggered opening and closing of the HW gate

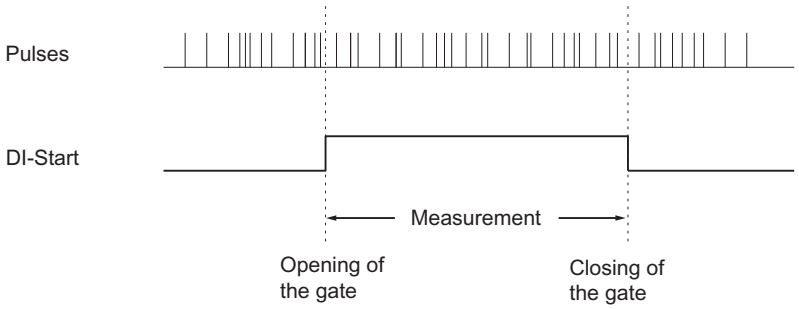


Figure 7-35 Level-triggered opening and closing of the HW gate (measuring)

You open the HW gate to start the measurement by setting a signal at digital input DI-Start. You close the HW gate to stop the measurement by resetting the signal at digital input DI-Start. The measured value which is valid at the time the HW gate is closed is retained at the checkback interface.

The level-triggered HW gate is activated by the first positive edge at input DI-Start DI after you set the parameters.

With this parameter setting, the module does not evaluate input DI-Stop, but indicates its status at the STS_STP status bit.

Edge-triggered opening and closing of the HW gate

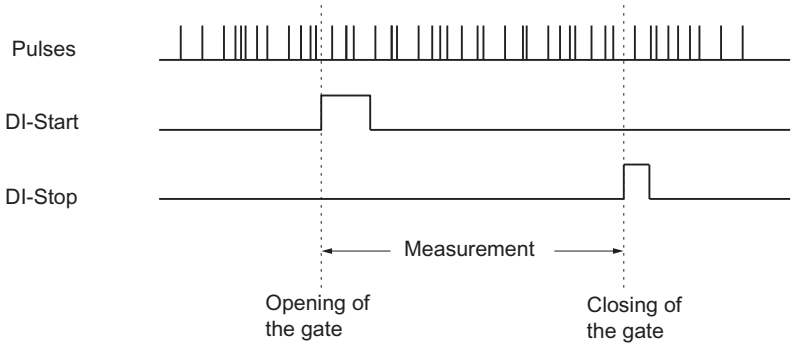


Figure 7-36 Edge-triggered opening and closing of the HW gate

You open the HW gate to start the measurement by setting a positive edge at digital input DI-Start. You close the HW gate to stop the measurement by setting a positive edge at digital input DI-Stop. The measured value which is valid at the time the HW gate is closed is retained at the checkback interface.

If a positive edges is set in parallel at both inputs, an open gate will be closed, whereas a closed gate remains closed. When digital input DI-Stop is set, a positive edge at digital input DI-Start can not open the gate.

Status at the inputs DI-Start and DI-Stop

The status at inputs DI-Start and DI-Stop is returned at the green LEDs I0 and I1, and in the user program at the STS_STA and STS_STP bits in the DB of FC CNT_CTL1.

Gate status

The gate status is indicated by the STS_GATE bit in the user program.

Opening and closing the SW gate

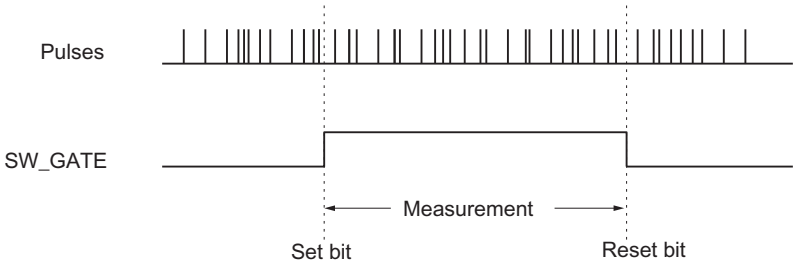


Figure 7-37 Opening and closing the SW gate

You open the SW gate to start the measurement by setting input parameter SW_GATE at FC CNT_CTL1. You close the SW gate to stop the measurement by resetting SW_GATE. The measured value which is valid at the time the SW gate is closed is retained at the checkback interface.

You can retrigger the closed gate by setting input parameter SW_GATE once again. Edge-triggered opening and closing of the SW gate is not supported.

SW gate status

The status of the SW gate is indicated at the STS_SW_G bit in the DB of FC CNT_CTL1.

Stopping measurements using the gate stop function

You can also use the gate stop function to stop a measurement, irrespective of any signal or software gate states. This is done by setting input parameter GATE_STP at FC_CNT_CTL1.

When this parameter is reset, the gate can only be opened by setting a positive edge at input DI-Start (HW gate), or by setting input parameter SW_GATE.

Hardware interrupt

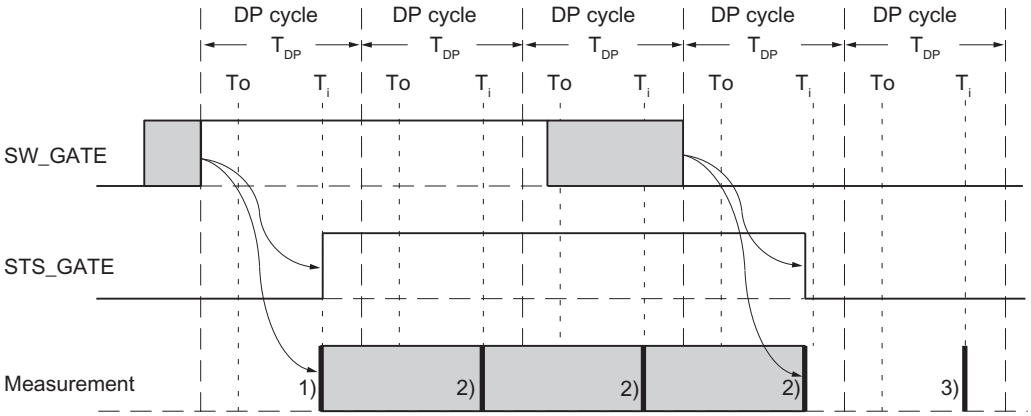
Opening and closing of a HW or SW gate can be used to trigger a hardware interrupt (see the chapter Triggering of a Hardware Interrupt (Page 156).)

Defaults

The SW gate is active by default.

Gate control in isochronous mode

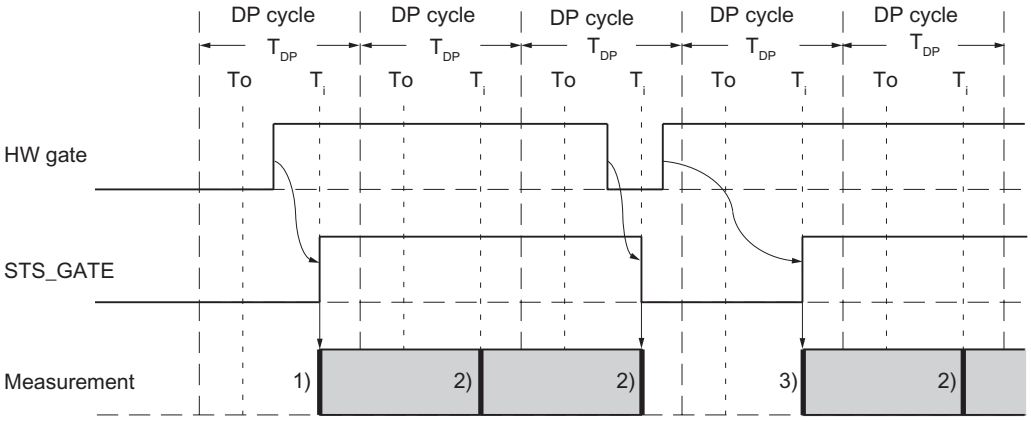
SW gate control: You control operations using the SW gate by setting and resetting the SW_GATE control bit in the user program. The measurement starts when the control bit is set, and stops at the time T_i in the next PROFIBUS DP cycle when the control bit is reset:



1) Measured value = -1
2) Provision of actual measured value
3) Provision of the measured value that was valid at the end of the measurement

Figure 7-38 Starting and stopping a measurement using the SW gate (SW_GATE)

HW gate control: You control a measurement using the HW gate by opening the HW gate to start the operation, and immediately stop the measurement at the time T_i by closing the HW gate:



1) Measured value = -1
2) Provision of actual measured value
3) Provision of the measured value that was valid at the end of the previous measurement

Figure 7-39 Starting and stopping measurements using the HW gate (HW_GATE)

7.4.7 Behavior of the Digital Outputs

Introduction

You can store an upper and a lower limit value for the frequency measurement, RPM measurement or cycle duration measurement. This will be activated when digital output DO0 is exceeded. You can set these limit values and modify them via the load function. You can use digital output DO1 as a normal digital output.

Enabling the Outputs

Before you can activate the outputs, you must first enable them by setting the appropriate bits in the DB (see the chapter DB assignments (Page 169)). When you reset one of these bits, the associated output is switched off immediately.

Table 7- 43 Enabling the Outputs

Output	... Is enabled by enable bit
DO0	CTRL_DO0
DO1	CTRL_DO1

Behavior of the Digital Outputs

Digital output DO0

For digital output DO0, you can set 4 possible reactions to reaching the limit values. The various options are shown in the table below.

Table 7- 44 Behavior of Digital Output DO0

Parameterization of Digital output DO0	Behavior of Digital output DO0	Switching time	
		Isochronous mode	Non-isochronous mode
No comparison	Not affected by the monitoring of limit values. If Output DO0 is already set, it can be reset by changing the parameter to "No comparison". You can use Output DO0 freely as a digital output and set and reset it with the control signal SET_DO0 if you have enabled it with the control signal CTRL_DO0.	To point in time T_o.	Immediately after setting or resetting the output
Out of limits	DO0 is set in both of the following cases: • Measured value < Lower limit • Measured value > Upper limit	At the end of the update time at time T_i	At the end of the update time
Below the low limit	DO0 is set if • Measured value < Lower limit		
Above the high limit	DO0 is set if • Measured value > Upper limit		

Digital output DO1

You can use Output DO1 freely as a digital output and set and reset it with the control signal SET_DO1, provided that it has been enabled.

DO1 is not affected by limit value monitoring.

In non-isochronous mode, DO1 switches immediately after the output is set or reset.

In isochronous mode, DO1 switches at the end of the update time at time T_o.

Status of the Outputs and Status Bits

The status of the two outputs is indicated by the green LEDs and the corresponding status bits in the DB.

Table 7- 45 Output DO0

Limit values	Enable bit CTRL_DO0	Status bit STS_CMP1/ Output DO0	LED DO0
Not exceeded	0	0	Out
	1	0	Out
Exceeded	0	0	Out
	1	1	is lit

Table 7- 46 Output DO1

Control bit SET_DO1	Enable bit CTRL_DO1	Status bit STS_CMP2/ Output DO1	LED DO1
0	0	0	Out
	1	0	Out
1	0	0	Out
	1	1	is lit

7.5 Triggering of a Hardware Interrupt

Introduction

With the FM 350-1, you can set which events are to initiate a hardware interrupt. For this purpose, parameterize the FM 350-1 interrupts in the parameterization screens.

What is a Hardware Interrupt?

If you want to program a response to a specific event independently of the CPU cycle, each counter of the FM 350-1 can initiate a hardware interrupt. The CPU interrupts the cyclic program on receiving the interrupts and executes the hardware interrupt OB.

Which Events Can Initiate a Hardware Interrupt?

Various events can initiate a hardware interrupt during operation of the FM 350-1:

Counter modes

- Opening of the gate (in the operating modes with hardware or software gate)
- Closing of the gate (in the operating modes with hardware or software gate)
- Overflow
- Underflow
- Zero pass
- Reaching Comparison value 1 or 2 in the up direction
- Reaching Comparison value 1 or 2 in the down direction
- Setting the counter with an external signal
- Latch

Measure Modes

- Opening of the gate (in the operating modes with hardware or software gate)
- Closing of the gate (in the operating modes with hardware or software gate)
- Measured value outside limits
- End of measurement

You can select any number of events for hardware interrupt initiation. For hardware interrupts on reaching the comparison value, you must observe the marginal conditions for the behavior of digital outputs (see the section Behavior of the Digital Outputs (Page 109)).

Enabling the Hardware Interrupt

You enable the interrupts for the module in the parameterization screens when configuring the hardware and you decide whether the module is to initiate a diagnostics interrupt and/or a hardware interrupt.

Hardware Interrupt OB, OB 40

If a hardware interrupt occurs, the user program is interrupted, the data is transferred from the module to the start information of OB40 and OB40 is called. The hardware interrupt is acknowledged by exiting OB 40.

If no OB 40 is programmed, the CPU goes to STOP. If you then switch back to RUN, the hardware interrupt requirements are deleted.

Start Information

The temporary variable OB40_POINT_ADDR is written in the start information of OB 40.

The variable OB40_POINT_ADDR (Bytes 8 to 11) consists of four bytes. The information about the event that has initiated the hardware interrupt is entered in Bytes 8 and 9.

The table shows which bits are set for which interrupt. All unlisted bits are not significant and are set to zero.

Table 7- 47 Assignment of the Bits of the Variable OB40_POINT_ADDR

Byte	Bit	Meaning: Interrupt in the case of...
8	0	Opening the gate
	1	Closing the gate
	2	Overflow (at Count mode)
		Measured value outside limits (at Measure mode)
	3	Underflow (at Count mode)
		End of measurement (at Measure mode)
	4	Reaching Comparison value 1 in the up direction
	5	Reaching Comparison value 1 in the down direction
	6	Reaching Comparison value 2 in the up direction
	7	Reaching Comparison value 2 in the down direction
9	0	Zero pass
	5	Setting the counter with an external signal (synchronization)
	7	Latch

Lost Hardware Interrupt

If an event occurs that is to initiate a hardware interrupt and the same previous event has not yet been acknowledged, no further hardware interrupt is initiated; the hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostic interrupt, depending on the parameterization.

Default setting

No hardware interrupt is parameterized in the default setting.

Encoder signals and their evaluation

8

Chapter overview

This chapter describes:

- which encoders you can connect to the counter module
- the time profile of the encoder signals
- the multiple evaluation of encoder signals by the counter module
- how the module monitors the various encoder signals
- which signals can be assigned input filter parameters.

8.1 Encoders which can be connected

Introduction

The counter module can process rectangular count signals which were generated by incremental encoders or pulse generators.

Incremental encoders scan a barcode to generate rectangular electrical pulses. They differ in terms of pulse amplitude and number of signals.

Pulse generators such as light barriers or proximity switches (BEROs) return only a rectangular signal at a specific amplitude.

Connecting different encoders

The counter module supports different encoders which return pulses for the count signals. The table shows these encoders and the corresponding signals.

Table 8- 1 Encoders which can be connected

Encoders	Signal
5-V incremental encoder	Differential signals A and /A, B and /B, N and /N
24-V incremental encoder	A*, B* and N*
24-V pulse encoder	24-V with directional signal
24-V proximity switch	24 V without directional signal

8.2 5-V differential signals

Count signals of 5-V incremental encoders

RS422 signals returned by the 5-V incremental encoder to the module:

- A and /A
- B and /B
- N and /N

The signals /A, /B and /N are the inverted signals of A, B and N. Signals A and B are phase-shifted by 90°.

The tracks A and B of 5-V incremental encoders are used for counting. Track N is used to initialize the counter with the load value, if programmed accordingly.

Encoders featuring these six signals are symmetrical encoders.

The diagram shows the time profile of the encoder signals:

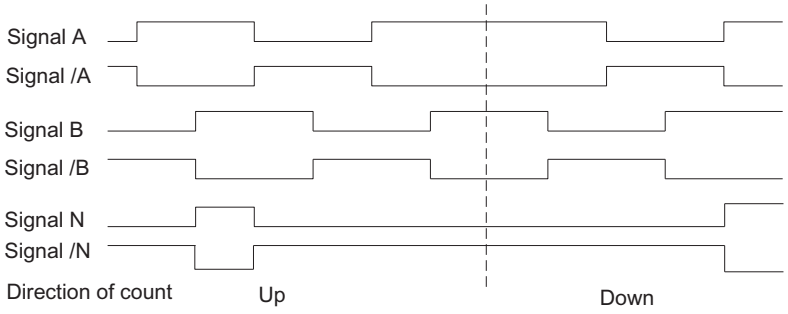


Figure 8-1 Signals of the 5-V incremental encoder

The module detects the count direction by evaluating the ratio of signals A and B. The diagrams in the chapter "Signal evaluation (Page 166)" show which edges of signals A and B are counted in down or up direction.

Changing the count direction

You can change the count direction using the "Count direction normal" and "Count direction inverted" parameters without having to modify the wiring.

Monitoring encoder signals

The module monitors the cable connection, and detects wire-break or short-circuit.

You can define which of the three signal pairs to include in monitoring in your program. There is no need to wire any unused signal pairs, if you have disabled the corresponding diagnostics functions in the program (monitoring.)

An error state at all three signals indicates a defective encoder, or a short-circuit at the "5.2 V DC" encoder supply, or a missing encoder.

When programming is completed, and the module detects an error, the error information will be written to the diagnostics data records DS0 and DS1. This situation my lead to a diagnostics interrupt if programmed accordingly.

Coding plug (only for FM 350-1)

To operate this encoder, insert the coding plug in position A.

8.3 24-V signals

Count signals returned by 24-V encoders

24-V incremental encoders

The 24-V incremental encoder returns the 24-V signals A*, B* and N* to the module. The A* and B* signals are phase-shifted by 90°.

24-V signals are marked with an asterisk "*" character.

The tracks A* and B* of a 24-V incremental encoder are used for counting. Track N* is used to initialize the counter with the load value, if programmed accordingly.

Encoders which do not return inverted signals asymmetrical encoders.

The diagram shows the time profile of the encoder signals:

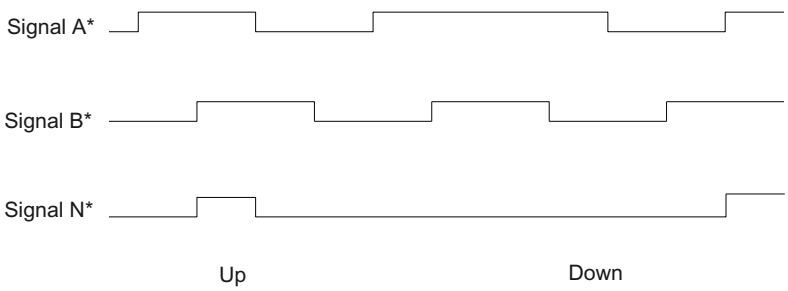


Figure 8-2 Signals of the 24-V incremental encoder

The module detects the count direction by evaluating the ratio of signals A* and B*. The diagrams in the chapter "Signal evaluation (Page 166)" show which edges of the A* and B* signals are incremented or decremented.

You can program the inputs of 24-V encoder signals for the connection of source outputs, or push-pull outputs, or sink outputs. For further information, refer to the encoder manual.

You can change the count direction using the "Count direction normal" and "Count direction inverted" parameters without having to modify the wiring.

24-V pulse encoders without/with direction signal

Encoders such as proximity switches (BERO) or light barriers return only a count signal which you wire to terminal A* of the front connector.

in additional, you can wire a signal for direction detection to terminal B* of the relevant counter. If your encoder does not return a corresponding signal, you can wire a corresponding ID signal you generate within the user program, or use a corresponding process signal.

The diagram shows the time profile of the encoder signals, and the resultant count pulses

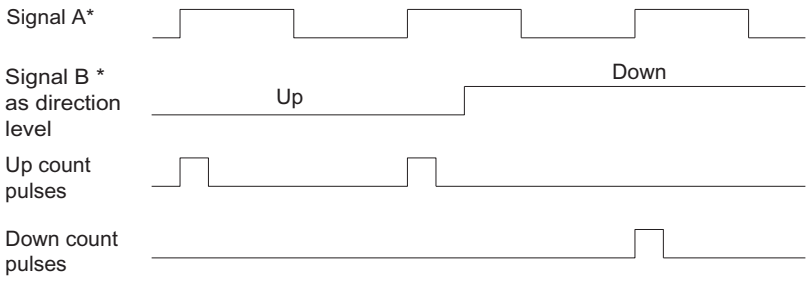


Figure 8-3 Signals of a 24-V pulse generator with direction signal

Programming the encoder inputs

The count direction is defined by programming the encoder inputs. The diagram shows a change of the count direction based on parameter settings.

Table 8- 2 Count direction determined by input parameters

Programming	Terminal B*	Count direction
current sourcing, push-pull	not wired	Up
	24 V connected	Down
current sinking	not wired	Down
	Short-circuited to ground	Up

Set the "24 V pulse and direction" parameter for the selected encoder.

You can not reverse the direction of these count signal by inverting the B* signal.

Note

This type of evaluation may cause the count value to "drift off" at the edges if count signal oscillates, as all signals are added.

Input filters for the 24-V count inputs

For the purpose of suppressing interference, you can parameterize input filters with a uniform filter time for the 24 V inputs A*, B* and N* and for the digital inputs. Input filters available:

Table 8- 3 Input filters

Features	Input filter 1 (default)	Input filter 2
Typical input delay	1 µs	15 µs
Maximum count frequency	200 kHz	20 kHz
Minimum pulse width of count signals	2.5 µs	25 µs

Monitoring encoder signals

The 24-V count signals are not monitored to detect wire-breaks or short-circuits.

Coding plug (only for FM 350-1)

To operate this encoder, insert the coding plug in position D.

8.4 Signal evaluation

Overview

The counter module supports the count of signal edges. It usually evaluates the edge at A (A*) (single evaluation). Options in the program of increasing the resolution:

- Single evaluation
- Double evaluation
- Quadruple evaluation

Multiple evaluation is only supported for 5-V incremental encoders which return the A and B signal with a phase shift of 90°, for 24-V incremental 24 V encoders with a phase shift of 90° of the A* and B* signals.

Single evaluation

In this mode, the module evaluates only one edge of signal A. Up count pulses are recorded at the positive edge at track A, and if track B is low. Down count pulses are recorded at the positive edge at track A, and if track B is low.

The diagram shows a single evaluation of signals:

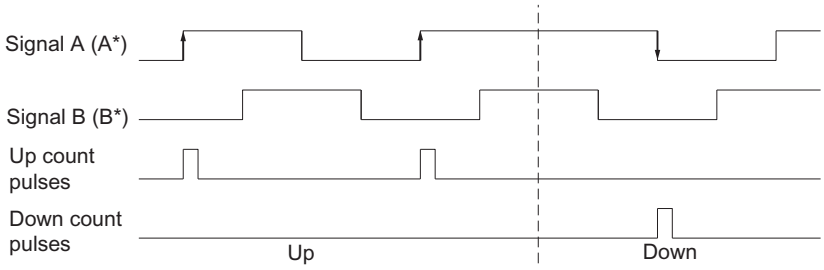


Figure 8-4 Single evaluation

Double evaluation

Double evaluation refers to the evaluation of the positive and negative edges of signal A. The logic level at signal B determines the count direction, i.e. the up or down count pulse.

The diagram shows the double evaluation of signals:

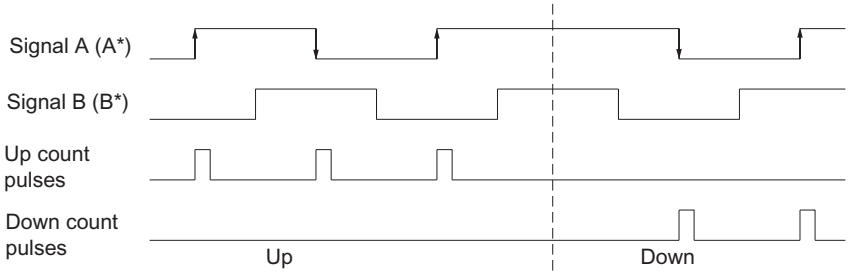


Figure 8-5 Double evaluation

Quadruple evaluation

Quadruple evaluation refers to the evaluation of the positive and negative edges of signals A and B. The logic level at the signals A and B determines the count direction, i.e. the up or down count pulse.

The diagram shows quadruple evaluation of signals:

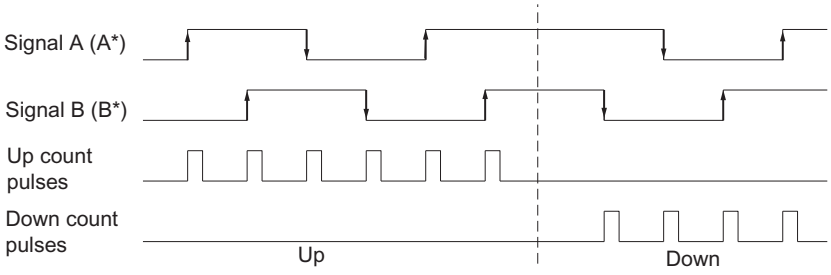


Figure 8-6 Quadruple evaluation

Default

Single evaluation is set by default.

DB assignments

9

DB for FC CNT_CTL1

All data belonging to a module channel are stored in the DB of FC CNT_CTL1. The data structure and length of the DB are defined by UDT2. You must assign the valid data listed below to the DB before assigning module parameters.

- Module address (address 6.0)
- Channel start address (address 8.0)
- User data length (address 12.0)

The DB was generated based on UDT2 as DB of a corresponding user-specific data type. The resultant DB assignments are shown below.

Table 9- 1 DB assignments

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
FC parameters, addresses					
0.0	AR1_BUFFER	DWORD	DW#16#0	AR1 buffer	AR1 buffer
4.0	FP	BYTE	B#16#0	Flag byte	Flag byte
5.0	RESERVED	BYTE	B#16#0	Reserved	Reserved
6.0	MOD_ADR	WORD	W#16#0	Module address	Module address
8.0	CH_ADR	DWORD	DW#16#0	Channel address	Channel address
12.0	U_D_LGTH	BYTE	B#16#0	User data length	User data length
13.0	A_BYTE_0	BYTE	B#16#0	Reserved	Reserved
Transfer area for write values					
14.0	LOAD_VAL[1]	DINT	L#0	New load value (write user)	Low limit (write user)
18.0	CMP_V1[1]	DINT	L#0	New comparison value 1 (write user)	High limit (write user)
22.0	CMP_V2[1]	DINT	L#0	New comparison value 2 (write user)	Update time (write user)

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
Control interface					
26.0	A_BIT0_0	BOOL	FALSE	Reserved	Reserved
26.1	A_BIT0_1	BOOL	FALSE	Reserved	Reserved
26.2	A_BIT0_2	BOOL	FALSE	Reserved	Reserved
26.3	A_BIT0_3	BOOL	FALSE	Reserved	Reserved
26.4	A_BIT0_4	BOOL	FALSE	Reserved	Reserved
26.5	A_BIT0_5	BOOL	FALSE	Reserved	Reserved
26.6	A_BIT0_6	BOOL	FALSE	Reserved	Reserved
26.7	A_BIT0_7	BOOL	FALSE	Reserved	Reserved
27.0	ENSET_UP[1]	BOOL	FALSE	Enable initialization in up direction (write user)	-
27.1	ENSET_DN[1]	BOOL	FALSE	Enable initialization in down direction (write user)	-
27.2	A_BIT1_2	BOOL	FALSE	Reserved	Reserved
27.3	A_BIT1_3	BOOL	FALSE	Reserved	Reserved
27.4	A_BIT1_4	BOOL	FALSE	Reserved	Reserved
27.5	A_BIT1_5	BOOL	FALSE	Reserved	Reserved
27.6	A_BIT1_6	BOOL	FALSE	Reserved	Reserved
27.7	A_BIT1_7	BOOL	FALSE	Reserved	Reserved
28.0	CTRL_DO0[1]	BOOL	FALSE	Enable digital output DO0 (write user)	Enable digital output DO0 (write user)
28.1	CTRL_DO1[1]	BOOL	FALSE	Enable digital output DO1 (write user)	Enable digital output DO1 (write user)
28.2	A_BIT2_2	BOOL	FALSE	Reserved	Reserved
28.3	A_BIT2_3	BOOL	FALSE	Reserved	Reserved
28.4	A_BIT2_4	BOOL	FALSE	Reserved	Reserved
28.5	A_BIT2_5	BOOL	FALSE	Reserved	Reserved
28.6	A_BIT2_6	BOOL	FALSE	Reserved	Reserved
28.7	A_BIT2_7	BOOL	FALSE	Reserved	Reserved
29.0	A_BIT3_0	BOOL	FALSE	Reserved	Reserved
29.1	A_BIT3_1	BOOL	FALSE	Reserved	Reserved
29.2	A_BIT3_2	BOOL	FALSE	Reserved	Reserved
29.3	A_BIT3_3	BOOL	FALSE	Reserved	Reserved
29.4	A_BIT3_4	BOOL	FALSE	Reserved	Reserved
29.5	A_BIT3_5	BOOL	FALSE	Reserved	Reserved
29.6	A_BIT3_6	BOOL	FALSE	Reserved	Reserved
29.7	A_BIT3_7	BOOL	FALSE	Reserved	Reserved

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
Transfer area for read values					
30.0	LATCH_LOAD[1]	DINT	L#0	Actual load or latch value (read user)	Actual measured value (read user)
34.0	ACT_CNTV[1]	DINT	L#0	Actual count value (read user)	Actual count value (read user)
Error numbers					
38.0	DA_ERR_W[1]	WORD	W#16#0	Data error word (read user)	Data error word (read user)
40.0	OT_ERR_B[1]	BYTE	B#16#0	Operator error byte (read user)	Operator error byte (read user)
Checkback interface					
41.0	E_BIT0_0	BOOL	FALSE	Reserved	Reserved
41.1	E_BIT0_1	BOOL	FALSE	Reserved	Reserved
41.2	E_BIT0_2	BOOL	FALSE	Reserved	Reserved
41.3	E_BIT0_3	BOOL	FALSE	Reserved	Reserved
41.4	DATA_ERR[1]	BOOL	FALSE	Data error bit (read user)	Data error bit (read user)
41.5	E_BIT0_5	BOOL	FALSE	Reserved	Reserved
41.6	E_BIT0_6	BOOL	FALSE	Reserved	Reserved
41.7	PARA[1]	BOOL	FALSE	Module is programmed (read user)	Module is programmed (read user)
42.0	E_BYTE_0	BYTE	B#16#0	Reserved	Reserved
43.0	STS_RUN[1]	BOOL	FALSE	Status counter running (read user)	Status counter running (read user)
43.1	STS_DIR[1]	BOOL	FALSE	Status count direction (read user)	Status count direction (read user)
43.2	STS_ZERO[1]	BOOL	FALSE	Status zero transition (read user)	End of measurement (read user)
43.3	STS_OFLW[1]	BOOL	FALSE	Status overflow (read user)	Status overflow (read user)
43.4	STS_UFLW[1]	BOOL	FALSE	Status underflow (read user)	Status underflow (read user)
43.5	STS_SYNC[1]	BOOL	FALSE	Status counter synchronized (read user)	-
43.6	STS_GATE[1]	BOOL	FALSE	Status internal gate (read user)	Status internal gate (read user)
43.7	STS_SW_G[1]	BOOL	FALSE	Status SW gate (read user)	Status SW gate (read user)

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
44.0	STS_SET[1]	BOOL	FALSE	Status digital input DI-Set (read user)	Status digital input DI-Set (read user)
44.1	STS_LATCH[1]	BOOL	FALSE	New latch value (only in isochronous mode)	-
44.2	STS_STA[1]	BOOL	FALSE	Status digital input DI-Start (read user)	Status digital input DI-Start (read user)
44.3	STS_STP[1]	BOOL	FALSE	Status digital input DI-Stop (read user)	Status digital input DI-Stop (read user)
44.4	STS_CMP1[1]	BOOL	FALSE	Status output comparison value 1 (read user)	Status output comparison value 1 (read user)
44.5	STS_CMP2[1]	BOOL	FALSE	Status output comparison value 2 (read user)	Status output comparison value 2 (read user)
44.6	STS_COMP1[1]	BOOL	FALSE	Saved status of comparator 1	-
44.7	STS_COMP2[1]	BOOL	FALSE	Saved status of comparator 2	-
45.0	E_BIT3_0	BOOL	FALSE	Reserved	Reserved
45.1	E_BIT3_1	BOOL	FALSE	Reserved	Reserved
45.2	E_BIT3_2	BOOL	FALSE	Reserved	Reserved
45.3	E_BIT3_3	BOOL	FALSE	Reserved	Reserved
45.4	E_BIT3_4	BOOL	FALSE	Reserved	Reserved
45.5	E_BIT3_5	BOOL	FALSE	Reserved	Reserved
45.6	E_BIT3_6	BOOL	FALSE	Reserved	Reserved
45.7	E_BIT3_7	BOOL	FALSE	Reserved	Reserved
FM 450 parameters					
46.0	ACT_CMP1	DINT	L#0	Reserved	Reserved
50.0	ACT_CMP2	DINT	L#0	Reserved	Reserved
The diagnostics data listed below are entered by FC DIAG_INF					
54.0	MDL_DEFECT	BOOL	FALSE	Module error	Module error
54.1	INT_FAULT	BOOL	FALSE	Internal error	Internal error
54.2	EXT_FAULT	BOOL	FALSE	External error	External error
54.3	PNT_INFO	BOOL	FALSE	Channel error (decoded starting at DW 58)	Channel error (decoded starting at DW 58)
54.4	EXT_VOLTAGE	BOOL	FALSE	Auxiliary voltage failure	Auxiliary voltage failure
54.5	FLD_CNNCTR	BOOL	FALSE	Front connector	Front connector
54.6	NO_CONFIG	BOOL	FALSE	No parameter assignment	No parameter assignment
54.7	CONFIG_ERR	BOOL	FALSE	Faulty parameter assignment	Faulty parameter assignment
55.0	MDL_TYPE	BYTE	B#16#0	Module type	Module type

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
56.0	SUB_MDL_ERR	BOOL	FALSE	Wrong/missing interface module	Wrong/missing interface module
56.1	COMM_FAULT	BOOL	FALSE	Communication error	Communication error
56.2	MDL_STOP	BOOL	FALSE	RUN/STOP mode indication	RUN/STOP mode indication
56.3	WTCH_DOG_FAULT	BOOL	FALSE	Watchdog timeout (FM)	Watchdog timeout (FM)
56.4	INT_PS_FLT	BOOL	FALSE	Internal power supply failure	Internal power supply failure
56.5	PRIM_BATT_FLT	BOOL	FALSE	Battery monitoring	Battery monitoring
56.6	BCKUP_BATT_FLT	BOOL	FALSE	Backup fault	Backup fault
56.7	RESERVED_2	BOOL	FALSE	Reserved	Reserved
57.0	RACK_FLT	BOOL	FALSE	Rack error	Rack error
57.1	PROC_FLT	BOOL	FALSE	CPU error	CPU error
57.2	EPROM_FLT	BOOL	FALSE	EPROM error	EPROM error
57.3	RAM_FLT	BOOL	FALSE	RAM error	RAM error
57.4	ADU_FLT	BOOL	FALSE	ADC error	ADC error
57.5	FUSE_FLT	BOOL	FALSE	Fuse	Fuse
57.6	HW_INTR_FLT	BOOL	FALSE	Hardware interrupt lost	Hardware interrupt lost
57.7	RESERVED_3	BOOL	FALSE	Reserved	Reserved
58.0	CH_TYPE	BYTE	B#16#0	Channel type	Channel type
59.0	LGTH_DIA	BYTE	B#16#0	Length of diagnostics data per channel	Length of diagnostics data per channel
60.0	CH_NO	BYTE	B#16#0	Channel number	Channel number
61.0	GRP_ERR1	BOOL	FALSE	Group error channel 1	Group error channel 1
61.1	GRP_ERR2	BOOL	FALSE	Not used on FM 350-1	Not used on FM 350-1
61.2	D_BIT7_2	BOOL	FALSE	DS1 byte 7 bit 2	DS1 byte 7 bit 2
61.3	D_BIT7_3	BOOL	FALSE	DS1 byte 7 bit 3	DS1 byte 7 bit 3
61.4	D_BIT7_4	BOOL	FALSE	DS1 byte 7 bit 4	DS1 byte 7 bit 4
61.5	D_BIT7_5	BOOL	FALSE	DS1 byte 7 bit 5	DS1 byte 7 bit 5
61.6	D_BIT7_6	BOOL	FALSE	DS1 byte 7 bit 6	DS1 byte 7 bit 6
61.7	D_BIT7_7	BOOL	FALSE	DS1 byte 7 bit 7	DS1 byte 7 bit 7

Address	Variable	Data type	Start value	Comment	
				Count	Measuring
62.0	CH1_SIGA	BOOL	FALSE	Channel 1, signal A error	Channel 1, signal A error
62.1	CH1_SIGB	BOOL	FALSE	Channel 1, signal B error	Channel 1, signal B error
62.2	CH1_SIGZ	BOOL	FALSE	Channel 1, zero signal error	Channel 1, zero signal error
62.3	CH1_BETW	BOOL	FALSE	Channel 1, error between channels	Channel 1, error between channels
62.4	CH1_5V2	BOOL	FALSE	Channel 1, error in 5.2-V encoder supply	Channel 1, error in 5.2-V encoder supply
62.5	D_BIT8_5	BOOL	FALSE	DS1 byte 8 bit 5	DS1 byte 8 bit 5
62.6	D_BIT8_6	BOOL	FALSE	DS1 byte 8 bit 6	DS1 byte 8 bit 6
62.7	D_BIT8_7	BOOL	FALSE	DS1 byte 8 bit 7	DS1 byte 8 bit 7
63.0	D_BYTE9	BYTE	B#16#0	DS1 byte 9	DS1 byte 9
64.0	CH2_SIGA	BOOL	FALSE	Reserved	Reserved
64.1	CH2_SIGB	BOOL	FALSE	Reserved	Reserved
64.2	CH2_SIGZ	BOOL	FALSE	Reserved	Reserved
64.3	CH2_BETW	BOOL	FALSE	Reserved	Reserved
64.4	CH2_5V2	BOOL	FALSE	Reserved	Reserved
64.5	D_BIT10_5	BOOL	FALSE	Reserved	Reserved
64.6	D_BIT10_6	BOOL	FALSE	Reserved	Reserved
64.7	D_BIT10_7	BOOL	FALSE	Reserved	Reserved
65.0	D_BYTE11	BYTE	B#16#0	DS1 byte 11	DS1 byte 11
66.0	D_BYTE12	BYTE	B#16#0	DS1 byte 12	DS1 byte 12
67.0	D_BYTE13	BYTE	B#16#0	DS1 byte 13	DS1 byte 13
68.0	D_BYTE14	BYTE	B#16#0	DS1 byte 14	DS1 byte 14
69.0	D_BYTE15	BYTE	B#16#0	DS1 byte 15	DS1 byte 15
[1] Variables in the DB that you can or must enter or read out during work with FM 350-1					

Errors and diagnostics

10

Chapter overview

Operator errors, faulty wiring or contradictory parameters (position of the coding plug does not match parameter data) can lead to errors which the module must indicate.

Error classes of the module:

- Errors indicated by the group error LED to report internal and external module errors.
- Errors which can trigger a diagnostics interrupt.
- Operator errors.

These different error classes are indicated at different positions, and must be acknowledged in different ways.

This chapter describes:

- errors which may occur
- where these errors are indicated
- how to acknowledge errors.

10.1 Error Display via the Group Error LEDs

Where is the Fault Indicated?

If the red group error LED lights up, a fault has occurred either on the module (internal fault) or at the cable connections (external fault).

Which Errors Are Displayed?

Table 10- 1 Error Types Displayed by the Group Error LED

Type of error	Cause of the error	Correction
Internal faults	Fault in EPROM TEST	Module replacement
	Fault in RAM TEST	Module replacement
	Watchdog tripped	Module replacement
	Lost hardware interrupt	Increase time between the interrupt causes
	Module parameterization missing	Assign parameters and transfer
External errors	Coding plug wrongly connected	Correct the position of the coding plug
	Auxiliary voltage 1L+/1M not connected or 24 VDC encoder supply short-circuited	Correct connection
	5.2 VDC encoder supply short-circuited or overloaded	Correct connection
	Fault in 5 V encoder signals (wirebreak, short-circuit, cable missing)	Correct connection
	Module parameterization does not match the position of the coding plug	Correct parameterization and transfer, or reconnect the coding plug

Initiating a Diagnostics Interrupt

All faults except the EPROM test fault, can initiate a diagnostics interrupt provided you have enabled the diagnostics interrupt in the relevant parameterization screen. You can see which fault has caused the LED to light up from the diagnostics data sets DS0 and DS1. The assignment of the diagnostic data records DS0 and DS1 is described in the next section.

10.2 Triggering diagnostics interrupts

Definition of a diagnostics interrupt

You can determine reactions to internal or external errors in the user program, by programming a diagnostics interrupt which interrupts cyclic program execution on the CPU, and triggers a call of diagnostics interrupt OB 82.

Events which can trigger a diagnostics interrupt

The list shows which events can trigger a diagnostics interrupt:

- Short-circuit or overload at the external auxiliary voltage 1L+/1M
- Error at the 5.2 V DC encoder supply
- No module configuration
- Faulty module parameters
- Watchdog timeout
- RAM defective
- Hardware interrupt lost
- Signal A error (wire break, short-circuit, cable missing)
- Signal B error (wire break, short-circuit, cable missing)
- Signal N error (wire break, short-circuit, cable missing)

Enabling diagnostics interrupts

You disable or enable interrupts at the module, and define whether it should generate diagnostics and/or a hardware interrupts using the programming interfaces.

Reactions to a diagnostics interrupt

Actions initiated when an event triggers a diagnostics interrupt:

- The diagnostics information will be written to the diagnostics data records DS0 and DS1.
- The group error LED is lit.

  The group error LED does dark when the error is eliminated.
- Call of the diagnostics interrupt OB 82.
- The diagnostics data record DS0 will be written to the start information of the diagnostics interrupt OB.
- The count continues unchanged.

If no OB 82 is programmed, the CPU goes into STOP.

Diagnostics data records DS0 and DS1

The information showing the event which has triggered a diagnostics interrupt is written to the diagnostics data records DS0 and DS1. Diagnostics data record DS0 consists of four bytes, and DS1 of 16 bytes. The first four bytes are identical with those at DS0.

Reading data records from the module

The module automatically writes the diagnostics data record DS0 to the start information of the diagnostics interrupt OB. These four bytes are saved to the local data area of OB82 (bytes 8 to 11.)

You can read diagnostics data record DS1 from the module, which includes the contents of DS 0, by calling FC DIAG_INF. However, this is only useful if DS0 reports a channel error.

Assignments of diagnostics data record DS0 in the start information

The table shows the start information assignments of diagnostics data record DS0. Any bits not listed bits are insignificant, and zero.

Table 10- 2 Assignments of diagnostics data record DS0

Byte	Bit	Meaning	Remarks	Event ID
0	0	Module in error state	Set upon all diagnostics events	8:x:00
	1	Internal error	Set at all internal error events: • RAM test error • Time monitoring (watchdog) triggered • Lost hardware interrupt	8:x:01
	2	External error	Set at all external error events: • Auxiliary voltage 1L+/1M not connected, or short-circuit at the 5.2 V DC encoder supply. • Short-circuit or overload at the 5.2 V DC encoder supply • Error at 5-V signals • Parameter error	8:x:02
	3	Channel error	See DS1, byte 4 for further details	8:x:03
	4	Failure of the external auxiliary voltage	Check the voltage	8:x.04
	6	No configuration	Assign parameters	8:x:06
	7	Parameter error	See section Data errors (Page 180) for further breakdown	8:x:07

Byte	Bit	Meaning	Remarks	Event ID
1	0...3	Type class	Always assigned the value 8	
	4	Channel information	Always assigned the value 1	
2	3	Time monitoring (watchdog) triggered	Module defective, or heavy interference	8:x:33
3	3	RAM defective	Module defective, or heavy interference	8:x:43
	6	Hardware interrupt lost	Check the configuration. A hardware interrupt was detected and can not be reported, because the same event is not yet acknowledged by the CPU	8:x:46

Diagnostics data record DS1

The diagnostics data record DS1 consists of 16 bytes. The first 4 bytes are identical with those of diagnostics data record DS0. The table below shows the assignments of the remaining bytes. Any bits not listed bits are insignificant, and zero. FC DIAG_INF writes this data record to the DB of FC CNT_CTRL1, starting at DW54.

Table 10- 3 Assignments of bits in bytes 4 to 11 of the diagnostics data record DS

Byte	Bit	Meaning	Remarks	Event ID
4	0...6	Channel type	Always assigned the value 76H	
	7	Further channel types	Always assigned zero value	
5	0...7	Diagnostics data length	Always assigned the value 10H	
6	0...7	Number of channels	Always assigned the value 1	
7	0	Channel error vector	Assigned 1 on channel error	
8	0	Signal A error		8:x:B0
	1	Signal B error		8:x:B1
	2	Signal N error		8:x:B2
	4	Error at the 5.2-V encoder supply		8:x:B4
	5...7	Reserved		
9 ... 15		Reserved		

How to enter diagnostics messages in the diagnostics buffer

If you want to enter the diagnostics message in the diagnostics buffer, you must call the SFC 52 "Enter user-specific message in diagnostics buffer" in your user program. The event number of the diagnostics message is defined at input parameter EVENTN. The interrupt is identified by the entries x=1 as incoming and x=0 as outgoing event in the diagnostics buffer. The diagnostics buffer contains the relevant diagnostics text entry in the `Meaning' column, including the time of its entry.

Defaults

The diagnostics interrupt is disabled by default.

10.3 Data error

Data error events

FM 350-1 checks all new parameters it receives. The module reports any errors returned in this check.

Where data errors are indicated

FC CNT_CTL1 enters the data errors and the error number in the DB of FC CNT_CTL1. You can access this data word in the user program using the variable identifier `DA_ERR_W'.

Possible data errors

Table 10- 4 Data error numbers and their meaning

No.	Meaning
0	No error
200	Coding plug in wrong position or missing
201	The position of the coding plug does not match the programmed encoder
202	Invalid diagnostics value of the signal pair
203	Incorrect value for signal evaluation
204	Invalid value at the input filter for 24-V count signals
205	Invalid value at digital input filters
206	Reversal of direction not allowed
207	Incorrect configuration of the reaction of DO0
208	Incorrect configuration of the reaction of DO1
209	Pulse duration out of limits
211	Wrong operating mode selected
212	No gate or both gates defined
213	Faulty parameters of main count direction
214	Count high limit exceeded
215	A count direction other than set at the hardware interrupt parameter `Reaching the comparison value in up or down count direction' was defined in the configuration of the Outputs `Active on reaching the comparison value of the pulse duration for up or down counts'. The directions set must match.
216	Gate control interrupts are only possible in modes with gate control.
217	Interrupt on reaching comparison values is not allowed when the output reaction "Active within the range between the comparison value and overflow" or "Active within the range between the comparison value and underflow".
218	Interrupt triggering at the zero transition is not allowed
219	Wrong coding of the "Latch Setting"
220	Faulty gate control parameters

No.	Meaning
221	Undershoot, or load value out of limits.
222	Overshoot, or comparison value 1 out of limits
223	Update time or comparison value 2 out of limits
224	Pulses per encoder revolution out of limits

How to acknowledge data errors

Correct the parameter values according to specifications. Return the corrected parameter set to FM 350-1. The module once again checks the parameters, and clears the data error in the DB.

10.4 Operator error

Operator errors events

Operator errors develop as a result of improper operation of the module caused by the incorrect input of control signals.

Objects which indicate operator errors

FC CNT_CTL1 enter the operator error numbers in the DB. FC CNT_CTL1 sets output parameter OT_ERR to indicate the occurrence of an operator error. You can access this data word in your program using the variable identifier `OT_ERR_B'.

Possible operator errors

Table 10- 5 Operator error numbers and their meaning

No.	Meaning
0	No error
1	Operating mode can not be started using the SW gate
2	Operating mode can not be canceled
4	Only allowed when the CPU is in STOP
5	Only the parameter assignment control bit may be set
6	Illegal job
10	Undershoot, or load value out of limits.
11	Overshoot, or comparison value 1 out of limits
12	Update time or comparison value 2 out of limits
20	Incorrect configuration of the reaction of DO0
21	Incorrect configuration of the reaction of DO1
22	Pulse duration out of limits
90	See section "The FC CNT_CTL2 function (FC 3) (Page 48)."
91	See section "The FC CNT_CTL2 function (FC 3) (Page 48)."

How to acknowledge operator errors

You acknowledge the error by setting input parameter OT_ERR_A at FC CNT_CTL1.

Technical data

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11.1 General technical specifications

These general technical specifications are described in the manual /1/:

- Standards and certifications
- Electromagnetic compatibility
- Shipping and storage conditions
- Mechanical and climatic environment conditions
- Specifications for insulation tests, protection class, degree of protection, and rated voltage
- Rated voltages

Observing the Design Guidelines

SIMATIC products meet the requirements if you observe the design guidelines described in the manual when installing and operating the equipment.

11.2 Technical data

Technical specifications of FM 350-1

Dimensions and weight	
Dimensions W x H x D (mm)	40 x 125 x 120
Weight	approx. 250 g

Current, voltage and power	
Current consumption (from backplane bus)	max. 160 mA
Power loss	typically 4.5 W
Auxiliary voltage 1L+ for the encoder supply Reverse polarity protection	24 V DC (permissible range: 20.4 V to 28.8 V) Yes
Encoder supply	• Current consumption at 1L+ (no-load): max. 20 mA • Encoder supply 24 V – 1L+ -3V – max. 400 mA, short circuit-proof • Encoder supply 5.2 V – 5.2 V ± 2% – max. 300 mA, short circuit-proof • Permissible potential difference between the input (ground) and central grounding busbar of the CPU: 1 V DC
Auxiliary voltage 2L+ for the load power supply Reverse polarity protection	24 V DC (permissible range: 20.4 V to 28.8 V) Yes

Digital inputs	
Low level	-30 V to + 5 V
High level	+11 V to +30 V
Input current	typically 9 mA
Minimum pulse width (max. input frequency)	≥ 2.5 µs (200 kHz), ≥ 25 µs (20 kHz) (programmable)
Input frequency and cable length of asymmetrical encoders (count or digital inputs)	Max. 200 kHz at 20 m length of the cable, shielded
Input frequency and cable length of asymmetrical encoders (count or digital inputs)	Max. 20 kHz at 100 m length of the cable, shielded

Digital outputs	
Supply voltage	2L+ / 2M
Electrical isolation	Yes, against all other circuits, except digital inputs
Output voltage • High signal "1" • Low signal "0"	 min. 2L+ - 1.5 V max. 3 V
Switching current • Rated value • Range	 0.5 A 5 mA to 0.6 A
Rise time	max. 300 µs
Shut-off voltage (inductive)	limited to 2L+ - (45 V to 55 V)
short circuit-proof	Yes

5-V count inputs	
Level	to RS422
Terminating resistor	approx. 220 Ohms
Differential input voltage	min. 1.3 V
Maximum count frequency	500 kHz
Electrical isolation to S7-300 bus	No
Input frequency and cable length of symmetrical 5-V incremental encoder	max. 500 kHz at 32 m length of the cable, shielded
Input frequency and cable length of symmetrical 24-V incremental encoder	max. 500 kHz at 100 m length of the cable, shielded

24-V count inputs	
Low level	-30 V to +5 V
High level	+11 V to +30 V
Input current	typically 9 mA
Minimum pulse width (max. count frequency)	≥ 2.5 µs (200 kHz), ≥ 25 µs (20 kHz) (assignable)
Electrical isolation to S7-300 bus	No
Input frequency and cable length of asymmetrical encoders (count or digital inputs)	Max. 200 kHz at 20 m length of the cable, shielded
Input frequency and cable length of asymmetrical encoders (count or digital inputs)	Max. 20 kHz at 100 m length of the cable, shielded

Replacement parts

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Spare parts

The table lists all spare parts of the S7-300 system. You can order these separately or in addition to your FM 350-1.

S7-300 parts	Order number
Bus connector	6ES7390-0AA00-0AA0
Labeling strip	6ES7392-2XX00-0AA0
Slot number label	6ES7912-0AA00-0AA0
Front connector (20-pin) screw-in contacts	6ES7392-1AJ00-0AA0
Front connector (20-pin) spring-loaded contacts	6ES7392-1BJ00-0AA0
Shield connection element (with 2 screw bolts)	6ES7390-5AA00-0AA0
Shield connection terminals for • 2 cables, each with 2 mm to 6 mm shield diameter • 1 cable with 3 mm to 8 mm shield diameter • 1 cable with 4 mm to 13 mm shield diameter	 6ES7390-5AB00-0AA0 6ES7390-5BA00-0AA0 6ES7390-5CA00-0AA0
Measuring range module for analog inputs (coding plug)	6ES7974-0AA00-0AA0

References

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Supplementary references

The table below lists all manuals to which reference is made in the present manual.

No.	Title
/1/	SIMATIC; S7-300 CPU 31xC and CPU 31x: Installation (http://support.automation.siemens.com/WW/view/en/13008499)
/2/	SIMATIC; System and Standard Functions for S7-300/400 (http://support.automation.siemens.com/WW/view/en/44240604)
/3/	Modifying the System during Operation via CiR (Can not be ordered separately) Online help and electronic manual as component of STEP 7

Glossary

Asymmetrical signals

Refers to two pulse sequences, phase-shifted by 90°, and with zero mark signal where applicable.

Configuration

Assignment of modules to racks, slots and addresses. Users configuring the hardware fill out a configuration table in STEP 7.

Double evaluation

In this mode, the module evaluates all positive edges of the pulses at track A and B of an incremental encoder.

Encoders

Encoders are used to for the precise recording of rectangular signals reflecting distances, positions, velocity, speed, dimensions, etc.

Encoders with asymmetrical output signals

These encoders return two differential pulse sequences with 90° phase-shift, including a zero mark signal where applicable.

Encoders with symmetrical output signals

These encoders return two differential pulse sequences with 90° phase-shift, including inverted signals to form a zero mark as required.

Function (FC)

According to IEC 1131-3 notations, this is a code block which does not contain static data. A function supports the transfer of parameters in a user program. Functions are thus particularly suitable for programming complex, recurrent functions

Function module (FM)

A module which relieves the CPU of the S7 automation system of process signal processing tasks which are critical in time or memory-intensive. As a rule, FMs use the internal communication bus for high-speed data exchange with the CPU. Examples of FM applications: Counting, positioning, controlling

Incremental encoder

Incremental encoders are used to record distance, position, velocity, speed or weight units by counting small increments.

Increments per encoder revolution

Defines the number of increments the encoder outputs per revolution.

OD

The "output disable" (OD) signal is used in STOP and HOLD state to force all modules of an S7 automation system to safe state. A safe state could be: all outputs are shut off, or supplied with a substitution value.

Power control

The power control unit controls the motor; its simplest form is a contactor relay circuit.

Proximity switch

A simple BERO switch, without directional information. The device returns only a single count signal. The counter records only the positive edges at signal A. The count direction is user-specific.

Pulse duration

The pulse duration setting defines the minimum on time of an output.

Push-pull

Push-pull output of an encoder; supplies an active low signal to 0 V (ground) and an active high signal to +24 V.

Quadruple evaluation

In this mode, the module evaluates all pulse edges at the tracks A and B of an incremental encoder.

SFC

An SFC (system function) is an integrated function of the CPU operating system. The SFC can be called in the STEP 7 user program as required.

Single evaluation

Refers to a the evaluation of positive edges of the pulses at track A of an incremental encoder.

Sinking output

Encoder output which returns an active low signal to 0 V (ground)

Sourcing output

Sourcing output of the encoder which returns an active high signal +24 V.

STOP

STOP as an international term, for example, as an operating command.

STOPP

STOPP (German spelling) as a term used in the manual to define an action which is not a command.

Zero mark

The zero mark is positioned on the third track of an incremental encoder. It returns a zero mark signal after each rotation.

Zero mark signal

The incremental encoder returns one zero mark signal per revolution.

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